*Pakistan J. Zool., vol. 45(1), pp. 177-182, 2013.*

# Influence of Prey Consumption on Life Parameters and Predatory Potential of *Chrysoperla carnea* against Cotton Mealy Bug

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**Abstract.-** Life parameters and predatory potential of *Chrysoperla carnea* was evaluated using *Phenacoccus solenopsis* as host in free choice feeding and no choice feeding trials. Results on biological parameters revealed that 3rd instar cotton mealy bug triggered: minimum larval period in days; moderate larval survival; minimum pupal period in days; maximum pupal weight, maximum percentage emergence; highest fecundity; and, adult longevity of *C.carnea*. Predatory potential showed that all the larval instars of *C. carnea* fed on the cotton mealy bug but the 3rd instar *C. carnea* proved to be more effective by consuming 9131.7, 1933.3, 1178.3 and 148.0, 1st instar, 2nd instar, 3rd instar and adult stage cotton mealy bugs, respectively. Results depict that *C. carnea* can be used as an effective biological control agent for successful implementation of integrated pest management program for the mealy bug control.

Key words: Green lacewing, life history parameters, feeding potential, biological control.

## INTRODUCTION

Cotton mealy bug, *Phenacoccus solenopsis* Tinsely (Hemiptera: Sternorrhyncha: Pseudococcidae), is a soft-bodied, polyphagous (Abbas *et al.*, 2010), multivoltine (Aheer *et al.*, 2009) invasive Caribbean insect pest, which sucks the cell sap of cotton plant and plays havoc with crop's economy. Cotton mealy bug has become major pest of cotton in Subcontinent since 2005 (Centre For Agro Informatics Research, 2007). Besides sucking the cell sap of host crop, it also releases toxic substances causing curling and drying of leaves which ultimately decreases yield (Hameed *et al.*, 2012).

Biological control is an effective means of achieving insect control (Pedigo and Rice, 2010). Invasive species are closely associated with biological control because the environment in which they are invasive most likely does not contain their natural enemies. If invasive species are not controlled, biodiversity may be at great threat in the affected area (Bellows, 2001).

Since introduction of cotton mealy bug in Pakistan area wide management practices were adopted to combat the menace. One of the strategies was identification of natural biocontrol agents, identification of their predatory potential against the invasive pest, augmentation, release and finally exploring their potential for better management of the key pest.

Biological control by the use of predator, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) has gained importance in pest management in Pakistan. Use of *C. carnea* in Pakistan dates back to 1993 before that use of predator was restricted to lack of knowledge of IPM and inunndative biocontrol agents. Spread of cotton mealy bug pointed the need for management of cotton mealy bug in Pakistan on area wide basis. The current research focused on explicating predatory potential of *C. carnea* against this key pest and the effect of prey consumption on biological parameters for the commercial management of cotton mealy bug.

## MATERIALS AND METHODS

The experiment was conducted in Cotton Mealy Bug Laboratory in Entomological Research Institute, Faisalabad. For the purpose of life history and predation studies temperature and humidity

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0030-9923/2013/0001-0177 $ 8.00/0

were maintained at 25±2°C and 65±5% R.H. The experiment was laid out in Completely Randomized Split plot design consisting of twenty treatments, and each treatment comprised of five replicates. Predatory efficiency of *C. carnea* was calculated at each instar on different stages of cotton mealy bug *i.e.*, 1st, 2nd, 3rd and adult stage, in free choice and no choice feeding trials. Life table parameters were studied in plastic vials of size 1.5 x 0.5cm with sieve of mesh size 80.

*Rearing of Phenacoccus solenopsis*

Cotton mealy bug were reared for the experimentation on bottle gourd (*Lagenaria siceraria* (Molina) in cages of dimensions 45 x 30 x 12 cm (L x H x W).

*Collection of adult green lacewing and rearing*

The adults of *C. carnea* were collected from different field crops where mealy bugs prevailed. Collected specimens were brought in laboratory and placed in cages and fed on sugar, honey, yeast, distilled water and casein (3.0: 2.5: 2.5: 10: 2.0 grams) according to Ulhaq *et al.* (2006). Adult lacewings were regularly observed and sexual balance was maintained. Eggs were collected on cotton tissue papers and the eggs were placed individually in 9cm diameter Petri dishes, provided with moistened filter papers to provide optimum conditions for larvae growth and avoid cannibalism.

*No choice feeding trials*

In no choice feeding trials fixed quantity of 1st instar, 2nd instar, 3rd instar and adult stages cotton mealy bug were offered to *Chysoperla* instars. These were stage specific trials *i.e.*, specific stage of cotton mealybug was released in treatments (T1 to T4) and *Chrysoperla* predation was recorded. No choice feeding trials consisted of 4 treatments and 5 replicates. Four treatments were 1st instar, 2nd instar, 3rd instar and adult stage cotton mealy bug. Each larval instar was offered definite quantity of host mealybug at specific instars. Predating efficiency of 1st instar, 2nd instar, 3rd instar of *C. carnea* was evaluated. For 1st instar *Chrysoperla*, 300 1st instar, 200 2nd instar, 50 3rd instar and 50 adult stage cotton mealybugs were offered in all 4 treatments. For 2nd instar *Chrysoperla* larvae 1500 1st instar, 400 2nd instar, 200 3rd instar and 25 adult stage cotton mealybugs were released in 4 treatments. For 3rd instar *Chrysoperla* 1500 1st instar, 400 2nd instar, 200 3rd instar and 50 adult stages were offered for each treatment.

*Free choice feeding trials*

In free choice feeding trials mealybugs were offered in mixture *i.e.* definite number of 1st instar, 2nd instar, 3rd instar and adult stages were offered for each replicate and each larval instar. In free choice feeding trials 2000 1st instar, 500 2nd instar, 200 3rd instar and 50 adults were offered for each larval instar. Predating efficiency of all larval instars was determined on day intervals.

*Biological parameters*

Each larval instar's weight, percent survival and duration was also recorded. Percent adult emergence, fecundity and adult longevity were recorded on different instars of cotton mealy bug.

*Statistical analysis*

Data was statistically analyzed through Statistix 8.0 (Anonymous, 2003). Means were separated through all pair comparison tests of treatment with LSD test, at the $P<0.05$ level of significance.

## RESULTS

Results on predatory potential of *C. carnea* against cotton mealy bug revealed that 3rd instar *C. carnea* consumed maximum number of cotton mealy bug (9131.7 1st instar, 1933.3 2nd instar, 1178.3 3rd instar and 148.0 adult stage) as compared to 1st instar and 2nd instar *Chrysoperla* instars. Predation of 1st instar cotton mealybug was maximum as compared to 2nd instar, 3rd instar and adult stage cotton mealybug in no choice feeding and free choice feeding (Table I). Results of free choice feeding were also similar to no choice feeding *i*.e., 3rd instar *C. carnea* consumed maximum number of cotton mealybugs (2020.7 1st instar, 1261.0 2nd instar and 470.67 3rd instar cotton mealybug).

Per day consumption of 1st instar *C. carnea* on 1st instar, 2nd instar, 3rd instar and adult stage

cotton mealy bug revealed that 1st instar larvae consumed I1 cotton mealy bug voraciously in all five days stadium, however, feeding was maximum on 5th day (218.67), similarly consumption of 2nd instar and 3rd instar was maximum on 5th day (166.56; 31.66) whilst consumption of adult stage was maximum on 3rd day (1.33 average cotton mealybug) (Table II). Low consumption of adult stage cotton mealybug might be due to fact that adults produce progeny and it consumed maximum number of eggs and 1st instar in later developmental days as further studies confirms that predator prefer fast crawlers than slow ones.

**Table I.- Predatory potential of *C. carnea* on cotton mealybug.**

| *C. carnea* instars | Instars of cotton mealybug | | | |
|---|---|---|---|---|
| | 1st instar | 2nd instar | 3rd instar | Adult |
| **No. choice feeding** | | | | |
| 1st instar | 736.3 c | 567.7 b | 81.0 c | 1.71 c |
| 2nd instar | 3163.3 b | 1953.3 a | 255.0 b | 121.00 b |
| 3rd instar | 9131.7 a | 1933.3 a | 1178.3 a | 148.00 a |
| LSD | 0.25 | 2.26 | 1.73 | 6.36 |
| **Free choice feeding** | | | | |
| 1st instar | 411.7 c | 299.0 c | 35.00 c | |
| 2nd instar | 798.3 b | 378.7 b | 91.33 b | |
| 3rd instar | 2020.7 a | 1261.0 a | 470.67 a | |
| LSD | 2.50 | 3.22 | 4.76 | |

Similarly per day consumption of 2nd instar of *C. carnea* on different cotton mealy bug instars clearly indicated that feeding of the cotton mealy bug was maximum at 5th day (*viz.*, 793.33 1st instar, 256 2nd instar; 387.33 3rd instar and 72.11 adult stage cotton mealybug) during 8th day stadium of 2nd instar *C. carnea* (Table II). Likewise per day consumption of 3rd instar larvae of *C. carnea* in no choice feeding with 8 day larval stadium showed that consumption was maximum in 4th day as compared to other days however consumption rate was negligible in all instars (Table II).

Free choice feeding test of *C. carnea* clearly depicted that feeding rate was maximum with 1st instar cotton mealy bug as compared to 2nd instar and 3rd instar instars (Table III). However, maximum feeding of 1st instar *C. carnea* was observed on 4th day (*viz.*, 88 1st instar, 67I2, 3.55 3rd instar, while no adults were consumed) during 6 days stadium (Table III). Another important point noticed was stadium of *Chrysoperla* instars was prolonged when fed on different instars of cotton mealy bug under no choice feeding. However, development was maximum, when fed on different instars of cotton mealy bug under no choice feeding.

Per day consumption of 2nd instar *Chrysoperla* against cotton mealy bug in choice feeding test depicted that 2nd instar *Chrysoperla* consumed maximum 1st instar, 2nd instar, 3rd instar and 3rd instar *P. solenopsis* on variable days while consumption of 3rd instar and 4th instar was maximum on 5th day as compared to other developmental time (Table III). Per day consumption of 3rd instar *C. carnea* on *P. solenopsis* revealed that 3rd instar *C. carnea* consumed maximum 1st instar, 2nd instar, and 3rd instar *P. solenopsis*, however maximum feeding was recorded on 3rd day (475.33 1st instar; 294.33 2nd instar; 111.67 3rd instar while adult consumption was higher on 1st day, Table III).

Biological parameters such as duration of larval instars, % age larval survival, pupal period, pupal weight, % age emergence, adult longevity, and fecundity results revealed that *C. carnea* when fed on adult cotton mealy bug showed maximum larval duration, while percent larval survival was maximum and pupae period was mediatory (Table IV).

## DISCUSSION

Present studies conducted on effect of prey consumption on life parameters and predatory potential of *C. carnea* against cotton mealy bug found that in no choice feeding 3rd instar *C. carnea* larvae consumed maximum number of cotton mealy bug as compared to other instars which might be due to larger size of 3rd instar larvae and more nutritional requirements. Similar results were reported by Gautam and Tesfaye (2002) and Sattar *et al.* (2007) that 3rd instar consumed maximum number of hosts as compared to 1st instar and 2nd instar due to their larger size and maximum food requirements (Ulhaq *et al.*, 2006)

In present studies all larval instars of *Chrysoperla* consumed maximum number of 1st

**Table II.- Consumption of different instars larvae of *C. carnea* against cotton mealybug (no choice feeding).**

| *C. carnea* developmental stages | Cotton mealybug instars | Developmental days | | | | | | | | LSD |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st day | 2nd day | 3rd day | 4th day | 5th day | 6th day | 7th day | 8th Day | |
| Fist instar | 1st | 95.22 d | 112.00 d | 138.00 c | 175.00 b | 218.67 a | | | | 8.18 |
| | 2nd | 64.33 e | 96.78 d | 116.56 | 155.22 b | 166.56 a | | | | 3.13 |
| | 3rd | 3.44 e | 8.00 d | 14.00 c | 24.00 b | 31.66 a | | | | 11.37 |
| | Adult | 1.00 a | 1.00 a | 1.33 a | 1.00 a | 0.78 a | | | | 93.83 |
| 2nd instar | 1st | 404.00 d | 453.89 c | 453.33 c | 702.89 b | 793.33 a | 359.67 e | 0.33 f | | 0.65 |
| | 2nd | 205.22 f | 159.78 g | 242.00 e | 306.00 c | 387.33 a | 353.67 b | 299.33 d | | 0.89 |
| | 3rd | 41.13 d | 48.00 c | 58.22 b | 72.11 a | 37.89 d | 1.00 e | 1.33 e | | 5.09 |
| | Adult | 10.23 | 18.11 | 17.66 | 26.11 | 29.78 | 19.52 | 1.00 | | 9.49 |
| 3rd instar | 1st | 703.8 h | 821.3 g | 910.1 f | 1211.8 e | 1365.2 b | 1302.9 d | 1479.8 a | 1334.7c | 0.35 |
| | 2nd | 304.89 e | 333.56 c | 475.17 b | 511.33 a | 318.67 d | 1.00 f | 1.00 f | 1.00 f | 0.91 |
| | 3rd | 101.67 g | 117.33 f | 131.33 e | 177.00 c | 143.45 d | 329.67 a | 191.00 b | 0.00 h | 1.29 |
| | Adult | 18.33 ab | 19.11 ab | 24.11 ab | 29.78 a | 25.89 ab | 27.00 ab | 15.66 a | 0.00 c | 35.12 |

**Table III.- Consumption of different instar larvae of *C. carnea* against cotton mealybug (free choice feeding).**

| *C. carnea* developmental stages | *Chrysoperla* instars | Development days of *C. carnea* | | | | | | LCD |
|---|---|---|---|---|---|---|---|---|
| | | 1st day | 2nd day | 3rd day | 4th day | 5th day | 6th day | |
| Fist instar | 1st | 56.22 | 68.44 | 79.00 | 88.00 | 69.89 | 50.00 | 3.98 |
| | 2nd | 39.89 | 46.55 | 55.66 | 67.00 | 59.33 | 29.50 | 5.74 |
| | 3rd | 2.55 | 3.22 | 4.00 | 3.55 | 10.44 | 11.66 | 34.03 |
| 2nd instar | 1st | 159.67 c | 179.11 a | 143.45 d | 168.89 b | 147.67 d | | 1.73 |
| | 2nd | 80.00 b | 88.33 a | 55.11 c | 76.44 b | 57.00 c | | 4.17 |
| | 3rd | 11.33 c | 12.55 c | 12.55 c | 20.33 b | 41.00 a | | 10.02 |
| | Adult | 3.00 a | 1.66 a | 2.00 a | 1.66 a | 1.00 a | | 77.63 |
| 3rd instar | 1st | 177.45 f | 297.89 e | 312.33 d | 441.50 b | 475.33 a | 322.67 c | 0.99 |
| | 2nd | 98.45 e | 146.33 d | 179.22 c | 245.17 b | 294.33 a | 294.67 a | 1.53 |
| | 3rd | 45.00 e | 61.11 d | 68.89 c | 79.00 b | 111.50 a | 111.67 a | 1.82 |
| | Adult | 4.00 a | 3.00ab | 3.33 ab | 1.00 c | 2.00 bc | 3.00 ab | 31.22 |

**Table VI.- Life history parameters of *C. carnea* (Stephens.)**

| Feed on nymphal instars/ adults of CMB | Larval period in days | %age of larval survival | Pupal period in days | Pupal weight (g) | %age emergence | Fecundity | Adult longevity |
|---|---|---|---|---|---|---|---|
| 1st | 15-20 | 90 | 9-11 | 0.0076 | 80 | 99.40 | 26.22 |
| 2nd | 10-20 | 80 | 8-11 | 0.0084 | 80 | 114.40 | 27.72 |
| 3rd | 14-18 | 85 | 8-13 | 0.0093 | 82 | 168.30 | 28.62 |
| Complex | 15-17 | 79 | 10-14 | 0.0090 | 78 | 158.30 | 28.82 |
| Adults | 13-17 | 67 | 9-14 | 0.0085 | 81 | 165.40 | 29.00 |

instar cotton mealy bug than 2nd instar and 3rd instar *Chrysoperla* preference of 1st instar *P. solenopsis* for consumption might also be due to fact that it prefers fast moving insects for predation as compared to slow feeding insects (later instar of cotton mealy bug) (Huang and Enkegaard, 2010). In the present studies when a feeding comparison was made between no choice feeding and free choice feeding, predator consumed more insects in free choice than in no choice feeding.

Sattar *et al.* (2007) reported that *C. carnea* in its entire larval period can consume cotton mealy bug with an average of 1604.0, 689 and 144.7 1st instar, 2nd instar, and 3rd instar stages, respectively. These results are similar to our results with few exceptions and reasons might be thermodynamic conditions prevailing in experimental work. Sattar and Abro (2011) reported that *C. carnea* can control cotton mealy bug population extensively and is a potential predator of mealy bug, which can be utilized to reduce mealybug populations.

Results of present studies on biological parameter depicts that C. *carnea* larvae fed on adult *P. solenopsis* completed growth in shortest time with moderate weight, maximum percentage emergence, highest fecundity and adult longevity. Larval duration was shortest when fed on 3rd instar cotton mealy bug and adult stage cotton mealy bug. Results of present studies revealed that 3rd instar cotton mealy bug, adults, complex can be good diet for fast growth of predator. This might be due to fact that 3rd instar and adult stage are rich in carbohydrates and lipids and provide nutritious and balanced diet for *C. carnea* growth, fertility and development (Zheng *et al.*, 1993b).

Results of our studies on percent larval survival revealed that survival was highest when fed on 1st instar, moderate when fed on 3rd instar, mixture and adult stage. This may be due to fact that 3rd instar and adults are rich source of carbohydrates and vitamins, which increase survival of C. *carnea*. McEwen *et al.* (1993) also concluded that when *C. carnea* were fed on eggs and yeast, the development was rapid. Uddin *et al.* (2005) found larval survival up to 90% when fed on natural host as compared to artificial diet. Zheng *et al.* (1993*a*) obtained 75-100% and 65-73% survival from egg to adult on high and intermediate amounts of larval food, respectively. Reasons for the high percent survival when fed on immature (eggs) will require further biochemical studies on the effect of nutrients present in insects on predator percent survival.

In our research pupal period was shortest when fed on 3rd instar cotton mealy bug while pupal weight was maximum when fed on 3rd instar cotton mealy bug. Syed *et al.* (2008) obtained pupal weight 0.828 x 100 g on nutritious diet while we obtained 0.93 x 100 g pupal weight which means that 3rd instar cotton mealy bug is more nutritious than *Sitotroga cereallela* eggs.

The findings of the research indicate that the increased prey consumption in immature stages resulted in higher reproduction rate. This may be due to the fact that adult and 3rd instar contain higher amount of proteins (amino acids), lipids, carbohydrates, ash, vitamins, caloric acid, cholesterol contents (Ulhaq *et al.*, 2006). Many authors also concluded that high reproduction is closely related to biochemical composition of diet (McEwen and Kidd, 1995; Corrales and Campos 2004; Ulhaq *et al.*, 2006). Thus *C. carnea* can be used as an effective predator of cotton mealy bug for implementation of area wide biological control program. *C. carnea* can efficiently consume mealy bug and since it is a candidate for inundative release as a biocontrol agent, maximum efforts should be focused on the management of cotton mealy bug with the use of *C. carnea*.

## CONCLUSIONS

Present research work aimed at exploring the predatory potential of C. *carnea* revealed that it can be used in efficient implementation of successful program of integrated pest management for control of cotton mealy bug. Also, cotton mealy bug provides a good diet for growth and development of *Chrysoperla* so it can be used for mass rearing of C. *carnea* as compared to *Sitotroga cerallela* for better management of crop systems in tropics and Subtropics and in Subcontinent.

## ACKNOWLEDGEMENTS

Research work was part of project, “Biological Control of Cotton mealy bug in

Pakistan" funded by Ministry of Agriculture, Pakistan Agricultural Research Board (PARB) and a part of National Control Program of cotton mealy bug in Pakistan. We thank Dr. Ghulam Mustafa Aheer, Ex-Director Entomological Research Institute Faisalabad, Malik Nazir Ahmad, Technical Officer Entomological Research Institute Faisalabad for help in designing and conducting the experiments.

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*(Received 19 October 2012, revised 27 December 2012)*