



Functional response of *Chrysoperla carnea* and *Coccinella septempunctata* against *Spodoptera frugiperda*

Saif Ullah

Muhamad Nawaz Sharif University of Agriculture Multan

Saifullahshafeeq786@gmail.com

Faiza khan

Sardar Bahadur khan women University Quetta

mirkhalil184@yahoo.com

Asad iftikhar

Department of Entomology Bahauddin Zakariya University Multan

asadiftikhar28@gmail.com

Nathen kumar

Department of Entomology, Faculty of Agriculture, Lasbela University of agriculture, water and marine science

samerrajput098@gmail.com

Muhammad Uzair

Department of Entomology Abdul Wali Khan University Mardan, Garden Campus

muzair1300@yahoo.com

Sohail Ahmed

Department of Entomology, University of Agriculture Faisalabad

jamalisohail7@gmail.com

Fayyaz Maqbool

Department of Entomology, Faculty of Crop protection, Sindh Agriculture University Tandojam, Pakistan

fayyazmaqboolf2@gmail.com

Muhammad Adeel

Department of Agriculture, University college of Dera Murad Jamali, Lasbela University of Agriculture, Water and Marine Science Uthal, Balochistan, Pakistan.

m.adeel@ucdmj.luawms.edu.pk

Sana Ullah

Department of Plant Pathology, University of Agriculture Faisalabad-Pakistan

sanaullhussain2003@gmail.com

Corresponding Author: Saifullahshafeeq786@gmail.com

Abstract: The Fall Armyworm (*Spodoptera frugiperda*) is a highly invasive pest that threatens global food security by causing significant yield losses in maize (*Zea mays* L.) and other cereal crops. To address this challenge through sustainable pest management, this study evaluates the predatory potential and functional response of two biocontrol agents, third-instar larvae of the green lacewing (*Chrysoperla carnea*) and adults of the seven-spotted ladybird beetle (*Coccinella septempunctata*), against early-instar *S. frugiperda* larvae. Experiments were conducted under controlled laboratory conditions, exposing individual predators to varying prey densities (2–40 larvae). Both predators exhibited a Type II functional response, characterized by an initial rapid increase in prey consumption that plateaus due to satiation and handling time constraints. Quantitative analysis revealed that *C. carnea* displayed superior predatory efficiency, with a higher attack rate ($a = 0.421 \text{ h}^{-1}$) and shorter handling time ($T_h = 0.25 \text{ h}$) compared to *C. septempunctata* ($a = 0.315 \text{ h}^{-1}$, $T_h = 0.38 \text{ h}$). Consequently, *C. carnea* achieved a maximum theoretical predation rate of 40 larvae/day, while *C. septempunctata* reached 26 larvae/day. However, *C. septempunctata* adults showed a higher predation rate on first- and second-instar *S. frugiperda* larvae compared to its own third- and fourth-instar larvae, with attack rates of $0.0496\text{--}0.0821 \text{ h}^{-1}$ and handling times of $0.0496\text{--}0.0915 \text{ h}^{-1}$. In contrast, *C. carnea* third-instar larvae outperformed second-instar larvae, with attack rates of $0.96\text{--}1.11 \text{ day}^{-1}$ and handling times of $0.10\text{--}0.14 \text{ day}^{-1}$. These findings highlight the significant predatory capacity of both species, with *C. carnea* emerging as a particularly effective candidate for augmentative biological control within Integrated Pest Management (IPM) programs for *S. frugiperda*, offering an environmentally sustainable alternative to chemical insecticides.

Keywords: Maize, fall armyworm, Biocontrol agents, Functional Response, Conservation

Introduction

S. frugiperda, also known as fall armyworm belongs to the order Lepidoptera that spread in the tropical-subtropical areas of the American continent (Prasanna *et al.*, 2021). Due to the high

mobility and dispersion it has happened and taken negative effects globally in the recent past (Zang, 2019). The International Center for Agricultural and Biosciences reports on the status of the world's plants and CABI rated them as one of the top ten plant pests in the world (Luginbill *et al.*,1996, Kenis *et al.*,2022). *S. frugiperda* is native to tropical and subtropical regions of the America. Invasion of *S. frugiperda* in Nigeria and Ghana in Africa for the first time from March 2016 to 2018 rapidly spreading to sub-Saharan 44 African countries causing a serious reduction in maize production (Kasoma *et al.*, 2021). the same year. In September, *S. frugiperda* invaded India and then quickly spread to Yemen, Thailand, Myanmar, Nepal, Bangladesh, and other Asian countries (Sharanabasappa *et al.*,2018, Wu *et al.*,2019). and formed an insect source base in Myanmar in 2019 (Guo *et al.*,2018). *S. frugiperda* has the following characteristics: a wide host range, including maize, wheat, rice, sugarcane, etc.76 divisions 353 host plant (Montezano *et al.*, 2018). Strong migration ability, adults use airflow to spread over long distances and can migrate every night many kilometers (Abrahams *et al.*,2017). Strong reproductive ability, the female can mate and lay eggs multiple times, and the average number of eggs laid is 1000 grains or so, reaching the maximum 2000 grain (Nagoshi and Meagher, 2008). Suitable area is wide, currently available all over the world. Many countries are affected by *S. frugiperda* (Wang *et al.*,2019). The degree of damage is serious, *S. frugiperda* larvae gather together and become gluttonous, and advanced larvae (4-6 days) can feed on the entire plant leaves or maize tassels and ears, resulting in reduced corn yields, and in severe cases, even the destruction of crops (FAO., 2017). *S. frugiperda* is a polyphagous pest, and its hosts include maize, cotton, rice, peanuts, sorghum, sugar beets, soybeans, tobacco, tomatoes, potatoes, onions, wheat, and more than 300 plants. It's threatening the food security and livelihood status of the common farmers as this invader is capable of spreading to South East Asia and south China, which is very vulnerable (FAO, 2017). As studied by formulated report provided by the council of agriculture research in India of maize plot in Chikkaballapur, Karnataka more than 70% of the maize plot was attacked by the fall armyworm (CGIAR, 2018). Because *S. frugiperda* occurs quickly and causes serious damage, there is an urgent need to research methods that can effectively control the damage. The current methods to control *S. frugiperda* mainly include, cultural, chemical control, and biological control among which chemical control is preferred by the farmers to control *S. frugiperda* (Tang *et al.*,2019, Burtet *et al.*,2017). However, frequent use of chemical pesticides *S. frugiperda* populations in many countries have been reported to be resistant to a variety of chemical pesticides to

conventional insecticide groups like organophosphates, carbamates, and synthetic pyrethroids. Larvae of *S. frugiperda* also burrow into maize heart leaves, leaf sheaths, and tassels, chemical agents not reach the insect body and cannot achieve good control effects (Jiang Yuying *et al.*, 2019). To achieve the overall prevention and control goals of *S. frugiperda*, new prevention and control methods need to be found as soon as possible.

Biological control is an effective way to control *S. frugiperda*. Natural enemy insects are of the core method of biological control. Besides the synthetic pesticides, other methods to control *S. frugiperda* include the application of botanicals on the young plants (Jiang *et al.*, 2013). and introduction of natural enemies comprising of parasitic insects such as Reduviidae, Carabidae, Anthocoridae, Coccinellidae, Pentatomidae, Chrysopidae and Pentatomidae families *C. carnea* (Wade *et al.*, 2004) (Neuroptera: Several chrysopids and other lacewings can regulate arthropod pests (Pappas *et al.*, 2013). for instance, *Alabama argillacea* (Lepidoptera: Noctuidae), *Aphis gossypii*, *Schizaphis graminum*, *Rhodobium* sp. and *Leptopharsa heveae* (Heteroptera: Tingidae) in crops such as rice, corn, beans, and cotton are managed by Chrysopid species (Pappas *et al.*, 2013, Souza *et al.*, 2008). There are many kinds of natural enemies of *S. frugiperda*, and many countries use beneficial stink bugs *Picromerus lewisi* Scott, Earbug *Arma chinensis* Fallou, East Asian stink bug *Orius sauteri*, Lacewing, *C. carnea*, many different ladybugs *Hippodamia variegata*, *C. septempunctata*. Predatory insects and Trichogramma wasps *Trichogramma* sp., *Telenomus remus*, Braconid wasps *Chelonus* sp., *Braconidis sternii* *Microplitis similis* have been relevant reports on the control of *S. frugiperda* by other parasitic wasps (Tang *et al.*, 2019, Chen *et al.*, 2019, Kong Lin *et al.*, 2019). The most harmful insect pests of maize are lepidopterans which include stem borers, cutworms, armyworms, and ear borers (Kotey *et al.*, 2020). Insect pests such as borers and particular fall armyworm inflict major losses in maize production (Kumar, 2002). According to survey findings, if *S. frugiperda* was allowed to spread unchecked, maize yield losses might range from 8.3 to 20.6 million tons per year (21-53% decrease in output) (Abrahams *et al.*, 2017).

C. septempunctata feed on different species of aphids, mealy bugs, sugarcane aleyrodorus, mites' citrus psyllid and the sorghum stem borer, maize fall armyworm (Shepard, 1998). Currently, effort is being made to focus on integrated pest management (IPM) in order to reduce complete chemical approach (Butt and Sherawat, 2012). Due to its predatory nature and cosmopolitan

distribution, *C. septempunctata* is one of the most important biological control agent. However, spiders dominantly occupying the cotton fields are 3935 generals and 44906 described species (Kumari, 2020). Prey searching behavior, ease of multiplication and polyphagy in nature is attributed this role as a potential predator for biological control of aphids, mites, and leafhoppers and lepidopterans in cotton and various agro-ecosystems. (Mohsin *et al.*,2015).

The number of successfully attacked prey per predator as a function of prey density is known as the functional response (Jeschke *et al.*,2002). It describes how a predator reacts to the changing prey density (Hammill *et al.*,2010). *C. septempunctata* has been reported feeding on *S. frugiperda* from Multan region. However functional response of *C. septempunctata* against *S. frugiperda* as biological control was evaluated attributes like Feeding rate, praying rate, consumption rate, acceptance threshold, foraging efficiency, predation rate) (Den Berg., 2019, Zang *et al.*, 2021). Ladybug *C. septempunctata*, has the advantages of wide distribution, long survival time, strong adaptability, large occurrence and high egg laying capacity. It is the dominant predatory natural enemy in many countries. This experiment tested the effects of adults of *C. septempunctata* on *S. frugiperda*. The predatory function response, search effect and interference effect of instar larvae were explored in order to scientifically evaluate the control effect of *C. septempunctata* on *S. frugiperda* and provide a theoretical basis for the application of *C. septempunctata* to control *S. frugiperda* (Wang *et al* 2013, Liu *et al.*,2006: Jan *et al.*, 2025). The larva of *C. carnea* (Stephens) (Neuroptera: Chrysopidae, a species of green lacewing, is an effective natural enemy of many soft-bodied Chrysopidae and is preferred for inoculative and inundative releases due to its diet which comprises of arthropods such as aphids, scale insects, leafhoppers, white flies, thrips, and mites and also eggs and small larvae of Coleoptera and Lepidoptera (Ulhaq *et al.* 2006). The lacewing has a wide diet and can prey on a variety of aphids, spider mites, leafhoppers, lepidopteran eggs and young larvae, etc. It plays an important role in field pest control. In conventional natural enemy insect pest control applications, it is a very effective technical method to evaluate the suitability of natural enemy insects for feeding target insects based on the fitted Holling functional response model. In a previous study, the researchers compared the feeding amount of lacewings under different densities of prey, and conducted an in-depth comparison of the effects of lacewings on *Aphis nerii* Boyer de Fonscolombe (Liu *et al.*, 2009). and *Bemisia tabaci*. The feeding potential of pests such as *Gennadius* (Wang *et al.*, 2016: Jan *et al.*, 2025) provides an important basis for systematic application of biological control work.

Therefore, developing lacewings as natural enemies of *S. frugiperda* for biological control applications requires us to carry out biological control applications. Based on field measurements, a fitting evaluation of the feeding function response was carried out, thereby laying a theoretical foundation for using lacewings to control *S. frugiperda*. Based on the result of field surveys with experiment and observation tests, it was concluded that lacewing was one of the most effective biocontrol agents for *S. frugiperda* in field control, Thus, further study on the predatory response function of the larvae of *C. carnea* to this pest of *S. frugiperda* would be helpful to practical apply. Advantages of employing *C. carnea* as a high-release rate biological control agent include: Its larvae are not easily affected by changes and the adult bugs are said to lay numerous eggs (Tavares *et al*, 2013). *C. carnea* has been cultured on an artificial medium in the laboratory; they may, however occasionally feed on *Corcyra cephalonica* eggs. Lacewings as prey has been studied extensively mostly in the laboratory (Pappas *et al*, 2013, Capinera, 2008, Souza *et al*, 2008: Jan *et al*., 2025). The predator has been tested on various prey species (Juárez *et al*., 2014, Silva *et al*, 2004). as well as diets (Farid *et al*., 2009). such as algae, honeydew (Ferkovich *et al*, 2007). and pollen grains *Anagasta kuehniella* (Zeller, 1879). (Lepidoptera: From the study it was agreed that Pyralidae could be among the foods that lacewings feed on though rearing it is a complex process that may demand hundreds of labor and space (Pappas *et al*, 2013; Jan *et al*., 2025). The commonly used control method is chemical control (Kansiime *et al*., 2019), but because of resistance occurrence against different pesticides, the efficiency of chemical control is reduced. Long-term use of pesticides, *S. frugiperda* has developed resistance to pesticides including carbamates, organophosphates, and pyrethroids (Zhao *et al*., 2019).

Therefore, there is an urgent need to study methods that can effectively replace or supplement chemical control to achieve efficient green control of night worm in grassland (Harrison *et al*., 2019).

Materials and methods: Experiments were carried out in Biological control laboratory of M NS, University of Agriculture, Multan.

Collection and rearing of *Coccinella septempunctata* and *Chrysoperla carnea*

C. septempunctata and *C. carnea* were collected by hand in collections vials from maize fields. Aphids were given as feed to *C. septempunctata*. Adults were brought to the laboratory for rearing. Almost 30 adults were kept in the rearing cages and they fed on aphids. Aphid were collected from maize field daily and serve to beetles till egg laying. Laboratory conditions with temperature 25 ± 1 °C and relative humidity 45 ± 2 % were maintained for insect rearing. Leaves were changed at least thrice a week. Fresh beetle eggs were collected from cages and shifted to petri dishes until hatching. Larvae emerged from eggs in 4 to 5 days, adults were emerged after 2 weeks at 25 ± 1 °C. The rearing of chrysoperla was done at temperature 27 ± 2 and relative humidity 60 ± 10 . Chrysoperla eggs brought from Muzzafargarh Agri. Extension Rearing laboratory. The eggs were evenly distributed on a tissue paper in the plastic box. Larvae hatched from them, they are separated in single petri dishes and were fed on eggs of rice moth (*Corcyra cephalonica*) then used for predatory functional response studies.

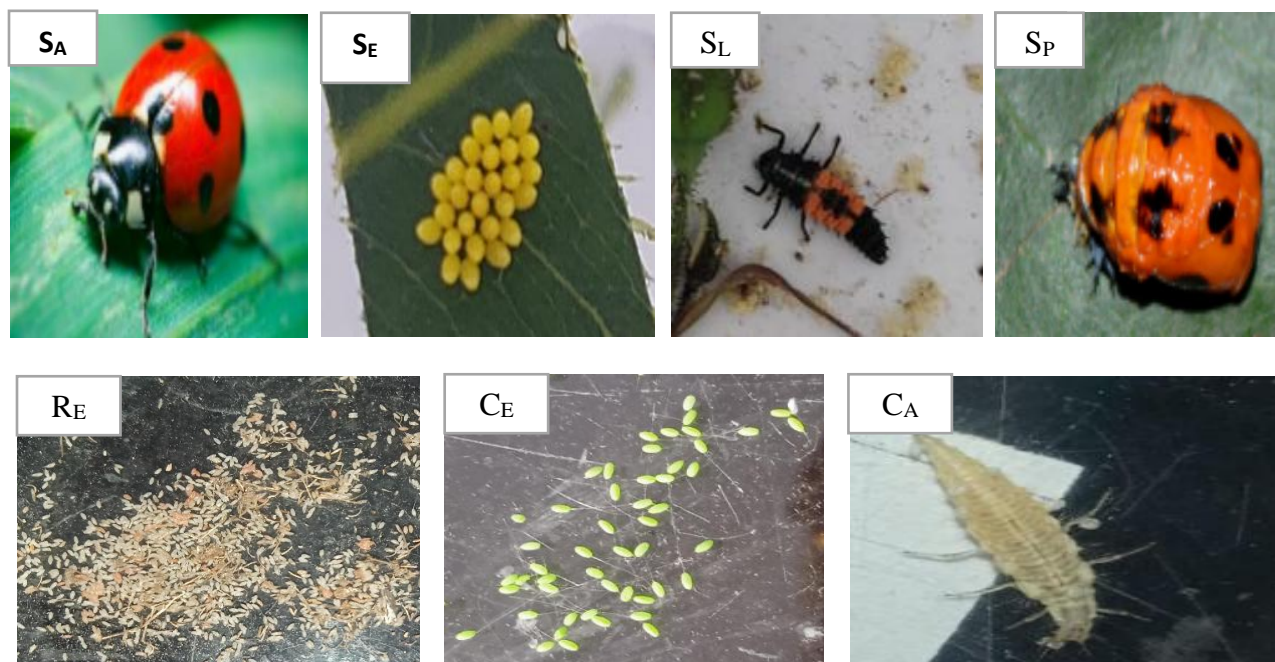


Fig 1.1 Rearing of *C. septempunctata* and *C. carnea* LBB Adult:SA ,Eggs:SE, Larva: SL, Pupa: SP, Rice Moth Eggs: RE, Chrysoperla Eggs: CE, Chrysoperla Adult:CA

2.2.4. Rearing of Fall Armyworm

The larvae of fall armyworm were collected from maize fields. The black spot pattern on the larvae's dorsal side, as well as they contain Y-shape on the top of their heads, allowed for their

identification. Larvae were collected from field in collection vials. In order to prevent the cannibalism one larvae per petri dish was reared on natural diet. Petri dishes were supplied fresh leaves and feces were removed daily. A photoperiod of L: D = 16: 8 hrs. was maintained with temperature 25 ± 2 °C, and $70\pm 10\%$ R.H.

In just a few short days, larvae undergo metamorphosis into pupae, and then eventually into adults. The adults were set free on the maize plants from a cage made of plastic. Adults were given a 10% sugar solution as a source of nutrition. To keep the necessary level of humidity for egg laying, the cage was sprayed with water. Eggs were being laid in batches on the plant leaves and cage walls after adults of the *S. frugiperda* species had successfully mated., the eggs were separated out on daily basis to use them in subsequent research. Eggs were laid in batches of about 100-150 eggs/batch on the underside of maize leaves, typically near the base of plant close to the junction of leaf and stem. It also lay eggs on other things rather than maize plants i.e., glass of the cage, wooden part of the cage and fine meshes of rearing cage. Eggs batch collected from maize leaves and wrapped into white soft part at the base of the leaf after egg hatching, the young caterpillars immediately feed on soft leaves and leaves semi-transparent patches called windows. After 3 to 4 day's eggs hatched. With the use of a fine brush, the larvae were deposited individually into petri dishes of diameter 6 cm. Caterpillar completes its growth in about 16 to 17 days comprising of 6 growth development stages (2.6 day/instar). Fresh, maize leaves were fed to the larvae as diet after every two days. After 16 to 17 day's larvae cover himself into leaf and pupate. After removing the pupae from the cage, they were transferred to other petri dishes with a diameter of 10 cm and contained tissue paper. These petri plates were then transferred to the rearing cage containing the host plant. Pupal period recorded was 8 to 9 days. After 8 to 9 day's pupa emerges into adult. The emergence of the adults took place in the rearing cage, which was fed on sugar solution (10%) during the process. The eggs were laid on the host plants that were collected on daily basis. The eggs were put in to leaves of maize for hatching, after hatching 1st and 2nd instar were used for functional response studies (Phambala *et al.*, 2020).

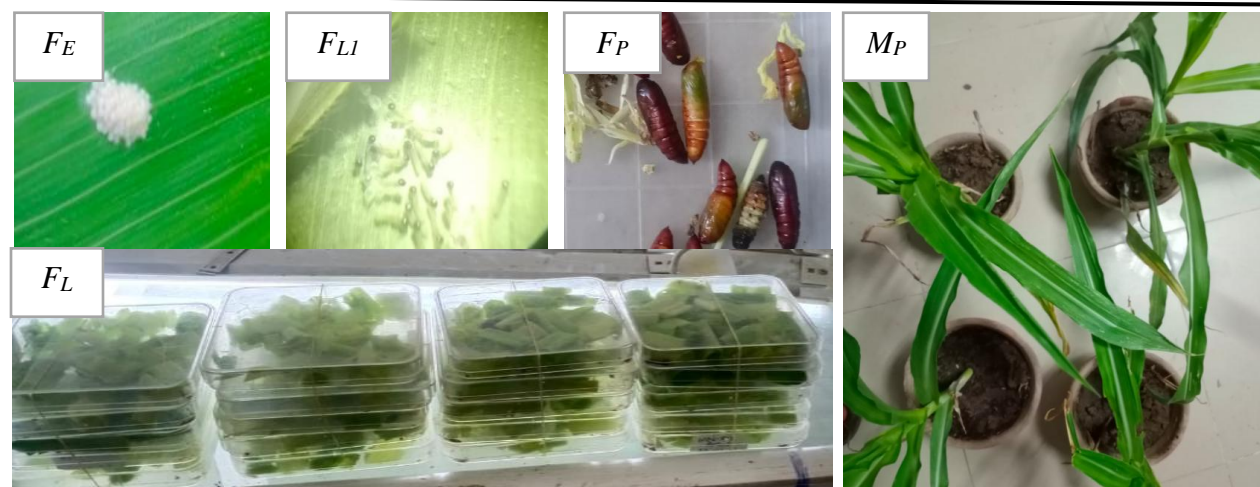


Fig 1.2 Rearing of FAW: Eggs of FAW(F_E), 1st instar larvae (F_{L1}), Pupae (F_P), Larval population in petri dishes(F_L), Maize Plant in Laboratory(M_P)

2.2.2. Functional Response Studies

The test was carried out on a diameter of 15 cm conducted in a petri dish. Culture was maintained under laboratory conditions temperature 25 ± 5 °C and relative humidity 65 ± 5 %. To determine the functional response of predatory *C. septempunctata* adult and larvae (2nd and 3rd instars) and *C. carnea* 2nd and 3rd instar larvae on 1st and 2nd instar larvae of *S. frugiperda* were tested. Both predators were kept starved for 24 hours. *S. frugiperda* larvae were put in petri dishes in sequence 1, 2, 4, 8, 16 and 32. After this, 24 h starving *C. septempunctata* was released using camel hair brush. Three replicates were kept for determining the feeding potential of each predatory stage of both predators. Larvae fed or killed by each predator counts were taken after every 24 hours.



Fig 1.3 Functional response of adult *C. septempunctata* (A), Larva (L_1) and *C. carnea* larvae (L_2)

2.2.4. Data Collection

Data were collected after every 24 hours. Dead individuals were counted. The larvae were considered dead when stirred with a needle and no response was observed data regarding mortality were arranged according to requirements on Excel sheet. Data on the preying rate and increasing predator density was also recorded.

2.2.5. Data Analysis

Functional response type II or III based on the equation was determined using the method logistic regression analysis suggested by Ali *et al.*,2011. Statistical software was used using glm method. Holling Type II disk equation: $N_a = a N T_r / (1 + a T_h N)$ (Hammill *et al.*,2010) in the formula **N_a** = number of *S. frugiperda* larvae, fed; **a** = instantaneous attack rate of the predator on the prey; **N**=the density of *S. frugiperda* larvae; **T_r** = total test time (in this test **T_r** = 1); **T_h** = The time it takes to kill prey. Search effect equation: $S = a T_r / (1 + a T_h N)$ (Ding, 1994), in the formula **S** For the search effect, **a**=is the instantaneous attack rate, **T_h** for processing 1, The time it takes to kill a prey, **N** is the density of *S. frugiperda* larvae.

The method used in analyzing it was logistic regression to determine whether it was a type II or type III functional response according to Ali *et al.*,2011. For the data analysis by logistic regression, R software version 2. 0 (2012). Statistical analysis was done using statistical software called Statistical, and the method used in the analysis was glm method.

Where:

$$\frac{N_{par}}{N} = \frac{\exp(p_0 + p_1 N + p_2 N + p_3 M_3)}{1 + \exp(p_0 + p_1 N + p_2 N + p_3 N_3)}$$

$$N_{par} = a T N / 1 + a T_h N \quad (2)$$

N = number of fall armyworm offered, **N_{par}** = numbers of *S. frugiperda* parasitized and **P**, **P₁**, **P₂** and **P₃** Fixed variables in logistic regression. Type II has a negative linear relationship with **P**, whilst type III has a positive linear relationship with **P** (Ali *et al.*,2011). In the case of handling time and predicted attack rates, Holling's Disc Equation proved to be useful (Hammill *et al.*,2010). Here is Holling's Disc equation for functional response of type II.

Since *C. septempunctata* and *C. carnea* is capable of parasitizing and feeding on host, data was recorded in terms of the number of *S. frugiperda* that was killed. Where: N_{par} = the number of parasitized, T = total time of exposure, N = the number of *S. frugiperda* offered, a = attack rate, and $T_{\{b\}}$ = handling time. Holling's disc equation was statistically parameterized using statistical software obtained from a dataset collected in 2012. In this study, scientists used SAS statistical software yet there are many earlier studies that have been conducted using this type of SAS software. These parameters were adopted with the aid of R statistical software and the Solver tool of Microsoft Excel 2010. For the evaluation of non-linear regression and estimate of the coefficients, Microsoft Excel's Solver was also used.

2.2. Results

This study therefore seeks to examine the effectiveness of Functional Response experiment on *C. septempunctata* and *C. carnea* against *S. frugiperda* and the linear parameter of logistic is therefore pointed out to be linear. Initially, there were negative and significant P values in the case of regression for *C. septempunctata* and *C. carnea* against *S. frugiperda*, as presented in Table 1, 2, 3 and 4. This could be due to the fact that the number of *S. frugiperda* killed by both predators hyperbolically rose to maximum and leveled off as *S. frugiperda* density rose thus exhibiting type II functional response. In the current study, Holling's disc equation was used to estimate the handling time (T) attack rates (a) and of *C. septempunctata* and *C. carnea*. When estimating parameters, Holling's disc equation performed better than the random parasitoid equation (Bruzzone *et al.*, 2023) the latter equation failed to provide a realistic and reasonable estimates. Attack rate (a) was of *C. septempunctata* (adult) (1.3 ± 0.14) day^{-1} and handling time (T) was (0.05 ± 0.0042), *C. septempunctata* (4th instars larva) shows attack rate (1.26 ± 0.23) day^{-1} and handling time (0.061 ± 0.01), *C. septempunctata* (3rd instar larva) showed attack rate (1.20 ± 0.15) day^{-1} and handling time (0.08 ± 0.01) against *S. frugiperda* (1st instar) and attack rate (a) was of *C. septempunctata* (adult) (1.10 ± 0.06) day^{-1} and handling time (T) was (0.068 ± 0.003), *C. septempunctata* (4th instar larva) showed attack rate (1.56 ± 0.30) day^{-1} and handling time (0.08 ± 0.01), *C. septempunctata* (3rd instar larva) showed attack rate (1.11 ± 0.12) day^{-1} and handling time (0.092 ± 0.01) against *S. frugiperda* (2nd instar). Attack rate (a) was of *C. carnea* (3rd instar larva) shows attack rate (1.1136 ± 0.1224) day^{-1} and handling time (0.0902 ± 0.0063), *C. carnea* (2nd instar larva) shows attack rate (0.9623 ± 0.1071) day^{-1} and handling time (0.1230 ± 0.0080) against

S. frugiperda (1st instar) was of *C. carnea* (3rd instar larva) shows attack rate (1.0240±0.0853) day⁻¹ and handling time (0.1075±0.0054), *C. carnea* (2nd instar larva) shows attack rate (0.7909±0.0998) day⁻¹ and handling time (0.1420±0.0108) against *S. frugiperda* (2nd instar). Another effect of increasing predator density was shown in which number of predator (*C. septempunctata*, *C. carnea*) was increased 2, 4, 6 individuals at constant rate of prey 1, 2, 4, 8, 16, 32 individuals of *S. frugiperda* (Table 8). All results showed that killing rate of *C. septempunctata* (Adult) is highest and very fast attack rate with low handling time followed by 4th and 3rd instar and *C. carnea* 3rd and 2nd instar on 1st and 2nd instar of *S. frugiperda*.

Table 1.1-Logistic regression analysis results of *C. septempunctata* against 1st instar of *S. frugiperda*

Predators	Coefficient	Estimate	Standard Error	Z value	P Value
<i>C. septempunctata</i> (Adult)	Constant (P ₀)	4.00e+00	4.64e-01	8.61	<2e-16***
	Linear(P ₁)	-2.31e-01	1.20e-01	-1.91	0.05
	Quadratic (P ₂)	8.62e-04	8.41e-03	0.10	0.91
	Cubic (P ₃)	6.64e-05	1.59e-04	0.41	0.67
<i>C. septempunctata</i> (4 th instar)	Constant (P ₀)	3.73	0.46	8.18	2.76e-16***
	Linear(P ₁)	-0.08	0.12	-0.66	0.50
	Quadratic (P ₂)	-0.02	0.01	-2.13	0.04*
	Cubic (P ₃)	0.01	0.01	3.18	0.01**
<i>C. septempunctata</i> (3 rd instar)	Constant (P ₀)	2.31e+00	2.48e-01	9.31	<2e-16***
	Linear(P ₁)	-1.34e-01	6.89e-02	-1.95	0.05
	Quadratic (P ₂)	-4.23e-03	4.99e-03	-0.84	0.39
	Cubic (P ₃)	1.66e-04	9.63e-05	1.72	0.08

Table 1.2: Logistic regression analysis results of *C. septempunctata* against 2nd instar of *S. frugiperda*

Predators	Coefficient	Estimate	Standard Error	Z value	P Value
<i>C. septempunctata</i> (Adult)	Constant (P ₀)	2.61e+00	2.52e-01	10.31	<2e-16***
	Linear(P ₁)	-2.80e-01	6.92e-02	-4.04	5.23e-05***
	Quadratic (P ₂)	8.51e-03	4.97e-03	1.71	0.08
	Cubic (P ₃)	-9.49e-05	9.57e-05	-0.99	0.32
<i>C. septempunctata</i> (4 th instar)	Constant (P ₀)	8.11e+01	1.58e+05	0.01	1.00
	Linear(P ₁)	-1.69e+01	3.47e+04	0.00	1.00
	Quadratic (P ₂)	1.03e+00	2.17e+03	0.00	1.00
	Cubic (P ₃)	-1.82e-02	3.87e+01	0.00	1.00
<i>C. septempunctata</i> (3 rd instar)	Constant (P ₀)	2.96e+00	2.55e-01	11.58	<2e-16***
	Linear(P ₁)	-4.54e-01	6.89e-02	-6.59	4.38e-11***
	Quadratic (P ₂)	2.09e-02	4.92e-03	4.25	2.14e-05***
	Cubic (P ₃)	-3.32e-04	9.46e-05	-3.51	0.04 ***

Table 1.3: Logistic regression analysis results of *C. carnea* against 1st instar of *S. frugiperda*

Predators	Coefficient	Estimate	Standard Error	Z value	P Value
<i>C. carnea</i>	Constant (P ₀)	3.52	0.292	12.04	<2e-16***
(3 rd instar)	Linear(P ₁)	-0.54	0.0765	-7.11	1.14e-12***
	Quadratic (P ₂)	0.02	0.005	4.59	4.29e-06***
	Cubic (P ₃)	-0.001	0.001	-3.69	0.00022***
<i>C. carnea</i>	Constant (P ₀)	1.46e+00	1.869e-01	7.85	4.08e-15***
(2 nd instar)	Linear(P ₁)	-2.38e-01	5.486e-02	-4.34	1.37e-05***
	Quadratic (P ₂)	8.42e-03	4.090e-03	2.06	0.0394*
	Cubic (P ₃)	-1.17e-04	8.024e-05	-1.46	0.1420

Table 1.4: Logistic regression analysis results of *C. carnea* against 2nd instar of *S. frugiperda*

Predators	Coefficient	Estimate	Standard Error	Z value	P Value
<i>C. carnea</i>	Constant (P ₀)	2.29e+00	2.173e-01	10.54	<2e-16***
(3 rd instar)	Linear(P ₁)	-3.66e-01	6.102e-02	-6.01	1.82e-09***
	Quadratic (P ₂)	1.53e-02	4.452e-03	3.44	0.001***
	Cubic (P ₃)	-2.27e-04	8.645e-05	-2.63	0.001**
<i>C. carnea</i>	Constant (P ₀)	2.86e-01	1.673e-01	1.71	0.087

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(2nd instar)	Linear(P ₁)	-3.97e-02	5.109e-02	-0.77	0.436
	Quadratic (P ₂)	-3.54e-03	3.881e-03	-0.91	0.361
	Cubic (P ₃)	9.15e-05	7.682e-05	1.19	0.233

In Tables 1.1, 1.2, 1.3 and 1.4 linear value of the coefficient showed functional response of either type II or type III and positive and negative values of significance. Likelihood estimates from logistic regression showed a significant negative linear co-efficient $P_1 < 0$. Responses from all the predatory stages of *C. septempunctata* (Adult, 3rd, and 4th instar) and *C. carnea* (2nd and 3rd instar) against *S. frugiperda* 1st and 2nd instar were negative, which means that functional responses are of type II. Quadratic and cubic coefficients show the degree of X (prey offered) values to making curves. The constant coefficient shows parameters of X values. For example, in this data parameters are stages of insects either larvae or adults. Here linear regression is a relationship between prey offered and prey killed.

Table 1.5: Rate of attacking (a) and handling time (T_h) of *C. septempunctata* on 1st instar of *S. frugiperda*

Predators	Coefficient	Estimate	S.E.	t value	Pr(> t)
<i>C. septempunctata</i> (Adult)	Attack rate (a) (day ⁻¹)	1.341	0.139	9.627	0.001***
	Handling time (T _h) (day)	0.049	0.004	11.754	0.001***
<i>C. septempunctata</i> (4 th instar)	Attack rate (a) (day ⁻¹)	1.263	0.226	5.587	0.005**
	Handling time (T _h)(day)	0.061	0.008	7.477	0.001**

<i>C. septempunctata</i> (3 rd instar)	Attack rate (a) (day ⁻¹)	1.194	0.146	8.159	0.001**
	Handling time (T _h)(day)	0.082	0.006	12.561	0.001***

Table 1.6 Rate of attack (a) and handling time (T_h) of *C. septempunctata* on 2nd instar of *S. frugiperda*

Predators	Coefficient	Estimate	S.E.	t value	Pr(> t)
<i>C. septempunctata</i> (Adult)	Attack rate (a) (day ⁻¹)	1.0694	0.0564	18.96	4.56e-05***
	Handling time (T _h)(day)	0.0681	0.0027	24.50	1.65e-05***
<i>C. septempunctata</i> (4 th instar)	Attack rate (a) (day ⁻¹)	1.5581	0.2919	5.337	0.005936**
	Handling time (T _h)(day)	0.0805	0.0085	9.382	0.000719***
<i>C. septempunctata</i> (3 rd instar)	Attack rate (a) (day ⁻¹)	1.1107	0.1185	9.368	0.000723***
	Handling time (T _h)(day)	0.0915	0.0062	14.712	0.000124***

Table 1.7: Rate of attack (a) and time of handling (T_h) of *C. carnea* on 1st instar of *S. frugiperda*

Predators	Coefficient	Estimate	S.E.	t value	Pr(> t)
<i>C. carnea</i> (3 rd instar)	Rate of attack (a) (day ⁻¹)	1.11	0.122	9.09	0.001***
	Handling rate (T _h)(day)	0.09	0.006	14.18	0.001***
<i>C. carnea</i> (2 nd instar)	Rate of attack (a) (day ⁻¹)	0.96	0.107	8.98	0.001***
	Handling rate (T _h)(day)	0.12	0.008	15.31	0.001***

Table 1.8: Rate of attack (a) and time of handling (T_h) of *C. carnea* on 2nd instar of *S. frugiperda*

Predators	Coefficient	Estimate	S.E.	t value	Pr(> t)
<i>C. carnea</i> (3 rd instar)	Rate of attack (a) (day ⁻¹)	1.02	0.085	12.00	0.001***
	Handling rate (T _h)(day)	0.10	0.005	19.69	3.92e-05***
<i>C. carnea</i> (2 nd instar)	Rate of attack (a) (day ⁻¹)	0.79	0.099	7.918	0.001**
	Handling rate (T _h)(day)	0.14	0.010	13.131	0.001***

In Table 1.5,1.6,1.7 and 1.8 attack rate and handling time of predator *C. septempunctata* and *C. carnea* showed the predatory ability in which for good predator shows low handling time and high attack rate is required in case of adult of *C. septempunctata* 0.04 h / day for 1st instar and 0.06 h / day for 2nd instar of *S. frugiperda* is required, in case of 4th instar 0.06 h / day for 1st instar and 0.08 h / day for 2nd instar of *S. frugiperda* is required and in case of 3rd instar for 1st instar of *S. frugiperda* 0.09 h / day and for 2nd instar 0.10 h / day is required. In case of 2nd and 3rd instar larvae of *C. carnea* 0.09h/day for 1st instar and 0.12 hours for 2nd instar of *S. frugiperda*. This is 0.14h/day, 0.10h/day for second and third instar of *c.carnea* on second instar of *S. frugiperda*. So table show high predation rate of adult and low predation rate of larvae and illustrates high predation for 3rd instar of predator on prey and low preference for 2nd instar predator on prey.

Table:1.9: Predator (*C. septempunctata* and *C. carnea*) density effect on prey (*S. frugiperda*)

Sr. No.	Predator	<i>S. frugiperda</i> (Prey)	Predator Density	Average Prey Killed	S.E
1	Adult LBB	2 nd instar	2	3.83	0.945
			4	5.50	1.727
			6	7.00	2.476
		1 st instar	2	4.33	1.256
			4	6.66	2.304
			6	8.16	3.092
2	4 th instar LBB	2 nd instar	2	3.50	0.885
			4	4.66	1.333
			6	6.16	2.039
		1 st instar	2	4.66	1.256
			4	5.66	1.801

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			6	7.16	2.587
3	3 rd instar LBB	2 nd instar	2	3.33	0.802
			4	4.33	1.201
			6	5.33	1.646
		1 st instar	2	3.83	1.108
	4		5.00	1.460	
	6		6.33	2.076	
4	3 rd instar chrysopa	2 nd instar	2	2.83	0.600
			4	3.83	1.077
			6	5.00	1.570
		1 st instar	2	3.16	0.703
	4		4.83	1.447	
	6		5.83	1.956	
5	2 nd instar Chrysopa	2 nd instar	2	2.33	0.421
			4	2.83	0.749
			6	3.83	0.945
		1 st instar	2	3.33	0.802
	4		3.66	1.115	
	6		4.50	1.258	

Table 1.9 showed the predatory ability of *C. septempunctata* (Adult ,3rd and 4th instar) and *C. carnea* (2nd and 3rd instar) by increasing predators increasing density 2, 4 and 6 individuals on 1,2,4,16,32 *S. frugiperda* (1st and 2nd instar) larvae. This table actually showed intraspecific competition among predator individuals. Prey killed average and standard error was calculated and

results showed increase in predation of prey by increasing predator numbers. In case of adult ladybird beetle Average killing rate of 2 predators is 3.83 larvae killed of 2nd instar of *S. frugiperda* and 4.33 larvae killed of 1st instar of *S. frugiperda* and by increasing predator 4 individuals (5.50,6.66 larvae killed) and by 6 individuals (7.00,8.16 larvae killed) from 1st & 2nd *S. frugiperda* instar and so on increased rate of predation was assumed for 3rd and 4th instar of predator against 1st & 2nd *S. frugiperda* instar (prey).The 3rd instar of *C. carnea* : The average killing rate of 2 predators is 2.83 larvae destroyed out of 2nd instar of *S. frugiperda* . 3.83 larvae eaten of the first instar of *S. frugiperda* by 4 individuals of *C. carnea* and 5.00 individuals by 6 individuals and so on as values mentioned in table. Hence increasing predator numbers is directly proportional to high predation rate

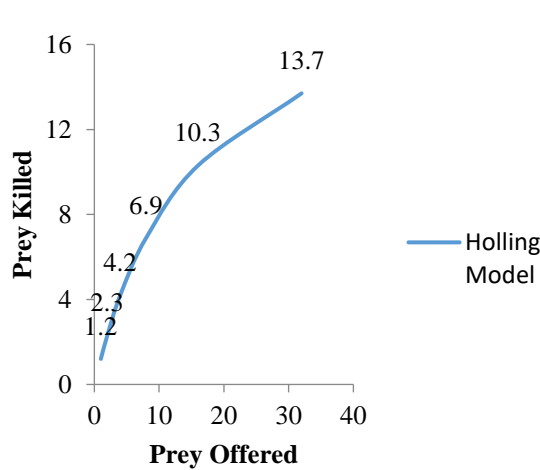


Fig 1.4: Number of *S. frugiperda* (1st Instar) killed by *C. septempunctata* (Adult)

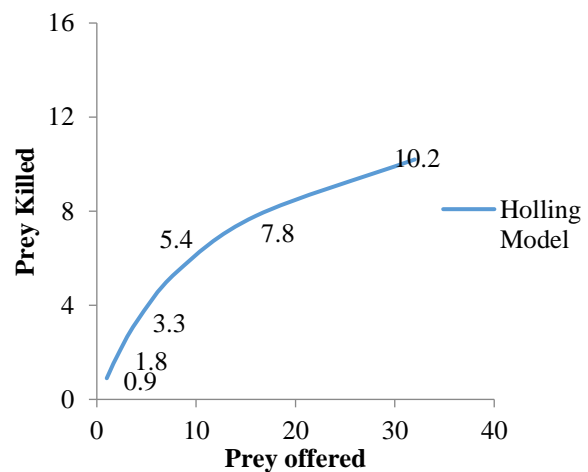


Fig 1.5: Number of *S. frugiperda* (2nd Instar) killed by *C. septempunctata* (Adult)

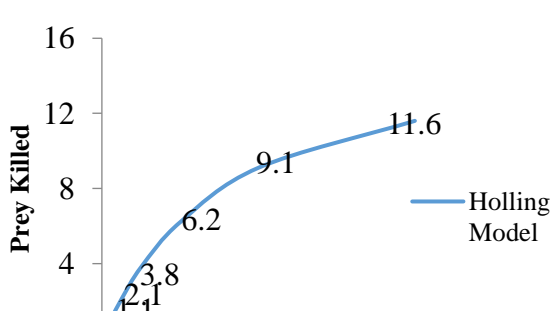


Fig 1.4: Number of *S. frugiperda* (1st Instar) killed by *C. septempunctata* (Adult)

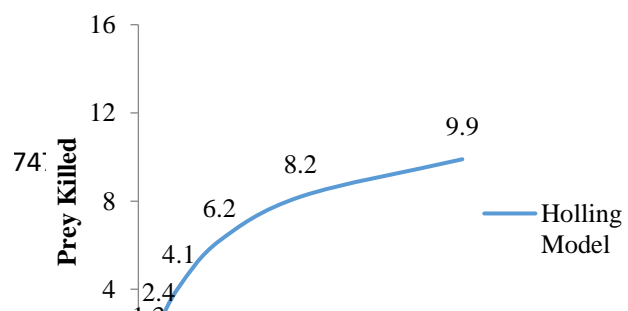


Fig 1.5: Number of *S. frugiperda* (2nd Instar) killed by *C. septempunctata* (Adult)

Fig1.6: Number of *S. frugiperda* (1st Instar) killed by *C. septempunctata* (4th Instar)

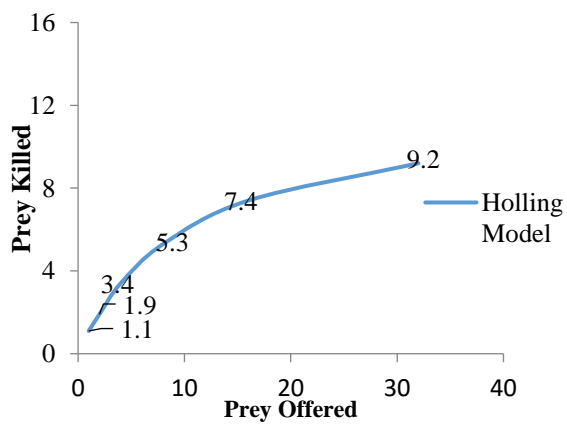


Fig 1.7: Number of *S. frugiperda* (2nd Instar) killed by *C. septempunctata* (4th Instar)

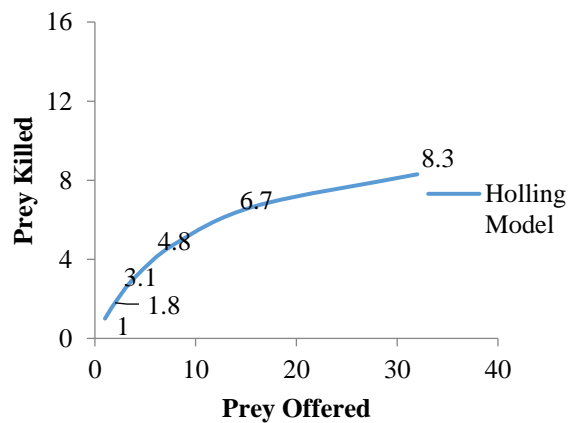


Fig 1.8: Number of *S. frugiperda* (1st Instar) killed by *C. septempunctata* (3rd Instar)

Fig 1.9: Number of *S. frugiperda* (2nd Instar) killed by *C. septempunctata* (3rd Instar)

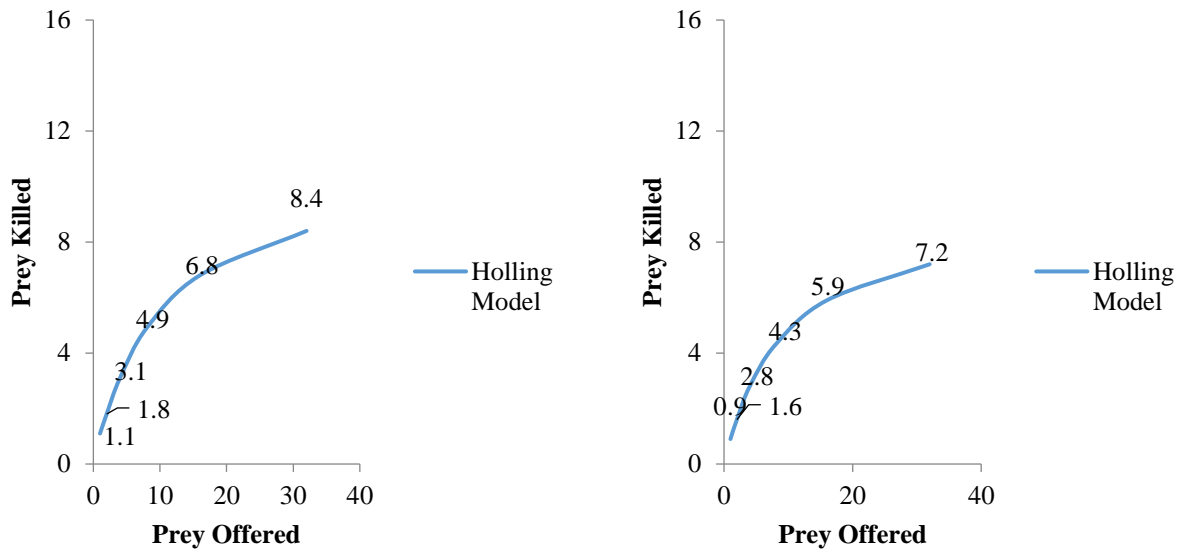


Fig 1.10: Number of *S. frugiperda* (1st Instar) killed by *C. carnea* (3rd Instar)

Fig 1.11: Number of *S. frugiperda* (2nd Instar) killed by *C. carnea* (3rd Instar)

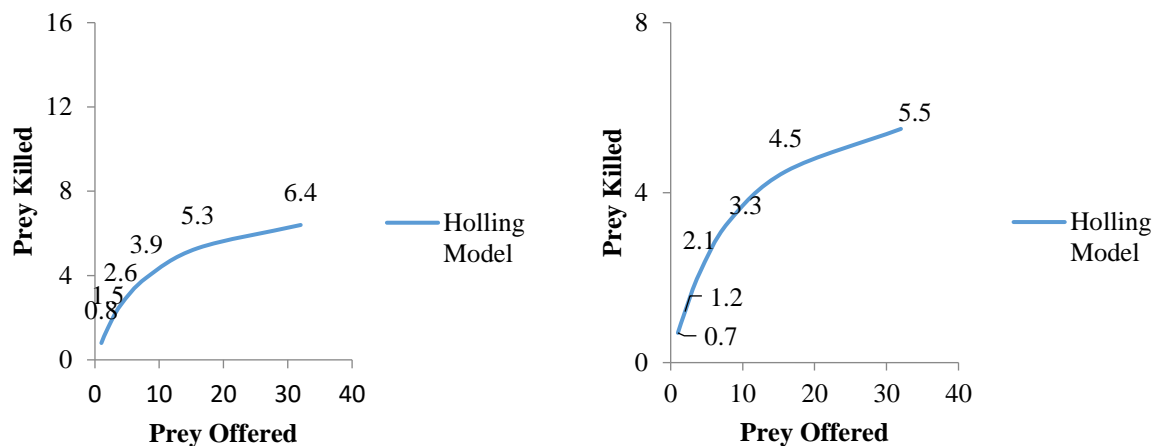


Fig 1.12: Number of *S. frugiperda* (1st Instar) killed by *C. carnea* (2nd Instar)

Fig 1.13: Number of *S. frugiperda* (2nd Instar) killed by *C. carnea* (2nd Instar)

Fig 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.12 and 1.13 describe the functional response of *C. septempunctata* adult, 3rd and 4th instar and *C. carnea* (2nd and 3rd instar) against 1st and 2nd instar of *S. frugiperda*. Values on X-axis showed *S. frugiperda* individuals offered to *C. septempunctata* and *C. carnea* by fitting a Holling's disc equation. Y- axis values showed average killed quantity of *S. frugiperda* by *C. septempunctata* and *C. carnea* circles showed the consumption of *S. frugiperda* by *C. septempunctata* and *C. carnea* average killed. Each individual of *C. septempunctata* and *C. carnea* (predator) was offered by prey 1st and 2nd instar of *S. frugiperda* (1,2,4,16 and 32 individuals).

2.4. Discussion

C. septempunctata is an important predatory natural enemy and is distributed in Asia, Europe and northern Africa. Because of its wide distribution, long survival time, strong

adaptability, large occurrence and high egg-laying capacity, it has been widely used in global biological control research, received widespread attention (Wang *et al.*,2014, Wu ,2016, Bouvet *et al.*,2019). This experiment studied the predation potential of the seven-spotted ladybird on young larvae (first and second instar) of *S. frugiperda*, which is of great significance for giving full play to the predation ability of the seven-spotted ladybird and preventing and controlling the major invasive pest *S. frugiperda* (Canas *et al.*,2013). The experimental results show that the predation model of *C. septempunctata* feeding on the young larvae of *S. frugiperda* is consistent with Holling Model II, which is related to *C. septempunctata* feeding on cabbage aphids *Brevicoryne brassicae*, radish aphid: *Lipaphis erysimi*, tobacco aphid: *Myzus persicae*, tea aphid :*Toxoptera aurantii*, rose tube aphid :*Macrosiphum rosirvorum*, wheat aphid: *Sitobion avenae* Fabricius, soybean aphid : *Aphis glycines*, pea aphid : *Acyrtosiphon pisum*, alfalfa spotted aphid *Therioaphis trifolii* and other insects such as wolfberry psyllid : *Poratrioza sinica*, Creepy bearded shield scale : *Kuwanaspis vermiformis*, stink bug *Stephanitis anagustata*. Predatory functional response models of nymphs are consistent (Ren *et al.*,2014, Zang *et al.*, 2019, Ren *et al.*,2015, Liu *et al.*,2009). Data shows that attack rate (a) was of *C. septempunctata* (adult) (1.34 ± 0.14) day¹ and handling time (T) was (0.0496 ± 0.0042) , *C. septempunctata* (4th instar larva) shows attack rate (1.2637 ± 0.2262) day⁻¹ and handling time (0.061 ± 0.01), *C. septempunctata* (3rd instar larva) shows attack rate (1.1949 ± 0.1464) day⁻¹ and handling time (0.082 ± 0.01) against *S. frugiperda* (1st instar) and attack rate (a) was of *C. septempunctata* (adult) (1.07 ± 0.06) day¹ and handling time (T) was (0.07 ± 0.003) , *C. septempunctata* (4th instar larva) showed attack rate (1.56 ± 0.29) day⁻¹ and handling time (0.0805 ± 0.0084), *C. septempunctata* (3rd instar larva) shows attack rate (1.11 ± 0.12) day⁻¹ and handling time (0.09 ± 0.01) against *S. frugiperda* (2nd instar) (Kong *et al.*, 2019) Studies on the preying of *S. frugiperda* by *A. heterochromia* and *A. heterochromia* have similar results. Predatory natural enemies include ladybugs, ladybugs, and lacewings against *S. frugiperda*. The maximum daily prey intake of *C. septempunctata* (Adult, 4th and 3rd instar larvae) is 1.34, 1.26, 1.19 head, on 1st instar of *S. frugiperda* respectively while the prey intake of *C. septempunctata* (Adult, 4th and 3rd instar larvae) is 1.106, 1.55, 1.10 head, on 2nd instar of *S. frugiperda* respectively indicating that the seven-spotted ladybug is also a predatory natural enemy with great advantages in controlling *S. frugiperda* (Wang *et al.*,2013, Wu *et al.*,2012). The entire feeding process of *C. septempunctata*; After all instar larvae have finished feeding, they will continue to search for the next prey to attack, while the polychromatic ladybirds and heterochromatic ladybirds will only

attack *S. frugiperda* in the early stages of feeding. (Kenis *et al.*,2022). All instar larvae have finished feeding, while later stages focus on attacking and only feed on part of the larvae's body. Therefore, at the same time, *Coccinella heterochromia* and *Coccinella heterochromia* will kill more *S. frugiperda* larvae, which is similar to the effect of *C. septempunctata* on *S. frugiperda*.(Ye, 2012,Liu *et al.*,2006). Thus, it may be stated *C. septempunctata* showed a type II functional response that varied quantitatively according on the stage at which it was fed an adult of *C. septempunctata*. There was a high search rate and a low time of handling from the 4th larval instar and 3rd larval instar and recorded high on the first larval instar of *S. frugiperda* than 2nd instar hence the adult has higher potential in the *S. frugiperda* management larval infestation. To evaluate this predator's effectiveness in its natural environment, more field research is necessary (Shukla *et al.*,1990, Youn *et al.*,2023, Hamid *et al.*,2021, Srivastava *et al.*,2003). The functional response of *C. carnea* against *S. frugiperda* by lacewings is significantly different between different prey densities. Lacewings (2nd and 3rd instar) feed on *S. frugiperda* 1st and 2nd instar larvae and at that time, their food intake increases significantly with the increase in prey density. In the selection of conventional biological control natural enemies, the effect of increased density on the capacity for consumption of natural enemy insects is the prerequisite for assessing outstanding natural enemy insects (Tang *et al.*, 2017). In the existing reports, when Dacauling feeds on whitefly, *Myzus persicae* Sulver, oleander aphid, *Megalothrips usitatus* Bagnall and *Aphis craccisora* Koch B, its food targets are objects of different ages. (Zhao *et al.*, 2008; Liu *et al.* 2011; Wang *et al.*, 2016;). All three instars identified in *C. carnea* resembled those observed for this predator that was fed with *Bemisia tabaci* (Gennadius, 1889) (Hemiptera: It was found Second instar nymphs in *Myzus persicae* (Sulzer, 1776) (Hemiptera: Aphididae) (Barbosa *et al.*, 2008). and *Aleyrodidae* (Silva *et al.*, 2004). Three instar stages have also been observed in other lacewings, including *Ceraeochrysa cubana* (Wade *et al.*, 2004) *Dichochrysa prasina* fed with *A. gossypii* and *Chrysopidae* fed with *A. kuehniella*, *Ephestia kuehniella* (Alcantra *et al.*, 2008). This suggests that just emerged larvae of *S. frugiperda* are sufficient to support *C. carnea* because if *S. frugiperda* offers unsuitable prey or if environmental conditions are unfavourable, either the number of instars may increase or decrease (Symondson *et al.*, 2005;Mushtaq *et al.*, 2010a).This study found that 2nd and 3rd instar larvae of the *C. carnea* feeding on *S. frugiperda* first and second larval instars fit the Holling type II functional response model, and there was no significant difference between the theoretically calculated food intake and the actual food intake at each density in the experiment. Therefore, the

feeding of *S. frugiperda* by lacewings gradually increases with the increase of prey density, and the feeding amount reaches saturation state at high density (Sokame *et al.*,2023, Kong *et al.*,2019). The parameters of the functional response model obtained after fitting show that the instantaneous attack rates between 2nd and 3rd instar lacewings feeding on *S. frugiperda* larvae feeding on *S. frugiperda* larvae are very close. Double the size of an armyworm larvae. The disposal time of adult lacewings feeding on 2nd instar larvae of *S. frugiperda* larvae is also longer than that of feeding 1st instar of *S. frugiperda*. This difference may be related to the different nutritional requirements of different stages of lacewings. In the adult stage, Dacauling needs to reduce consumption caused by search attacks and other activities to prepare for egg laying and reproduction (Adjaoke *et al.*,2023). In the larval stage, lacewings need to supplement a large amount of energy to complete their development, so they show a stronger desire to attack larger prey larvae. The results show that adult lacewings are suitable for release when the grassland contains night city harmful insects and the density of offspring eggs of field pests is high; while lacewing larvae can be released to target the damage of *S. frugiperda* larvae, which is the best way to prevent and control *S. frugiperda* (Wu ,2012, Wu ,2016). According to the results of this study. The maximum daily prey consumption of 2nd instar lacewings on *S. frugiperda* 1st and 2nd instar larvae, *C. carnea* (3rd instar larva) shows attack rate $(1.1136 \pm 0.1224) \text{ day}^{-1}$ and handling time (0.0902 ± 0.0063) , *C. carnea* (2nd instar larva) shows attack rate $(0.9623 \pm 0.1071) \text{ day}^{-1}$ and handling time (0.1230 ± 0.0080) against *S. frugiperda* (1st instar) was of *C. carnea* (3rd instar larva) shows attack rate $(1.0240 \pm 0.0853) \text{ day}^{-1}$ and handling time (0.1075 ± 0.0054) , *C. carnea* (2nd instar larva) shows attack rate $(0.7909 \pm 0.0998) \text{ day}^{-1}$ and handling time (0.1420 ± 0.0108) against *S. frugiperda* (2nd instar). According to field observations by the research team, large lacewings can be seen preying on *S. frugiperda* in Yunnan corn fields. It can be seen that the giant lacewing has great potential in controlling *S. frugiperda* (Papanikolaou *et al.*,2014)

However, due to the low population density of naturally occurring lacewing in the field, it is impossible to form an effective pest control model in the short term. The next step can be to study the use of a model that combines protection and utilization with field release to explore whether it is possible to use less or even no chemical pesticides. Under certain circumstances, large lacewings are used to control *S. frugiperda* on corn.

The same duration spent by the stages of the larva of *C. carnea* feeding on just emerged *S. frugiperda* instar larvae was the same spent by predators of Neuroptera that feed on this and other prey (Pappas et al., 2013, Souza et al., 2008). The remaining *C. carnea* that was fed with one to two-day old *S. frugiperda* larvae died, which could mean that this specific predator was unable to capture larger larvae. They also noted that the first or second instar *S. frugiperda* larvae did not attack *C. carnea* significantly and the body exterior became rigid as the larva developed. Reduced prey availability and increased handling have been seen in previous studies to negatively affect the fitness of *C. carnea* pupae (Kong Lin, 2019, Tavares et al., 2013). Continuous release of *S. frugiperda* in the same site may increase prospects for the development of this predator. The third instar *C. carnea* larvae gave lower survival and the larval and pupal stages were more prolonged in federation with the just emerged *S. frugiperda* larvae, Daily container modifications, and restricted prey demonstrate that manipulation and limited prey are not the best conditions for this predator (Tavares et al., 2013). In this stage, first instar *C. carnea* larvae were able to penetrate the egg-shell of *S. frugiperda* but this prey species was not suitable for larval development (Chan et al., 2017). This has been noted earlier in this predator fed with *S. frugiperda* (Tavares et al., 2013). Similarly, the predatory ladybeetle's development was hampered *Stethorus punctillum* (Coleoptera: The ladybird Coccinellidae preying on *Tetranychus urticae* (Acari: Tetranychidae) and green lacewing *D. prasina* feeding on *A. nerii* (Pappas et al., 2013). From these findings it can be inferred that *C. carnea* may be less likely to survive within the corn crop in the first instances of *S. frugiperda* invasion particularly in the eggs and the adult form of the pest (Chan et al., 2017). Therefore, research on the relationship between these insects, particularly in the natural setup especially in the field, should be done. This was due to the increase in the growth of the Chrysopidae and the increase in its food requirement which resulted in the consumption of a higher number of *A. kuehniella* eggs in their early and late stages of development. Additionally, this was noted for *Casana viridula* *C. carnea* fed with *Bemisia tabaci* biotype B, *Myzus persicae*, *Aleyrodes kuehniella*, or *S. frugiperda* (Barbosa et al., 2008). As was noted for *Podisus nigrispinus*, prey density can also affect consumption (Campos et al., 2014). Some predators that feed on *S. frugiperda* larvae are Pentatomidae (Zanuncio et al., 2008). Food intake leads to an increased body size in females about the size and mass of prey, thus being linked to greater reproductive rates (Zanuncio et al., 2008). *C. sanguinea* serves as an example; when fed *T. citricida* instead of *Aphis spiraecola*, (Called the green peach aphid of Aphididae) it becomes more prolific and heavier

(Mushtaq *et al.*, 2010a). This is significant because an insect's body weight indicates how much nutrition it has stored, which affects the insect's ability to reproduce, disperse, fly, and reproduce (Barros *et al.*, 2018). Although there is a stronger consumption of *A. kuehniella* eggs by *C. carnea*, this could be as a result of the smaller and lighter Chrysopidae that requires the large number of insects to Overall, 40 *A. kuehniella* eggs had a weight of 1.56 mg which was significantly lighter than the weight of 40 newly laid eggs (2.03 mg), 40 one day old eggs (2.60 mg), 40 just emerged (1.93 mg), 40 containing the age of one day (5.06 mg) or containing age of two days (5.70 mg) This was seen for *C. carnea* and *C. cubana* that were fed with eggs of Pyralidae (Souza *et al.*, 2008). However, it was observed that *D. prasina* consumed more *A. kuehniella* eggs as compared to Toxoptera sp. (Hemiptera: Both Aphididae eggs and or Pinnaspis sp. indicates that this prey is right for this predator (Pappas *et al.*, 2013). Moreover, the similar prey consumption (number of eggs or larvae) of *Diatraea saccharalis* (Lepidoptera: A study done by Pappas *et al.* (2013) where *Ceraeochrysa cincta* (Neuroptera: Chrysopidae) larvae preyed on *Sitotroga cerealella* (Lepidoptera: Gelechiidae) and *Acyrtosiphon kuehniella*, it can then be Thus, it can be concluded that recently deposited eggs *S. frugiperda* eggs that are one day old or recently hatched larvae can be utilized as diet for *C. carnea*, however the growth of this predator was better when it was offered with *A. kuehniella* eggs, thereby suggesting that the latter might be more suitable for large scale rearing (Aguirre and Gonzalez, 2017).

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