BIG-EGED BUGS GEOCORIS: DIETS RESEARCH AND POTENTIAL OF USE IN PREVENTION OF A NUMBER OF INSECT PESTS IN VIETNAM

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ABSTRACT

Big-eyed bugs *Geocoris* spp. (Lygaeidae, Hemiptera) are small insects that is found in many parts of the world. They are beneficial because they eat a multitude of insect pests in agriculture. Big-eyed bugs *Geocoris* spp. are insects that receive research attention in Florida and elsewhere because of the benefits that this species give to plants (Mead, 2001). Big-eyed bugs reproduce many generations in a year on weeds, perennial crops, bushes. In spring the female big-eyed bugs start laying eggs on the bud, the leaves of the host plant. Understanding the biology and the role of predator *Geocoris* spp. in ecosystem will provide an alternative method in sustainable agriculture development. In this short review, we discuss some convenient diets for the application of mass rearing *Geocoris* spp.

Keywords: Big-eyed bugs; *Geocoris* spp.; insect pests; predator.

1. Introduction

Big-eyed bugs *Geocoris* spp. in the order Hemiptera are small insect that are found in many parts of the world. *Geocoris* spp. distributed in regions of the US such as Texas, Colorado, California, Hawaii, and other places such as southern Canada, Panama, Guatemala. Big-eyed bugs *Geocoris* spp. which have about 25 species found in the US and Canada.

Geocoris punctipes appear throughout Florida and many other places: western New Jersey, southern Indiana, southern Colorado, southwest Texas, Arizona, Califorina and Mexico. *Geocoris punctipes* are the most common species on cotton plants, living in gardens, lawns, agricultural crops. In addition, *Geocoris punctipes* are also found in bonsai gardens, vegetable gardens and in strawberry greenhouse systems (Mead, 2001).

The *Geocoris bullatus* and *Geocoris uliginosus* species are widely distributed in the United States and Canada.They are beneficial because they eat a multitude of insect pests in agriculture such as thrips, small Lepidopteran larvae, whitefly larvae, mites, ect. Recently, Liu and Zeng, 2014 reported the influence of artificial diet versus live prey on the functional response of *G. pallidipennis* to understand of the interaction between nutritional history and predation. In addition, study by Yokoyama, 1980 indicatec that *Geocoris pallens* was successfully reared on a diet of sunflower seeds and nymphs of the large milk-weed bug *Oncopeltus fasciatus* (Dallas). *Geocoris punctipes* nymphs and adults successfully attack and suck dry *Heliothis virescens* larvae of various sizes (Chiravathanapong and Pitre, 1980).

With the aim of developing a sustainable and safe agriculture, a series of products have been researched and produced: fertilizers, bio-pesticides, pest-resistant plants,… At the same time, the use of natural enemies in pest control is a recent interest, such as *Plutella xylostella* to harm cruciferous vegetables and ladybirds *Coccinella transversalis,* to control of gray mealybug, *Brevicoryne brassicae* Linnaeus. Big-eyed bugs *Geocoris* spp. are also species of natural enemies that have high pest control efficiency. Knowledge of a predator's diets is important for the development of effective rearing methods. However no such studies have been reported for *Geocoris* spp. in Vietnam where conditions are likely to differ from others countries.

2. Diets for mass rearing *geocoris*

Nymph and adult big-eyed bugs can eat a variety of small-sized preys including aphids, red spiders, insect eggs, small nymphs, larvae, white beetles, and mite species, categorizing them as generalist predators. Big-eyed bugs kill their prey immediately, sucking them dry, and eat many prey individuals to complete their development (Fig.1). Sometimes lack of food they eat other carnivorous insects or plant tissue to survive but the ability to harm plants is negligible. They have great benefits for agricultural crops, ornamental plants and many other plants. In addition, many studies have demonstrated big-eyed bugs *Geocoris* spp. can be fed with artificial food in the laboratory and has the same effect in natural condition (Table 1).

Figure 1. Big-eyed bug is sucking prey (Photo by: Nguyen Quynh Phuong Anh)

Geocoris spp. are primarily predaceous, although some species require plant food for optimal development. Supplementary feeding on plant material allows limited survival of *G. punctipes* when only poor quality prey or no prey are available (Eubanks and Denno, 1999). The eggs of *Ephestia kuehniella* Zeller (Lepidoptera; Pyralidae) are used as the major food source for mass rearing *Geocoris varius* (Uhler) (Hemiptera: Geocoridae) resulting in high production costs of *G. varius* (Igarashi and Nomura, 2013). On the otherhands, *G. punctipes*, have been reared for more than 6 years (60 continuous generations) on meat products and eggs consist of ingredients that have a high moisture content. In addition, the occurence of *Geocoris ochropterus* amongst crop pests as well as on fallow weeds can be understood as a part of predator-weed-crop interaction, the dietary influence of vegetative food on the biology of some species of *Geocoris* have been studied by Tamaki and Weeks (1972), Naranjo and Stimac (1985). Based on the findings of these authors, a combination diet of ant pupae as animal food and weed (twigs) as vegetative food was made to rear *Geocoris*. In ant pupal diet, high carbohydrate, intermediate protein and less lipid levels supported a quick development and high fecundity in *G. ochropterus*. However, Cohen (1985) documented that higher protein, intermediate lipid, and low carbohydrate contents in an artificial diet was ideal for mass culture of *Geocoris punctipes* (Say). Cohen, 1989 explained that lower ingestion efficiency on ant pupae (39.20%) of *G. ochropterus* as compared to that of *G. punctipes* (65%) on aphids may be due to greater amount of nonconsumable chitin of ant pupae.

Lepidopteran eggs have been researched on the development and survival of *Geocoris lubra*. Eggs of *Anagasta kuehniella* (Zeller) were also found suitable for rearing of *G. punctipes* (Calixto et al., 2014). *Sitotroga cerealella* eggs can be effectively utilized for mass-rearing of *G. ochropterus*. Diet of *Helicoverpa armigera* (Hubner) eggs was successful on the development and survival of *Geocoris lubra* Kirkaldy from egg to adult rather than *A. gossypii* at 27°C. *Helicoverpa zea* (Boddie) and the mirid, *Lygus hesperus* (Knight), provide a high quality diet for development and survival of *G. punctipes* when a water source is also present (Lopez et al., 1976). In contrast, pea aphids (*Acyrthosiphum pisum* Harris) were a poor quality diet for *G. punctipes* (Eubanks and Denno, 1999 and 2000).

Table 1

List of some diets for rearing *Geocoris* spp.

Geocoris species	Diets	Reference
G. lubra	*Helicoverpa armigera* (Hubner) eggs, aphids (*Aphis gossypii* Glover)	Mansfield et al., (2007)
G. punctipes	*Helicoverpa zea, Lygus hesperus,* Eggs of *Anagasta kuehniella* (Zeller), Aphids, Whitefly *Bemisia tabaci* (Genn.), meat products and eggs,	Eubanks and Denno, 1999 and 2000; Calixto et al., 2014; Cohen and Byrne, 1992
G. ochropterus	*Sitotroga cerealella* eggs, ant pupal	Tamaki and Weeks 1972; Naranjo and Stimac (1985)
G. varius	eggs of *Ephestia kuehniella* Zeller, liver and ground pork	Igarashi and Nomura, 2013
G. pallidipennis	*Myzus persicae*	Liu and Zeng, 2014

Liu and Zeng, 2014 compared functional response curve of both the nymphs and the adult female of *Geocoris pallidipennis* when fed to natural prey (*M. persicae*) and an artificial diet (included liver, yeast, chicken eggs and sugar) and the results showed that the functional response curve of both the nymphs and the adult female of *G. pallidipennis* to *M. persicae* reflected similar trends on both nutritional histories and confirmed the type II response (Figure 2). Adult female *G. pallidipennis* reared on either *M. persicae* or artificial diet produced a significantly better performance than the juvenile stages tested, and displayed high rates of predation.

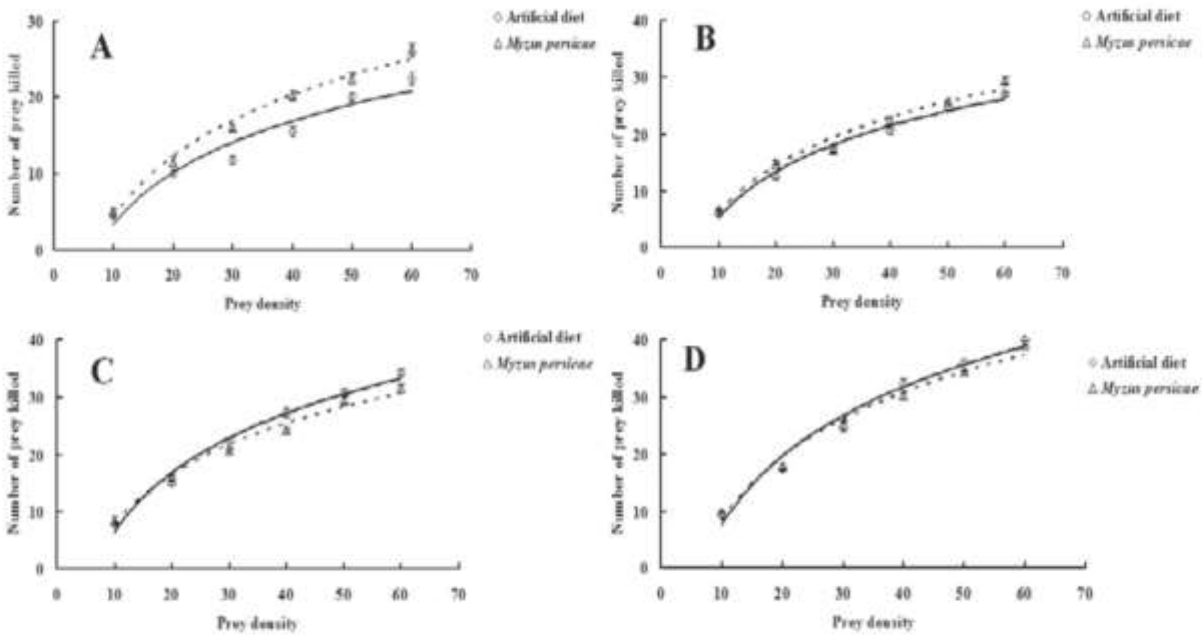

Figure 2. Functional response of *G. pallidipennis* from different nutritional history to *M. persicae* over 24h, data are presented as mean number ± SE and predicted lines are fitted using the random predator equation. A-The third instar *G. pallidipennis*, B-the fourth instar *G. pallidipennis*, C-the fifth instar *G. pallidipennis* and D-the female *G. pallidipennis* (Liu and Zeng, 2014).

Scientists have demonstrated that *Geocoris* reared on artificial diets are able to kill an equivalent amount of prey as those fed on natural prey or moth eggs such as *Corcyra cehalonica* eggs (Hagler & Cohen, 1991; Bonte & De Clercq, 2010). Cohen (2000) also demonstrated that domesticated predators and their feral counterparts show similar characteristics of prey selection, metabolic efficiencies and digestive abilities.

3. Research about big-eyed bugs and potential applications in Vietnam

The selection of prey, feeding behavior, fertility and culture method as well as the reproductive parameters of big-eyed bugs with different physical conditions play an important role for successful breeding of natural enemies. Some species have been studied recently such as *Geocoris punctipes* (Say) (Ruberson et al., 2001), *Geocoris lubra* (Mansfield et al., 2007), are distributed in temperate regions; but there are no scientific parameters for *Geocoris ochropterus* in Vietnam, which was recorded in Madras, India (Kumar and Ananthakrishnan, 1985) and is native to Vietnam by Nga and Khuong, 2011.

According to Hagler and Cohen (1991), big-eyed bugs *Geocoris* spp. have the potential for effective biological control. As listed in table 1, *Geocoris* spp. have widened diets during their life. Both adults and nymphs can eat dozens of prey each day. In Arkansas, *Geocoris punctipes* and *Geocoris uliginosus* are one of the most important and effective predatory insects on cotton from June to September, big-eyed bugs also eat aphids, eggs and larvae of cotton insect pests (Bell and Whitcomb, 1964). In addiotn, Lingren et al., (1968) noted that nymph big-eyed bugs eat an average of 47 spiders and adult big-eyed bugs eat about 83 red spiders each day. Research shows that the nymph stage can eat 1600 spiders to develop until becomes adult.

In Viet Nam, *Geocoris* spp. are found in many places such as: Ninh Thuan, Can Tho provinces and Cu Chi (Ho Chi Minh city) on okra, eggplant, pepper, and Vietnamese wax gourd (*Benincasa hispida*) ect. They are considered as an important natural enemies to control insect pest in the country (Chau et al., 2017, unpublished data). Under laboratory condition, *Geocoris* spp. female lay from 43,77 to 77 eggs at 29,75°C, 70,7% RH, 27°C, 80% RH respectively. Adult preyed upon 232,4 leafhopper *Amrasca devastans* Distant (Nguyen Van Chinh, 2012). In addition, *Geocoris* spp. were also found on tea plantations at very low population density (Pham Van Lam, 2013). We have attempted to multiply the *G. ochropterus* population in the laboratory and to study its biology, life table and feeding potential to meet the predator requirement for large-scale releases by developing an inexpensive and simple mass rearing system.

Mass rearing of *G. ochropterus* on any convenient diets is essential for successful biological control programs. Chau et al., 2017 have examined the development and reproduction of *G. ochropterus* fed on three kinds of convenient diets: ant pupae *Oecophylla smaragdina* (AP), *Bombyx mori* pupae (BM), and adult aphids *Aphis gossypii* (A) as control. Results indicated that there was not significant difference on the body length, head width, and forewing length of grown-up *G. ochropterus* compared to control, except for BS in which the female body length and male forewing length was smaller. Significant differences were observed in adult weight (mg) of females fed on BS diet. There was no significant difference on development time (days) from first to five larval instar of *G. ochropterus* among the treatments. Besides, some diets affected total number of eggs laid; the bugs fed on AP produced the highest total number of eggs (68.63 ± 11.04, mean ± SD, n = 8), that was significantly different from the control ($P<0,01$). Finally, diets did not influence egg hatching percentage and survival rate of *G. ochropterus*. Our study suggests that all of ant pupae *Oecophylla smaragdina* (AP) and *Bombyx mori* pupae (BM) can be used for mass rearing of *G. ochropterus* (unpublished data).

4. Conclusion

Vietnam is an agricultural country, with up to 70% of the population working in this area. Therefore, agricultural production plays a very important role in the national economy. Because of that, the application of researches on inoculants and species of natural enemies to control insects that cause harm to plants is essential when aiming at a large-scale agriculture with ensuring productivity and quality, as well as minimize the use of chemical pesticides, ensuring VietGap standards and towards sustainable agriculture■

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