



Predatory response of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) feeding on the Euonymus aphid, *Aphis fabae solanella* Theobald (Homoptera: Aphididae) in Kashmir

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ABSTRACT: The functional response and numerical response of third instar larvae of *Chrysoperla carnea* (Stephens) feeding on the Euonymus aphid, *Aphis fabae solanella* Theobald, which is a key pest of *Euonymus japonicus* L. in Kashmir were investigated. The Type II functional response curve exhibited a curvilinear rise to plateau as the aphid densities increased and the curve predicted by Holling's disk equation did not differ significantly from the observed functional response curve. The attack rate and the handling time predicted by disk equation were 0.54 and 2.17, respectively. The attack rate (*a*) increased with the increase of prey (aphid) density. The numerical response curve had a linear rise to a plateau at fixed aphid density with varying density of *C. carnea*.

KEY WORDS: *Aphis fabae solanella*, attack rate, *Chrysoperla*, *Euonymus japonicus*, functional response, handling time, numerical response

INTRODUCTION

Chrysoperla carnea (Stephens) is an important predator of aphids. The adults of many species of chrysopids feed on honeydew and pollen. The larvae are predacious, feeding on the eggs and neonate larvae of lepidopterous larvae, nymphs and adults of aphids and whiteflies (Singh and Narasimhan, 1992; Tesfaye and Gautam, 2002). They feed on aphids in most of the agricultural and horticultural ecosystems including plantation crops and ornamental hedges like *Euonymus japonicus*. During May-June, this predator reaches high population levels, which aid significantly in reducing aphid infestation on *E. japonicus*. The

density-dependent predation by III instar larvae is affected by two characteristics: (i) feeding behaviour (functional response) and (ii) densities (numerical response) (Huffaker *et al.*, 1971). The functional response is the change in number of prey eaten per unit time by each predator in relation to change in prey density (Solomon, 1949) and numerical response is the change in number of prey eaten per unit of time by differential density of predator in relation to a fixed prey density. A response has three essential components: the exposure of prey to predator, the instantaneous attack rate and the handling time required for each prey (Hassell *et al.*, 1976). The functional and numerical responses are usually measured to provide insights into the

suitability of a predator as a biological control agent. The type of response, that is the shape of the relationship of the number of prey eaten versus prey available, influences the dynamics of the predator-prey population and may contribute to stability of predator-prey systems (Hassell, 1978; Tayler, 1980). On the basis of the importance of this predator, the present study on the predatory responses of *C. carnea* on Euonymus aphid, *A. fabae solanella* Theobald, in Kashmir was undertaken.

MATERIALS AND METHODS

The experiment was carried out during 2005 in Division of Entomology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar. The response of III instar larvae of *C. carnea* exposed to *A. fabae solanella* was assessed in controlled laboratory condition. All the experiments were conducted in a controlled temperature room providing a cyclic temperature of 17-29°C with a 14: 10 (Light: dark) photoperiod and 60-80% relative humidity.

The eggs of *C. carnea* were collected from the field and reared up to III instar larvae. The aphids were collected from euonymus hedge and maintained in a cage (25x25x25cm) for the experiments. Twenty-four hours before the experiments, *C. carnea* was starved individually in separate cages. This was to minimize differences in individual hunger level (Nakamura, 1977). The functional response was evaluated at prey densities of 1, 2, 4, 8, 16, 32 and 64 aphids per predator per cage and the numerical response was evaluated at fixed prey density of 20 aphids with varying densities of predator, i.e., 1, 2, 3, 4, 5, 6 and 7 per cage on excised euonymus leaves stuck to agar medium. The experiment lasted for 24h with three replications and from each replication three observations were taken. One treatment (control) was also designed for natural mortality of aphids. After 24h, the number of aphids consumed by *C. carnea* was recorded by counting the aphids remaining alive in each cage. Constant prey number was maintained despite prey consumption. Holling's disk equation (Holling, 1959, 1965, 1966;

Hassell *et al.*, 1976) for type II functional response can be written as:

$$Na = a T_i N / 1 + a T_h N,$$

where, Na = the number of prey consumed per predator, a = the rate of successful search, N = the density of prey, T_i = the handling time for each prey and, T_h = the total time for prey and predator are exposed to each other.

The successful search rate of *C. carnea* over the experiment period was computed as:

$$a = 1/P \ln [N_1/(N_1 - N_2)],$$

where, a = Search rate, P = number of predator used, N_1 = density of prey, N_2 = number of prey consumed

RESULTS AND DISCUSSION

The functional response of *C. carnea* larvae to increasing prey densities of *A. fabae solanella* is shown in Fig. 1. The actual numbers of aphid eaten per *C. carnea* were 0.87, 1.75, 3.50, 5.66, 7.33, 8.66, and 9.66 feeding on 1, 2, 4, 8, 16, 32 and 64 aphid densities. The response curve was curvilinear, reaching a plateau characteristic of a Type II functional response curve (Holling, 1965). Athhan *et al.* (2004) studied the functional response of *C. carnea* feeding on different densities of *Hyalopterus pruni* (Geoffroy) and observed that the larvae responded to increasing prey densities with increasing food consumption. The older larval stages display a higher rate of predation than younger ones. The behaviour of each of three larval stages matched Holling's Type II functional response. Due to very little information on the functional response of *C. carnea*, comparison was made with other predators and a similar predation pattern was recorded by Khan and Zaki (2007) for *Coccinella septempunctata* Linnaeus and *Chilocorus infernalis* Mulsant on *A. fabae solanella*. The Type II curvilinear curve reported here differed from Holling's Type I (increasing linearly to plateau) and Type III (s-shaped curve) functional response. The difference in the two response curves is possibly related to the substrates on which the experiments were

performed. The constants a and Th were estimated by a method given by Holling (1959). To improve the estimates, these constants were placed in a interactive non-linear function nls provided by the R-software (R Development Core Team, 2005).

The improved estimates of a , Th and r were 0.54, 2.17 and 0.68. The predicted and observed values of functional response (Fig. 1.) did not differ significantly (X^2 , $P = 0.01$) from each other. The handling time of *C. carnea* includes the time spent pursuing, eating and digesting the aphids (Hassell *et al.*, 1976). Handling time ($Th / Tt \times 100\%$) was approximately 9% of the total time available to *C. carnea*. Ambient temperature would have a marked effect on the handling time of each prey. The number of prey consumed by *C. carnea* decreased with temperature. The temperature during the dark period of this experiment dropped to 17°C that would have a marked effect on the number of aphids consumed by *C. carnea* with decreased temperature. It is possible that the handling time increased as a result. The search rate (a) varied in increasing trends from 0.36 to 2.45 with increasing prey density from 1 to 64 (Fig. 2). Athhan *et al.* (2004) reported that the search rates of older instars increased with

increased prey density.

The numerical response at a fixed prey density of 20 aphids with varied density of *C. carnea* (1 to 7) is shown in Fig. 3. The actual number of aphids eaten by *C. carnea* varied, i.e., 5.83, 7.16, 7.83, 10.50, 11.50, 14.83 and 15.16 in 24h with fixed density of prey and increasing densities of predator. The response exhibited a linear rise culminating in plateau (Holling, 1965), attaining a form that attack behaviour should take for density-dependent predations to occur. Particularly, if the equilibrium populations of the aphid fall within the accelerating phase of the linear response, then this type of response is density-dependent contributing to the stability of predator-prey interaction (Murdoch, 1977). Hassell (1978) showed that numerical response produces general stability in predator-prey interacting population only when there is no time lag between predation and reproduction. The search rate (a) varied from 0.27 to 0.13 with decreasing trends due to increasing density of predator (Fig. 4). It showed that the increasing predator density encouraged intra-specific competition and as a result the search rates decreased.

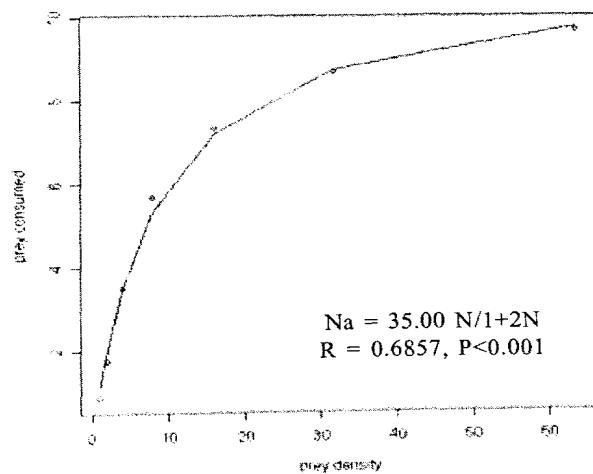


Fig. 1. Functional response of III instar larvae of *C. carnea* exposed to increasing densities of aphid, *A. fabae solanella* over 24 h period. The equation of the solid line is given by disk equation, $Na=35.00N/1+2N$. The dots represent the means of 3 replications

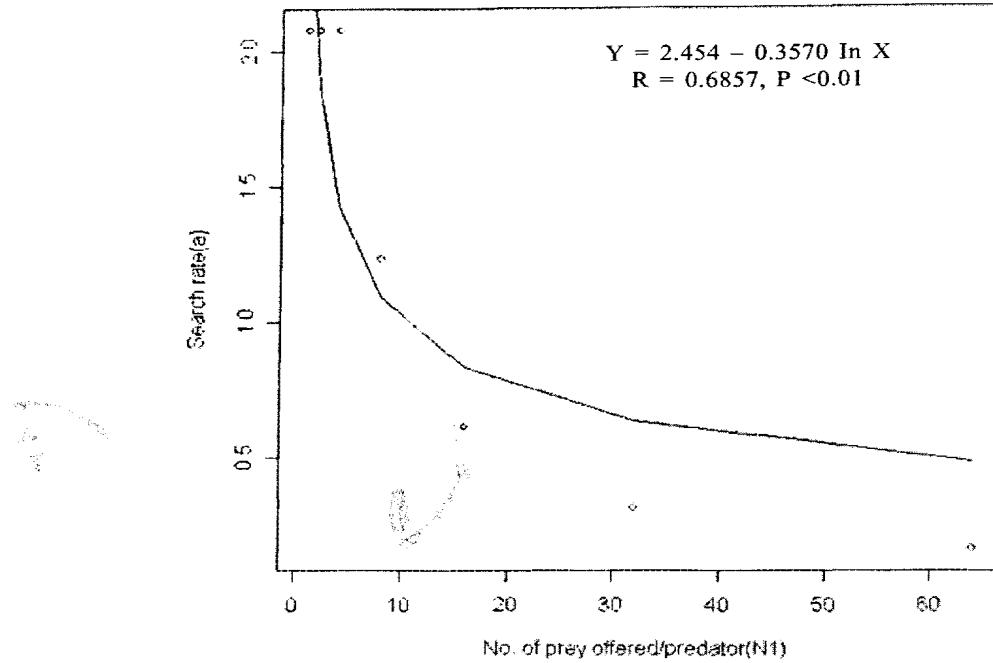


Fig. 2. Relationship between search rate (*a*) and varying density of prey, *A. fabae solanella* offered to single larva of *C. carnea* in 24h. Na= 35.00 N/1+2N; R= 0.6857, P<0.001

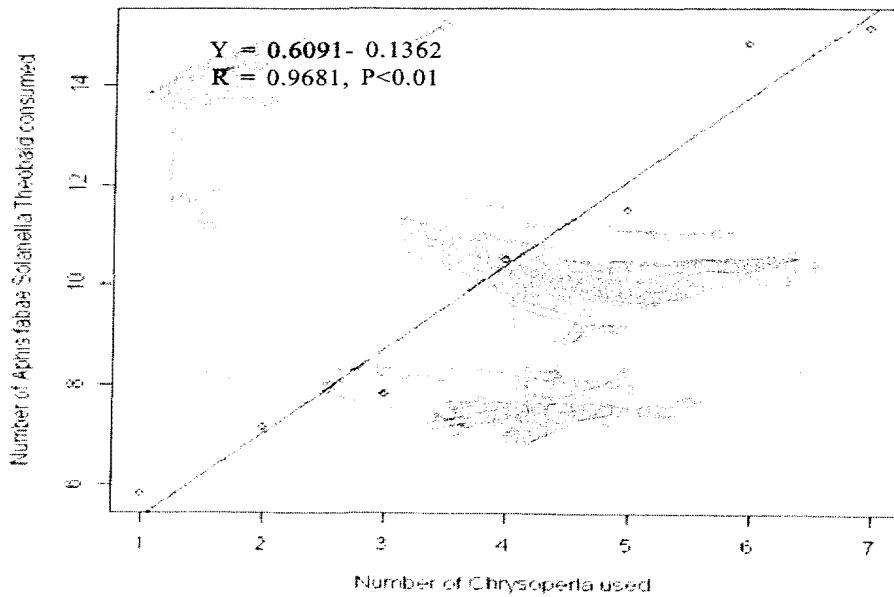


Fig. 3. Numerical response of varying densities of *C. carnea* larvae to fixed density of *A. fabae solanella* over 24 hrs period. The equation of the solid line is given by Linear equation, reg.lm1, lm (Na~P). The dots represent the means of 3 replications

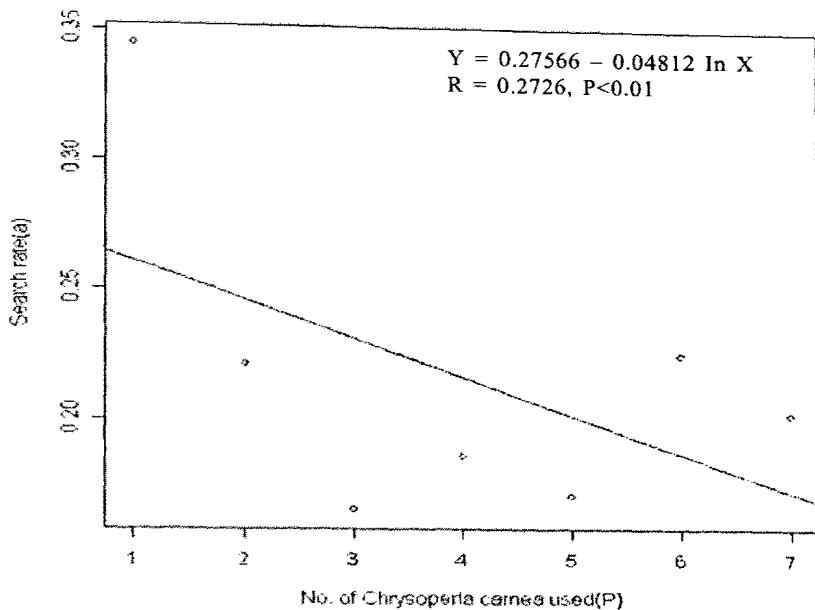


Fig. 4. Relationship between search rate (*a*) and fixed prey density of *A. fabae* at varying densities of *C. carnea* in 24h

We conclude that a curvilinear functional response occur in inter-specific interaction between III instar larvae of *C. carnea* and *A. fabae solanella* and search rate of predator was increased due to increase in prey density.

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