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Research Article

Functional response of green lacewing, *Chrysoperla zastrowi silemmi* (Esben-Petersen) to its prey, cabbage aphid, *Brevicoryne brassicae* L.

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ABSTRACT: Functional response influences the prey-predator interactions and hence is crucial for assessing the predatory potential of a given species. Laboratory studies were conducted at Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India during 2019-20 to assess the functional response of a generalist predator, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae) against the cabbage aphid, *Brevicoryne brassicae* L. The feeding efficiency of larvae of *C. zastrowi sillemi* against varying densities of aphid i.e. 5, 10, 15, 20 and 30 was evaluated. The number of aphids consumed differed with prey densities and it was in direct proportion to the host density. All the three instars of *C. zastrowi sillemi* followed type II functional response. The attack rate (a) of the third instar larvae was maximum compared to first and second instars indicating the higher efficiency of later instar in prey consumption. Other parameters viz., the effectiveness of predator (a/th) and maximum predation rate (K) also followed similar trend while the prey handling time (Th) by the first instar took longer period (0.50 h) compared to second and third instars (0.46 h and 0.27 h, respectively). Searching efficiency was highest in the third instar which can be attributed to the higher mobility of fully grown larvae.

Keywords: *Brevicoryne brassicae*, cabbage aphid, *Chrysoperla zastrowi sillemi,* functional response, green lacewing

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INTRODUCTION

The functional response is an important parameter in any trophodynamic model which indicates the rate at which prey is consumed by its predator (Holling, 1959; Beddington, 1975). It is a crucial factor that influences the prey-predator interactions and hence studies on functional response have a greater ecological relevance. It is assumed that a predator does systematic searching of its prey with the least possible waste of time in reaching the target. The relationship can either be constant density dependent or an inversely density dependent or positive density dependent (Solomon, 1949). There are three types of functional responses. In the Type I response, prey consumption by predator per unit time is certain and the type II response depicts where the predator handles its prey and is a typical response of arthropod predators wherein the rise of curve follows a decreasing rate (Holling, 1959; Thompson, 1975). In the case of type III, the relationship of predator-prey follows a sigmoid pattern where the time taken for handling prey expands in the available time (Hassell, 1978). Thus understanding the functional response is significant in evaluating the feeding potential of a predator against a particular prey species. In this study, the functional response of a generalist predator, *Chrysoperla zastrowi sillemi* (Esben-Petersen) (Neuroptera: Chrysopidae), commonly called green lacewing, has been evaluated against the aphid, *Brevicoryne brassicae* L.

The aphid, *B. brassicae* is an economically important sucking pest of cabbage. Nymphs and adults of aphids colonise on leaves and leaf whorls and suck the plant sap. Aphid infestation results in withering of leaves and stunted growth of the plants (Jamaya and Ronald, 1998). Besides causing direct damage by sucking sap, the honeydew excreted by them causes the growth of black sooty mold on leaves that hampers the photosynthetic efficiency of the plants. Aphid infestation causes significant yield losses, both quantitatively and qualitatively, in cabbage. in all the cabbage growing areas (Bhalla, 1990; Bashir *et al.,* 2013). In order to manage cabbage aphid, generally farmers resort to spray of synthetic insecticides indiscriminately, which leads to undesirable effects such as pest resurgence, insecticide resistance build up in pests and residue problems besides causing environmental pollution. Hence, it is essential to explore safer alternatives to chemical control and biological control is an ideal and viable option to manage sucking pests like aphids. There are many biocontrol agents reported against cabbage aphid among which, the green lacewing, *C. zastrowi sillemi* has a greater potential (Singh and Jalali, 1994). It is a generalist predator and occurs naturally in a wide range of agro ecosystems and is also commercially reared. The adults of *C. zastrowi sillemi* are not insectivorous and they feed on pollen and honeydew, while the larvae are polyphagous and predatory in nature. It is reported to feed on a large number of prey species across five insect orders. However, maximum number of prey species is from the order Hemiptera and predominantly aphids (Principi and Canard 1984; Venkatesan *et al.,* 2008). The polyphagous nature coupled with its amenability for mass rearing and compatibility with microbial agents make this predator an effective biocontrol agent. In order to standardize the biocontrol protocol of cabbage aphid using *C. zastrowi sillemi*, an insight into its predatory potential is very essential and functional response, as mentioned above, is one of useful yard stics. Accordingly the present studies were conducted with the objective of understanding the functional response of *C. zastrowi sillemi* to its prey, *B. brassicae*.

MATERIALS AND METHODS

The cultures of *C. zastrowi sillemi* and *B. brassicae* were maintained at the Department of Entomology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, India. The studies on functional response were carried out under controlled conditions of temperature (28^{o}C ± 2) and relative humidity (65-70%). The response of different larval instars of *C. zastrowi sillemi* to varying densities of aphid i.e. 5, 10, 15, 20 and 30 was evaluated. For this purpose, first, second and third instars of chrysopid larvae were starved for 24 h before exposing them to the aphids of different densities. There were five replications for each density for each larval instar. Data on the searching time, prey handling time by predator and total number of aphids consumed in each test density over 24 h were recorded.

After 24 h, the number of live prey was counted and the data on prey consumed in 24 h was subjected to logistic regression between prey eaten and prey density and the pattern of functional response was determined.

Na/N = exp (p0 + p1N +p2N2 +p3N3) /1+exp (p0+ p1N + p2N2 + p3N3)

Where Na indicates the number of prey consumed;
N, the initial prey numbers while p0 gives intercept, p1 the linear coefficient,
p2 is quadratic coefficient and p3 is cubic coefficient.

In each case, there was the type-II functional response and hence, Roger's random predator equation (Rogers 1972) was used to calculate the functional response parameters:

Na = N {1 – exp [a (ThNa-T)]}

Where Na = number of prey consumed by a predator,
N = prey density offered,
T = duration of the experiment (24h),
Th = handling time i.e. time required by the predator to pursue, kill and digest the prey
a = predators attack rate, also called predation coefficient

The predator effectiveness was calculated by dividing 'a' by 'Th'. The maximum predation rate K was calculated using the formula T/Th.

RESULTS AND DISCUSSION

The studies indicated that the units of prey consumed by the larvae of predators differed significantly across instars and prey densities (Table 1). The average number of aphids consumed by an individual first instar larva of chrysopid at five levels of density were 3.4, 6.4, 7.8 and 10.2 respectively. It clearly showed that the number of aphids consumed had increased in a linear fashion. Similar trend was observed with subsequent instars too. The second instar larva consumed 11.4, 3.8, 7.2, 9.6 and 12.2 aphids in 24 hours. The mean numbers of aphids preyed on by the third instar were significantly higher than early instars and they were. 14.8 8.4, 12.8, 16.6 and 22.8, respectively. The number of prey consumed by predators increased with host density, whereas the proportion of prey consumed (Na/N) declined with an increase in host density. Alhamawandy (2017) also reported a similar trend that the functional response of common green lacewing was in direct relation to the density of prey.

After fitting the logistic regression between number of aphids consumed (Na) and density provided (N), the constant (P_0), linear (P_1), quadratic (P_2) and cubic (P_3) coefficients for first, second and third instars were obtained as 1.1385, -0.078, -0.0014 and -0.000002, 1.4713, -0.0646, 0.0008 and -0.000009 and 2.5244, -0.1503, 0.0089 and -0.0002 (Table 1). Since the linear coefficient was negative, it indicates that all the three instars followed a type II functional response. After confirming the type of functional response, the data were fitted to Roger's random predator equation (type II) to calculate the parameters of the functional response.

The parameters of functional response *viz.,* attack rate (a), handling time (Th), effectiveness of predator (a/Th)

Table 1. Coefficients obtained by logistic regression analysis of *C. zastrowi sillemi* feeding on *B. brassicae*

Coefficients	Estimates		
	1st instar	2nd instar	3rd instar
Constant (P_0)	1.138	1.471	2.524
Linear (P_1)	- 0.078	-0.065	- 0.150
Quadractic (P_2)	- 0.001	0.001	0.009
Cubic (P_3)	- 0.000	- 0.000	- 0.000

Table 2. Functional response parameters of different instar larvae of *C. zastrowi sillemi* to *B. brassicae*

Parameters	Estimate		
	1st instar	2nd instar	3rd instar
Searching efficiency or attack rate (a)	0.052	0.064	0.092
Handling time in hours (Th)	0.502	0.463	0.269
Effectiveness of predator (a/Th)	0.103	0.139	0.342
Maximum predation rate (K) (T/Th)	47.81	51.76	89.15
R^2	0.99	0.98	0.89

and maximum predation rate (K) of first instar larvae of *C. zastrowi sillemi* to adults of *B. brasssicae* were 0.052, 0.502, 0.103 and 47.80, respectively. In case of second instar, these values were 0.064, 0.463 h, 0.139 and 51.755, respectively and 0.092, 0.269 h, 0.342 and 89.14, respectively for third instar larvae (Table 2). This gives an indication that the first instar larvae required more handling time compared to second and third instars. Highest attack coefficient of third instar over early instars was also observed by Alhamawandy (2017). The searching efficiency or attack rate was highest in third instar larvae compared to the early instars. This could be due to the higher mobility of full grown larvae. The other two parameters of functional response *viz*., effectiveness of predator (a/Th) and maximum predation rate (K) were also in direct proportion to the growth stage of the larvae. The third instar recorded the highest values of these parameters (0.342 and 89.14, respectively) (Figure 1). It indicates that the feeding potential and predation efficiency increased with larval age and size. These findings are in line with those of Alhamawandy (2017) and Saljoqi *et al*. (2016). In another study, Sultan and Khan (2014) found two different types of functional responses in larval instars of *C. carnea* against sugarcane whitefly. While first instar followed type II, second and third instar larvae followed type III functional response. This deviation could be due to the difference in the host species.

CONCLUSION

Based on findings of present studies, it can be inferred that the prey density had significant positive impact on the feeding rate of the larvae of *C. zastrowi sillemi* and all the three instars of *C. zastrowi sillemi* followed type II functional response. The attack rate (a) and maximum predation rate (K) were higher with the third instar larvae while the prey handling time (Th) was in reverse order with the first

Figure 1. *Chrysoperla zastrowi sillemi* feeding on *Brevycoryne brassicae* (a) first instar, (b) second instar, (c) third instar.

instar taking longer period (0.50 h) compared to second and third instars. These findings would be of immense value in planning and executing biological control of cabbage aphid, *B. brassicae* using *C. zastrowi sillemi* as a biocontrol agent.

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