RESEARCH ARTICLE

FEEDING POTENTIAL OF LADY BIRD BEETLE *CHEILOMENES SEXMACULATA*, FABRICIUS (COLEOPTERA: COCCINELLIDAE) ON COTTON MEALY BUG *PHENACOCCUS SOLENOPSIS* (TINSLEY) UNDER CHOICE AND NO CHOICE CONDITION OF LABORATORY

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Abstract: An experiment was conducted to determine the feeding potential of lady bird beetle, *cheilomenes sexmaculata* (Fab.) on cotton Mealy bug, *Phenacoccus solenopsis* under choice and no choice condition in the laboratory at Department of Agricultural Entomology, Navsari Agricultural University, Navsari during July–August, 2016. The results revealed that *C. sexmaculata* was mostly preferred eggs of *P.solenopsis* as compared to nymph and adult of mealybug. The per day prey consumption rate of larval and adult stage of *C. sexmaculata* were varied from 35.00 to 44.00 (Av. 38.80±2.18) and 25.58 to 27.03 (Av. 26.38±0.35) eggs, 13.00 to 18.33 (Av. 14.97±1.47) and 15.52 (Av. 14.83±0.45) nymphs, and 9.67 to 14.00 (Av. 11.58±1.14) and 10.95 to 12.79 (Av. 12.02±0.40) adults of mealybug, respectively in no choice condition. In free choice feeding, grub of *C. sexmaculata* preferred eggs of mealybug more as compared to adult and nymph stage of mealybug. Which indicated by consumption of 65.55 ± 16.63 eggs, 10.75 ± 3.78 nymphs and 5.70±1.75 adults out of 82.00±21.04 (mixed stage) by larvae and 490.55±53.39 eggs, 139.35±15.56 nymphs and 93.25±7.72 adults out of 723.15±3.15 (mixed stage) by adult of *C. sexmaculata* on mealybug.

Keywords: *Cheilomenes sexmaculata*, *Phenacoccus solenopsis*, Feeding potential

INTRODUCTION

The cotton crop is attacked by both sucking and chewing type insects. The sucking type including, whitefly, aphid, thrips, mealy bugs and mites while chewing type including, grasshopper, termite, weevils and lepidopteron insects. Among these mealy bug is the serious pest of cotton and has resulted in severe damage during the last few years (Solangi *et al.*, 2008; Lohar and Khuhro, 2005). Mealybug, (Hemiptera: Pseudococcidae) are small, soft-bodied, sap sucking insect that cause severe damage to various field crops, fruits and vegetables (Arif *et al.*, 2009). Cotton mealybug, *Phenacoccus solenopsis* Tinsley was described originally from USA in 1898 (Tinsley, 1898) and regarded as an exotic pest of Asia. Mealybug which was not hitherto familiar earlier started destroying cotton crops caused economic damage, reducing yields up to 40-50% in affected 6 fields since 2006. Several parts of Gujarat which are located on the border of Pakistan which had recent history of mealybug infestation were severely affected. Mealybug infestation were recorded in 2006 on *G. hirsutum* in all the nine cotton-growing states of India, Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Tamil (Rao and David, 1958; Dean *et al.*, 1971).

The ladybird beetle belongs to the family coccinellidae of order Coleoptera. The members of the family are exclusively predator on aphids, mealybugs, scales, whiteflies, thrips, leafhoppers, mites and other small soft bodied insect pests (Omkar and Pervez, 2000). The predatory coccinellids occupy all the habitats and niches of their prey and distributed worldwide. Nine different species of ladybird beetle have been recorded in middle Gujarat. Of these, *Cheilomenes sexmaculata* (Fabricius.) found to be predominant species in middle Gujarat region. The ladybird beetles are predaceous on nymphs of cowpea aphids (*Aphis craccivora*), nymphs of cotton mealybug (*P. solenopsis*), nymphs of sorghum aphids (*Rhophalosiphum maydis*), nymphs of cotton aphids (*A. gossypii*) (Shepard, 1998). Keeping in view the above facts and importance of biological control of cotton mealy bug, the study on feeding potential of *Cheilomenes sexmaculata* against cotton mealy bug in laboratory was undertaken

MATERIAL AND METHOD

Maintenance of *C. sexmaculata* culture: Laboratory experiments were conducted under ambient and protected conditions at Bio-control Laboratory, Department of Agricultural Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during 2016-2017. Grubs, eggs and adults of predatory coccinellids were collected from the cotton fields of Research farm, Main Cotton Research Station, Navsari Agricultural University, Surat during 2016-17 and brought to the laboratory.

Maintenance of prey insects (aphid and mealybug) culture: The initial culture of mealybug collected from the Research farm, Main Cotton Research Station, Navsari Agricultural University, Surat during 2016-17. For the purpose, mealybug

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infested central twig with leaves were plucked and collected in perforated plastic bags, separately. The initial culture was released on 45 days old cotton plants raised in pots of dimension 45 × 18.5 cm in the wire netting inventory of Bio-control Laboratory, Department of Agricultural Entomology, Navsari Agricultural University, Navsari for establishment. The culture was established within one and half month which utilized as prey hosts for studying feeding potential of *C. sexmaculata*.

Assessment of feeding potential of *C. sexmaculata* on *P. solenopsis:* The predatory potential of different stages of *C. sexmaculata* against eggs (ovisac), nymphs and adults (freshly formed) stage of mealybug studied under no choice and free choice feeding trials separately under laboratory condition. In no choice feeding experiment, 20 larva of *C. sexmaculata*were kept individually in the plastic vial (5.0 × 2.5 cm). Three such sets of 20 larvae under plastic vials were prepared. One set was utilized for studying predatory potential against eggs (ovisac) of mealy bug; second set for nymphs and third for adults were provided as prey insect stages throughout the total larval and adult development of *C. sexmaculata*. Number of prey consumed by the predatory larvae in each instars and adult stage of *C. sexmaculata* calculated for each individual and the total consumption during total larval and adult stage of *C. sexmaculata* worked out. In free choice feeding, 20 larvae of *C. sexmaculata* kept individually in the plastic vial (5.0 × 2.5 cm). The set of 20 larvae under plastic vials were prepared. The set utilized for studying predatory potential against mixed stages of mealybug (ovisac, nymph and adult) as prey. In the set, known numbers of mixed stages offered as food and the record maintained separately on rate of consumption daily. On next day, again counted numbers of mixed stages offered as food and the consumption of prey insect calculated daily. Number of prey consumed by the predatory larvae and adult of *C. sexmaculata* in each prey stage and in each instars and adult of *C. sexmaculata*was calculated for each individual and the total consumption during total larval and adult stage of *C. sexmaculata* worked out. The total larval and adult duration of *C. sexmaculata*was also estimated and per day consumption of prey stages calculated.

RESULTS AND DISCUSSION

No choice condition

The data on feeding potential of all four larval instars and adult of *C. sexmaculata* on eggs (ovisac), nymphs and adults of *P. solenopsis* under no choice feeding conditions presented in Table 1 and Fig. 4, fig. 5 and fig. 6. Grubs and adult of *C. sexmaculata* consumed 8.35±2.11, 11.95±1.85, 34.50±9.10, 43.70±7.03 and 764.00±94.36 eggs(ovisac) of mealybug in developmental durations of 2.15±0.49, 2.30±0.47, 2.50±0.51, 2.75±0.44 and 28.95±3.41 days of first, second, third and fourth instar of grub, and adult respectively. The total grub period consumed 71.00 to 118.00 (Av. 98.50±16.05) eggs of mealybug during developmental durations of 9.70±1.56 days. The prey consumption rate varied from 2.33 to 6.00 (Av. 3.93±0.86), 4.33 to 6.50 (Av. 5.27±0.62) and 11.00 to 16.00 (Av. 13.68±1.45), 13.67 to 18.00 (Av. 15.93±1.05) and 25.58 to 27.03 (Av. 26.38±0.35) eggs of mealybug per day during first, second, third, fourth instar larvae, and adult of *C. sexmaculata* respectively. During entire larval period, per day prey consumption rate was varied from 35.00 to 44.00 (Av. 38.80 ± 2.18) eggs. The grubs and adult of *C. sexmaculata* consumed 1.20±0.52, 1.90±0.91, 13.10±1.92, 22.50 ± 6.94 and 400.45±35.34 nymphs of mealybug in developmental durations of 1.85±0.37, 2.10±0.31, 2.50±0.51, 2.75±0.44 and 27.00±2.22 days of first, second, third and fourth larval instars, and adult respectively. The *C. sexmaculata* grub consumed 13.00 to 18.33 (Av. 14.97±1.47) nymphs of mealybug during developmental durations of 5.00 to 7.00 (Av. 9.20±0.69) days. The prey consumption rate varied from 0.00 to 2.00 (Av. 0.73±0.50), 0.50 to 1.50 (Av. 0.89±0.37), 4.33 to 6.50 (Av. 5.33±0.59), 5.50 to 11.33 (Av. 8.03±1.62) and 13.88 to 15.52 (Av. 14.83±0.45) nymphs of mealybug per day during first, second, third and fourth instar, and adult of *C. sexmaculata*, respectively. During entire larval period, prey consumption rate varied from 13.00 to 18.33 (Av. 14.97±1.47) nymphs per day. When grubs and adult of *C. sexmaculata* feed on adults of mealybug, consumed 1.25±0.79, 1.80±0.62, 10.65±2.39, 15.70±3.20 and 342.90±49.59 adults of mealybug in developmental durations of 1.45±0.51, 1.80±0.62, 2.75±0.44, 2.75±0.44 and 28.50±3.87 days of first, second, third and fourth larval instars, and adult respectively. The *C. sexmaculata* grub consumed 20.00 to 38.00 (Av. 29.40±4.73) adults of mealybug during developmental durations of 6.00 to 10.00 (Av. 8.75±1.25) days. The prey consumption rate varied from 0.00 to 2.00 (Av. 0.85±0.56), 1.00 to 2.00 (Av. 1.10±0.31), 2.50 to 5.67 (Av. 3.91±0.81), 4.33 to 7.00 (Av. 5.73±0.79) and 10.95 to 12.79 (Av. 12.02±0.40) adults of mealybug per day during first, second, third and fourth instar grubs, and adult of *C. sexmaculata* respectively. During entire larval period, prey consumption rate varied from 9.67 to 14.00 (Av. 11.58±1.14) adults.

No choice condition

The data (Table 2 and Fig. 3) showed that grubs of *C. sexmaculata* consumed 6.90±2.43, 10.40±3.22, 27.50±9.58, 37.20±12.15 and 723.15±73.15 mixed stages of mealybug (eggs, nymphs and adult) in developmental durations of 1.65±0.49, 1.75±0.44, 1.90±0.64, 2.15±0.81 and 28.60±2.96 days of first, second, third and fourth larval instars, and adults respectively. The *C. sexmaculata* grubs consumed 42.00 to 113.00 (Av. 82.00±21.04) numbers of

mealybug (mixed stages) during developmental durations of 4.00 to 10.00 (Av. 7.45±1.85) days. In free choice feeding, grub of *C. sexmaculata* preferred eggs of mealybug as compared to adult and nymph stage of mealybug. It indicated by consumption of 65.55±16.63 eggs, 10.75±3.78 nymphs and 5.70±1.75 adults out of 82.00 ± 21.04 (mixed stage) by larvae and 490.55±53.39 eggs, 139.35±15.56 nymphs and 93.25±7.72 adults out of 723.15 ±73.15 (mixed stage) by adult of *C. sexmaculata* on mealybug. This might be due to soft body, small size of younger stages of mealybug favoring the easy capture and disliking of waxy coating on body of adult stage of mealybug. The prey consumption rate varied from 2.00 to 6.00 (Av. 4.15±0.88), 4.00 to 7.50 (Av. 5.88±0.92) and 12.50 to 17.00 (Av. 14.39±1.24), 14.33 to 22.00, (Av. 17.81±2.12), and 24.27 to 26.00 (Av. 25.30±0.43) number of mealybug (mixed stages) per day during first, second third and fourth instar, and adults of *C. sexmaculata* respectively. During entire larval period, prey consumption rate varied from 36.83 to 48.50 (Av. 42.53±3.19) numbers of mealybug (mixed stages) per day.

In present study, observed the larvae and adult of *C. sexmaculata* preferred eggs (ovisac) of mealybug and nymph as compared to freshly formed adult mealybug as prey in free choice feeding condition. Which was confirmed with different workers *viz.*, Kaur and virk (2012) reported that fourth instar grubs and adults of *C. montrouzieri* were the most voracious feeders on first instars of mealybug.. Lad *et al.* (2012) reported the consumption of total 306.6 ± 10.79 and 345.60 ± 3.56 nymphs of mealy bug during total larval and adult period. Asifa *et al.* (2013) found that first, second, third, fourth instar grubs of beetle consumed 44.00 and 5.44, 45.00 and 7.11, 54.33 and 8.21, 33.00 and 7.33 medium sized nymph and adult of cotton mealybug. Aggarwal and Neetan (2014) found that the. *C. sexmaculata* beetle consumed first, second, third instar nymphs and adult of mealybug were 1371.10, 361.40, 225.40, and 27.90, respectively during its life cycle. Dumaniya *et al.* (2015) observed that *C. montrouzieri* grub and adult consumed186.52 ± 9.23 and 944.12 ± 31.02 nymphs and 117.24 ± 3.73 and 93.64 ± 3.86 adults of *P. solenopsis.*

CONCLUSION

The larvae and adult of *C. sexmaculata* preferred eggs (ovisac) of mealybug and nymph as compared to freshly formed adult mealybug as prey in free choice feeding condition. There was not much variation in development duration of larvae of *C. sexmaculata* when fed on mixed stages (eggs, nymphs and adults) in no choice feeding then fed on eggs, nymphs and adults of mealybug fed in free choice feeding conditions. However, larvae of *C. sexmaculata* developed little bit slower when fed exceptionally on eggs of mealybug in no choice feeding conditions.

Table 1. Feeding potential of *C. sexmaculata* on different stages of *P. solenopsis* (no choice feeding)

Larval stages of *C. sexmaculata*	No. of larvae exposed	No. of mealy bug consumed			Rate of consumption/day			Developmental duration in days		
		Min.	Max.	Av. ± S. D.	Min.	Max.	Av. ± S. D.	Min.	Max.	Av. ± S. D.
Eggs of Mealy bug as prey										
I instar	20	3.00	12.00	8.35 ± 2.11	2.33	6.00	3.93 ± 0.86	1.00	3.00	2.15 ± 0.49
II instar	20	9.00	16.00	11.95 ± 1.85	4.33	6.50	5.27 ± 0.62	2.00	3.00	2.30 ± 0.47
III instar	20	22.00	48.00	34.50 ± 9.10	11.00	16.00	13.68 ± 1.45	2.00	3.00	2.50 ± 0.51
IV instar	20	29.00	51.00	43.70 ± 7.03	13.67	18.00	15.93 ± 1.05	2.00	3.00	2.75 ± 0.44
Total	80	71.00	118.00	98.50 ± 16.05	35.00	44.00	38.80 ± 2.18	7.00	12.00	9.70 ± 1.56
Adult	20	597.00	931.00	764.00 ± 94.36	25.58	27.03	26.38 ± 0.35	23.00	35.00	28.95 ± 3.41
Nymphs of Mealy bug as prey										
I instar	20	0.00	2.00	1.20 ± 0.52	0.00	2.00	0.73 ± 0.50	1.00	2.00	1.85 ± 0.37
II instar	20	1.00	4.00	1.90 ± 0.91	0.50	1.50	0.89 ± 0.37	2.00	3.00	2.10 ± 0.31
III instar	20	10.00	16.00	13.10 ± 1.92	4.33	6.50	5.33 ± 0.59	2.00	3.00	2.50 ± 0.51
IV instar	20	11.00	34.00	22.50 ± 6.94	5.50	11.33	8.03 ± 1.62	2.00	3.00	2.75 ± 0.44
Total	80	26.00	52.00	38.70 ± 8.35	13.00	18.33	14.97 ± 1.47	5.00	7.00	9.20 ± 0.69
Adult	20	326.00	459.00	400.45 ± 35.34	13.88	15.52	14.83 ± 0.45	22.00	30.00	27.00 ± 2.22
adults of Mealy bug as prey										

I instar	20	0.00	2.00	1.25 ± 0.79	0.00	2.00	0.85 ± 0.56	1.00	2.00	1.45 ± 0.51
II instar	20	1.00	3.00	1.80 ± 0.62	1.00	2.00	1.10 ± 0.31	1.00	3.00	1.80 ± 0.62
III instar	20	5.00	17.00	10.65 ± 2.39	2.50	5.67	3.91 ± 0.81	2.00	3.00	2.75 ± 0.44
IV instar	20	10.00	21.00	15.70 ± 3.20	4.33	7.00	5.73 ± 0.79	2.00	3.00	2.75 ± 0.44
Total	80	20.00	38.00	29.40 ± 4.73	9.67	14.00	11.58 ± 1.14	6.00	10.00	8.75 ± 1.25
adult	20	230.00	401.00	342.90 ± 49.59	10.95	12.79	12.02 ± 0.40	21.00	33.00	28.50 ± 3.87

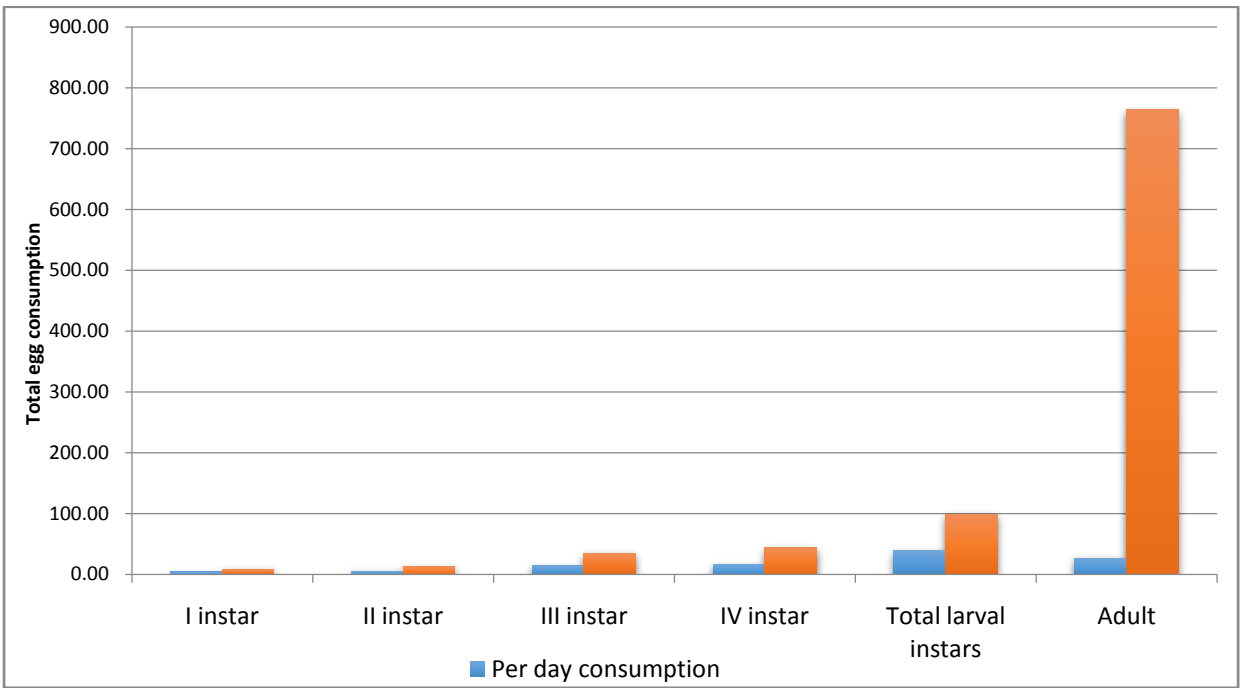

Fig. 1: Feeding potential of larva and adult of *C. sexmaculata* on eggs of *P. solenopsis* Tinsely (No choice condition)

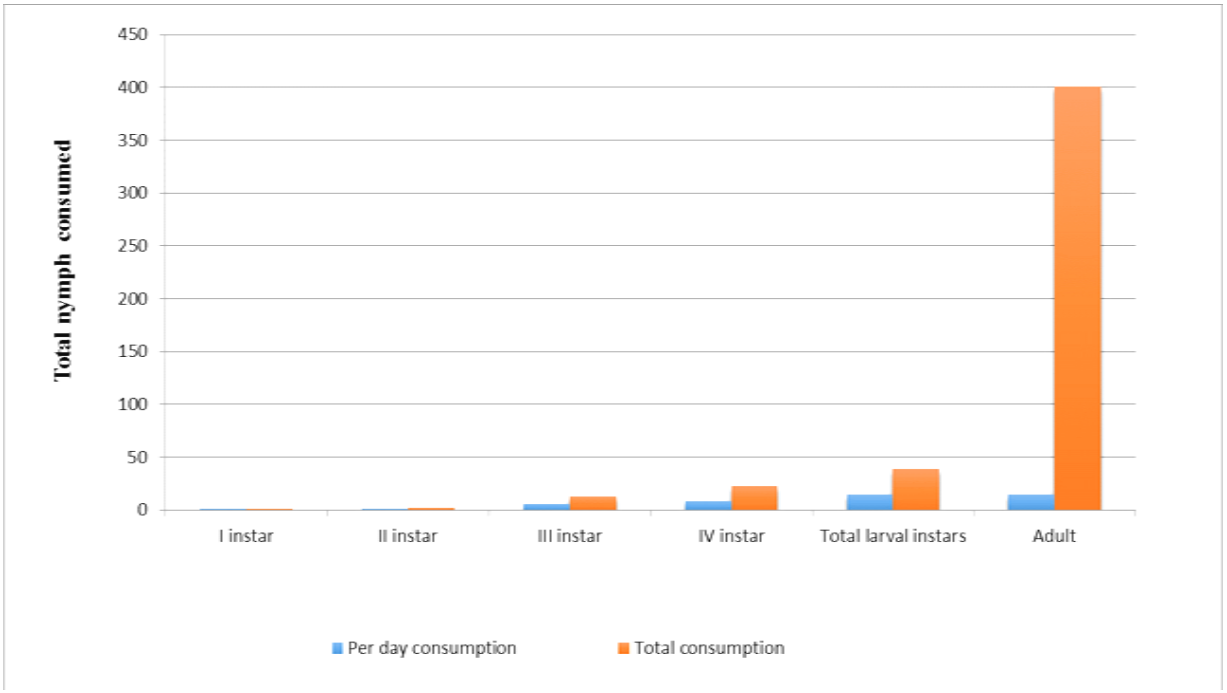

Fig. 2: Feeding potential of larva and adult of *C. sexmaculata* on nymph of *P. solenopsis* Tinsely (No choice condition)

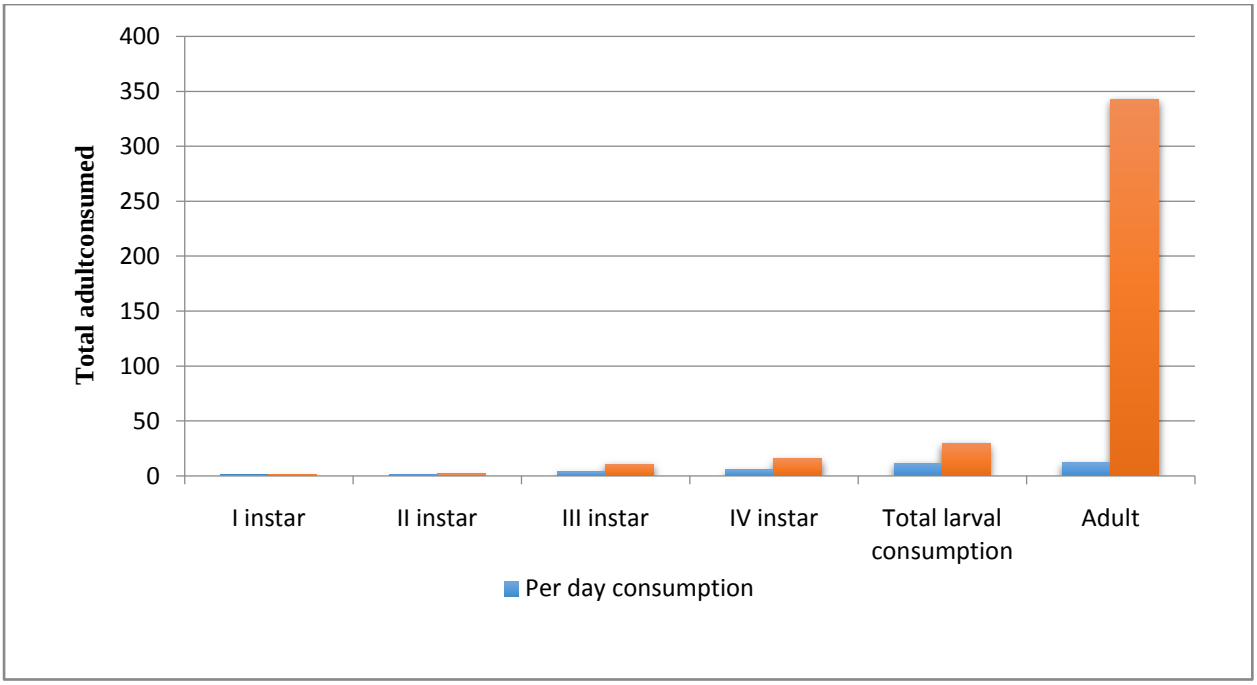

Fig. 3: Feeding potential of larva and adult of *C. sexmaculata* on adult of *P. solenopsis* Tinsely (No choice condition)

Table 2. Feeding potential of larva and adult of *C. sexmaculata on P. solenopsis* (free choice method)

Larval stages of *C. sexmaculata*	Mathematical functions	No. of mixed stages of mealy bug consumed				Rate of consumption (No./day)				Duration in days
		Eggs	Nymphs	Adults	Total	Eggs	Nymphs	Adults	Total	
I instar	Min.	2.00	0.00	0.00	2.00	2.00	0.00	0.00	2.00	1.00
	Max.	9.00	2.00	1.00	10.00	4.50	1.00	1.00	6.00	2.00
	Av ± S. D.	5.10 ± 2.02	1.20 ± 0.62	0.60 ± 0.50	6.90 ± 2.43	3.05 ± 0.72	0.73 ± 0.34	0.38 ± 0.36	4.15 ± 0.88	1.65 ± 0.49
II instar	Min.	4.00	0.00	0.00	4.00	3.50	0.00	0.00	4.00	1.00
	Max.	11.00	3.00	2.00	15.00	5.50	1.50	1.00	7.50	2.00
	Av ± S. D.	8.25 ± 2.45	1.30 ± 0.80	0.85 ± 0.59	10.40 ± 3.22	4.70 ± 0.62	0.73 ± 0.41	0.45 ± 0.32	5.88 ± 0.92	1.75 ± 0.44
III instar	Min.	10.00	1.00	0.00	13.00	10.00	0.50	0.00	12.50	1.00
	Max.	37.00	6.00	3.00	44.00	14.50	2.00	1.50	17.00	3.00
	Av ± S. D.	23.25 ± 8.02	2.75 ± 1.52	1.50 ± 0.83	27.50 ± 9.58	12.23 ± 1.23	1.41 ± 0.45	0.75 ± 0.40	14.39 ± 1.24	1.90 ± 0.64
IV instar	Min.	15.00	1.00	1.00	17.00	11.67	1.00	0.50	14.33	1.00
	Max.	42.00	9.00	5.00	55.00	17.00	4.00	2.50	22.00	3.00
	Av ± S. D.	28.95 ± 9.09	5.50 ± 2.44	2.75 ± 1.37	37.20 ± 12.15	13.94 ± 1.70	2.51 ± 0.64	1.36 ± 0.57	17.81 ± 2.12	2.15 ± 0.81
Total	Min.	35.00	4.00	3.00	42.00	28.83	2.50	1.67	36.83	4.00
	Max.	87.00	18.00	8.00	113.00	38.50	6.67	4.50	48.50	10.00
	Av ± S. D.	65.55 ± 16.63	10.75 ±3.78	5.70 ± 1.75	82.00 ± 21.04	33.93 ± 2.76	5.37 ± 1.02	2.93 ± 0.81	42.23 ± 3.11	7.45 ± 1.85
Adult	Min.	387.00	114.00	77.00	582.00	16.00	4.38	2.83	24.27	23.00
	Max.	574.00	170.00	108.00	840.00	17.60	5.43	3.78	26.00	33.00
	Av ± S. D.	490.55 ± 53.39	139.35±5.65	93.25±7.72	723.15 ± 73.15	17.14±0.25	4.88 ±0.28	3.28±0.25	25.30 ±0.43	28.60 ±2.96

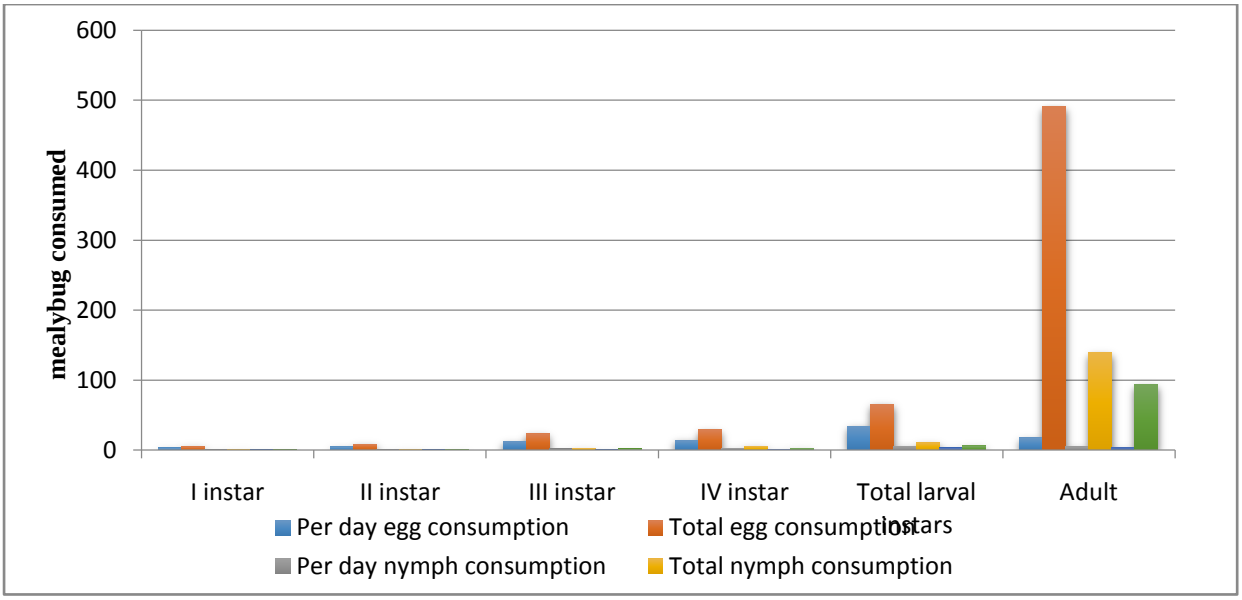

Fig. 4: Feeding potential of larva and adult of *C. sexmaculata* on eggs, nymph and adult of *P. solenopsis* Tinsely (Free choice condition).

REFERENCES

Aggarwal, N. and Neetan (2014). Predatory efficiency of *Cheilomenes sexmaculata* (Fab.) and *Chrysoperla zastrowi sillemi* (Esben-Peterson) on cotton mealybug, *Phenacoccus solenopsis* Tinsley under laboratory conditions.*Acta Phytopathologica et Entomological Hungerica.*,**49**(1): 73-81.

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

Asifa, H., Saleem, M., Haider, K., Saghir, A., Mussarat, H., Wajid, N. Akram, M., Hammad, H., and Shuaib, F. (2013).Life history and predatory potential of eleven spotted beetle (*Coccinella undecimpunctata* Linnaeus) on cotton mealybug (*Phenacoccus solenopsis* Tinsley).*Afr. J. Agric Res.*, **8**(48): 6142-6148.

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

Dumaniya, S. G., Patel, M. B., Siddhapara, M. R. And Kapadiya, I. B. (2015).Feeding potential of lady bird beetle, *Cryptolaemus montrouzieri* (Mulsant) on cotton mealybug, *Phenacoccus solenopsis* (Tinsley).*J. Cotton Res. Dev.*, **29**(2):311-314.

Kaur, H., Virk, J. S. (2012). Feeding potential of *Cryptolaemus montrouzieri* against the mealybug *P. solenopsis.Phytoparasitica.*, **40**(2): 131–136.

Lad, S. K., Patil, P. D., and Narangalkar, A. L. (2012).Feeding potential of *cryptolaemus montrouzieri* (mulsant) on mealy bug *maconellicoccus hirsutus* (green) under climatic conditions of Konkan, Maharashtra (India).*J. Appl. Zool. Res.*,**23**(2): 112- 114.

Lohar, M.K. and Khuhro, R.D. (2005). First Annual Report on Mass rearing of Coccinellid Predators on different insect pests, Submitted to Higher Education Commission, Islamabad and Sindh Agric. Univ. Tandojam, Pakistan. 211p.

Omkar, S. and Pervez, A. (2000).Biodiversity in predaceous coccinellids in India.*A review. J. Aphido*. **14**(1&2): 41-66.

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

Shepard, B. M. (1998). Insects and their natural enemies association with vegetables and soybean in Southeast Asia.Quality Printing Co. Orangeburg, South Carolina, U.S.A. pp. 22-24.

Solangi, G.S., Mahar, G.M. and Oad, F.C. (2008). Presence and abundance of different insect predators against suckinginsect pest of cotton. J. Entomol. 5(1): 31-37.

Tinsley, J. D. (1898). Notes on Coccidae, with descriptions of new species.*Canadian Ento.*, **30**: 317-320.