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Biology and Predation Potential of Green Lacewing, *Chrysoperla zastrowi sillemi* (Esben-Petersen) under Laboratory Conditions

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ABSTRACT: Biology of polyphagous predator, green lacewing (*Chrysoperla zastrowi sillemi* (Esben-Petersen)) on *Corcyra cephalonica* eggs along with its predation potential on *C. cephalonica* and *A. gossypii* was studied under laboratory conditions. Biological studies indicate that the incubation period, total larval period, pupal period, adult male and female period of *C. zastrowi sillemi* averaged at 3.00±0.06, 8.53±0.54, 8.03±0.26, 27.75±1.17 and 33.25±1.45 days, respectively. The average pre-oviposition, oviposition and post-oviposition period was reported as 4.70±0.76, 25.30±1.18 and 3.25±1.02 days respectively. All the three larval stages of *C. zastrowi sillemi* are voracious predator of insect eggs and soft bodies insects. A green lacewing grub on an average consumed 276.40±11.88 eggs of *C. cephalonica* and 349.00±21.19 nymphs and 179.80±9.32 adults of cotton aphids during its developmental period. This study explores the possibilities of ease of rearing of chrysopids for field release as well as its effectiveness in pest control.

Keywords: Biological control, Biology, predation potential, *Chrysoperla zastrowi sillemi*, *C. cephalonica.*

INTRODUCTION

Green lacewings, *Chrysoperla*sp. (Neuroptera: Chrysopidae) are widespread in agricultural ecosystem worldwide with 1300 recognized species included in about 87 genera and 3 subfamilies(Brooks and Barnard, 1990). In India, 65 Chrysopid predator species have been reported from different ecosystems belonging to 21 genera. The most common species found throughout Asia is *C. carnea* (Henry *et al.,* 2002), which is in fact a complex of cryptic, sibling species including *C. carnea*, *C. plorabunda*, *C. lucasina* and *C. nipponensis* that are reproductively isolated by their mating songs (Henry *et al.,* 2010). Across the Indian subcontinent, *Chrysoperla zastrowi sillemi* (Esben-Petersen) *stat. rev* (Henry *et al.,* 2010) is the most common and agriculturally important species of Chrysopids used to manage various sucking pests. The grubs are effective predators of insect eggs and soft bodied insects (McEwen *et al*., 2001) while the adults are free living and feed on nectar, pollen and honeydew. *C. zastrowi sillemi* is considered an effective biological control agent due to the larvae voracious feeding capacity, excellent searching ability, wide distribution, ease of mass rearing, greater adaptability in field than other predators and tolerance to a wide range of ecological factors (Tauber *et al.,* 2000; Senior and McEwen 2001; Pappas *et al.,* 2011; Porcel *et al.,* 2013). An exhaustive biological study was undertaken to access ease of rearing of biocontrol agent for mass multiplication and field release.

MATERIAL AND METHODS

The experiment was carried out in Bio-control Laboratory of College of Agriculture, CCS Haryana Agricultural University, Hisar with following materials and methods,

Stock culture. To obtain eggs of *C. cephalonica* throughout the experimental period, the culture was multiplied on large scale under laboratory conditions to have continuous supply as food to *C. zastrowi sillemi*. The culture was maintained on sorghum, bajra, maize and wheat based artificial diet. No culture of biocontrol agent, *C. zastrowi sillemi* was available with Bio-control Laboratory of College of Agriculture , Hisar; so initial stock culture was requested from Navsari Agricultural University, Gujarat and ICAR - NBAIR (National Bureau of Agricultural Insect Resources), Bangalore. This stock culture was named stock culture "A" and was raised on eggs of *C. cephalonica* until adult emergence. Upon emergence, adults were transferred to oviposition chamber wrapped with black paper sheet from inside and fed with cotton swabs dipped in drinking water, 50 per cent honey solution, and proteinex mixture. Eggs collected from stock culture "A" produced stock culture "B". The Stock Culture "B" was prepared to remove any error in experimentation caused due to heterogeneity which may be due to feeding on different prey, parasitization of field collected individuals, improper mating or any pathogen attached with the adults. Eggs, larvae, pupae

or adult for any study were used from this stock culture "B".

Biology of green lacewing, *C. zastrowi sillemi* on eggs of rice meal moth, *C. cephalonica.* A total of 300 eggs laid by ten different females, 30 from each female, were collected from stock culture "B" and observed for incubation period and hatching percentage. Thirty larvae were observed daily for number of larval instars, larval duration, percentage pupation and mortality. Fresh eggs of *C. cephalonica* were provided to growing larvae every morning. Thirty pupae, each placed in different petri-plates were observed to record the data on pupal period, per cent male and female emergence and sex ratio. A day after the emergence, adults were paired with sexually mature adults of opposite sex and kept in glass jars. The experiment was performed using ten replicates. The observation on pre-oviposition, oviposition, post-oviposition periods and adult longevity were also recorded using the same pairs of adults. The experiment was repeated for two consecutive generations at constant temperature of 27±1°C, 65±5% RH, 16:8 L:D in a B.O.D. incubator.

Statistical analysis. Biological study data for two consecutive generations of *C. zastrowi sillemi* were subjected to statistical analysis by calculating mean value, standard deviation and 't' test.

Predation potential of green lacewing, *C. zastrowi sillemi*. Observations on the rate of feeding of prey by various immature stages of *C. zastrowi sillemi* were recorded. Petri plates (size 5 cm diameter) were used for these studies. Known numbers of prey (eggs of *C. cephalonica* and nymphs and adults of *A. gossypii*) were given to each larval instar under different sets of experiments. After every 24 hours, total number of prey consumed by each larvae were counted to find out the actual predatory potential by the various larval stages of the predator. Only completely consumed prey were counted for finding the exact predatory potential of biocontrol agent.

RESULTS ANS DISCUSSION

Biology of pre-imaginal stages of green lacewing, *C. zastrowi sillemi.* The green lacewing, *C. zastrowi sillemi* freshly laid eggs were pale green, oval shaped laid individually on top of the hair like silken stalk to avoid cannibalism. Incubation period ranged from 3.00-4.00 days with an average of 3.00days; with 86.00 and 90.00 per cent egg hatchability during 1st and 2nd generations, respectively. Incubation period of *C. zastrowi sillemi* ranging from 2.80-3.40 days on different host and temperature range is reported by many authors (Kubavat *et al*., 2017; Khanzada *et al.*, 2018), giving support to present findings. *C. zastrowi sillemi* passed through three larval instars, each of campodeiform type, larval period ranging from 8.00 to 10.00 days with an average of 8.57±0.57 and 8.50±0.51 days during 1stand 2nd generation, respectively. Manjunatha *et al.* (2016) reported that *Chrysoperla* sp. passes through three larval instars with total larval period ranging from 8.00-10.00 days, all these findings lending credence to our results. The duration of 1st, 2nd and 3rd instar larvae averaged at 2.87±0.34, 2.57±0.50 and 3.13±0.43 days during 1st generation while it averaged at 2.80±0.40, 2.53±0.51 and 3.16±0.38 days during 2nd generation (Table 1). Similar results were obtained by Khan and Mushtaq (2011) while studying biology of *C. carnea* on eggs of *C. cephalonica* as they reported the duration of 1st, 2nd and 3rd instar as 2.0, 3.7 and 4.4 days, respectively with total larval period of 9.0 days. Thefull-grown3rd instar larva spun a white coloured spherical cocoon, covered with silken threads and pupated inside. The pupal period ranged from 8.00-9.00 days with an overall average of 8.07±0.25and 8.00±0.26 days during 1st and 2nd generation, respectively (Table 1). Findings analogues to these have been reported by Manjunatha *et al.* (2018); Khanzada *et al.* (2018); who reported that full grown 3rd instar larvae of *Chrysoperla* sp. turned into a spherical cocoon lasting for 8.00-10.00 days.

Table 1: Duration of different pre-imaginal stages of green lacewing, *C. zastrowi sillemi* feeding on eggs of rice meal moth, *C.cephalonica* at 27±2° C, 65±5 % RH

	1st generation	2nd generation	Pooled mean	
Insect stage	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**t-test**
Incubation period (days)	3.00 ±0.00	3.00 ±0.00	3.00 ±0.00	
Larval duration (days)				
1st larval instar	2.87±0.34	2.80±0.40	2.83±0.38	1.00**
2nd larval instar	2.57±0.50	2.53±0.51	2.55±0.50	0.57**
3rd larval instar	3.13±0.43	3.16±0.38	3.15±0.38	0.44**
Total larval period (days)	8.57±0.57	8.50±0.51	8.53±0.54	0.70**
Pupal period (days)	8.07±0.25	8.00±0.26	8.03±0.26	1.44**
Total development period (days)	19.63±0.56	19.50±0.58	19.57±0.56	1.28**

*Significant at p=0.05, ** Non-significant

Biology of adult stages of green lacewing, *C. zastrowi sillemi.* Adults typically had soft bodies, filiform antennae, appearing light green in color and possessing transparent wings. The wingspan of both males and females exceeded their body length. The sexes could be distinguished based on size and abdominal characters. In males, the abdomen was narrow and tapering, whereas in females, it was 2 to 3 times broader than in males and bulging. Their compound eyes exhibited hues of copper or gold. Sex ratio of 1:1.72 (M:F) and 1:1.66 (M:F) was reported during 1st and 2nd generation, respectively. Longevity of females varied from 30.00-35.00 days with an average of 33.57±1.33 and 32.9±1.53 days while those of males ranged from 26.00-30.00 days with an average of 27.93±1.31 and 27.57±0.94 days during 1st and 2nd generation, respectively (Table 2).

Table 2: Duration of different adult stages of green lacewing, *C. zastrowi sillemi* feeding on eggs of rice meal moth, *C. cephalonica* at 27±2°C, 65±5 % RH.

Insect stage	Mean ± SD	Mean ± SD	Mean ± SD	t-test
Sex ratio (M: F)	1:1.72	1:1.66	1:1.60	
Fecundity (number)	375.83±55.26	269.33±50.52	322.58±74.60	8.92*
Adult Longevity (days)				
Male	27.93±1.31	27.57±0.94	27.75±1.17	1.73**
Female	33.57±1.33	32.97±1.53	33.25±1.45	1.57**
(i) Pre-oviposition period	4.80±0.82	4.60±0.73	4.70±0.76	1.06**
(ii) Oviposition period	25.40±0.98	25.20±1.36	25.30±1.18	0.60**
(iii) Post-oviposition	3.37±0.97	3.17±1.07	3.25±1.02	0.74**

*Significant at p=0.05, ** Non-significant

Table 3: Egg hatchability, larval survival and adult emergence *C. zastrowi sillemi* feeding on eggs of rice mealmoth, *C. cephalonica* at 27±2° C, 65±5 % RH.

Parameters (%)	Number observed	1st generation	2nd generation	Pooled mean
Egg hatchability	300	86.00	90.00	88.00
Larval survival	30	96.66	90.00	93.33
Adult emergence	30	93.00	86.66	90.00

Pre-oviposition, oviposition and post oviposition period. The pre-oviposition, oviposition and post-oviposition period averaged at 4.80±0.82, 25.40±0.98 and 3.37±0.97 days during 1st generation; and 4.60±0.73, 25.20±1.36 and 3.17±1.07 days during 2nd generation, respectively. A single female of laid 290-455 eggs (average 375.83±55.26 eggs) during 1st generation and 190-370 eggs with an average of 269.33±50.52 eggs during 2nd generation.

Geethalakshmi *et al.* (2000) in their biological studies of *C. carnea* on eggs of *C. cephalonica* reported sex ratio of 1: 0.95 (F:M) with 80.00 per cent adult emergence and male and female longevity of 26.50 days and 39.00 days, respectively with 4.00 days female pre-oviposition period; all these findings lending credence to our results. Our results are consistent with Khanzada *et al.* (2018) who reared *C. carnea* on *C. cephalonica* and reported 76.00 per cent adult emergence with sex ratio (M:F) of 1:1.5 and adult male and female longevity of 29.00 and 39.60 days, respectively. Manjunatha *et al.* (2018) biological studies of *C. carnea* on *C. cephalonica* reported an average male and female longevity of 19.23 and 32.03 days, with an average female pre-oviposition, oviposition and post-oviposition period of 4.47, 25.06 and 4.43 days, respectively and fecundity of 343.00 eggs/female, additionally supporting our findings. On biology of *C. zastrowi sillemi*, 90.20 per cent adult emergence was reported with an average female pre-oviposition period of 4.47 days and oviposition period of 29.57 days with 371.60 fecundity/female, consistent with the findings elucidated here.

Predation potential of green lacewing, *C. zastrowi sillemi.* Only larval stages of green lacewing, *C. zastrowi sillemi* are voracious predators. 1st, 2nd and 3rd instar larvae of green lacewing, *C. zastrowi sillemi* fed on an average of 38.70±3.27, 85.60±7.70 and 152.10±11.45 eggs of *C. cephalonica*/larvae; 60.30±6.77, 108.90±12.81 and 179.80±17.04 nymphs of *A. gossypii*/larvae; and 22.30±3.56, 59.20±3.55 and 98.30±6.10 adults of *A. gossypii*/larvae, respectively. The total prey consumption by a single larva was 276.40±11.88 eggs of *C. cephalonica*, 349.00±21.19 nymphs and 179.80±9.32 adults of *A. gossypii* during its entire larval period (Table 4).

Gosalwad *et al.* (2010) reported that the 1st, 2nd and 3rd larvae instar of *C. carnea* consumed 20.0, 55.0 and 190.40 eggs of *C. cephalonica*, aligning with our findings. Aravind *et al.* (2012) give support to present findings who reported that 1st, 2nd and 3rd instar larva of *C. zastrowi sillemi* consumed 30.19, 139.82 and 196.65 eggs of *C. cephalonica.* Similar results were obtained by Naruka *et al.* (2015) whose investigations on predatory potential of *C. zastrowi arabica* on eggs and neonate larva of *C. cephalonica* and nymphs of five aphid species showed that *C. zastrowi arabica* larva highly preferred *Corcyra* eggs which consumed 298.24 eggs. While studying predation potential of *C. carnea*, Rana *et al.* (2017) reported that highest preferred host was *C. cephalonica* with average consumption of 235.12±43.32 eggs, lending credence to current findings. Khanzada *et al.* (2018) conducted an experiment on feeding potential of *C. carnea* on *A. gossypii* where a single larva consumed 309.2±8.11 individuals of aphid, consistent with the findings elucidated here. Kumar *et al.* (2019) reported that single larva of *C. carnea* consumed 277.67±4.37 individuals of *A.gossypii*, results of present investigations are in confirmatory with our findings.

Table 4: Predation potential (Mean ± SD) of different larval instar of *C. zastrowi sillemi* under laboratory conditions.

Prey host	1st instar	2nd instar	3rd instar	Total
Eggs of *C. cephalonica*	38.70±3.27	85.60±7.70	152.10±11.45	276.40±11.88
A. gossypii				
Nymphs	60.30±6.77	108.90±12.81	179.80±17.04	349.00±21.19
Adults	22.30±3.56	59.20±3.55	98.30±6.10	179.80±9.32

CONCLUSIONS

The biological studies of *Chrysoperla* species are crucial for advancing sustainable agricultural practices. Understanding their lifecycle, feeding habits, and functional responses aids in optimizing their use as biological control agents. These natural predators offer an eco-friendly alternative to chemical pesticides, effectively managing pest populations while minimizing environmental impact and preserving beneficial insects. Promoting such biological control strategies is essential for achieving long-term agricultural sustainability and food security.

FUTURE SCOPE

Green lacewing, *C. zastrowi sillemi* remains understudied, keeping in view the fast-pacing biological control technologies. At present only a few Chrysopids mass culture labs are present in India, especially in Haryana. Present study will enable researchers to opt for most suitable rearing techniques, ultimately enabling them to mass culture biocontrol agent for field release aimed at target insect-pest control.

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