International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 3 Issue 6, June – 2019, Pages: 49-56

Functional Response of Green Lacewing, *Chrysoperla carnea* (Neuroptera: Chrysopidae) Larvae on Different Insects Pests

[1]Ameer Uddin, [2]Shafique Ahmed, [3]Arif Ali, [4]Abdul Ghaffar Khoso*, [5]Mansab Khan, [6]Farrukh Asghar, [7]Khalil Asghar

[1,2,3]Department of Entomology, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, 90150, Pakistan

[4,5,6]Department of Entomology, Sindh Agriculture University, Tando Jam, 70060, Pakistan
[4]khoso05@hotmail.com

[7]Department of Plant Breeding and Genetics, Balochistan Agriculture College, Quetta, 87300, Pakistan

Abstract: *The study was carried out on Functional response of Green lacewing, Chrysoperla carnea (Neuroptera: Chrysopidae) larvae on different insects pests in Department of Entomology at Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Pakistan. Observations on search rate (a')' Handling time (Th)' Maximum predation rate (pr) and R^2 of Green lacewing on the various densities of different aphids species i.e., cotton aphid (A. gossypii), black bean aphid (A. fabae), wheat aphid (S. graminum), corn leaf aphid (R. maidis) and papaya mealybug (P. marginatus) were recorded under laboratory conditions of 25±2ºC. The larvae of Chysoperla carnea showed type II functional response to different aphids species and papaya mealybug. The highest search rates (á) of first larval instar were of 0.653 and 0.625 on wheat aphid and cotton aphid, while followed by 0.580, 0.480 and 0.231 on corn leaf aphid, black bean aphid and papaya mealybug respectively. The highest search rates (á) of second larval instar were of 0.715 and 0.683 on cotton aphid and wheat aphid, while followed by 0.620, 0.559 and 0.270 on corn leaf aphid, black bean aphid and papaya mealybug respectively. The highest search rates (á) of third larval instar were of 0.834 and 0.727 on cotton aphid and wheat aphid, while followed by 0.711, 0.700 and 0.407 on black bean aphid, corn leaf aphid and papaya mealybug respectively. The C. carnea first larval instar showed maximum handling time on cotton aphid (0.368) and minimum handling time showed on papaya mealybug (0.215). The C. carnea second larval instar showed maximum handling time on corn leaf aphid (0.419) and minimum handling time showed on papaya mealybug (0.240). The C. carnea third larval instar showed maximum handling time on corn leaf aphid (0.462) and minimum handling time showed on papaya mealybug (0.147). The maximum predation rate of C. carnea first larval instar was recorded on cotton aphid (32.86) and minimum predation rate was recorded on papaya mealybug (9.50) respectively. The maximum predation rate of C. carnea second larval instar was recorded on cotton aphid (38.13) and minimum predation rate was recorded on papaya mealybug (11.53) respectively. The maximum predation rate of C. carnea third larval instar was recorded on cotton aphid (46.23) and minimum predation rate was recorded on papaya mealybug (14.43) respectively. The results clearly indicated that C. carnea could be a better biological control agent against different aphid species which are major sucking insect pests of different crops in Pakistan.*

Keywords: Functional response, green lacewing, aphids, mealybug, wheat, cotton, papaya, corn leaf, black bean.

1. INTRODUCTION

Human interests are always threatened by the presence of pest and pesticides as the most extensively applied methods for pest control. Approximately 2.7 million tons of pesticides were applied in the world in 2011 to control noxious pests [9] however, pesticide usage has many adverse effects on human and their environment, often results in pest resurgence and the killing of non target and beneficial individuals [32]. Moreover, either directly or indirectly, pesticides are responsible for over 25 million cases of pesticides poisoning and 20,000 unintended death [15];[30] considering these adverse impacts, scientists always strive for alternate methods to control pests that could provide better pest management with less hazardous to humans and their environment. Biological control is a method to control pests through the use of natural enemies as it is environmentally sound and economically efficient in mitigating the pest densities [23], [24], [25] and [26]. Biological control of insect pests is an important component of integrated pest management (IPM) and can be used in combination with other control methods in pest management programs. Different bio control agents are available for the management of insect pests. Among these, *C. carnea* is one of the important generalist predator and can be mass reared easily in the laboratory and released in the field for the management of particular insect pests. *C. carnea* can be easily mass reared on *Sitotroga cerealella* (Oliver) eggs under laboratory conditions widely in the world. The natural enemies are living organisms that kill or weaken the pests and cause their premature death or reduce their reproductive potential. A natural enemy feeds on its prey or host and thus promotes its own population. The preservation and maintenance of the natural enemies in the agro-ecosystem are essential for the establishment of the biological equilibrium and reduction of the production costs as well as to avoid side effects of the chemicals to environment. But the indiscriminate use of pesticides created number of problems such as environmental pollution, resistance in insect pests, upsurge of the secondary pests due to elimination of their natural enemies, increased cost of production and hazards for human beings and animals. Green lacewing, *Chrysoperla carnea* (Stephens) generally known as aphid lion is a generalist predator of a wide range of pest species such as mealybugs, aphids, thrips, whiteflies, mites and eggs of insect pests [6]. *C. carnea* is the most intensively studied species of *Chrysopids* because of its wide geographical distribution,

International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 3 Issue 6, June – 2019, Pages: 49-56

broad habitats with a high relative frequency of occurrence, good searching ability and easy rearing in the laboratory. The larvae of lacewing feed on a wide range of pest species, while adults are free living and feed only on nectar, pollen and honeydew[8], it plays an important part in natural control of sucking pest and effectiveness of *C. carnea* as a biological control agent has been demonstrated in field crops, orchards and greenhouses [14]. *Chrysoperla* sp. received much attention of farmers as well as researchers as a potential biological control agent due to its broad host range, vast geographical distribution, ease of mass multiplication and tolerance to some pesticides. The larvae are predaceous, feeding on eggs and neonates lepidopterous larvae, nymphs and adults of whiteflies, aphids, thrips, scale insects, mealy bugs, mites, etc. It have basically be worn during augmentative liberate to organize different aphid class within nurseries and outside items. In any case, this class is a generalist predator, and is also identified to begin before on additional responsive bodied arthropods, including scale bugs, leafhoppers, whiteflies, psyllids, thrips, lepidopterans, and vermin [19]. Functional response is an important factor in the population dynamics of the predator–prey interaction [18] and [31] an important aspect in assessing the efficiency of the predator is its attack rate and searching behavior when exposed to a broad range of host densities [2], [10] and [29]. One of the most informative ways of studying the predator-prey interaction is to measure the functional response of a predator to prey abundance, which can be used as a measure of searching efficiency and is often correlated with its bio-control efficiency [11], [4] and [5]. Many studies explained how to estimate the functional responses of predators on prey [8], [7], [12] and [28]. Since Holling, 1959 & 1963[17] the functional response has received much attention in the entomological and ecological literature [33] and [13]. 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. In Pakistan, there are many studies on the biological parameters of *C. carnea* feeding on different host insects but there is no information on the biological parameters and larval predatory potential of *C. carnea* feeding on *S. graminum*, wheat aphid under laboratory conditions. Keeping in view the lack of studies on functional response of *Chrysoperla* spp. in Pakistan, this study was planned to evaluate the functional response of *C. carnea* against different densities of preys i.e., *Aphis gossypii, Aphis fabae*, *Schizaphis graminum, Rhophalosiphum maidis* and papaya mealy bug, *Paracoccus marginatus.* The results obtained could be helpful to improve the practical predictive powers of *C. carnea* to develop pest management strategies based on biological control. The objectives of present study were the functional response of all (three) larval instars of *Chrysoperla carnea* to varying densities of different aphid species and mealybug, *Paracoccus marginatus* and could be utilized for the development of quality mass rearing technique of *Chrysoperla carnea* to ensure maintenance of their enough population for successful IPM against various noxious insect pests.

2. MATERIALS AND METHODS

The functional responses of all three larval instars of green lacewing, *Chrysoperla carnea* on different insects pests were studied on second nymphal stages of cotton aphid (*Aphis gossypii)*, black bean aphid (*Aphis fabae*), wheat aphid

(*Schizaphis graminum)*, corn leaf aphid (*Rhophalosiphum maidis*) and mealybug (*Paracoccus marginatus)* under the

research center conditions (25 ± 2°C).

The adults *Chrysoperla carnea* in cages 37 x 28 x 22cm under the research lab. conditions (25 ± 2°C) at Lasbela University

Different insects pests under the research lab. conditions (25 ± 2°C) at Lasbela University

2.1 Culture of green lacewing, *Chrysoperla carnea*

The culture of *Chrysoperla carnea* was established in 2017 from eggs collected from the surrounding agricultural fields of Lasbela University. The culture was maintained in a laboratory condition at 25 ± 2^{o}C. Larvae of green lacewings are cannibalistic; thus each larva was reared separately in trays of ELISA wells. The adults that emerged from the pupae were transferred to the glass rearing cages measuring 37cm x 28cm x 22cm in size. The cages were covered with black muslin cloth on top of the cage as a substrate for egg laying. The standard adult diet was composed according to [1]. It comprised of 2.5 g yeast, 3 g sugar, 2.5 ml honey, 3 g milk powder (instead of casein) 2.5 ml distilled water and the mixture forms a slurry that was provided on a plastic strip in the rearing cages with measurement of 2 × 15cm. Wet cotton was given in glass vials as a source of water. The eggs deposited on the black muslin cloth were harvested daily.

2.2 Rearing of factitious host, Angoumois grain moth, *Sitotroga cerealella*

Culture of angoumois grain moth, *Sitotroga cerealella* (Olive) was maintained on wheat grains in glass jar. 2 mg of *S. cerealella* eggs were mixed in each glass jar 1 kg of wheat grains. The *S. cerealella* culture was maintained at 25 ± 2 ^{0}C. On emergence of *S. cerealella* adults, they were collected manually using glass tubes and released into an ovipositional cage for mating and egg laying. Before release of adult moths of *S. cerealella* for egg laying, the narrow end of the funnel was plugged with cotton while the broader end was fitted with the net using rubber bands through which the eggs can pass onto a paper. Adult moths were released from narrow end so that they move to broad end and mate. Adult moths were reared on maize starch in ovipositional cage. Eggs laid by the female moths passed through the net and were collected on the white paper beneath the egg laying cage. The adults placed in the ovipositional cage laid most of their eggs on the first week. By first week egg lying started ceasing and hence after first week adults were discarded and the cycle of the collection of the eggs continued with fresh batch of adults. These eggs were provided to the predatory larvae of green lacewing, *C. carnea* in order to multiply their number for the experiment.

Rearing of factitious host, Angoumois grain moth, under the research lab. conditions (25 ± 2°C) at Lasbela University

2.2 Culture of preys i.e., *Aphis gossypii, Aphis fabae, Schizaphis graminum, Rhophalosiphum maidis* and papaya mealybug, *Paracoccus marginatus.*

The cultures of different preys were established on their respected hosts under the laboratory conditions. The aphids were maintained in cages. The top of the cages was covered with organza cloth for aeration and the rearing conditions for culture were 25 ± 2°C. New host nymphs/adults were given to the every larval instar of green lacewing, *C. carnea* in the petri dishes.

2.2.1 Culture of cotton aphid, *A. gossypii*

Cotton aphid, *A. gossypii* were collected from the farmer cotton field near the Lasbela University. The culture of *A. gossypii* was maintained on cotton plants (*Gossypium hirsutum*) in the cages measuring 20 x 13cm x 10cm size under the laboratory conditions. The preys were transferred directly to Petri dishes (9cm diameter plastic Petri dish) and provided with wetable filter paper.

2.2.2 Culture of black bean aphid, *Aphis fabae*

The black bean aphid, *Aphis fabae* were collected from the farmer mung bean (*Vigna radiata)* field Uthal. The aphids were maintained in cages measuring 20 x 13cm x 10cm size under the laboratory conditions. The top of the cages was covered with organza cloth for aeration and the rearing conditions for culture were 25 ± 2°C. The preys were transferred directly to Petri dishes (9cm diameter Petri dish) and provided with wetable filter paper.

2.2.3 Culture of wheat aphid, *Schizaphis graminum*

Wheat aphid, *Schizaphis graminum* were collected from the farmer wheat crop near the Lasbela University. The culture of *S. graminum* was maintained on wheat plants (*Triticum aestivum*) in the cages measuring 20 x 13cm x 10cm size under the laboratory conditions. The preys were transferred directly to Petri dishes (9cm diameter plastic Petri dish) and provided with wetable filter paper.

Wheat aphid, *Schizaphis graminum* collection near the Lasbela University

2.2.4 Culture of corn leaf aphid, *Rhophalosiphum maidis*

Corn leaf aphid, *Rhophalosiphum maidis* were collected from the farmer field near the Lasbela University. The culture of *R. maidis* was maintained on corn plants (*Zea mays*) in the cages measuring 20 x 13cm x 10cm size under the laboratory conditions. The preys were transferred directly to Petri dishes (9cm diameter plastic Petri dish) and provided with wetable filter paper.

2.2.5 Culture of papaya mealybug, *P. marginatus*

Papaya mealybugs, *P. marginatus* were collected from the farmer field near the Lasbela University. The culture of *P. marginatus* was maintained on papaya fruits (*Carica papaya*) in the laboratory. The rearing of *P. marginatus* was continued for more than one month in order to obtain a sufficient number of prey for predatory larvae. The preys were transferred directly to Petri dishes (9cm diameter petri dish) and provided with wetable filter paper.

International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
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2.3 Predation

2.3.1 The predation on the cotton aphid *(Aphis gossypii*), black bean aphid (*Aphis fabae*), wheat aphid (*Schizaphis graminum)*, corn leaf aphid (*Rhophalosiphum maidis*) and papaya mealybug (*Paracoccus marginatus).*

The predation on different preys second nymphal instars of *A. gossypii, A. fabae, S. graminum, R. maidis* and *P. marginatus* were computed as useful reaction of each of the (three) larval instars of *C. carnea*. The six prey densities were utilized as 15, 30, 60, 90, 120 and 150 per petri dish. The predatory larvae were starved for 12 hours before the experiment. The larvae were then transferred to the experimental arena (9cm diameter petri dish) using the fine camel hair brush. The experiment lasted for 24 hours. The quantity of preys of every species devoured by the cruel hatchlings were recorded by calculation the live preys. The tests were recreated five times for each prey density.

Experiment replication in the laboratory at Lasbela University

2.4 Data analysis

The experiment was conducted in a completely randomized design. The functional response of predatory larvae to various prey densities of five prey species was expressed by fitting the data to the Holling's disc equation [17]:

Na= á TN/ (1+aThN).

Na = is the number of prey consumed by the predator per time unit.

á = is the search rate of a predator to prey species.

T = is the total exposure time (1day).

N = is the original number of preys presented to every predatory larva at the start of the experiment.

Th = defines the handling time for each prey caught (proportion of the exposure time that a predator spends in identifying, pursuing, killing, consuming and digesting prey).

The relationship between the mean number of preys consumed versus the original number of preys presented to predatory larvae at the beginning of the experiment (prey consumed) / (prey density x 100) will be estimated.

The results obtained were fitted with regression lines using Statistical Analysis Software version 9.4 (SAS Institute Inc. 2014).

3. RESULTS

The functional response of all three larval instar of *C. carnea* fed on various insect pests, for example, cotton aphid *(Aphis gossypii*), black bean aphid (*Aphis fabae*), wheat aphid (*Schizaphis graminum)*, corn leaf aphid (*Rhophalosiphum maidis*) and papaya mealybug *(Paracoccus marginatus*) at different prey densities are showed in various Tables 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6.

3.1 The predation on cotton aphid, *Aphis gossypii*

The data in Table-3.1 showed that the rate of successful search (á) was the highest value of 0.834 happened at the third larval instar, following the 0.715 second larval instar, while the briefest search rate was 0.625 for the first larval instar. Clearly the handling time (Th) per prey was most limited at first (0.368), second (0.377) and third (0.405) larval instars. Thus, the maximum predation rate was evaluated for the third larval instar achieving 46.23 aphids/day pursued by second and first larval instars being 38.13 and 32.86 aphids/day, individually. The maximum R^2 value of cotton aphid was recorded (0.938) in first larval, (0.935) in second larval while the minimum was recorded (0.931) in third larval instars, respectively.

Table 3.1: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* larvae on cotton aphid, *A. gossypii* at different prey densities.

Larval Instars	Search rate (a')	Handling time (Th)	Maximum predation rate (pr)	R^2
First	0.625	0.368	32.866	0.938
Second	0.715	0.377	38.133	0.935
Third	0.834	0.405	46.233	0.931

3.2 The predation on black bean aphid, *Aphis fabae*

The data in the tables- 3.1 showed that the highest search rate (á) of black bean aphid, *Aphis fabae* was recorded á TN/ (1+aThN). (0.711) in third, (0.559) second and (0.480) in first larval instars respectively. The handling time (Th) per prey was the shortest (0.328) in first, (0.365) third and (0.384) second larval instar when fed on black bean aphid, *Aphis fabae*. The highest predation rate on black bean aphid was recorded (37.23) in third, (30.13) second and (23.80) in first larval instar aphids/day, respectively. The maximum R^2 value was recorded (0.946) in first, (0.939) in second while the minimum R^2 value was recorded (0.936) in third instar larvae when the *C. carnea* larvae fed on black bean aphid.

Table 3.2: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* on black bean aphid, *A. fabae* at different prey densities.

Larval Instars	Search rate (a')	Handling time (Th)	Maximum predation rate (pr)	R^2
First	0.480	0.328	23.80	0.946
Second	0.559	0.384	30.133	0.939
Third	0.711	0.365	37.233	0.936

3.3 The predation on wheat aphid, *Schizaphis graminum*

The data in the table- 3.3 indicated that the highest search rate (á) of *C. carnea* larvae was recorded in third larval instar (0.727), in second larval instar (0.683) and lowest search rate (a') was recorded in first larval instar (0.653) on wheat aphid, *Schizaphis graminum.* The handling time (Th) per prey was shortest (0.310) in first larval instar, (0.397) in second larval instar and highest handling time (Th) was (0.434) in third larval instar when fed on wheat aphid, *Schizaphis graminum.* Accordingly, the highest predation rate on wheat aphid, *Schizaphis graminum* was recorded (42.00) in third, (37.50) in second and (31.50) in first larval instars for 24 hours, respectively.

Table 3.3: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* larvae on wheat aphid, Schizaphis graminum at different prey densities.

Larval instars	Search rate (a')	Handling time (Th)	Maximum predation rate (pr)	R^2
First	0.653	0.310	31.50	0.940
Second	0.683	0.397	37.50	0.935
Third	0.727	0.434	42.0	0.932

3.4 The predation on corn leaf aphid, *Rhophalosiphum maidis*

The data in the table- 3.3 showed that the highest search rate (á) of corn leaf aphid, *Rhophalosiphum maidis* was recorded (0.700) in third, (0.620) in second and (0.580) in first larval instar respectively. The handling time (Th) per prey was the shortest (0.303) in first, (0.419) in second and (0.462) in third larval instar when fed on corn leaf aphid, *Rhophalosiphum maidis.* The highest predation rate on corn leaf aphid was recorded (41.96) in third, (35.06) in second and (27.60) in first larval instar per day, respectively. The maximum R^2 value was recorded (0.943) in first, (0.936) in second while the minimum R^2 value was recorded (0.932) in third larval instar when the *C. carnea* larvae fed on corn leaf aphid.

Table 3.4: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* larvae on corn leaf aphid, *Rhophalosiphum maidis* at different prey densities.

Larval instars	Search rate (a')	Handling time (Th)	Maximum predation rate (pr)	R^2
First	0.580	0.303	27.60	0.943
Second	0.620	0.419	35.06	0.936
Third	0.700	0.462	41.96	0.932

3.5 The predation on mealybug, *Paracoccus marginatus*

The data in the table 3.5 indicated that the highest search rate (á) of mealybug, *P. marginatus* was recorded (0.407) in third, (0.270) in second, and (0.231) in first instar larvae respectively. The lowest handling time (Th) per prey by larvae was recorded on papaya mealybugs (0.147) in third, (0.231) in first and (0.240) in second respectively as they took more time to handle the prey. Thus, the maximum predation rate on papaya mealybug was recorded for the larvae (14.43) in third, (11.53) in second and (9.50) in first instar for 24 hours, respectively. The maximum R^2 value of papaya mealybug was recorded (0.976) in first instar, (0.971) in third instar while the minimum was recorded (0.969) in second instar larvae respectively.

Table 3.5: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* larvae on papaya mealybug, *Paracoccus marginatus* at different prey densities.

Larval Instars	Search rate (a')	Handling time (Th)	Maximum predation rate (pr)	R^2
First	0.231	0.215	9.50	0.976
Second	0.270	0.240	11.53	0.969
Third	0.407	0.147	14.43	0.971

Obtained results in Figures 3.1, 3.2, 3.3, 3.4 and 3.5 indicated increasing in the number of consumed prey at decreasing rate of increasing prey density where curve slope consumption decreased gradually until leveling 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. The number of prey 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. Obtained results were fitted to second degree of polynomial curve.

3.6 The predation on different aphid species and mealybug, *P. marginatus*

The data in the table 3.6 indicated that the highest search rate (á) was recorded (0.724) in cotton aphid (*A. gossypii*), followed by (0.687) in wheat aphid (*S. graminum*), (0.633) in corn leaf aphid (*R. maidis*), (0.584) in black bean aphid (*A. fabae*) and lowest search rate (a') was recorded (0.302) in mealybug (*P. marginatus*) respectively. The results showed that the maximum handling time was recorded (0.394) in corn leaf aphid (*R. maidis*), followed by (0.383) in cotton aphid (*A. gossypii*), (0.380) in wheat aphid (*S. graminum*), (0.359) in black bean aphid (*A. fabae*) and minimum handling time showed (0.201) in mealybug (*P. marginatus*) respectively. Thus, the maximum predation rate was recorded (39.073) in cotton aphid (*A. gossypii*), followed by (37.00) in wheat aphid (*S. graminum*), (34.873) in corn leaf aphid (*R. maidis*), (30.386) in black bean aphid (*A. fabae*) and minimum predation rate was recorded (11.83) in mealybug (*P. marginatus*) at different densities for 24 hours, respectively. The maximum R^2 value was recorded (0.972) in mealybug (*P. marginatus*), followed by (0.940) in black bean aphid (*A. fabae*), (0.937) in corn leaf aphid (*R. maidis*), (0.935) in wheat aphid (*S. graminum*) and while the minimum was recorded (0.934) in cotton aphid (*A. gossypii*) respectively.

Table 3.6: The rate of successful search (a'), handling time (Th) and the maximum predation rate (pr) describing type II functional response parameters of *Chrysoperla carnea* larvae on *A. gossypii*, *A. fabae*, *Schizaphis graminum*, *Rhophalosiphum maidis* and *Paracoccus marginatus* at different prey densities.

International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
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4. DISCUSSION

Larval Instars					Search rate (a')					Handling time (Th)					Maximum predation rate (pr)					R^2
Different insect pests	*A. gossypii*	*A. fabae*	*S. graminum*	*R. maidis*	*P. marginatus*	*A. gossypii*	*A. fabae*	*S. graminum*	*R. maidis*	*P. marginatus*	*A. gossypii*	*A. fabae*	*S. graminum*	*R. maidis*	*P. marginatus*	*A. gossypii*	*A. fabae*	*S. graminum*	*R. maidis*	*P. marginatus*
1st	0.625	0.48	0.653	0.580	0.231	0.368	0.328	0.310	0.303	0.215	32.86	23.8	31.5	27.6	9.5	0.938	0.946	0.94	0.943	0.976
2nd	0.715	0.559	0.683	0.62	0.27	0.377	0.384	0.397	0.419	0.24	38.13	30.13	37.5	35.06	11.53	0.935	0.939	0.935	0.936	0.969
3rd	0.834	0.711	0.727	0.7	0.407	0.405	0.365	0.434	0.462	0.147	46.23	37.23	42	41.96	14.43	0.931	0.936	0.932	0.932	0.971
Mean	0.724	0.584	0.687	0.633	0.302	0.383	0.359	0.38	0.394	0.201	39.073	30.386	37	34.873	11.83	0.934	0.94	0.935	0.937	0.972

The results of this study showed that all larval instar of *Chrysoperla carnea* exhibited type II functional response when fed on different aphid species and mealybug, *P. marginatus* at different prey densities.

Present results were also related those [13] and [21] studied that the only useful in comparing the effectiveness of natural enemies required as bio-control agents. In laboratory conditions the search rate is limited by handling time that time needs to capture and adsorb one prey, whereas, in the field it is limited to searching behaviour. Several factors affecting the searching efficiency and handling time of organisms including their age host developmental stages and temperature and relative humidity.

In the present study agrees with those [10] reported the type II functional response of *Chrysoperla carnea* raised on various aphids species and mealybug was similar to several reports on the functional response in *C. carnea*, *C. rufilabris*, *C. externa*, and *C. congrua*. Result of the present investigation uncovered that *C. carnea* has significant potential for natural control program, the present examinations provide an unpleasant measure of discharge rate on the foundation of prey thickness in the field or the attack level. The prey thickness influences the prey utilization as well as modify the predator search rate and dealing with time which at last intended to influence the future rate of increment of predator and resulting predation also. The revelations still require a more confirmation and in feature learns at ground stage considering greater moving natural factors in points of view.

Our results are similar to [29] who reported that the type II functional response, consumed prey was not density-dependent i.e. the intensity of consumed prey did not increase with prey density. The parameters recorded for functional response are not an accurate measurement by laboratory testing and could not be directly linked to the field conditions, because of either very low prey density or most prey is already consumed. The specifications concurred with the type II functional response that predators appear towards varied densities of its preys which were determined by consumption of prey and handling time. The type II functional response was also the most commonly observed model in insect predators when they were released on their prey. Most of the scientists studied functional response of *Chrysoperla carnea* found type II functional response.

The present study agrees with those [16] were conducted an experiment of the green lacewing, *Chrysoperla carnea* is an important predator of soft-bodied pests in many crop systems such as cotton in many parts of the world. First and second larval instars of the predator exhibited Type II functional responses against the prey. The attack rates (a) and handling times (Th) of the first and second larval instars of the predator were estimated and the third instar larvae of the predator, the attack coefficient (b) and handling time. The highest theoretical maximum predation was found for the last instar larvae of the predator followed by for 2nd and 1st larval instars. Results revealed that the larvae of *C. carnea*, especially the last instar, have a good predation potential in preying. Therefore, by including *Chrysoperla carnea* predator in control programs the use of pesticides against this pest will likely be reduced.

Our study agrees with [27] studied on the functional response of common green lacewing *Chrysoperla carnea* on black bean aphid (*Aphis fabae* Scopoli) in the biology unit at $25\ C^{0}$. Functional response curves indicated that the *Chrysoperla carnea* larvae followed the II type of functional response patterns. The functional response of the predator *Chrysoperla carnea* increased with the increase in population density, i. e. The opportunities for the common green lace wing to face the prey increased in high density and then increased in the number of prey consumed compared to the low density. When calculating the attack coefficient (a) and handling time (Th), increase in (a) and decrease in (Th) were found during the development of the predator common green lacewing *C. carnea*. The highest attack coefficient (a) was at the third instar of the predator *C. carnea*, whereas, the lowest attack coefficient (a) was at the first instar of predator *C. carnea*, and it was at the second instar. In contrary, handling time (Th) decreased, the shortest period of handling time (Th), at the third instar of the predator *C. carnea*, whereas the longest period of handling time (Th) was at the first instar of predator *C. carnea* at the second instar the handling time (Th) of predator *C. carnea*. Also attack coefficient (a) increased and handling time (Th) decreased during the development of *C. carnea* larvae.

Our study also agrees with [22] an experiment conducted on the functional response of the larval instars of *Chrysoperla carnea* Stephen (Neuroptera: Chrysopidae) fed with *Brevicoryne brassicae* L. under lab. conditions at 28 ± 1ºC with 65 ± 5% of R.H. The prey densities used for the larvae of the first stage were 10, 15, 20, 25 and 30 (2^{nd} – 3^{rd}) aphids of instar nymph, while for the larvae of the second instar the prey densities used were 10, 20, 30 , 40 and 50 and for the third larval instar the prey densities used were 15, 30, 45, 60 and 75 aphids. The increase in prey density resulted in a greater consumption of prey up to a certain limit in stages 1, 2 and 3 of the larval stage of *C. carnea*. The highest number of preys consumed recorded was 22, 24 and 45 for the highest prey densities of 30, 50 and 75 in instar stage 1, 2 and 3 of the larval stage of *C. carnea*. The same trend of search, management and resting time was recorded in the three stages of the larval stage of *C. carnea*. The potential consumption rate of the 3rd instar larvae of the *C. carnea* was higher than that of the 1st and 2nd ones. The 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*. The larvae of *C. carnea* on 3rd instar had a good predation potential in preying of *B. brassicae*.

Present study partially agree with [3] experiment conducted on effect of prey density on biology and functional response of green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) under 25±1ºC, 65±5% RH. Newly emerged larvae of *C. carnea* were fed fresh eggs of *Sitotroga cerealella* (Lepidoptera: Gelechiidae) and the prey density had a significant effect on positive consumption rate. Lacewing larvae provided with an overabundance of Angoumois grain moth eggs developed faster than the larvae provided with fewer eggs.

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