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FEEDING POTENTIAL OF *CHRYSOPERLA CARNEA* AND *CRYPTOLAEMUS MONTROUZIERI* ON COTTON MEALYBUG, *PHENACOCCUS SOLENOPSIS*

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ABSTRACT

The feeding potential of *Chrysoperla carnea* larvae and adults of *Cryptolaemus montrouzieri* on different nymphal instars of cotton mealybug, *Phenacoccus solenopsis* was investigated in ambient laboratory conditions at Agricultural Research Institute, Dera Ismail Khan, Pakistan. Both predators were found very active and successfully consumed all the nymphal instars of *P. solenopsis*. The daily predation rate of *C. carnea* larvae increased slowly during the first two larval instars and reached to its peak in the third larval instar. First instar nymphs of *P. solenopsis* were the most preferred food of different larval instars of *C. carnea*. Third instar larvae of *C. carnea* were the most voracious feeder and consumed significantly high number of first, second and third instars nymphs of mealybug as compared to first and second instar larvae of the predator. Adult *C. montrouzieri* consumed significantly more first instar nymphs of mealybug than second and third instar nymphs. These results indicate that *C. carnea* and *C. montrouzieri* have great potential for the biological control of *P. solenopsis*.

Key words: Feeding potential, *Chrysoperla carnea*, *Cryptolaemus montrouzieri*, cotton mealybug.

INTRODUCTION

Mealybugs, (Hemiptera: Pseudococcidae) are small, soft-bodied, sap sucking insects that cause severe damage to various field crops, fruits and vegetables (Arif *et al*., 2009; Nagrare *et al*., 2009). Cotton mealybug, *Phenacoccus solenopsis* was described originally from U.S. A. in 1898 (Tinsley, 1898) and is regarded as an exotic pest in Asia. It was first recorded damaging cotton crop in Pakistan during 2005, since then it has become the most serious arthropod pest of cotton in Asia (Ben-Dov *et al*., 2010; Wang *et al*., 2010). Cotton mealybug is a highly polyphagous pest of 154 plant species belonging to more than 52 plant families (Aheer *et al*., 2009; Arif *et al*., 2009; Abbas *et al*., 2010). In Pakistan, farmers mainly rely on synthetic chemicals for the management of mealybug. Although, recently various insecticides, like profeophos, triapophos, carbaryl, thiodicarb, buprofezin and acephate have been recommended for the management of mealybug (Dhawan *et al*., 2009; Nikam *et al*., 2010; Patel *et al*., 2010; Rashid *et al*., 2011) but it is difficult to achieve perfect control of mealybugs with conventional insecticides due to waxy material which covers the bodies of adult females (Rao and David, 1958; Dean *et al*., 1971). Due to growing environmental and economic concerns involved in the use of synthetic chemicals there is a dire need to develop alternate measures for the sustainable management of *P. solenopsis*. Biological control represents the most important method of controlling mealybugs and under pesticide free conditions several species of predators attack *P. solenopsis* and can effectively regulate mealybug populations (Tanwar *et al*., 2007; Gautam *et al*., 2010; Ram and Saini, 2010).

Ladybird beetles are naturally occurring and one of the most important and well known biological control agents. They prey on aphids, mealybugs, scales, mites and other soft bodied insects (Bozsik, 2006; Jalali *et al*., 2009). Among these *Cryptolaemus montrouzieri* is the most voracious predator of mealybug in nymphal as well as adult stages.

The coccinellid predator, *C. montrouzieri* commonly known as mealybug destroyer is one of the most commonly used bio-control agent in various parts of the world. It has played a major role in the natural control of different sucking pests, especially mealybugs (Mani, 1990; Mani and Krishnamoorthy, 2008). It has been mass reared and marketed into more than 40 countries (Barlette, 1977; Malaise and Ravensberg, 1992).

Green lacewing, *Chrysoperla carnea* generally known as aphid-lion is generalist predator of a wide range of pest species such as mealybugs, aphids, thrips, whiteflies and mites (Canard and Principi, 1984; Liu and Chen, 2001; Yadav and Pathak, 2010). *C. carnea* is the most intensively studied specie of chrysopids because of its wide geographical distribution, broad habitats with high relative frequency of occurrence, good searching ability and easy rearing in the laboratory (Tolstova, 1986). The larvae of lacewing feed on a wide range of pest species while adults are free living and feed only on nectar, pollen and honey dew (Coppel and Mertins, 1977). In a field cage study investigating biological control of *Heliothis zea* and *H. virescens* Ridgway and Jones (1969) found that inundative release of *C. carnea* offered considerable potential in cotton. Ballal *et al*. (1999) studied the ovipositional behavior of *C. carnea* and reported that females had a higher preference for egg laying on cotton. Because of its voracious feeding on soft bodied insects it is an important component of IPM programs.

So far, very little information is available on the predation potential of both predators on *P. solenopsis*. This paper reports the potential and preference of both predators as bio-control agents of *P. solenopsis* under laboratory conditions.

MATERIALS AND METHODS

Culture of Phenacoccus solenopsis: The mass culture of *P. solenopsis* was established from individuals collected during spring 2009 from ornamental plants and crop plants in Dera Ismail Khan (Pakistan). *P. solenopsis* were reared on pumpkin fruits (*Cucurbita moschata*) under laboratory conditions at 30 ± 5°C with 50 ± 10% R.H.

Cultures of Chrysoperla carnea and Cryptolaemus montrouzieri: The adults of *C. montrouzieri* were obtained from CABI south Asia and were mass reared on *P. solenopsis* infesting pumpkin fruits (*Cucurbita moschata*) as suggested by Chako *et al*. (1978) and Singh (1978) under laboratory conditions at 25 ± 5°C with 65 ± 5% R.H. The *C. carnea* adults were collected from the fields and reared in 10 liter plastic jars on artificial diet Ashfaq *et al*. (2004); Gautam *et al*. (2010).

Predation of *Chrysoperla carnea* on cotton mealybug

No choice feeding: An experiment was conducted in the laboratory of Entomology Section, Agricultural Research Institute, Ratta Kulachi, Dera Ismail Khan, Pakistan to find out the predatory potential of *C. carnea* on cotton mealybug under no choice experimental conditions. After hatching each larval instar of *C. carnea* were provided with a counted number of 1st, 2nd and 3rd nymphal instars of mealybugs for feeding. *C. carnea* larvae were offered 20 nymphs of cotton mealybug on 1st day after hatching. Ten insects were increased daily after 1st day. In this way each larval instar of *C. carnea* were provided with 1st, 2nd and 3rd nymphal instars of cotton mealybug in no choice conditions. A single *C. carnea* larva was released into each Petri dish 1 hour after the release of the cotton mealybug. This interval was maintained to ensure the settling of the mealybug nymphs. The predatory potential of *C. carnea* was recorded by counting the number of mealybugs fed by 1st, 2nd and 3rd instar larvae of C. *carnea* up to pupation.

Free Choice feeding: To investigate the predatory potential of *C. carnea* on cotton mealybug under free choice experimental conditions single larva of each larval instar of the predator was introduced into 9 cm Petri dish with the help of a camel hair brush along with the known number of mealybugs of 1-3 nymphal instars for feeding. Free choice feeding of each predator instar on each instar of prey (*P. solenopsis*) was recorded daily till the completion of each instar of the predator.

Predation of *Cryptolaemus montrouzieri* on cotton mealybug: To find out the predatory potential of *C. montrouzieri* on cotton mealybug newly emerged adults were provided with counted number of 1st, 2nd and 3rd instar nymphs of cotton mealybug in Petri dishes. After 24 hours the numbers of mealybugs consumed were noted. The feeding trial of *C. montrouzieri* was divided into three stages, i.e. early, mid and late; each comprising of three days. Each consumption trial was started 15 days after the completion of previous trial. The experiment was laid out in Randomized Complete Block Design with four replications.

RESULTS AND DISCUSSION

Predation of *Chrysoperla carnea*

No choice test: The data presented in Table 1 show significant differences ($P<0.05$) in the mean consumption of *C. carnea* on different stages of *P. solenopsis*. The feeding potential of *C. carnea* increased significantly with the advancement of larval stage of the predator. The third instar larvae of *C. carnea* consumed significantly higher number of 645.9 total first instar nymphs of *P. solenopsis* which differed significantly from 406.0 nymphs consumed by first instar and 426.3 nymphs consumed by second instar larvae of *C. carnea*. Similarly the average number of total second instar nymphs of mealybug consumed by first instar larvae of *C. carnea* was significantly less than the other developmental stages of *C. carnea* (Table 1). The first instar of *C. carnea* consumed minimum number of 62.12 second instar nymphs of *P. solenopsis* whereas; third instar of *C. carnea* consumed maximum number of 144.7 second instar nymphs of *P. solenopsis*. A similar feeding trend was observed for third instar of mealybug. The third instar of *C. carnea* consumed maximum number of 122.2 total third instar nymphs of mealybug whereas, the first instar of *C. carnea* consumed minimum number of 31.13 third instar nymphs of mealybug (Table 1). Third instar of *C. carnea* consumed higher number of first, second and third instars nymphs of mealybug per day compared with first and second instar of predator. Third instar predator proved to be the most voracious feeder of all the nymphal instars of the prey (*P. solenopsis*) compared to 1st and 2nd instars. The reason for higher feeding potential of third instar predator might be due to its large size than other developmental stages of the predator. The increase in feeding potential of *C. carnea* with the advancement in development stage is in line with the findings of Canard and Principi (1984); Silva *et al*. (2002). Atlihan *et al*. (2004) reported that older larval instars of *C. carnea* displayed a higher rate of predation of *Hyalopterus pruni* than younger ones. Scopes (1969) and Yuksel and Gocmen (1992) reported that more aphids were consumed by 3rd instar larvae than by 2nd and 1st instars of *C. carnea*.

Table-1. Feeding potential of *Chrysoperla carnea* on different nymphal instars of *Phenacoccus solenopsis* under no choice conditions.

Different instars of *C. carnea*	Number of different instars of mealybug consumed (mean ± SE)					
	1st instar nymph		2nd instar nymph		3rd instar nymph	
	Total consumption	Average/day consumption	Total consumption	Average/day consumption	Total consumption	Average/day consumption
1st	406.0 ± 1.15b	74.76 ± 0.75b	62.12 ± 2.25c	18.06 ± 0.61c	31.13 ± 3.15c	7.783 ± 0.70c
2nd	426.3 ± 2.18b	87.61 ± 0.94a	73.23 ± 1.95b	21.10 ± 1.20b	59.67 ± 2.99b	17.20 ± 0.95b
3rd	645.9 ± 2.45a	95.35 ± 0.46a	144.70 ± 1.66a	36.21 ± 0.85a	122.2 ± 1.88a	30.52 ± 1.90a
LSD value	29.40	12.67	10.95	2.78	1.88	2.90

Means within columns followed by the same letter are not significantly different at 5% level of probability using LSD test.

Free choice test: When different prey stages of mealybug were offered together to different larval instars of *C. carnea* the first instar larvae of *C. carnea* consumed significantly ($P<0.05$) maximum number of 28.28 first instar nymphs of mealybug whereas, the first instar predator consumed minimum number of 0.76 third instar nymphs of mealybug. The second instar of the predator consumed significantly higher number of 33.19 first instar nymphs of mealybug which differed significantly from 16.71 second instar and 4.94 third instar mealybug nymphs consumed by second instar larvae of *C. carnea*. The third instar of *C. carnea* consumed all the nymphal instars of mealybug. The third instar of *C. carnea* consumed significantly higher number of 28.80 first instar nymphs of mealybug. The third instar of predator consumed minimum number of 8.52 third instar nymphs of mealybug (Table 2). The higher response of the predator towards the 1st instar prey could be attributed to the absence of thin white waxy layer on the bodies of the 1st instar compared to 2nd and 3rd instar prey. Similar trend was also reported by Liu and Chen (2001) for *C. carnea* reared on *Lipaphis erysmi*. In the present study, the observed preference of *C. carnea* for 1st instar prey may also be associated with the greater mobility of 1st instar prey compared to older instars. Similar results were also reported by Sattar *et al*. (2007). They observed that first instar nymph of the mealybug was the most preferred food of *C. carnea*.

Table-2. Feeding potential of *Chrysoperla carnea* on different nymphal instars of *Phenacoccus solenopsis* under free choice conditions.

Mealybug instars	*C. carnea* instars		
	1st	2nd	3rd
1st	28.28 ± 0.25a	33.19 ± 0.99a	28.80 ± 1.20a
2nd	9.52 ± 0.45b	16.71 ± 0.60b	15.09 ± 0.35b
3rd	0.76 ± 0.22c	4.94 ± 0.15c	8.52 ± 0.15c
LSD value	1.74	2.34	1.54

Means within columns followed by the same letter are not significantly different at 5% level of probability using LSD test.

Predation of *Cryptolaemus montrouzieri*: The prey stage has significant effect on the feeding potential of adult *C. montrouzieri*. Adult *C. montrouzieri* consumed significantly ($P<0.05$) higher number of 98.59 first instar nymphs of mealybug which was significantly different from 45.85 second instar nymphs and 10.15 third instar nymphs consumed by adult *C. montrouzieri* (Table 3). Adult *C. montrouzieri* consumed almost similar number of first, second and third nymphal instars of mealybug during different feeding trials. Overall first instar nymphs of mealybug were the most preferred food of adult *C. montrouzieri*. These findings are in accordance with the work of Gautam *et al*. (1998) and Kairo *et al*. (2000). These results are similar to the findings of Kaur and Virk (2011). They found that *C. montrouzieri* adults consumed maximum number of first instar nymphs of *P. solenopsis* as compared to second and third instar nymphs.

Table-3. Feeding potential of adult *Cryptolaemus montrouzieri* on different nymphal instars of *Phenacoccus solenopsis*.

Instars of mealybug	Average mealybug consumed/day			Mean ± SE
	Early Stage	Mid Stage	Late Stage	
1st	99.55	96.66	99.55	98.59 ± 3.99a
2nd	45.75	46.05	45.75	45.85 ± 1.95b
3rd	11.51	9.38	9.55	10.15 ± 0.73c
LSD value				3.94

Means within columns followed by the same letter are not significantly different at 5% level of probability using LSD test.

REFERENCES

Abbas, G, M. J. Arif, M. Ashfaq, M. Aslam, and S. Saeed (2010). Host plants distribution and overwintering of cotton mealybug (*Phenacoccus solenopsis*: Hemiptera: Pseudococcidae). Int. J. Agri. Biol., 12, 421-425.

Aheer, J. H., Z. Shah and M. Saeed (2009). Seasonal history and biology of cotton mealybug, *Phenacoccus solenopsis* Tinsley. J. Res., 47, 423-431.

Arif, M. I., M. Rafiq and A. Ghaffar (2009). Host plants of cotton mealybug, (*Phenacoccus solenopsis*): a new menace to cotton agro-ecosystem of Punjab, Pakistan Int. J. Agri. Biol., 11, 163-167

Ashfaq, M. A. Nasreen and G. M. Cheema, (2004). Advances in mass rearing of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). South Pacific Stud., 24, 47-53.

Atlihan, R., B. Kaydan and M. S. Ozgokee (2004). Feeding activity and life history characteristics of generalist predator, *Chrysoperla carnea* (Neuroptera: Chrysopidae) at different prey densities. J. Pest. Sci., 77, 17-21.

Ballal, C. R., S. Singh and P. Singh (1999). Host plant mediated orientational and ovipositional behavior of three species of chrysopids (Neuroptera: Chrysopidae), Biocont., 16, 47-53.

Bartlett, B. R. (1977). Pseudococcidae. In: Introduced parasites and predators of arthropod pests and weeds: A World Review (ed C. P. Clausen), pp. 137-169. United State Department Agriculture, Hand Book No. 480.

Ben-Dov, Y., D. R. Miller and G. A. P. Gibson (2010). ScaleNet: A searchable information system on scale insects. Available on-line at http://www.sel.barc.usda.gov/scalenet/scalenet.htm.

Bozsik, A. (2006). Susceptibility of adult *Coccinella septempunctata* (Coleoptera: Coccinellidae) to insecticides with different modes of action. Pest Manag. Sci., 62, 651-654.

Canard, M. and M. M. Principi, (1984). Life histories and behavior. In Biology of Chrysopidae (M. Canard, Y. Semeria and T. R. New eds.). Dr W. Junk Publishers, The Hague, pp. 57–149.

Chacko, M. J., P. K. Bhat, L. V. A. Rao, M. B. D. Singh, E. P. Ramanarayan and K. Sreedharan (1978). The use of the ladybird beetle *Cryptolaemus montrouzieri* for the control of coffee mealybugs. J. Coff. Res., 8, 14-19.

Coppel, H. C. and J. W. Mertins (1977). Biological Insect Pest suppression. Springer-Verleg, Berlin, Germany.

Dean, H. A., W. G. Hart and S. J. Ingle (1971). Citrus mealybug, a potential problem on Texas grapefruit. J. Rio Grande Val. Hortic. Soc., 15, 46-53.

Dhawan, A. K. and S. Saini (2009). Study on biology of mealy bug, *Phenacoccus solenopsis* Tinsley on cotton in Punjab. Proceedings of the National Symposium on IPM Strategies to Combat Emerging Pests in the Current Scenario of Climate Change. pp 35-36. CAU, Pasighet (Arunachal Pradesh).

Gautam, R. D., W. D. Chi and M. Lessey (1998). Preliminary studies on inoculative releases of Australian beetle, *Cryptolaemus montrouzieri* Muslant and another Indian ladybird, *Scymnus coccivora* Aiyar against pink mealybug, *Maconellicoccus hirsutus* Green at point Fortin. In: Proceed. 1st Sem. *Hibiscus* mealybug. Ministry of Agriculture, Land and Marine Resources Centeno. Trinidad and Tobago. Pp. 25-29.

Gautam, S., A. K. Singh and R. D. Gautam (2010). Olfactory responses of green lacewing, *Chrysoperla* sp. (*carnea* group) and *Mallada desjardinsi* on mealybug, *Phenacoccus solenopsis* (Homoptera: Pseudococcidae) fed on cotton. Acta Ento. Sinica., 53, 497-507.

Jalali, M. A., L. Tirry and P. D. Clerq (2009). Food consumption and immature growth of *Adalia bipunctata* (Coleoptera: Coccinellidae) on a natural prey and a factitious food. Europ. J. Ento., 106, 193-198.

Kairo, M. T. K., G. V. Pollard, D. D. Peterkin and V. F. Lopez (2000). Biological control of the *Hibiscus* mealybug, *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae) in the Caribean. Integr. Pest Manag. Rev., 5, 241-254.

Kaur, H. and J. S. Virk (2011). Feeding potential of *Cryptolaemus montrouzieri* against the mealybug, *Phenacoccus solenopsis*. Phytoparasit., 40, 131-136.

Liu, T. X. and T. Y. Chen (2001). Effects of three aphid species (Homoptera: Aphididae) on development, survival and predation of *Chrysoperla carnea* (Neuroptera: Chrysopidae). Appl. Entomol. Zool., 36, 361–366.

Malaise, M. and W. J. Ravensberg (1992). The biology of glasshouse pests and their natural enemies: knowing and recognising. Berkelen Rodenrijs, The Netherlands.

Mani, M. (1990). The grapevine mealybug. Ind. Hortic., 35, 28–29.

Mani, M. and A. Krishnamoorthy (2008). Biologicl suppression of the mealybugs *Planococcus citri* (Risso), *Ferrisia virgata* (Cockerell) and *Nipaecoccus viridis* (Newstead) on pummelo with *Cryptolaemus montrouzieri* Muslant in India. J. Bio. Cont., 22, 169-172

Nagrare, V. S., S. Kranthi, V. K. Biradar, N. N. Zade, V. Sangode, G. Kakde, R. M. Shukla , D. Shivare, B. M. Khadi and K. R. Kranthi (2009). Widespread infestation of the exotic mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) on cotton in India., 99, 537-541.

Nikam, N. D., B. H. Patel and D. M. Korat (2010). Biology of invasive mealy bug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on cotton. Karnataka J. Agri. Sci., 23, 649-651.

Patel, M. G., R. C. Jhala, N. M. Vaghela and N. R. Chauhan (2010). Bio-efficacy of buprofezin against mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) an invasive pest of cotton. Karnataka J. Agri. Sci., 23, 14-18.

Ram, P. and R. K. Saini (2010). Biological control of *solenopsis* mealybug, *Phenacoccus solenopsis* Tinsley on cotton: a typical example of fortuitous biological control. J. Biol. Cont., 24, 104-109.

Rao, T. V. and L. A. David (1958). The biological control of coccid pests in South India by use of beetle, *Cryptolaemus montrouzieri* Muslant. Indian J. Agric. Sci., 28, 545-552.

Rashid, M. M., M. K. Khattak and K. Abdullah (2011). Toxic and residual activities of selected insecticides and neem oil against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Pseudococcidae) under laboratory and field conditions. Pakistan Entomol., 33, 151-155.

Ridgway, R. L. and S. L. Jones (1969). Field-cage releases of *Chrysoperla carnea* for suppression of population of the bollworm and the tobacco budworm on cotton. J. Econ. Entomol., 61, 892–897

Sattar, M., M. Hamed and S. Nadeem (2007). Predatory potential of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) against cotton mealy bug. Pakistan Entomol., 29, 103-106.

Scopes, N. E. A. (1969). The potential of *Chrysoperla carnea* as a biological control agent of *Myzus persicae* on glasshouse chrysanthemums. Ann. Appl. Biol., 64, 433-439.

Silva, G. A., C. F. Carvalho and B. Souza (2002). Biological aspects of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) fed on *Alabama argillacea* (Hubner, 1818) (Lepidoptera: Noctuidae) larvae. Cienc. Agrotecnol., 26, 682–698

Singh, S. P. (1978). Propagation of coccinellid beetle for biological control of citrus and coffee mealybugs. Scientific Conference, 2.

Tanwar, R. K., P. Jeykumar and D. Monga (2007). Mealy bugs and Their Management, NCIPM Technical Bulletin 19, pp 16.

Tinsley, J. D. (1898). Notes on coccidae with descriptions of new species. Canad. Entomol., 30, 317-320.

Tolstova, Y. S. (1986). Pesticides and arthropod fauna. Zaschita Rastenii., 11, 38-39.

Wang, Y. P., G. W. Watson and R. Z. Zhang (2010). The potential distribution of an invasive mealybug, *Phenacoccus solenopsis* and its threat to cotton in Asia. Agri. Forest Entomol., 12, 403-416.

Yadav, R. and P. H. Pathak (2010). Effect of temperature on the consumption capacity of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) reared on four aphid species. The bioscan., 5, 271-274.

Yuksel, S. and H. Gocmen (1992). The effectiveness of *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) as a predator on cotton aphid *Aphis gossypii* Glov. (Homoptera: Aphididae). Proc. the Sec. Turk. National Cong. Entomol. Pp 209-216.