Philipp Ent 20 (2):137-149 ISSN 0048-3753 October 2006

PREY CONSUMPTION OF THE EARWIG (*Euborellia annulipes* Lucas) (Dermaptera; Labiduridae) GIVEN COTTON APHID (*Aphis gossypii* Glover) AND COTTON LEAFHOPPER (*Amrasca biguttula biguttula* Ishida)[1]

V. O. Marbun[2], B. Morallo-Rejesus[3] and V. J. Calilung[3]

[1] Portion of the Master of Science thesis of the senior author, Graduate School, University of the Philippines Los Baños (UPLB) under the supervision of the junior authors.

[2] Former graduate student, IPM-SECP Jakarta, Indonesia

[3] Professor Emeritus, Crop Protection Cluster, College of Agriculture, UPLB, College, Laguna 4031 Philippines. (*corresponding author)

ABSTRACT

The prey consumption of the earwig (*Euborellia annulipes* Lucas) given cotton leafhopper (*Amrasca biguttula biguttula* Ishida) and cotton aphid (*Aphis gossypii* Glover) was determined. The adult earwig consumed more aphids and leafhoppers than the 3rd or 4th instar nymph. In the laboratory, it consumed in 24 hours a mean of 32.12 ± 1.09 leafhoppers, 31.36 ± 1.06 aphid nymphs and 31.29 ± 1.06 aphid adults; while in the greenhouse, it consumed 26.05 ± 0.88 leafhoppers, 26.29 ± 0.89 aphid nymphs and 22.99 ± 0.78 adults.

The adult earwig preyed on cotton aphid and cotton leafhopper at all growth stages, whereas the 4th instar nymph preferred the nymphs over the adult preys. The 3rd instar nymph exhibited the least predation.

The functional response curve of the earwig fitted the Type II model of predation of Holling . The earwig rapidly consumed all the 20 or 30 preys offered but consumption rate leveled off at 40 to 50 preys within 24 hours, probably reaching the satiation point. The functional response showed that it is dependent on the length of time that the prey is exposed, the prey density and the developmental stage of the prey.

Key words: *Aphis gossypii, Amrasca biguttula biguttula,* functional response, predatory earwig, *Euborellia annulipes,* prey consumption

Abreviation: Abb - *Amrasca biguttula biguttula,* Ag - *Aphis gossypii,* ANOVA - Analysis of Variance, CRD – Completely Randomized Design, Ea - earwig, Gh greenhouse, Lab - laboratory

INTRODUCTION

Cotton (*Gossypium hirsutum* Linn) is one of the most important and versatile fiber crops in the world today. The use of cotton lint is about 3 kg per person per year in the industrialized nations and 1.5 kg per person per year in the developing countries. So far, the biggest producer of cotton lint is the USA with 4.0 MT followed by China (3.7 MT), India (2.5 MT), Pakistan (1.5 MT), Uzbekistan (1.12 MT), Brazil (0.4 MT) and Egypt (0.3 MT). The principal exporting countries are the USA, Egypt, the Asian Republics of the former USSR, and China (CABI, 1999).

In Indonesia, cotton production started during the Dutch colonization. About 60% of Eastern and Central Java were planted to cotton with an area of 82,120 hectares (Kemala et al. 1975). However, it was reduced to 17,278 hectares during the Japanese regime (Sulistyo dan Mawarni, 1991). In spite of this, the government is continuously supporting the cotton industry. Under the five-year development program, 15,000 to 36,000 hectares were planted to cotton with a total production of 2.5 to 6.5 tons of cotton fiber per year (Kapas, 2001).

One of the constraints to high production of cotton in the country is the pest problem. The cotton plant, like any other crop, has a wide array of insect pests. There are about 62 species of insects and 2 species of mites found associated with cotton. Among the major insect pests are *Amrasca biguttula biguttula* (Ishida), *Helicoverpa armigera* (Hubner), *Earias vitella* (Fabr.), *Pectinophora gossypiella* (Saunders), *Spodoptera litura* (Fabr.), *Aphis gossypii* Glover, *Cosmophyla (Anomis) flava* (Fabr.), and *Syllepta derogata* (Fabr.) (Nurindah dan Subiyakto, 2000).

Indonesian farmers, as in other countries, rely heavily on insecticidal sprays for the control of insect pests. It has been known that with heavy dependence on insecticidal sprays, cotton is one of the first crops for which the effectiveness of chemical control declined due to development of resistance in the target pests (Nurindah dan Subiyakto, 2000). Thus, the government opted for biological control tactics.

Several investigations on the use of biological control agents against insect pests of cotton have been done in Indonesia. Among them is the use of parasitoids such as *Trichogramma* sp. against *P. gossypiella*, *Apanteles* sp. against *C. flava*, and *Aphelinus gossypii* against the cotton aphid. Likewise, predators such as coccinellids, syrphid flies, staphylinid flies, predatory hemipterans like *Geocoris ochropterus* Fieber, *Campylomma diversicornis* Reuter, *Rhinocoris fuscipes* Fabr., *Eocanthecona furcellata* Wolff, and *Antilochus* sp., asilid fly and spider have been evaluated (Nurindah dan Subiyakto, 2000). Earwigs are also promising biological control agents against insect pests of cotton. Several species have also been reported preying on different phytophagous and coleopterous insect pests of other agricultural crops (Bishara, 1973; Tawfik et al. 1972; Ammar and Farrag, 1974; Shepard et al. 1978; Situmorang and Gabriel, 1988; and Javier et al. 1993).

In the Philippines, one predatory earwig, *Euborellia annulipes* (Lucas), was observed to be dominant in the corn agro-ecosystem. It was identified by Dr. A. Brindle[1] in 1967, Srivastava[2] in 1976 and Sakai[3] in 1982, but re-identified as *E. annulipes* by Dr. Victor P. Gapud[4] in 2005. The earwig preys on eggs, early instar larvae and pupae of the Asian corn borer, *Ostrinia furnacalis* Guenee (Situmorang and Gabriel, 1988 and Javier et al. 1993). They also observed *E. annulipes* preying on other lepidopterous pests.

The augmentative release of *E. annulipes* has been shown to effectively control the Asian corn borer in the field (Morallo-Rejesus and Punzalan, 2001). Probably, it could also be used as biological control agent against insect pests of cotton such as *A. biguttula, biguttula* Ishida and *A. gossypii* Glover. The cotton leafhopper is one of the important pests in cotton plantations in Indonesia, causing yield loss greater than 135 kg lint per hectare. However, only chemical control and use of resistant variety have been practised for controlling this pest in Indonesia. In addition, the cotton aphid is also an important pest in cotton plantation. This aphid adversely affects flowering of cotton resulting in low production of cotton balls. Chemical application on young plants to control the cotton aphid usually results in increased population of the pest (Nurindah dan Subiyakto, 2000). Hence, this study was conducted in the laboratory and greenhouse of the Department of Entomology, UPLB from November 2002 to May 2003 to determine the prey preference and functional response of the earwig at different developmental stages to the cotton leafhopper and the cotton aphid.

---

[1] Department of Entomology, the Manchester Museum, England
[2] Division of Crop Physiology, Biochemistry & Microbiology, Indian Institute of Pulses Research,Kanpur-208 024, India
[3] Professor, Daito Bunka University, Japan
[4] Professor, Department of Entomology, College of Agriculture, University of the Philippines Los Baños, College, Laguna, Philippines

MATERIALS AND METHODS

Mass Rearing of the Predator and Preys

The earwig, *E. annulipes Lucas* (Fig 1)

Initial population of the predator was obtained from the existing stock culture maintained in the laboratory and reared following the method of Punzalan and Morallo-Rejesus (2004). The adult earwigs were confined in an acrylic pan with 2 or 3 cm of soil mixed with corncob and dog food kept moist throughout the rearing period. After oviposition, the eggs together with the female earwigs were transferred to a plastic cup lined with moistened cloth for egg hatching. Three days after hatching, the nymphs were separated from the adult, kept individually in plastic cups and observed for molting to adult stage. Nymphs and adults were used in the experiment.

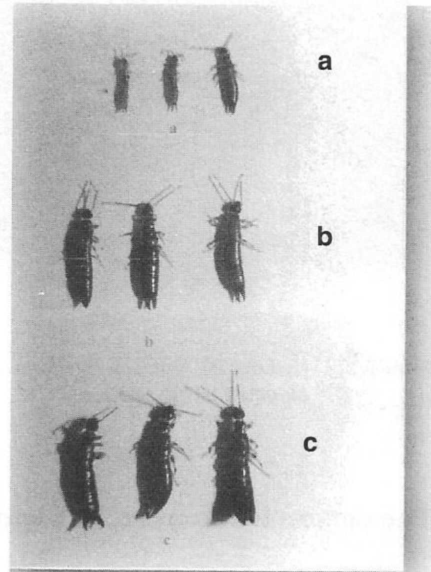

Figure 1 The predatory earwig *Euborellia annulipes* Fabr. (a - 3rd instar nymphs, b- 4th instar nymphs and c-Adults, 2X).

The cotton aphid, *A. gossypii* Glover (Fig. 2)

The initial population of the cotton aphid was collected from the field and reared on potted okra seedlings in the greenhouse. About 20 adult aphids were introduced on each seedling using a camel's hair brush and allowed to reproduce for 24 hours. The following day the adults were removed, leaving the progeny. About 20 to 30 okra seedlings were maintained in the greenhouse. These were kept individually in screen cages to avoid the attack of predators. Staggered planting of okra was done to ensure availability of host seedlings for maintenance of the cotton aphid population.

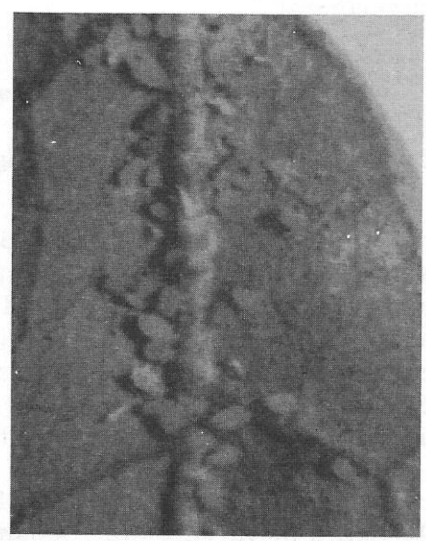

Figure 2. Adults and nymphs of *Aphis gossypii* Glover (5x)

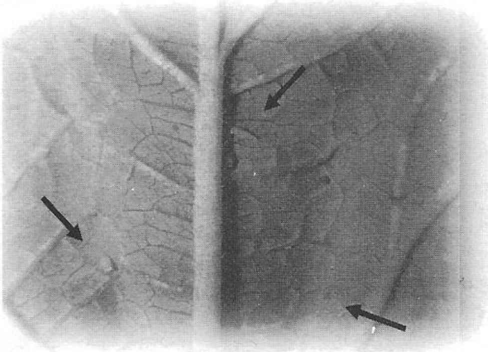

Figure 3. Nymphs of *Amrasca biguttula biguttula* Ishida (2X).

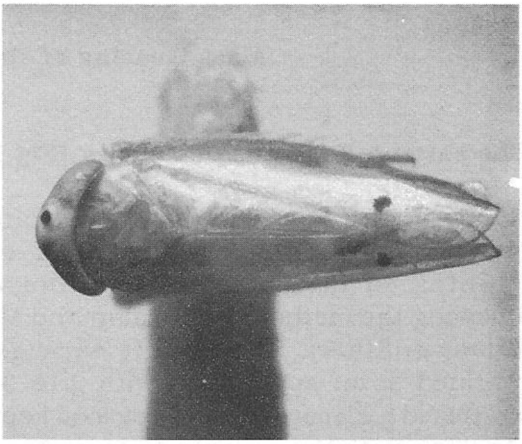

Figure 4. Adult *Amrasca biguttula biguttula* Ishida (60x)

The cotton leafhopper, *A. biguttula biguttula* Ishida (Figs. 3 & 4)

Okra was also used for rearing the cotton leafhopper. Using an aspirator, about 20 adults were introduced per screen cage containing one okra seedling. Similarly, staggered planting of okra was done to ensure continuous supply of host plants for maintenance of the cotton leafhopper culture used in the experiment.

Prey Consumption of *E. annulipes*

Under laboratory condition (Fig. 5)

Cotton aphid as prey. Both nymphs and adult cotton aphids were offered as prey to third and fourth instar nymphs and adults of *E. annulipes*. Using a camel's hair brush, nymph and adult aphids were placed separately on excised okra leaves on petri dishes lined with moistened tissue or filter paper. One predator at each instar starved for 48 hours was introduced in each of ten petri dishes. Each dish contained 20, 30, 40 or 50 preys and kept for 24 hours. There were three replications per test and ten samples per replication.

The prey consumption of *E. annulipes* was determined after 4, 8, 12 and 24 hours at varying prey densities. The functional response of the nymph and adult *E. annulipes* to the nymph and adult aphids was determined after 24 hours at different prey densities.

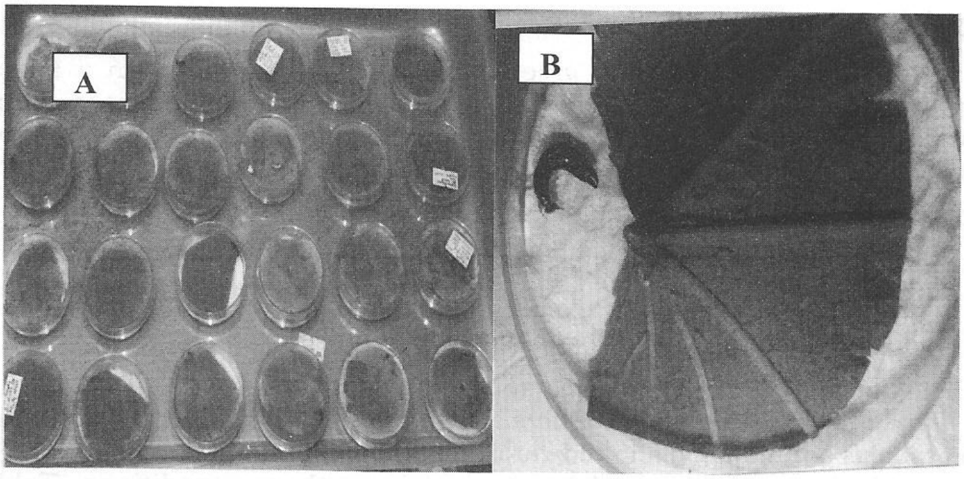

Figure 5. Set–up for determining the prey consumption of *Euborellia annulipes* in the laboratory (A). The preys were placed on excised okra leaf in petri dish lined with filter paper (B). Close-up of a petri dish with excised okra leaf on top of moist filter paper where the prey and predator were confined.

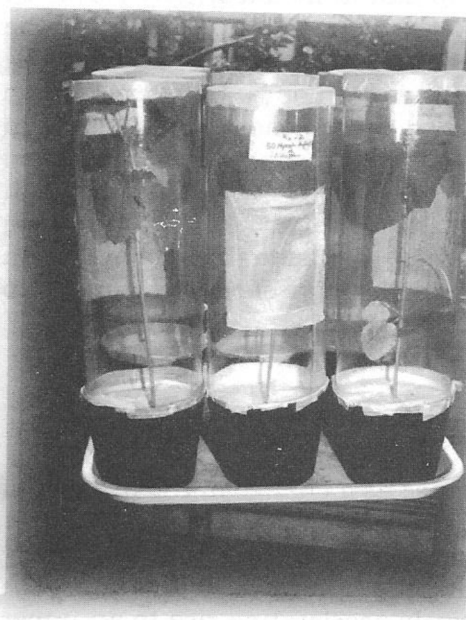

Figure 6. Set-up for determining the prey consumption of *Euborellia annulipes* in the greenhouse. Preys were placed on each potted okra seedling inside a mylar cage.

Cotton leafhopper as prey. The methodology used for cotton aphid was followed for the parallel test on cotton leafhopper nymphs at various instars. Adults were not evaluated since they were too mobile for the earwigs to prey on.

Under greenhouse condition

Cotton aphid as prey. A fifteen-day old okra seedling was placed inside a cage and one earwig starved for 48 hours was introduced. Twenty, 30, 40 or 50 nymphs or adult aphids were placed on each potted plant. Ten cages represented one replicate. There were three replicates per earwig stage. Prey consumption was determined at 4, 8, 12 and 24 hours after prey introduction.

Cotton leafhopper as prey. The methodology used for the cotton aphid was followed in the test using cotton leafhopper nymphs.

Analysis

Both the laboratory and greenhouse tests were laid out in a Factorial Completely Randomized Design replicated three times. The data on prey consumption of *E. annulipes* under laboratory and greenhouse conditions were statistically analyzed using the ANOVA for Factorial CRD.

RESULTS AND DISCUSSION

Prey Consumption

The prey consumption of *E. annulipes* (Ea) when offered *A. bigutulla bigutulla* (Abb) or *Aphis gossypii* (Ag) showed variation among the four feeding periods (4, 8, 12 and 24 hours) tested under laboratory and greenhouse conditions (Tables 1 and 2). The adult Ea showed the highest predation on all prey, followed by the 4th instar nymph, and the 3rd instar nymph the least. There was a continuous increase in predation of Ea on Abb and Ag when the feeding time was prolonged from 4 to 24 hours. Lower consumption of preys by Ea was observed in the greenhouse (Table 2) but the trend was similar to that in the laboratory (Table 1). The 3rd instar nymph Ea consumed more nymphal Ag than adult Ag in the laboratory. In the greenhouse it also consumed more nymphs than adults Ag at 8, 12 and 24 h but not in the initial feeding period of 4 hours. Between the two nymphal preys, the 3rd instar nymph Ea consumed slightly more Abb than Ag in all feeding durations in the laboratory. While in the greenhouse, it consumed slightly more Ag than Abb nymphs at 12 and 24 h. Usually, the 3rd instar nymph Ea avoided feeding on the adult prey but fed on the nymphs of Ag. The clumping and gregariousness of the nymphal Ag preys also contributed to the high predation by the Ea. The adult and 4th instar nymph Ea could be more effective against Abb and Ag in the field than the 3rd instar nymph predator.

Functional Response

Solomon (1949) defined functional response as a change in the number of preys attacked in a fixed period of time by a single predator when the initial prey density is changed. The functional response of adult Ea to either Abb or Ag (Fig. 7 to 8) fitted well the type II model of predation of Hollings (1959), that is, the number of attacks per predator shows a negatively accelerating rise to an upper plateau. Asanti (1995) reported similar observation with European earwig (*Forficula auricularia* Linnaeus) exposed to varying densities of the prey, *Eriosoma lanigerum* Hausmann. The type II model is widespread amongst insect parasitoids and invertebrate predator (Hassel 1976). According to Holling (1959) the other types are type I, where there is a linear rise to a plateau in the attack per predator; type III, a sigmoid curve and type IV, a dome shape curve.

Table 1. Predatory capacity of *E. annulipes* offered *A. biguttula biguttula* and *A. gossypii* for different feeding durations under laboratory condition

PREDATOR	PREY (No. consumed/predator)[1]		
	Abb	Ag	
	Nymph	Nymph	Adult
<u>4 Hours</u>			
3rd instar nymph	2.15c	2.10c	1.43c
4th instar nymph	12.23b	10.86b	8.89b
Adult	12.95a	11.52a	10.98a
<u>8 Hours</u>			
3rd instar nymph	3.70c	3.61c	2.66c
4th instar nymph	18.86b	16.16b	13.05b
Adult	19.70a	17.66a	17.74a
<u>12 Hours</u>			
3rd instar nymph	5.44c	5.23c	4.20c
4th instar nymph	21.79b	20.38b	17.85b
Adult	24.68a	24.34a	24.30a
<u>24 Hours</u>			
3rd instar nymph	8.69c	8.07c	6.67c
4th instar nymph	29.83b	28.21b	26.04b
Adult	32.12a	31.36a	31.29a

[1] Means followed by the same letter in the column for a given feeding period are not significantly different using DMRT at 5% level
Abb - *A. biguttula biguttula* Ag - *A. gossypii*

Table 2. Predatory capacity of *E. annulipes* offered *A. biguttula biguttula* and *A. gossypii* for different feeding durations under greenhouse condition.

PREDATOR	PREY (No. consumed/predator)[1]		
	Abb	Ag	
	Nymph	Nymph	Adult
<u>4 Hours</u>			
3rd instar nymph	1.29c	1.09c	1.19c
4th instar nymph	8.62b	7.11b	5.62b
Adult	9.14a	9.27a	8.35a
<u>8 Hours</u>			
3rd instar nymph	2.20c	2.20c	1.19c
4th instar nymph	11.69b	9.58b	7.68b
Adult	12.55a	12.78a	10.95a
<u>12 Hours</u>			
3rd instar nymph	3.04c	3.50c	3.21c
4th instar nymph	15.00b	12.37b	9.95b
Adult	16.52a	16.61a	13.85a
<u>24 Hours</u>			
3rd instar nymph	4.39c	5.50c	4.72c
4th instar nymph	22.48b	18.76b	13.59b
Adult	26.05a	26.29a	22.99a

[1/] Means followed by the same letter in the column for a given feeding period are not significantly different using DMRT at 5% level
Abb - *A. biguttula biguttula* Ag - *A. gossypii*

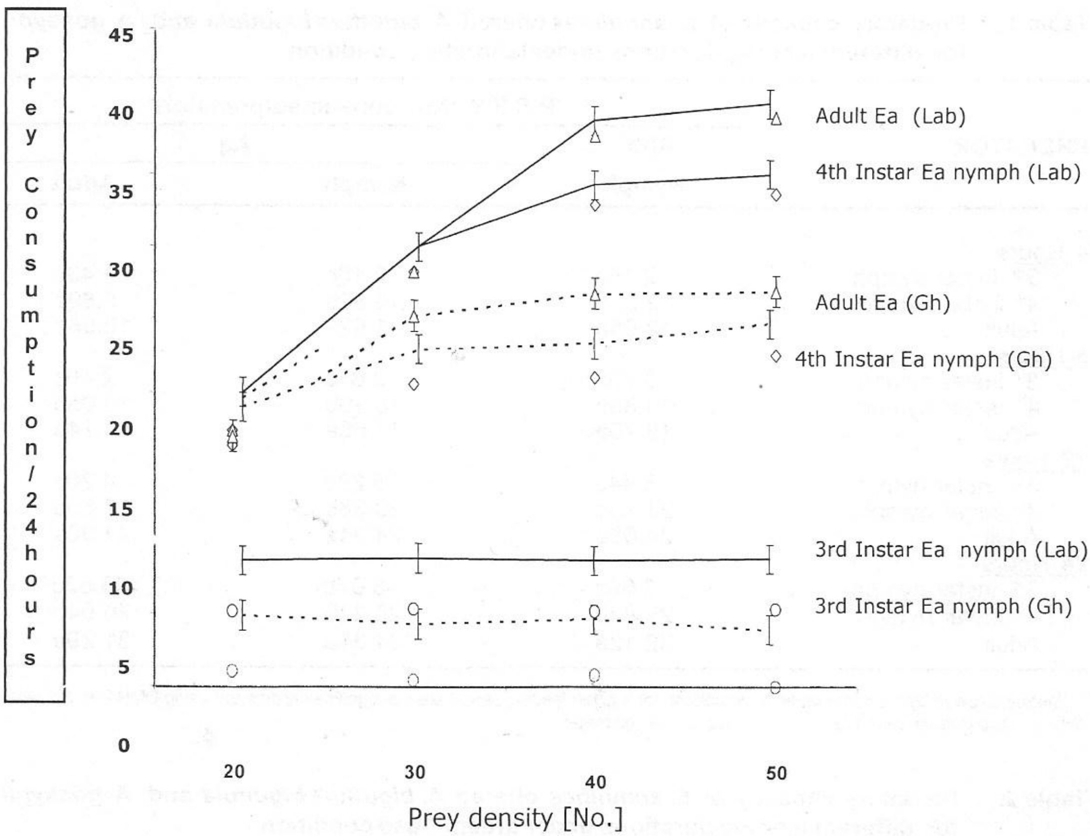

Figure 7. Functional response of *E. annulipes* (Ea) to cotton leafhopper nymphs offered as prey in the laboratory (Lab) and greenhouse (Gh).

The functional response curves of the adult and 4th instar nymph Ea to Abb in the laboratory and greenhouse (Fig. 7) showed an increase at 20 to 40 and leveling off when 50 preys were offered within 24 hours. It indicates that the satiation point was reached at density 40 to 50. The higher consumption in the laboratory than in the greenhouse could be attributed to the small searching area in the former (preys in Petri dish) than in the latter, where Ea had to climb the cotton seedling in search of the preys.

On the other hand, the flat shaped functional response of the 3rd instar nymph Ea indicates that it can only consume less than the 10 Abb preys even if offered 20 to 50 preys within 24 hours; the consumption was even less when Abb was offered in the greenhouse.

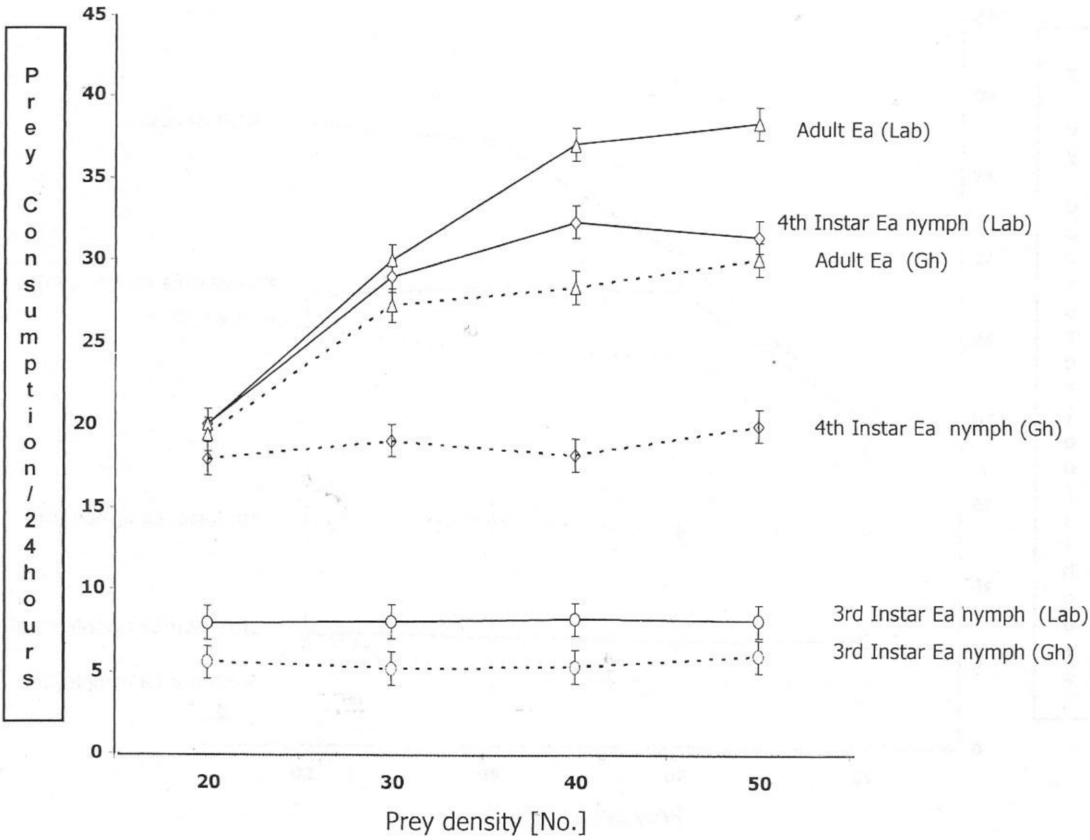

Figure 8. Functional response of *E. annulipes* (Ea) to cotton aphid nymphs offered as prey in the laboratory (Lab) and in the greenhouse (Gh).

The functional response curves with cotton aphids as prey were similar to those with Abb adult but with less prey consumed by the Ea. The consumption of adult aphid prey (Fig. 9) by Ea was less than when offered aphid nymphs (Fig. 8). This is expected since the former is more mobile than the latter prey which could easily be caught by the Ea. Dixon (1973) also reported that the predators consumed large number of nymphs than adult aphids. The functional response curve of the 3rd instar nymphs offered cotton aphids was similar to that with Abb as prey but with slightly fewer aphids consumed.

The declining curve from 40 to 50 preys observed with the 4th instar nymph Ea in the laboratory with cotton aphids as prey (Figs. 8 and 9) can be attributed to the decrease in success of catching the prey and, to a lesser extent, to resting period. Functional response curves deviating from the fundamental types described

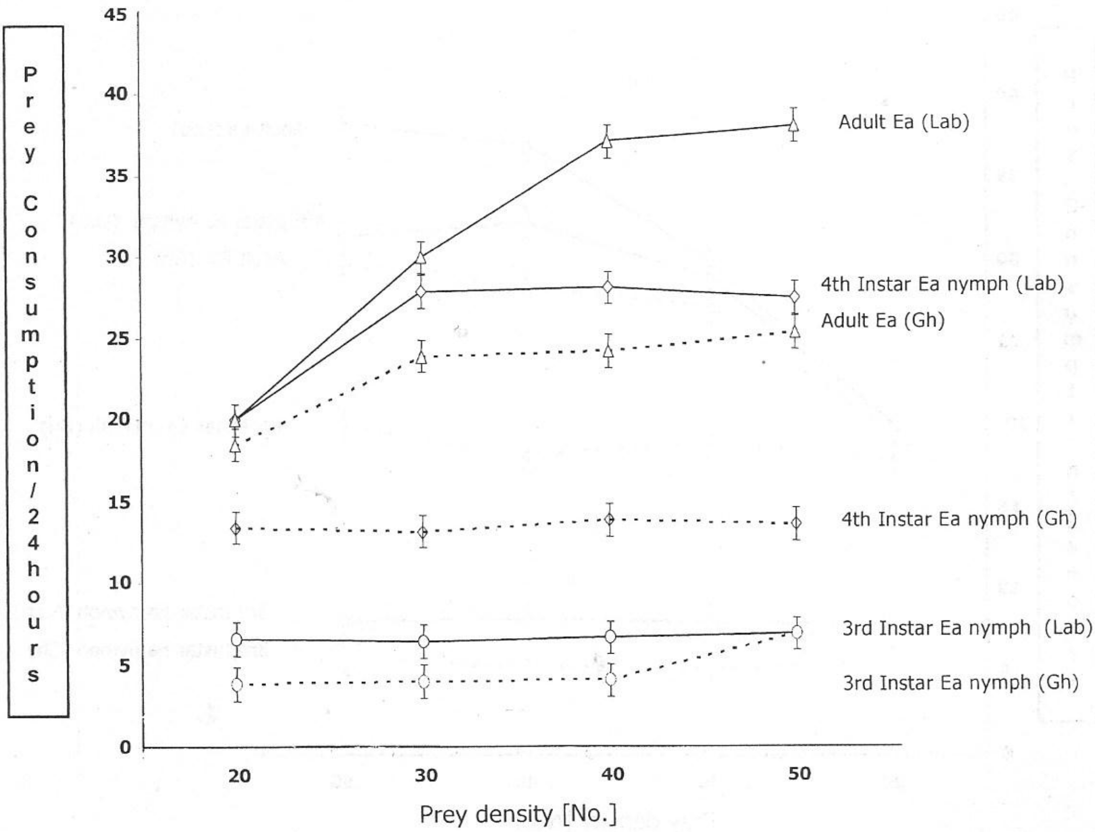

Figure 9. Functional response of *E. annulipes* (Ea) to cotton aphid adults offered as prey in the laboratory (Lab) and in the greenhouse (Gh).

by Holling (1959, 1961) have been frequently observed in experiments with predators (Chant 1961, Mori 1969, Sandness and McMurtry 1970, and Fransz 1974). The deviation could be attributed to behavior of a predator that alternately searches for and feeds on the prey, and may pause for resting or digestion (Holling 1966). The time of handling, feeding and resting do differ with the different stages, instars, ages within a stage or instar and the starvation period before the experiments. In this study, the Ea were starved for 48 hours before exposure to the prey. Based on the preliminary experiments, this length of starvation was the most appropriate for a more or less uniform feeding of the Ea.

SUMMARY AND CONCLUSIONS

The functional response of the adult and 4th instar nymph predatory earwig (*E. annulipes*) offered four densities (20, 30, 40 ,50) of each of the preys for 24 hours fitted the type II model of predation of Holling (1959). The preys were nymphs of cotton leafhopper (*A. biguttula biguttula*), and nymphs and adults of cotton aphid (*A. gossypii*). The satiation point was reached at prey density 40 to 50. This is the first report on the functional response of this predatory earwig to the two preys.

E. annulipes consumed more nymphs than adult cotton aphids. The adult earwig consumed significantly more preys than the 4th instar nymph; while the latter consumed significantly more preys than the 3rd instar nymph in 24 hr.

The results show that *A. bigutulla* and *A. gossypii* can serve as prey for *E. annulipes.* The potential of the earwig as biocontrol agent against these insect pests of the cotton crop needs to be explored.

LITERATURE CITED

AMMAR ED, FARRAG SM. 1974. Studies on behavior and biology of the earwig, *Labidura riparia* Pallas (Dermaptera: Labiduridae), Z. Angew. Entomol. 75: 189-196.

ASANTI SK. 1995. Functional responses of the European earwig and two species of coccinellids to densities of *Eriosoma lanigerum* (Hausmann) (Hemiptera: Aphididae). J. Aust. Ent. Soc. 34:105-109.

BISHARA I. 1973. The cotton cutworm, *Prodenia litura* F. in Egypt. Soc. Roy. Entomol. D'Egypte. 27I: 288-420.

CABI. 1999. Crop Protection Compendium 1999 edition.

CHANT DA. 1961. The effect of prey density on prey consumption and oviposition in adults of *Typhlodromus occidentalis* Nesbitt (Acarina:Phytoseiidae) in the laboratory. Can. J. Zool. 39:311-315.

DIXON AFG. 1973. The biology of aphids. Edward Arnold. London. p. 12-13.

FRANSZ HG. 1974. The functional response to prey density in an acarine system. Wageningen Centre for Agricultural Publishing and Documentation. 143p.

HASSEL MP. 1976. Dynamics of arthropod predator-prey systems. Princeton University Press; Princeton. p 249-262.

HOLLING CS. 1959. Some characteristics of simple types of predation and parasitism. Can. Entomol. 91:385-398.

HOLLING CS. 1961. Principles of insect predation. Ann. Rev. Ent. 6:163-182.

HOLLING CS. 1966. The functional response of invertebrate predators to prey density. Mem. Ent. Soc. Can. 48:86 p.

JAVIER PA, DAYAOEN-ABELLON CL, MORALLO-REJESUS B. 1993. Studies on the life history of earwig predatory to the Asian corn borer, *Ostrinia furnacalis* (Guenee). The Philippine J. Sci. 122 (4): 57-376.

KAPAS, 2001. Balai Penelitian Tembakau dan Tanaman Serat. Monograf Balittas Vol 7, 76p.

KEMALA S, HASMAN A, SASTROSUPADI M, PALILU, Z AZZAINO. 1975. Faktor-faktor yang mempengaruhi pengembangan kapas di Indonesia. Lembaga Penelitian Tanaman Industri. 103 p.

MORALLO-REJESUS B, PUNZALAN EG. 2001. Mass rearing and field augmentation of the earwig *Euborellia annulata* against ACB. Ann. Rept. 2001. Dept. of Entomology, College of Agriculture, University of the Philippines Los Baños, College, Laguna. p1-19.

MORI H. 1969. The influence of prey density on the predation of *Amblyseius longispinosus* (Evans) (Acarina:Phytoseiidae). p. 149-153. *In* Proc. 2nd Int. Congr. Acarology, Sutton-Bonington 1967.

NURINDAH dan SUBIYAKTO. 2000. Organisme Pengganggu Tanaman Kapas dan Musuh Alami Serangga Hama Kapas. Edisi BPTTS. p 1-52.

PUNZALAN EG, MORALLO-REJESUS B. 2004. Mass-rearing of predatory earwig, *Euborellia annulata* (Fabricius), on artificial diet. Philipp. Ent. 18:16-23.

SANDNESS JN, MCMURTRY JA. 1970. Functional response of three species of Phytoseiidae (Acarina) to prey density. Can. Ent. 102:692-704.

SHEPARD M, WADDIL V, KLOFT W. 1978. Biology of the predacious earwig, *Labidura riparia* (Dermaptera: Labiduridae) Ann. Entomol. Soc. Hon 66:837-884.

SITUMORANG J and BP GABRIEL. 1988. Biology of two species of predatory earwigs, *Nala lividipes* (Dofour) (Dermaptera: Labiduridae) and *Euborellia annulata* (Fab.) (Dermaptera: Carcinophoridae) Philipp. Ent. 7(3):215-238.

SOLOMON ME. 1944. The natural control of animal populations. J. Anim. Ecol. 18: 1-35.

SULISTYO dan A MARWANI. 1991. Kapas. Kajian Sosial Ekonomi. Aditya Media. Yogyakarta. p 67.

TAWFIK MF, S. ABDUL-NASR and MM HUSSEIN. 1972. Biology of *Labidura riparia* (Pallas), Bull. Soc. Entomol. Egypte. 56:75-91.