Australian Journal of Basic and Applied Sciences, 4(8): 2182-2187, 2010
ISSN 1991-8178

Functional Response of *Chrysoperla Carnea* (Stephens) (Neuroptera: Chrysopidae) Larvae to *Phthorimaea Operculella* Zeller (Lepidoptera: Gelechiidae) Eggs

[1]Hany A.S. Abd El-Gawad, [1]ATEF M.M. Sayed and [2]Sayed A. Ahmed

[1]Plant Protection Research Institute, A.R.C., Dokki, Giza, Egypt.
[2]Faculty of Environmental Agricultural Sciences, Suez Canal University, El-Arish, Egypt

Abstract: A functional response study of the predator green lacewings, *Chrysoperla carnea* (Stephens) (Neuroptera, Chrysopidae) larvae to various densities of potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae) eggs was conducted under laboratory conditions of 27±1ºC, 65 ± 5% RH and 14:10 h (L: D). Based on Holling's disk equation, the first and third larval instars showed searching rates (á) of 1.03 and 0.894, respectively. These were greater than the second larval instar (*i.e.* 0.695). Handling time (T_h) per prey decreased as predator aged being 0.0009 day for the third larval instar. This value was shorter than at each of the first and second larval instars (*i.e.* 0.0163 and 0.00148 day, respectively). The greatest theoretical maximum number of potato tuber moth eggs to be consumed was estimated for the third larval instar as 1111.11 eggs/day followed by second and first larval instars as 675.68 and 61.35 eggs/day, respectively.

Key word: *Chrysoperla carnea*, *Phthorimaea operculella,* functional response

INTRODUCTION

Potato is ranked as number four as a major food source in the world. Egypt recently produces 2.6 million metric tons of potatoes and exports 411,000 metric tons to Europe and Arab countries per year (El-Sinary, 2006). The potato tuber moth *Phthorimaea operculella* Zeller is considered the most damaging potato pest in the field and in storage making it difficult to control. It attacks in addition to potatoes many of solanaceous crops (Makee and Saour 2001).

The green lacewings, *Chrysoperla carnea* (Stephens) is voracious predators of a wide variety of soft-bodied arthropods including aphids, scales, mealybug, caterpillars, leafhoppers, psyllids, white flies, thrips, insect eggs, spiders, mites and others (Canard and Principi, 1984). Biological control by using *C. carnea* has gained importance in pest management because of its ability to control a host range soft bodied pests, having high searching ability, vast geographical distribution, ease of mass production, wide adaptability in field than other predators and its tolerance to the wide ranges of ecological factors (Saminathan, *et al*., 1999 and Tauber *et al*., 2000). It has received much attention from researchers as well as farmers as a potential biological pest control agent (Gautam and Tesfay, 2002). Interest in utilizing this beneficial predator as a component of integrated pest management (IPM) programs for field and horticultural crops has recently increased as growers seek alternatives to insecticides for managing insect pests. Since green lacewings are generalists, the proper use of these predators is essential for a positive effect within IPM programs.

Functional response has received much attention in the entomological and ecological literature since Holling, 1959&1963 (*i.e.* Rogers, 1972; Fan & Petitt, 1994; Williams & Juliano, 1996 and Gitonga *et al*., 2002). They showed the functional response as the change in the number of prey consumed by each predator in response to the change in density of prey within a specific time. Also, they divided it into three main types expressed graphically by the relationship between density of prey and the consumed number from each predator at a specific time.

The objective of the present study was to find out the functional response of *C. carnea* to potato tuber moth eggs as abiocontrol agent.

MATERIALS AND METHODS

I. Prey Rearing Technique:

Insects used in the experiments were obtained from laboratory stock culture at Plant Protection Department of Ismailia Agricultural Research Station. This culture which was renewed each year with a field collection

Corresponding Author: Hany A.S. Abd El-Gawad, Plant Protection Research Institute, A.R.C., Dokki, Giza, Egypt.

of infested potatos with tuber moths. Fresh potato tubers were cleaned from dust and parasites by washing and drying with clean towels or tissue paper. Larvae reared on these potatoes were placed in plastic containers (40-25-10 cm). A thin layer of clean sand (which previously was exposed to high temperature in an oven to kill any insects or parasites) was placed on the bottom of the rearing plastic containers for pupation. The newly emerged adults were collected and confined in 2.5l glass jars (15–20 pairs/jar). A band of filter or tissue paper was added to the bottom and upper of each jar for oviposition and 10% sucrose solution was presented as a food source (Saour and Makee, 1997). The rearing procedures were conducted at a constant temperature of 26 ± 1ºC with 60 ± 5% RH and a photoperiod of 12: 12 h. (L:D).

II. Predator Rearing Technique:

Colony of *C. carnea* was established using adults collected from clover plantations at Ismailia Agricultural Research Station. Adult insects were kept in glass jars 8 cm in diameter and 20 cm in height. Jars were covered with black cloth screen and fed on artificial diet consisted of 4 g brewers yeast, 7 g honey and 5 ml water. The mixture forms a paste that was smeared on transparent plastic tapes and placed in rearing containers. Extra water was provided using wet cotton placed on the screen on top of the jar. Eggs deposited on the walls of rearing jars and the cloth screens were removed with a brush on daily basis. Newly hatched larvae were reared on *Sitroroga cerealella* (Olivier) (Lep: Gelechiidae) eggs (Ashfaq *et al*., 2004). Rearing conditions were 27 ± 1ºC, 65 ± 5% R.H. and a photoperiod of 14:10 h. (L:D). The rearing was carried out for six months to obtain sufficient number of the predators.

III. Experimental Procedures:

The experiment was performed at the same laboratory conditions used for rearing the predator to calculate the functional responses of each instar larva of *C. carnea* to *P. operculella* eggs. Seven densities of *P. operculella* eggs were tested. The densities were increased gradually to be synchronyzed with the developmental stage of the larvae (*i.e.* 5, 10, 20, 40, 60, 80 and 100 eggs for first; 10, 20, 40, 80, 120, 160 and 200 eggs for second; 20, 40, 80, 120, 160, 200 and 250 eggs for third larval instar). Each larval instar of predator was used once and discarded. The experimental arena was a 9cm diameter glass Petri dish. Each larva was starved for 12 hours before tested. Starved predators were transferred to the experimental arena using smooth hair brush and left for 24 h. The number of dead or live eggs was counted. Ten replicates of each prey density were performed for larval instar each of *C. carnea*. Control with no predator as also replicated 10 times for each prey density to consider the natural mortality of the prey. They were assessed with a binocular microscope.

IV. Data Analysis:

The functional response of predators to different prey densities was expressed by fitting the data to Holling's disc equation (Holling, 1959):

$$N_a = áTN/ (1+aT_hN)$$

Where: N_a defines the number of prey attacked by a predator per time unit, á is search rate of a predator, T is the total time of exposure time (1day in this experiment), N is the original number of prey items offered to each predator at the beginning of the experiment, and T_h is handling time for each prey caught (proportion of the exposure time that a predator spends in identifying, pursuing, killing, consuming and digesting prey). Search rate, handling time and their standard errors were calculated from linear regression of disc equation. The relationship between the mean number of consumed preys versus original number of prey items offered to each predator at the beginning of the experiment (prey consumed) / (prey density x 100) for all larval instars were estimated.

Obtained results were fitted to regression lines using SAS (Anonymous, 1988).

RESULTS AND DISCUSSION

Obtained results in Fig. (1) indicated increasing in the number of consumed prey at decreasing rate of increasing prey density where curve slope consumption decreased gradually until levelling off. These specifications concurred with type II functional response that predators appear towards varied densities of its preys which is determined by consumption of predator and handling time.

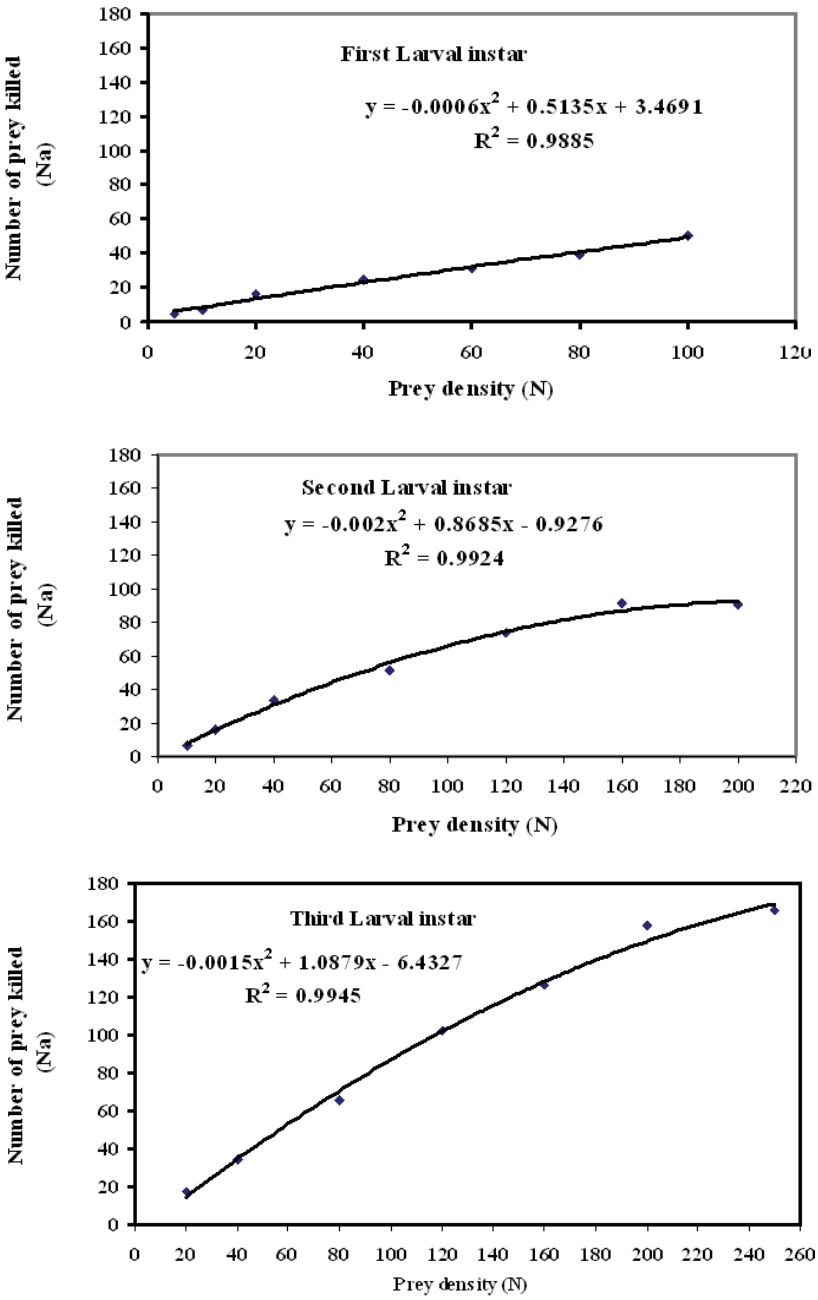

Fig. 1: Type II functional response of *C. carnea* to *P. operculella* eggs under laboratory conditions.

The number of prey eggs consumed by the three larval instars of predator increased significantly as predator development. The percentage of prey consumed of each larval instar was negatively correlated with the offered prey densities (Fig. 2). Obtained results were fitted to second degree of polynomial.

Results presented in Table (1) showed the rate of successful search (á) was the highest value of 1.03 occurred at the first larval instar, following the third larval instar, while the shortest search rate was 0.695 for the second larval instar.

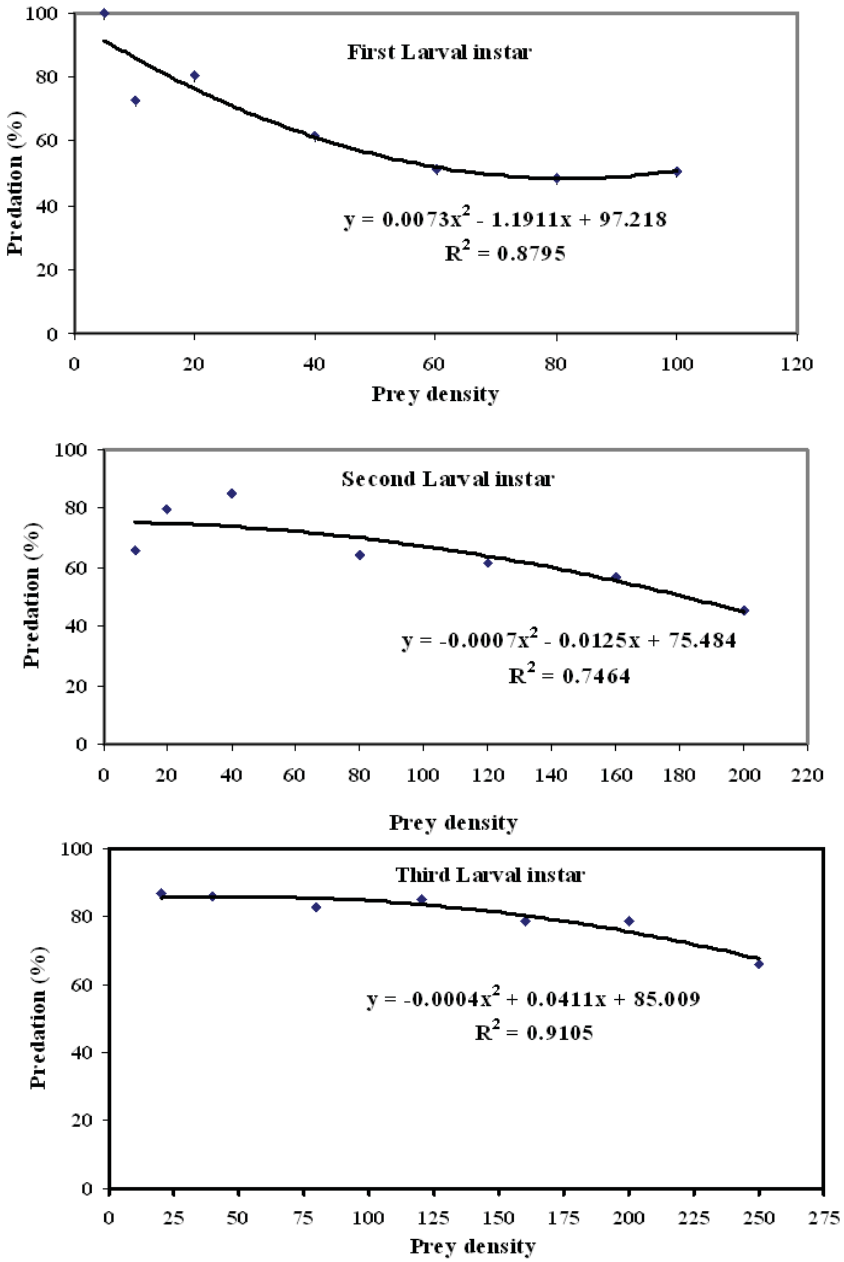

Fig. 2: Percentages of predation of *C. carnea* to *P. operculella* eggs under laboratory conditions.

Table 1: The rate of successful search (a), handling time (T_h), and the maximum predation rate ($1/T_h$) describing type II functional response parameters of *C. carnea* at different densities of *P. operculella* eggs.

Instar	á	T_h	$1/T_h$	R^2
First larval instar	1.030	0.0163	61.35	0.989*
Second larval instar	0.695	0.00148	675.68	0.992*
Third larval instar	0.894	0.0009	1111.11	0.995*

* Significant at 0.05

It is obvious that the handling time (T_h) per prey was shortest at third larval instar (0.0009 day) than that at each of first (0.0163 day) and second (0.00148 day) larval instars. Obtained results were fitted to second degree of polynomial with R^2 value of 0.989, 0.992 and 0.995 for first, second and third larval instar respectively.

The greatest theoretical maximum predation rate was estimated for the third larval instar reaching 1111.11 eggs/day followed by second and first larval instars being 675.68 and 61.35 eggs/day, respectively.

The results demonstrated the calculation of the attack rate à and handling time T_h significantly declined as stages reseed. Those values have been associated with the changes on the prey and predator through their developmental stage. It has revealed generally increasing in the attack rate and decreasing in handling time with developing predator when fed on a particular stage of the prey.

It should be noted that the search rate and handling time values from the functional response curves represent the mean values of these parameters for 24 hour exposure time which the predator was starved before lead to decreasing of starvation levels throughout the duration of the experiment at different rates of prey density. This change in the starvation level carries on secondary components affects the values of the attack rate and handling time Holling, (1963). It has been observed in similar studies to increase the speed of movement of starved individuals compared with individuals less starved giving it an increase in cases of convergence with the prey (Glen, 1975).

For the type II response, consumed prey is not density dependent (i.e. the intensity of consumed prey does not increase with prey density Hassell, (1978). Stark and Witford, (1986) referred to similar type of functional response of *C. carnae* feeding on *Heliothis virescens* eggs. The parameters estimated for functional response are not accurate measurement by laboratory testing and could not be directly linked to the field conditions, because of the very low prey density or because most prey are already consumed, It is only useful in comparing the effectiveness of natural enemies required as a biocontrol agents (Ives *et al.,* 1993; Gitonga *et al*., 2002 and Lee & Kang, 2004). In laboratory conditions the search rate is limited by handling time that time need to capture and adsorb one prey whereas, in field it is limited to searching behaviour. Therefore, the response of *C. carnea* may be different from its response in nature.

It is suggested that interested in the control of potato tuber moth by means of the predator should pay more attention to this specie as a biocontrol agent and so enhancing our natural enemies potential.

REFERENCES

Anonymous, 1988. SAS/STAT User`s Guide, Ver. 6.03. SAS Institute Inc., Cary, North Carolina, pp: 22.

Ashfaq, M., A. Nasreen and G.M. Cheema, 2004. Advances in mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). South Pacific Studies, 24(2): 47-53.

Canard, M. and M.M. Principi, 1984. Life histories and behavior. *In* Biology of Chrysopidae (M. Canard, Y. Semeriaand T. R. New (eds.). Dr W. Junk Publishers, The Hague, pp: 57-149.

El-Sinary, N.H., 2006. Evaluation of the insecticidal effect of pumpkin *Cucurbita pepo* against potato tuber moth *Phthorimaea operculella* (Zeller) Combined with gamma irradiation. American-Eurasian J. Sci. Res., 1(1): 18-22.

Fan, Y. and F.L. Petitt, 1994. Parameter estimation of the functional response. Environ. Entomol., 23: 785-794.

Gautam, R.D. and A. Tesfaye, 2002. Potential of green lacewing, *Chrysoperla carnea* (Stephens) in crop pest management. New Agriculturist, 13(1/2): 147-158.

Glen, D.M., 1975. Searching behaviour and prey-density requirements of *Blepharidopterus angulatus* (Fall.) (Heteroptera : Miridae) as a predator of the lime aphid *Eucallipterus tiliae* (L.) and the leafhopper *Alenetoidea alneti* (Dahlbom). J. Anim. Ecol., 44: 114-185.

Gitonga, L.M., W.A. Overholt; B. Löhr; J.K. Magambo and J.M. Mueke, 2002. Functional response of *Orius albidipennis* (Hemiptera: Anthocoridae) to *Megalurothrips sjostedti* (Thysanoptera: Thripidae). Biol. Control., 24: 1-6.

Hassell, M.P., 1978. The dynamics of Arthropod predator-prey system. Princeton University Press, New Jersey, pp: 248.

Holling, C.S., 1959. The components of predation as revealed by a study of small mammal predation of the European pine sawfly. Can. Entomol., 91: 293-320.

Holling, C.S., 1963. An experimental component analysis of population processes. Mem. Entomol. Soc. Can., 32: 22-32.

Ives, A.R., R. Kareiva and R. Perry, 1993. Response of a predator to variation in prey density at three hierarchical scales lady beetles feeding on aphids. Ecology, 74(7): 1929-1938.

Lee, J. and T. Kang, 2004. Functional response of *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) to *Aphis gossypii* Glover (Homoptera: Aphididae) in the laboratory. Biol. Control., 31: 306-310.

Makee, H. and G. Saour, 2001. Factors influencing mating success, mating frequency, and fecundity in *Phthorimaea operculella* (Lepidoptera: Gelechiidae). Environ. Entomol., 30: 31-36.

Rogers, D.J., 1972. Random search and insect population models. J. Anim. Ecol., 41: 369-383.

Saminathan, V.R., R.K. Baskaran and N.R. Mahadeva, 1999. Biology and predatory potential of green lacewing (*Chrysoperla carnea*) (Neuroptera: Chrysopidae) on different insect host. Indian J. Agri. Sci., 69(7): 502-505.

Saour, G. and H. Makee, 1997. Radiation induced sterility in male potato tuber moth *phthorimaea operculella* zeller (Lep., Gelechiidae). J. Appl. Ent., 121: 411-415.

Stark, S.B. and F. Witford, 1987. Functional response of *Chrysopa carnea* (Neuroptera: Chrysopidae) larvae feeding on *Heliothis virescens* (Lep. : Noctuidae) eggs on cotton in field cages. Entomophaga, 32(5): 521-527.

Tauber, M.J., C.A. Tauber; K.M. Daane and K.S. Hagen, 2000. Commercialization of predators: recent lessons from green lacewings (Neuroptera: Chrysopidae: Chrysoperla). Am. Entomol., 46: 26-38.

Williams, F.M. and S.A. Juliano, 1996. Functional responses revised. Environ. Entomol., 25: 549-550.