Biology and Feeding Potential of Green Lacewing

Adane Tesfaye[1] and R.D. Gautam[2]
[1]Sirinka Agricultural Research Center,
P. O.Box 74, Woldia, Ethiopia
[2]Division of Entomology
Indian Agricultural Research Institute, New Delhi - 110012, India

Abstract

Laboratory studies were conducted on consumption of three prey species by the larvae of the green lacewing, *Chrysoperla carnea*. The feeding potential of first instar larva of *C. carnea* was in decreasing order of *Aphis craccivora, Drosophila melanogaster* and *Corcyra cephalonica.* The total number of prey species consumed by second and third instars of *C. carnea* larvae were in the order of *A. craccivora* > *C. cephalonica* > *D. melanogaster* and *C. cephalonica* > *A. craccivora* > *D. melanogaster*, respectively. Larval and cocoon periods of *C. carnea* were significantly affected due to difference in prey species. The total developmental periods of *C. carnea* (egg to adult) fed on different prey species ranged from 18.40 days (on *C. cephalonica*) to 21.35 days (on *A. craccivora).* The survival of *C. carnea* larvae fed on *A. craccivora, D. melanogaster* and *C. cephalonica* were 51.85, 80.95 and 86.67 per cent, respectively, whereas, cocoon weight increase were 11, 22 and 8 mg, respectively. *C. carnea* adult laid a maximum of 1079 eggs/ female when reared on *C. cephalonica* followed by *D. melanogaster* (582) eggs/female and *A. craccivora* (173 eggs/female). Oviposition period and oviposition per day were also significantly affected by the three prey species, while pre-oviposition and post-oviposition periods, hatchability and sex-ratio were not significantly affected. Based on these studies, *C. cephalonica* and *D. melanogaster* appear to be promising for mass production of the predator, *C. carnea.*

Introduction

The common green lacewing, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae), has long been considered an important natural predator, which can be also used in augmentation biocontrol. Kaitazov & Kharizanov (1976) indicated that *C. carnea* larva attacks about 80 species of insects and 12 species of tetranychid mites. The adults of *C. carnea* are not predatory and can be easily cultured on relatively simple diets (Nordlund & Morrison 1992). The important characteristics of this species include its wide geographical distribution and host range, broad habitats, resistance to certain pesticides and voracious feeding capacity. Further, from a commercial point of view, *C. carnea* is an ideal biological control agent because it can be effective against such a wide variety of pests in many different cropping systems.

In India, *C. carnea* is mass-reared on the eggs of rice moth, *Corcyra cephalonica* (Stainton) (Gautam 1994). The present studies were taken up to compare the biology and feeding potential of *C. carnea* reared on rice moth prey as well as on other alternative species (aphids, drossophilids) in order to contribute towards efficient and economical mass production technology for the predator.

Materials and Methods

The feeding potential of *C. carnea* larval instars was studied in the laboratory. Daily and total consumption of each predator was studied by providing known number of the above mentioned prey species to the larva of the same age, kept in individual vials. This experiment had five replications and the number of *Aphis craccivora*, *Drosophila melanogaster* maggots and *Corcyra cephalonica* eggs consumed per day were recorded. The different instars of *C. carnea* were provided with live maggots of *D. melanogaster*, adults & nymphs of *A. craccivora* and frozen eggs of *C. cephalonica*. The experiment was conducted under natural photoperiod at 27$\pm$2°C temperature and 60 $\pm$ 10 % R.H. The hosts *C. cephalonica and A. craccivora* were cultured on broken sorghum grains and cowpea sprout/ seedlings as suggested by Gautam (1994), while *D. melanogaster* larvae were reared on a semi-synthetic powder diet as well as ripe banana.

Emerged adults were kept in rearing jars (4cm x 7.5cm) and provided with 50% honey solution, castor pollen and baker's yeast granules. The time after emergence of adult and start of oviposition was considered as pre-ovipositional period (days). The number of eggs laid by individual female on black muslin cloth and the inner sides of the rearing jar was recorded every day. The period of egg laying was considered for oviposition period (days). Post-oviposition period (days) was recorded as the period between the day the female ceased egg laying up to the day of death. To study hatchability, 50 eggs in five replications were used for each prey species. The number of eggs laid by each female was recorded every day to determine fecundity (eggs per female) while weekly egg laying was used to determine the productive age.

The data collected on the feeding potential, larval and pupal period, fecundity and other parameters were subjected to analysis of variance, and treatment means were compared using Duncan's Multiple Range Test (Gomez & Gomez 1984) with the help of MSTAT-C.

Results

Feeding potential and larval survival

The total number of prey species consumed by the first instar larva was in a decreasing order of *A. craccivora, D. melanogaster* and *C. cephalonica,* while the order was *A. craccivora*, *C. cephalonica*, *D. melanogaster* for the second and *C. cephalonica*, *A. craccivora*, *D. melanogaster* for the third instars larvae (Table 1). Further analysis revealed that, the third instar larva consumed significantly more number of preys than the first and second instar. The predator consumed more number of *C. cephalonica* eggs followed by *A. craccivora* (Table 1). Average per day prey consumption by first instar larva was in the order of *A. craccivora* > *C. cephalonica* > *D. melanogaster*, whereas in case of second and third instar as *C. cephalonica* > *A. craccivora* > *D. melanogaster*. Further analysis revealed that the third instar larva consumed significantly ($p \leq 0.05$) higher number of *A. craccivora* than the first and second instars (Table 2). On *D. melanogaster*, the second instar larva consumed significantly higher number of prey than the first instar larva and on *C. cephalonica* all the instars were significantly different and the late instars consumed more number of prey (Table 2). The per day consumption pattern of *C. carnea* larva varied from prey to prey depending on the larval age (Fig. 1).

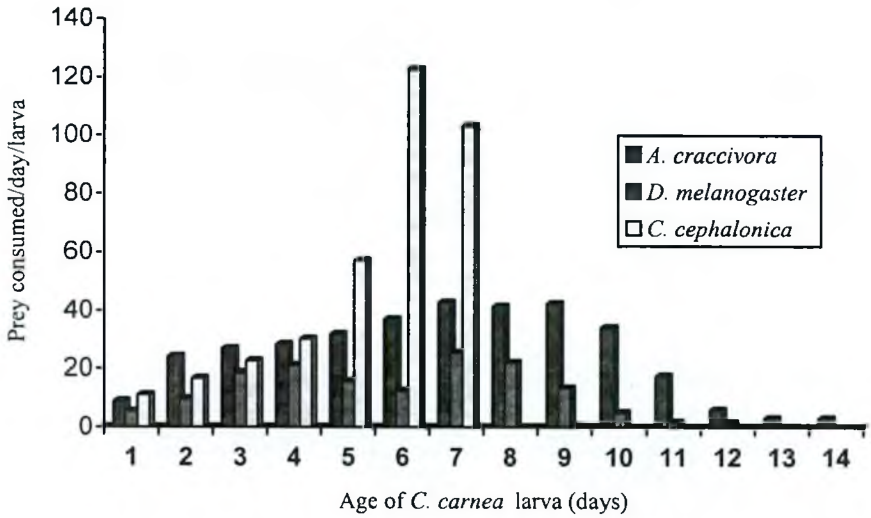

Figure 1. Feeding pattern of *C. carnea* larva on *A. craccivora, D. melanogastor and C. cephalonica* in the laboratory.

The highest survival (86.67%) was observed when the predator was reared on *C. cephalonica* followed by on *D. melanogaster* (80.95%) while the lowest was (51.85%) on *A. craccivora*.

Developmental period of different growth stages

The incubation period of eggs laid by progeny of *C. carnea* was 3.7, 3.5 and 3.4 days when reared on *A. craccivora*, *D. melanogaster* and *C. cephalonica,* respectively (Table 3).

Mean first instar larval duration was 2.3, 3.2 and 2.2 days on *A. craccivora, D. melanogaster* and *C. cephalonica,* respectively. In the case of second instar larva, the durations was 3.4, 2.8 and 2.0 days on *A. craccivora, D. melanogaster* and *C. cephalonica,* respectively (Table 3). Average *third* instar larva duration was prolonged up to 4.1, 3.8 and 3.4 days on *A. craccivora, D. melanogaster* and *C. cephalonica,* respectively. The total larval period was similar for *A. craccivora* and *D. melanogaster* (9.9 days) and shorter on *C. cephalonica* (6.9 days) (Table 3). The cocoon took 7.8, 6.4 and 8.1days on *A. craccivora, D. melanogaster* and *C. cephalonica,* respectively (Table 3). A single *C. carnea* cocoon on the average weighed 11, 22 and 8 milligram on *A. craccivora, D. melanogaster* and *C. cephalonica*, respectively.

Adult male longevity was 23.8 days on *A. craccivora*, 37.8 on *D. melanogaster* and 43.2 on *C. cephalonica.* Longevity of adult females was 32.0 days on *A. craccivora*, 51.4 days on *D. melanogaster* and 55.8 days on *C. cephalonica* days (Table 3). In general, irrespective of prey species, adult females of *C. carnea* survived longer than males.

Table 1. Total number of prey consumption of *C. carnea* in the laboratory.

C. carnea (Instar)	Prey species		
	A. craccivora (Adult/ nymphs)	*D. melanogastor* (Maggot)	*C. cephalonica* (Egg)
1st	38.24c	36.52b	36.28c
2nd	92.21b	47.50b	86.78b
3rd	220.27a	63.25a	227.37a
LSD value.	61.60	8.54	37.55
SE +	0.344	0.092	0.227

SE = Standard error of the mean
LSD value = Least Significant difference ((P≤ 0.05).
The values followed by same letter in columns are not significantly different according to DMRT at (P≤ 0.05).

Table 2. Average per day consumption of *C. carnea* larval instars in the laboratory.

C. carnea (instar)	Average no. of prey consumed per day		
	A. craccivora (adult/ nymphs)	*D. melanogaster* (maggot)	*C. cephalonica* (eggs)
1st	16.28b	11.24b	16.23c
2nd	27.12 b	16.55a	42.32b
3rd	53.43a	15.60ab	67.04a
LSD Value	17.89	3.64	11.58
SE	2.687	0.547	1.739

SE = Standard error of mean LSD = Least Significant Difference (P≤ 0.05).
The values followed by same letter in columns are not significantly different according to DMRT at (P≤ 0.05).

Reproductive attributes

The average pre-oviposition period of *C. carnea* when fed on *A. craccivora, D. melanogaster* and *C. cephalonica* was 5.1, 4.2 and 5.4 days, respectively, whereas the respective average oviposition periods were 18.8, 30.8 and 40.6 days. The average post-oviposition period was 9.0, 18.4 and 10.6 days when reared on *A. craccivora, D. melanogaster* and *C. cephalonica* respectively. However, the percent hatchability of *C. carnea* eggs among the three treatments ranged between 75.2 to 80.9%. Equal sex ratio of the predator was observed when it fed on *D. melanogaster* while the ratio (Male to female) of newly emerged adults was 0.63, and 0.67 on *A. craccivora* and *C. cephalonica,* respectively (Table 4).

Table 3. Influence of different hosts on developmental and fitness attributes of *C. carnea.*

Studied attributes	Response to prey species			LSD	SE
	A. caraccivora	*D. melanogaster*	*C. cephalonica*		
Incubation period	3.70a	3.52a	3.40a	0.780	0.117
Instars period					
I instar	2.33b	3.25a	2.25b	0.563	0.084
II instar	3.43a	2.87a	2.05b	0.561	0.084
III instar	4.15	3.82	3.34	1.995	0.299
Larval period	9.85a	9.93a	6.88b	1.285	0.193
Cocoon period	7.80a	6.43b	8.12a	0.933	0.140
Egg to adult	21.35a	19.88b	18.40c	0.892	0.134
Longevity of adult					
Male	23.8	37.8	43.2	2.408	0.250
Female	32.0b	51.4ab	55.8a	1.473	0.153

SE = Standard error mean
LSD value = Least Significant difference (P≤ 0.05).
The values followed by same letter in columns are not significantly different according to DMRT at (P≤ 0.05).

Table 4. Influence of different hosts on the reproductive attributes of *C. carnea*.

Studied attributes	*A. craccivora*	*D. melanogaster*	*C. cephalonica*	LSD	SE
Pre- oviposition period (Days)	5.1	4.2	5.4	0.793	0.060
Oviposition period (Days)	18.8[c]	30.8[b]	40.6[a]	2.574	0.267
Oviposition/ day/female	9.12[c]	18.30[b]	26.16[a]	1.630	0.169
Post-oviposition period (Days)	9.0	18.4	10.6	2.380	0.247
Hatchability (%)	80.89	75.22	75.51	15.16	2.278
Sex-ratio (M/F)	0.63	1.03	0.67	0.447	0.046
Fecundity (eggs/female)	172.8[b]	582.0[ab]	1079.0[a]	15.04	1.563

SE = Standard error of mean
LSD value = least significant difference ($P \leq 0.05$).
Values in rows followed by same letter are not significantly different according to DMRT at ($P \leq 0.05$).

Fecundity

The mean fecundity of *C. carnea* was higher (1079) on *C. cephalonica* compared to *D. melanogaster* (582) and *A. craccivora* (173). The average oviposition /female for the progeny were 9.1, 18.3 and 26.2 eggs when reared on *A. craccivora*, *D. melanogaster* and *C. cephalonica*, respectively (Table 4).

The fecundity of *C. carnea* differed with the prey species consumed in addition to the age of the predator (Fig. 2). The egg productivity peaked at the age of 2 for *A. craccivora* and *D. melanogaster* 3 weeks *C. cephalonica* and decreased on later ages of the adult.

The fecundity of adult female developed on *C. cephalonica* was significantly higher than *A. craccivora* through out their life span except the first week (Table 4). From these data, it is evident that, *C. cephlonica* was the best prey for *C. carnea* followed by *D. melanogaster* and *A. craccivora.*

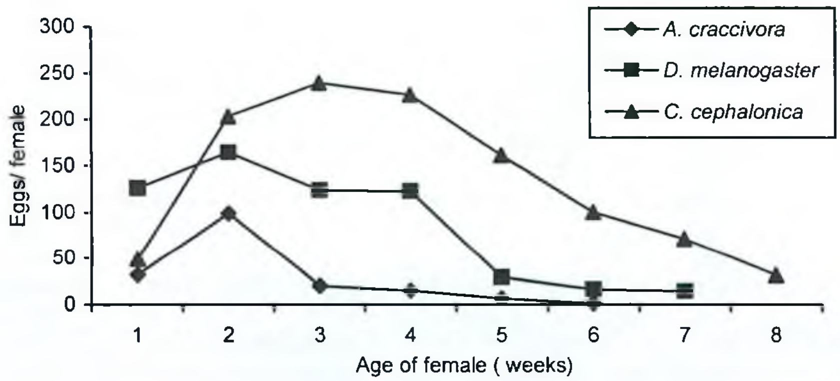

Figure 2. Effect of prey and female age on fecundity of *C. carnea* .

Discussion

The studies on prey species revealed that larval mortality was least when reared on *C. cephalonica,* follwed by *D. melanogaster* whereas it was maximum in the case of *A. craccivora.* Similarly, Pawor (1982) observed higher mortality when reared on Sorghum aphids (*M. sacchari*), Cotton aphid (*Aphis gossypii*), and on eggs of Achaea, Pyrilla and Spodoptera as compared with storage pests. Osman & Selman (1996) have also indicated that the juvenile mortality of *C. carnea* larvae reared on different prey species was in decreasing order of Tribolium, *Pieris brassicae* larvae, *D. melanogaster, Aphis fabae, Myzus persicae, Pieris brassicae* eggs, and *Acyrthosiphon pisum.*

The rate of consumption by *C. carnea* varies from prey to prey. The feeding rate based on the total consumption and the duration of the three larval instars on *C. cephalonica* and *A. craccivora* were comparable. This result was in agreement with the results of Thite and Shivpuje (1999) who reported *C. carnea* larvae consumption on *C. cephalonica* and *A. gossypii*. A single larva of *C. carnea* on the average consumed 357.9 *A. craccivora* nymphs and adults, 147.3 *D. melanogaster* larvae and 358.3 *C. cephalonica eggs* in the course of its development. The feeding potential of a single *C. carnea* larva on *M. persicae* ranged from 600 to 950 nymphs and adults (Kharizanov & Dimitrov 1972), about 487.2 aphids or 510.8 pupae of white flies (Afzal & Khan 1978) and about 160 to 200 eggs of *H. armigera* (Bar et al. 1979). Recently, Karuppuchamy et al. (1998) reported 423 nymphs or 216 adults of aphids as feeding capacity of *C. carnea* during the entire larval period. Bakthavatsalam et al. (1995) estimated 3.5ml eggs of *C. cephalonica* to be the optimum number of eggs required for mass rearing of 100 *C. carnea* larvae.

The developmental period of the different growth stages of *C. carnea* varied with the prey the larva fed on. The duration of third instar was longest (4.2 days) after consuming 220.3 nymphs and adults of *A. craccivora* and second instar was the shortest (2.1 days) after consuming 86.8 eggs of *C. cephalonica.* In general, results of the developmental periods of eggs, larvae, pupa and adult (M/F) of *C. carnea* after feeding on preys are in agreement with the study of Rahaman (1940) on the life history of *C. carnea*, which recorded developmental periods of 2–5 days for egg, 6–17 for larva and 5–13 for pupa stage. Similarly, Osman & Selman (1996) studied *C. carnea* larvae instars, cocoon developmental periods when fed on *A. pisum*, *P. brassicae* eggs and larvae, *M. persicae*, *A. fabae*, *D. melanogaster* and Tribolium, and concluded that the developmental period is very much influenced with prey species consumed. Mannan et al. (1997) reported the duration of first, second and third instars larvae as 2.6, 2.3 and 2.4 on *A. Gossypii* and 3.8, 2.8 and 3.4 days when reared on *M. persicae*. The pupal period was 9.4 and 11.4 days on *A. gossypii* and *M. persicae*, respectively. In addition, the study showed that the females lived longer (35.7 and 38.8 days) than males (32.2 and 35.8 days) on these two respective hosts. The current study also showed that females lived longer than males for all the prey species the predator preyed.

There was no difference in preoviposition when *C. carnea* fed on different prey species. However, *C. carnea* females had significantly longer oviposition periods when larvae were reared on *C. cephalonica* while the shortest oviposition period was recorded for those larvae reared on *A. craccivora.* There is evidence that the sex ratio of *Chrysopa* spp. can be influenced by the larval food. Pawor (1982) reported the sex ratio (M/F) of *Chrysopa seceletes* as 2:1 when fed on eggs of Spodoptera and Achaea, while

1:2 when fed on of Pyrilla and sorghum aphid *(M. sacchari)*. In the current study there were more females from larvae reared on *A. craccivora* and *C. cephalonica.*

The mean hatchability ranged from 75.2% to 80.9% and was lower than results obtained from other studies. Gautam (1994) reported that the mean hatchability of Anand, Coimbatore, Banglore and Delhi stocks of *C. carnea* as 91.1, 91.10, 97.0 and 100 %, respectively. Also, Saminathan et al. (1999) documented hatchability of *C. carnea* eggs were more than 80% when reared on *A. craccivora* and eggs of *C. cephalonica* and *E. Vitella.*

A female *C. carnea* laid on average 9.1, 18.3 and 26.2 eggs per day when reared on *A. craccivora, D. melanogaster* and *C. cephalonica,* respectively and the respective total mean fecundity was 172.8, 582.0 and 1079.0 eggs. The fecundity of the insect has been reported variedly. Singh (1995) documented high mean fecundity of *C. carnea* ranging from 600 to 800 eggs/female, which agrees with the observation of Srinivasan & Babu (2000) who recorded a mean fecundity of 874.7eggs/female, when larva was fed on *C. cephalonica.* On the other hand, Mannan et al. (1997) reported mean fecundity of *C. carnea* as 84.7 and 103 eggs/female when larvae were reared on *A. gossypii* and *M. persicae,* respectively. Saminathan et al. (1999) also recorded mean fecundity of 271.2, 266.8 and 262.4 eggs/ female from larvae feeding on *A. gossypii* (okra), *A. gossypii* (guava) and A. *gossypii* (cotton), respectively.

However, productivity of *C. Carnea* female reared on *C. cephalonica* is high when reared on either *D. melanogaster* or *A. craccivora.* When the insect was reared on *C. cephalonica* the productivity age of female peaked at the third week; while on *D. melanogaster* and *A. craccivora* the peak period was the second week. It was observed that female reared on *C. cephalonica* had prolonged productivity age.

When considering the over all efficiency in mass production of *C. carnea, C cephalonica* is superior. However, *D. melanogaster* can also be used for mass raring as it is comparable with *C. cephalonica* with most of the fitness attributes and can result in maximum turn over.

Acknowledgements

The authors are grateful to the Ethiopian Agricultural Research Organization for giving study grant and Indian Agricultural Research Institute for providing research facilities. We also thank Dr. P Kumar, Senior Scientist, and NCIPM for his kind help in providing the nucleus culture of *C. carnea* and *C. cephalonica.*

References

Bakthavatsalam N, SP Singh, NA Pushpalatha and BS Bhummannavar. 1995. Optimum dosage of *Corcyra* eggs for mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). Journal of Insect Science **8:** 90–92.

Bar D, D Gerling and Y Rossler. 1979. Bionomics of the principal natural enemies attacking *Heliothis armigera* in cotton fields in Israeal. Journal of Environmental Entomology **8:** 468–474.

Gautam RD. 1994. Biological pest suppression. Westvill Publishing House. New Delhi. pp. 221.

Kaitazov A and A Kharizanov. 1976. The possibilities for using chrysopidae. Rastitelna-Zashchita. **24**: 22–26.

Karuppuchamy P, G Balasubramanian and PCS Babu. 1998. Seasonal incidence and management of aphid, *Aphis punicae* on pomegranate. Madras Agricultural Journal **85**: 224–226.

Kharizanov A and A Dimitrov. 1972. Some biological characterstics of *Chrysopela carnea.* Rastitaelna – Zashchita. **20:** 36–38.

Mannan VD, GC Varma and KS Brar. 1997. Biology of *Chrysoperla carnea* (Stephens) on *Aphis gossypii* Glover and *Myuzs persicae* (Sulzer). Indian Journal of Insect Science **10**: 143–145.

Nordlund DA and RK Morrison. 1992. Mass rearing of *Chrysoperla* spp. *In*: Anderson TE and Leppla NC. (eds.) Advances in insect rearing for research and pest management. Boulder, Coloradol Westview press, pp. 427–39.

Osman MZ and BJ Selman. 1996. Effect of larval diet on the performance of the predator

Chrysoperla carnea Stephens (Neuroptera: Chrysopidae). Journal of Applied Entomology **120**: 115–117.

Pawor AG. 1982. Influence of different hosts on biology and screening of some insecticides against *Chrysopa scelestes* Banks (Neuroptera: Chrysopidae): A predator. Ph. D Thesis. IARI, New Delhi. pp. 76.

Rahaman RA. 1940. Important insect predators of India. Proceedings of Indian Academy of Sciences **12**: 67– 4.

Saminathan VS, RK Muralibaskaran and NR Mahadevan. 1999. Biology and predatory potential of green lacewing (*Chrysoperla carnea*) (Neuroptera: Chrysopidae) on different insect hosts. Indian Journal of Agricultural Sciences **69**: 502–505.

Singh SP. 1995. Technology for production of natural enemies. ICAR. *Bangalore*, India. pp. 221.

Srinivasan G and PCS Babu. 2000. Effect of neem products on predatory green lacewing, Chrysoperla carnea Stephens(Chrysopidae: Neuroptera). Pesticide Research Journal **12**: 123–126.

Thite NR and PR Shivpuje. 1999. Biology, feeding potential and development of *Chrysoperla carnea* (Stephens) on *Aphis gossypii* Glover. Journal of Maharshtra Agricultural University **24**: 240–241