



Functional Response of *Chrysoperla carnea* Stephen (Neuroptera: Chrysopidae) Fed on Cabbage Aphid, *Brevicoryne brassicae* (Linnaeus) Under Laboratory Conditions

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ABSTRACT

Functional response study of *Chrysoperla carnea* Stephen (Neuroptera: Chrysopidae) larval instars fed on cabbage aphid, *Brevicoryne brassicae* (Linnaeus) was carried out under laboratory conditions at 28±1°C, with 65±5% R.H and 16:8 L: D photoperiod. The prey densities used for 1st instar larvae were 10, 15, 20, 25 and 30 (2nd– 3rd) nymphal instar aphids, while for 2nd instar larvae the used prey densities were 10, 20, 30, 40 and 50 and for 3rd instar larvae the used prey densities were 15, 30, 45, 60 and 75 aphids. Results showed that increase in the prey density resulted in increased consumption of prey up to certain limit in the 1st, 2nd as well as in the 3rd larval instar stage of *C. carnea*. The recorded highest consumed prey number were 22, 24 and 45 for the highest prey densities of 30, 50 and 75 in the 1st, 2nd and 3rd larval instar stage of *C. carnea*. Same trend was also recorded for searching, handling and resting time in all the three larval instar stage of *C. carnea*. The potential regarding the consumption rate of the 3rd instar larvae of the *C. carnea* was found higher than that of the 1st and 2nd ones. Also results showed lower searching time, handling time and resting time in the first instar larvae followed by an increase in the 2nd and 3rd instar larval stage of *C. carnea*. Results of this study also showed that the larvae of *C. carnea*, especially the 3rd instar had a good predation potential in preying of *B. brassicae*. Therefore, by including *C. carnea* in control programs the use of the pesticides against this pest will be minimized.

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ARS, JK and EH designed the study. ARS, NA, JK, EH, MN, HZ and BA were involved in Lab. work. ARS, NA, MN and ZH were involved in writing the article and data analysis.

Key words

Chrysoperla carnea, cabbage aphid, functional response.

INTRODUCTION

The cabbage aphid, *Brevicoryne brassicae* (Linnaeus) feeds on all cultivated and wild cruciferous plants. Aphids feed by sucking sap from their hosts. Seedlings infested by aphids may become stunted and distorted. Continued feeding on mature plants causes wilting, yellowing and general stunting of the plants (Inayatullah *et al.*, 1993). The cabbage aphid is a vector of 23 virus diseases of Cruciferae and many diseases of citrus. Turnip Mosaic Virus is vectored by over 40 aphid species but especially by the cabbage aphid (Mannan *et al.*, 1997; Jones *et al.*, 2002).

Chrysoperla carnea Stephens (Neuroptera: Chrysopidae) is one of the most important generalist predators. The larval stages are active in suppressing pests, while it is free living in adult stages. Larvae of *C. carnea* are voracious predators of soft bodied arthropods such as aphids, whitefly, thrips, American bollworms, mites, army worms, small larvae of beetles, and eggs of

lepidopterous insects etc. (Carrillo *et al.*, 2004). It has received much attention from researchers as well as farmers as a potential biological control agent (Gautam *et al.*, 2007; Alasady *et al.*, 2010; Saljoqi *et al.*, 2013). Interest in utilizing this useful predator as one of the most important components of integrated pest management (IPM) programs for field and horticultural crops has recently increased as growers found alternatives to pesticides for managing insect pests. Since green lacewings are generalists, the effective and proper use of these predators is essential for a positive effect in the IPM programs.

Functional response studies have received much attention in the ecological literature. Functional response is the change in the number of prey consumed by each predator in response to the change in density of prey within a specific time (Holling, 1959).

Functional response of predators is one of the major factors in regulating the population dynamics of the predator prey system. Functional response can be defined as an increase in the number of prey attacked by predators in per unit time as the density of prey increases. It characterizes the relationship between the predator attack rate and its prey. The relationship can be represented by 1) constant density dependent. 2)

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Inversely density dependent. 3) Positive density dependent over a short range of time (Solomon, 1949).

Holling,⁵ disc equation assumes that predators search its prey systematically and do not waste any effort in searching the area. On the other hand, Roger (1972) assumes that predator searches for their prey randomly.

Functional response of predators is of great importance which helps to determine up to what extent and how species are dependent on their hosts. Functional response on predator to prey depends upon the physical heterogeneity of the habitat. There are three types of functional response. The Type I functional response of predators is a typical response of predators in which predators eat a certain number of prey ~~in~~ per unit time. When enough prey or food is available, it cannot digest more than its maximum and any increase in food does not affect its growth. The type II functional response of an organism is in which the predator handle its prey. In handling the predator takes more time, the predator catches more prey, the more time is spent in handling and that time is used from the total time available for predator to ingest prey. The resulting response takes the form of saturation curves which will go asymptotically towards the maximum growth rate. Type II response is a typical arthropod predator in which the curve rises with decreasing rate (Hollings, 1959; Thompson, 1975). In type III functional response the predator-prey relationship is sigmoid. Prey handling time becomes the dominant component in the available time (Hassell, 1978).

A few studies have been performed on the predation capacity of lacewings fed on different host under different environmental conditions and some other related aspects, but not on the functional response *i.e.* number of prey killed as a function of prey density. The objective of this study was to study functional response of three larval instars of *C. carnea* fed on *B. brassicae* under laboratory conditions at $28\pm 1^\circ\text{C}$.

MATERIALS AND METHODS

Rearing of host insect, B. brassicae

For mass rearing of cabbage aphid, cabbage plants were sown in plastic pots of size $7\frac{1}{2}$ " x 6" (Height x Width). The plants were sown with different time intervals to ensure proper supply to the predator. The aphid colonies were renewed with new seedlings to ensure continuous supply to the predator throughout the experimental duration. The rearing procedures were conducted at a constant temperature of $28\pm 1^\circ\text{C}$, with $65\pm 5\%$ R.H and 16:8 L: D photoperiod.

Rearing of predator, C. carnea

C. carnea adults were reared in a rectangular cage,

made 6 cm thick. The length of the cage was 35 cm, 35 cm high and 20 cm wide. Two circular windows, each of 13 cm diameters, covered with lids of the same material, situated diagonally near opposite corners of a front wall of the cage, were made for handling adults, as well as for cleaning sanitation and provision of water in the Petri dish, etc. Artificial standard foods containing yeast, sugar, honey and water were provided in small food bowls, of 0.5 cm diameter, engraved in the upper side of two plastic rods each of 4 mm thick and 22 cm long, running the width at the opposite ends inside the cage where the adult *C. carnea* were available in high numbers and allowed to feed maximum.

The eggs were collected from a black sheet at the top of the cage and were kept for hatching in plastic petri dishes. Upon hatching the 1st instar larvae were provided the 1st and 2nd instar aphid nymphs as food in Petri dishes on potato leaves and lady fingers, and with the passage of time as the larvae entered the second instar then the 2nd and 3rd instar nymphs were provided daily in abundance to maintain stock culture of the predator on both host insect separately (Hany *et al.*, 2010). The rearing procedures were conducted at a constant temperature of $28\pm 1^\circ\text{C}$, with $65\pm 5\%$ R.H and 16:8 L: D photoperiod.

Experimental procedures

The experiment was performed to calculate the functional response of three larval instars of *C. carnea* at the same laboratory conditions used for rearing the predator. Different prey densities of cabbage aphid of the same physiological ages (4-8 days) were used for feeding to first, second and third instar larvae of *C. carnea*. The prey densities used for first instar larvae of *C. carnea* were 10, 15, 20, 25 and 30 (2nd – 3rd) nymphal instar aphids, while for 2nd instar larvae the prey density was 10, 20, 30, 40 and 50 and for 3rd instar larvae the prey density was 15, 30, 45, 60 and 75 aphids. Each prey density was replicated 10 times for each larval instar of *C. carnae*. Control was also replicated 10 times for each prey density to know the natural mortality of the *B. brassicae*. The experimental arena was 10 cm transparent Petri dish. Each larval instar was starved for 24 h before using in the experiments. Starved predators were transferred to the experimental arena on each prey density using camel hair brush and were left for 24 h. The observations regarding searching time of each larval instar, handling time of prey, resting time and total number of aphid consumed in 24 h at each respective density were recorded with 6 h interval.

After 24 h, number of alive and dead insects were counted and the functional response of different instars at different prey densities were expressed by fitting the data

to Holling's disc equation (Holling, 1959).

$$Na = a + N(1 + aT_h N)$$

Where, Na defines the number of prey attacked by a predator per unit time, a defines the search rate of a predator, T is the total time of exposure (1 day), N is the original number of prey item offered to each larval instars of at the beginning of the experiment and T_h is the handling time for each prey caught. Search rate and handling time will be calculated by using linear regression of disc equation.

RESULTS

The functional responses of the 1st larval instar of *C. carnea* to *B. brassicae* are presented in Figures 1, 2. Obtained results showed that increasing in the predator density the consumed prey density increased up to some extent. The densities for the first instar were 10, 15, 20, 25 and 30 and their respective recorded consumed prey numbers were 6, 9, 11, 15 and 22. Similarly lower searching time (0.224 h), handling time (0.247 h) and resting time (0.341 h) were recorded for predator at density 10. These figures were increased as the density of the predator increased and finally highest figures for searching time, handling time and resting time were obtained for the predator at density 30.

The results regarding the functional response study of 2nd instar larvae of *C. carnea* demonstrated higher number of consumed prey as compared with the figures recorded for 1st instar larvae of *C. carnea* (Figs. 1, 2). The recorded numbers of the consumed prey were 7, 12, 18, 23 and 24 for the predator at densities 10, 20, 30, 40 and 50, respectively. Similarly higher figures for searching time (0.706 h), handling time (0.787 h) and resting time (0.848 h) were recorded for the highest 2nd instar larvae of the predator at density 50.

The greatest maximum predation rate was recorded for the 3rd larval instar as compared with the 1st and 2nd larval instars (Fig. 1). The recorded consumed prey numbers were 11, 21, 35, 45 and 45 for the predator densities 15, 30, 45, 60 and 70 at its 3rd larval stage, respectively. Fig. 2 shows that at lowest density (15) of the 3rd larval instar of the predator, least values were recorded for searching time (0.449 h), handling time (0.553) and resting time (0.710 h). Like the 1st and 2nd instars an increasing trend up to some extent was observed in these values with the increase of the consumed host density. Highest figures were recorded for searching time (0.610 h), handling time (0.653) and resting time (0.759 h) at the highest host density (75) of the predator.

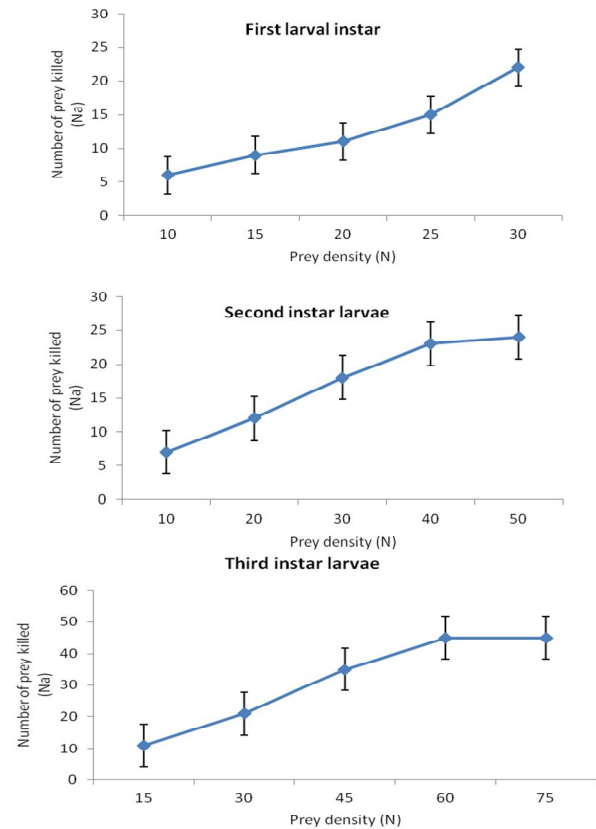


Fig. 1. Type II functional response of *C. carnea* to *B. brassicae* in the controlled laboratory conditions.

DISCUSSION

Result showed that almost all larval instars of *C. carnea* showed a good predation potential to the *B. brassicae*, but third instar larvae of *C. carnea* were found more effective on this prey. The potential regarding the consumptive rate of the 3rd instar larvae of the *C. carnea* was found higher than that of the 1st and 2nd ones. Yüksel and Göçmen (1992), Atlihan *et al.* (2004), Hassanpour *et al.* (2009) and Hany *et al.* (2010) reported higher predation figures on the last instar of *C. carnea* stage as compared with the younger ones. The higher predation of the last instar is a logical reflection of its larger size and thus an ensuing higher voracity. Before experimentation starvation for a fixed time period may have a significantly influenced the three larval stages of the *C. carnea*. Also increase in the movement speed with *C. carnea* larval age may likewise play a role (Houck and Strauses, 1985).

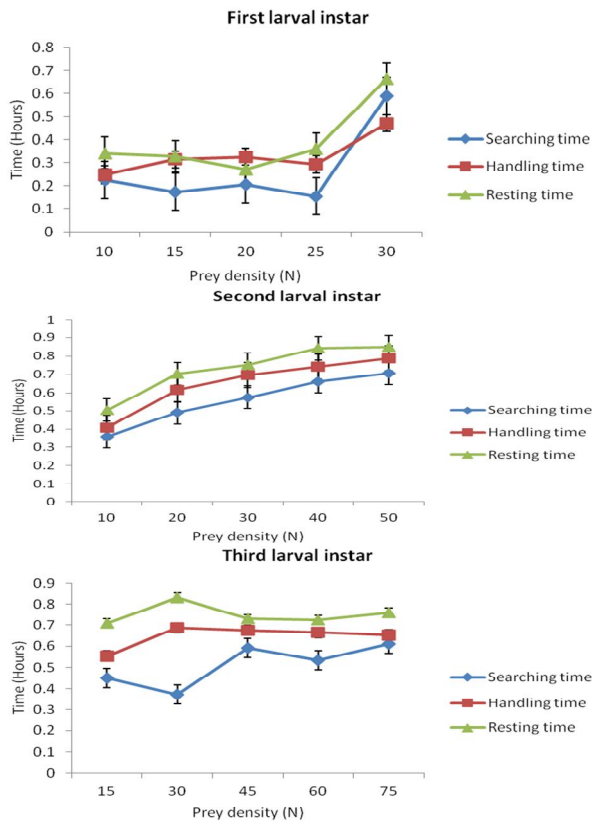


Fig. 2. Functional response of *C. carnea* to *B. brassicae* in the controlled laboratory conditions.

Our results showed lower searching time, handling time and resting time in the first instar larvae followed by an increase in the 2nd and 3rd instar larval stage of *C. carnea*. It should be noted that search rate and handling time values from the functional response curves represent the mean values of these parameters for 24 h exposure time which the predator was starved before lead to decreasing of starvation levels throughout the duration of the experiment at different rate of prey density. This change in the starvation level carries on secondary components affects the values of the searching rate, handling and resting time (Holling, 1963). Stark and Witford (1987) referred to similar type of functional response of *C. carnea* feeding on *Heliothis virescens* eggs.

Hassel (1978) described that for the type II response, consumed prey is not density dependent i.e. consumed prey intensity does not increase with prey density. The parameters estimated for functional response are not accurate measurement by laboratory testing and could not be linked to the field conditions (O'Neil, 1989).

Wiedenmann and O'Neil (1991) described that under simple laboratory conditions the attack rate is limited mostly by consumptive behavior (e.g. handling time), where as in the field conditions the attack is limited by searching behavior. However, even though several factors e.g. host plants, weather conditions, interference from competing beneficial and presence of alternative prey, may influence the effectiveness of the predators (Holling, 1959; De Clercq *et al.*, 2000; Ding-Xu *et al.*, 2007). The laboratory studies are only useful in comparing the effectiveness of natural enemies required as a bio-control agent (Ives *et al.*, 1993; Lee and Kang, 2004).

CONCLUSIONS

The present findings demonstrates potential of *C. carnea* for control of *B. brassicae* and development of pest management strategies based on the biological control. Results showed that increase in the prey density resulted in increased prey number consumption in all the larval instars of *C. carnea*. The consumption rate of the 3rd instar larvae of *C. carnea* was higher because of greater predatory potential of *B. brassicae* compared to that of 1st and 2nd instars. By using *C. carnea* the use of pesticides will be minimized.

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