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Predatory potential of Australian lady bird beetle *Cryptolaemus montrouzieri* Mulsant on papaya mealybug

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Abstract
Predatory potential of *Cryptolaemus montrouzieri* on different stages of papaya mealybug was studied. The mean predatory potential of I, II, III and IV instar grub on Ovisac, I, II and III instar nymphs of mealybug was 1.40±0.12, 30.60±0.51, 20.53±0.98 and 13.46±1.15; 1.68±0.13, 43.52±0.41, 30.40±0.68 and 17.33±0.88; 1.90±0.14, 47.04±0.84, 31.56±0.51 and 20.45±0.84 and 1.91±0.15, 54.10±0.45, 38.20±0.58 and 26.32±1.13. Average consumption capacity of male and female on ovisac, I, II and III instar nymphs was 2.98±0.09, 57.81±0.24, 41.39±0.12 and 28.51±0.02 and 3.05±0.10, 58.19±0.26, 43.00±0.19 and 29.28±0.08, respectively.

Keywords: Predatory potential, *Cryptolaemus montrouzieri*, Papaya mealybug

Introduction
Papaya is infested by several insect pests of which mealybug cause major losses to the yield. The papaya mealybug *Paracoccus marginatus* Williams and Granara de Willink 1992 (Hemiptera: Pseudococcidae), is a notorious pest of papaya. It is a highly polyphagous pest of 133 plant species belonging to 48 families [13].

The mealybug is called as "hard to kill pest of fruit crops" [8]. However, there are several reasons which may account for this fact. So far, various pesticides have been attempted for the management of mealybug either singly or in combinations but did not give desired control of the pest. The reason is that only those sheltering in the crevices of the bark escape and re-establish their population quickly [5]. The most important factors are their habitat and the waxy coating present on the body. The waxy coating present on their body limits the efficiency of insecticides.

Regarding natural control, the entomophages occurring in the nature bring nearly about 60 per cent of the natural control of pest provided, they are not destroyed by the use of chemicals [9].

Among the predators of mealybugs, the Australian lady beetle, *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) has been reported to be a general predator of mealybugs at all stages of its development. Both the stages of the predator that is grub and adult are voracious feeder of all the stages of mealybug. It is commonly referred as mealybug destroyer. It has been employed as the possible solution for combating the menace of the pest around the world.

It is native of Australia and was introduced in California for the control of citrus mealybug. Following the success, the beetle was introduced in India in 1898 by H.O. Newport to control the coffee green scale [6]. Though, the predator did not establish on green scale, it was responsible to check mealybug in coffee growing zones [2, 4].

The biological suppression of mealybugs through this potent predator in India was well documented [12, 1]. In other countries, *C. montrouzieri* had proved effective as it is evident from the study of [16] that succeeded in keeping under the destructive mealybugs in California by large scale multiplication of beetles. It has played a major role in the control of different sucking pests especially mealybugs [15, 3].

The insecticides are used in higher concentrations as well as along with stickers to manage this pest. This leads to higher residue problem especially in fruit crops. The consumer of domestic as well as international markets prefer the fruits that are having minimum insecticide residue. This condition limits the use of insecticides for management of mealybug. The effective and safer method to manage this pest is said to be the biological control [11].

Considering the importance of management of papaya mealybug, it is highly essential to study the *C. montrouzieri* as biological agent on *P. marginatus.* Studies are lacking in the aspects of predatory potential. Hence, the present work was proposed.

Materials and Methods

Laboratory multiplication of papaya mealybug, *Paracoccus marginatus*

The papaya mealybug (PMB), *Paracoccus marginatus* was used as prey throughout the study period. Mass multiplication of papaya mealybug, *Paracoccus marginatus* was done on potato sprouts under laboratory conditions at 25 ± 2 °C and 75 ± 2% RH.

Maintenance of potato sprouts

Potatoes were used as an alternate food source for rearing of mealybugs [14]. Seed potatoes with eyes were brought from local market at Tirupati, washed and disinfected in 5 per cent sodium hypochlorite solution. After cleaning, the potatoes were treated with Gibberellic acid 100 ppm solution for half an hour and placed under dark condition in wet gunny bags for four to five days to induce sprouting. Later, these sprouted potatoes were transferred to rearing cages for inoculation of PMB

Inoculation of PMB on potato sprouts

P. marginatus colonies were collected from the infested papaya plants from surroundings of Tirupati. The colonies were transferred on to the sprouted potatoes using camel hair brush or entire infested leaves were placed over the sprouted potatoes for two to three days. The sprouted potatoes became fully infested within 20-30 days

Mass Rearing and Biology of the Predator, *C. montrouzieri*

Initial culture of *C. montrouzieri* was obtained from National Institute of Plant Health Management (NIPHM), Hyderabad and reared in laboratory on mealybug, *P. marginatus.*

Freshly emerged adults of *C. montrouzieri* were released and maintained on the sprouted potatoes infested with *P. marginatus* in the same rearing cages. Freshly laid eggs and grubs were gently removed with the help of camel hair brush and used for further studies and multiplication.

In order to determine the predatory potential of predator, the laboratory experiment was conducted in Completely Randomized Design with four treatments (egg and nymphal stages of PMB) repeated five times (single individual in each replication).

Individual larva of *C. montrouzieri* was fed with known number of respective host stages right from first day of egg-hatching, until grubs pupate and adults died (predatory grubs and adults was starved for 12 hours prior to feeding). Initially few hosts were provided as food but increased proportionally with the advancement of larval stage.

Observations were recorded at an interval of 24 hours on number of preys consumed by the grubs and adults. It was computed by subtracting the number of mealybugs left out from total number of insects provided.

Experimental details was represented in the Table 1

Table 1: Predatory potential of different stages of *C. montrouzieri* on different stages of PMB

Stage of predator	Stage of prey
1st Instar *C. montrouzieri*	Ovisac of *P. marginatus*
1st Instar *C. montrouzieri*	1st Instar of *P. marginatus*
1st Instar *C. montrouzieri*	2nd Instar of *P. marginatus*
1st Instar *C. montrouzieri*	3rd Instar of *P. marginatus*
2nd Instar *C. montrouzieri*	Ovisac of *P. marginatus*
2nd Instar *C. montrouzieri*	1st Instar of *P. marginatus*
2nd Instar *C. montrouzieri*	2nd Instar of *P. marginatus*
2nd Instar *C. montrouzieri*	3rd Instar of *P. marginatus*
3rd Instar *C. montrouzieri*	Ovisac of *P. marginatus*
3rd Instar *C. montrouzieri*	1st Instar of *P. marginatus*
3rd Instar *C. montrouzieri*	2nd Instar of *P. marginatus*
3rd Instar *C. montrouzieri*	3rd Instar of *P. marginatus*
4th Instar *C. montrouzieri*	Ovisac of *P. marginatus*
4th Instar *C. montrouzieri*	1st Instar of *P. marginatus*
4th Instar *C. montrouzieri*	2nd Instar of *P. marginatus*
4th Instar *C. montrouzieri*	3rd Instar of *P. marginatus*
Adult *C. montrouzieri* (male or female)	Ovisac of *P. marginatus*
Adult *C. montrouzieri* (male or female)	1st Instar of *P. marginatus*
Adult *C. montrouzieri* (male or female)	2nd Instar of *P. marginatus*
Adult *C. montrouzieri* (male or female)	3rd Instar of *P. marginatus*

Results and Discussion

The grubs and adults of *Cryptolaemus montrouzieri* were found to be active predators of mealybugs. The predatory potential of grubs and adults were studied by providing different stages *i.e.* ovisacs, I, II and III instar nymphs of papaya mealybug.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by I instar grub of *C. montrouzieri* was 1.40 ± 0.12, 30.60 ± 0.51, 20.53 ± 0.98 and 13.46 ± 1.15 (Table 4). The total consumption capacity of I instar grub of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 5.60 ovisacs, 122.40, 61.60 and 40.40 nymphs (Table 2), respectively.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by II instar grub of *C. montrouzieri* was 1.68 ± 0.13, 43.52 ± 0.41, 30.40 ± 0.68 and 17.33 ± 0.88 (Table 4). The total consumption capacity of II instar grub of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 8.40 ovisacs, 217.60, 121.60 and 52 nymphs (Table 2), respectively.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by III instar grub of *C. montrouzieri*

was 1.90 ± 0.14, 47.04 ± 0.84, 31.56 ± 0.51 and 20.45 ± 0.84 (Table 4). The total consumption capacity of III instar grub of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 11.40 ovisacs, 235.20, 157.80 and 81.80 nymphs (Table 2), respectively.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by IV instar grub of *C. montrouzieri* was 1.91 ± 0.15, 54.10 ± 0.45, 38.20 ± 0.58 and 26.32 ± 1.137 (Table 4). The total consumption capacity of IV instar grub of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 13.40 ovisacs, 324.60, 229.20 and 131.60 nymphs (Table 2), respectively.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by adult male of *C. montrouzieri* was 2.98 ± 0.09, 57.81 ± 0.24, 41.39 ± 0.12 and 28.51 ± 0.02 (Table 4). The total consumption capacity of adult male of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 188.00 ovisacs, 3526.41, 2317.84 and 1425.5 nymphs (Table 3), respectively.

The mean number of ovisacs, I, II and III instar nymphs of *P. marginatus* consumed by adult female of *C. montrouzieri* was 3.05 ± 0.10, 58.19 ± 0.26, 43.00 ± 0.19 and 29.28 ± 0.08 (Table 4). The total consumption capacity of adult female of *C. montrouzieri* on ovisacs, I, II and III instar nymphs of *P. marginatus* was 211.40 ovisacs, 3898.73, 2709.00 and 1610.40 nymphs (Table 3), respectively.

The predatory potential of each instar was gradually increased from first to fourth instar. Whereas, the predatory potential of adult male and female was almost similar but the difference was due to the difference in longevity of male and female. Hence, females were more predaceous than males. Results revealed that there is significant difference in predatory potential among different stages of *C. montrouzieri*. [10] reported that under no choice feeding the predatory potential of I instar of *C. montrouzieri* was 4.38, 124.75, 67.00 and 31.88, II instar was 7.13, 174.25, 97.00 and 54.13, III instar was 9.63, 218.00, 169.25 and 83.25 and IV instar was 13.13, 337.50, 209.25 and 137.38, on ovisac, first, second and third instar nymphs of *P. marginatus* respectively.

The present results are in close agreement with [7] who reported that the females of *C. montrouzieri* consumed more number of ovisacs and nymphs of *P. marginatus* when compared to that of males.

Table 2: Consumption capacity of grub of *Cryptolaemus montrouzieri* on life – stages of *Paracoccus marginatus*

Parameters of *C. montrouzieri*	Life stages of *P. marginatus*			
	Ovisac	**1st instar**	**2nd instar**	**3rd instar**
Duration of 1st instar grub(days)	4.40	3.60	3.20	2.80
Total prey consumption by 1st instar grub	5.60	122.40	61.60	40.40
Consumption by 1st instar grub per day	1.40	30.60	20.53	13.47
Duration of 2nd instar grub(days)	5.40	4.80	3.80	3.40
Total prey consumption by 2nd instar grub	8.40	217.60	121.60	52.00
Consumption by 2nd instar grub per day	1.68	43.52	30.40	17.33
Duration of 3rd instar grub(days)	6.60	5.40	5.60	4.40
Total prey consumption by 3rd instar grub	11.40	235.20	157.80	81.80
Consumption by 3rd instar grub per day	1.90	47.04	31.56	20.45
Duration of 4th instar grub(days)	7.60	6.40	5.80	4.20
Total prey consumption by 4th instar grub	13.40	324.60	229.20	131.60
Consumption by 4th instar grub per day	1.91	54.10	38.20	26.32
Duration of 1st to 4th instar(days)	24.00	20.20	18.40	14.80

Table 3: Consumption capacity of adult beetles of *Cryptolaemus montrouzieri* on life stages of *Paracoccus marginatus*

Parameters of *C. montrouzieri*	Life stages of *P. marginatus*			
	Ovisac	**1st instar**	**2nd instar**	**3rd instar**
Duration of male adult beetle (days)	66.00	61.00	56.00	50.00
Total prey consumption by male adult beetle	188.00	3526.41	2317.84	1425.50
Consumption by male adult beetle per day	2.98	57.81	41.39	28.51
Duration of female adult beetle (days)	71.00	67.00	63.00	55.00
Total prey consumption by female adult beetle	211.40	3898.73	2709.00	1610.40
Consumption by female adult beetle per day	3.05	58.19	43.00	29.28

Table 4: Predatory potential of *Cryptolaemus montrouzieri* on different instars of *Paracoccus marginatus*

Different stages of *C. montrouzieri*	Mean consumption of different instars of mealybug per day (Mean ± SE(m))				
	ovisac	**1st instar nymph**	**2nd instar nymph**	**3rd instar nymph**	**SE(m)**
I instar	1.40 ± 0.12	30.60 ± 0.51	20.53 ± 0.98	13.46 ± 1.15	0.80
II instar	1.68 ± 0.13	43.52 ± 0.41	30.40 ± 0.68	17.33 ± 0.88	0.60
III instar	1.90 ± 0.14	47.04 ± 0.84	31.56 ± 0.51	20.45 ± 0.84	0.65
IV instar	1.91 ± 0.15	54.10 ± 0.45	38.20 ± 0.58	26.32 ± 1.37	0.78
Adult male	2.98 ± 0.09	57.81 ± 0.24	41.39 ± 0.12	28.51 ± 0.02	0.14
Adult female	3.05 ± 0.10	58.19 ± 0.26	43.00 ± 0.19	29.28 ± 0.08	0.15

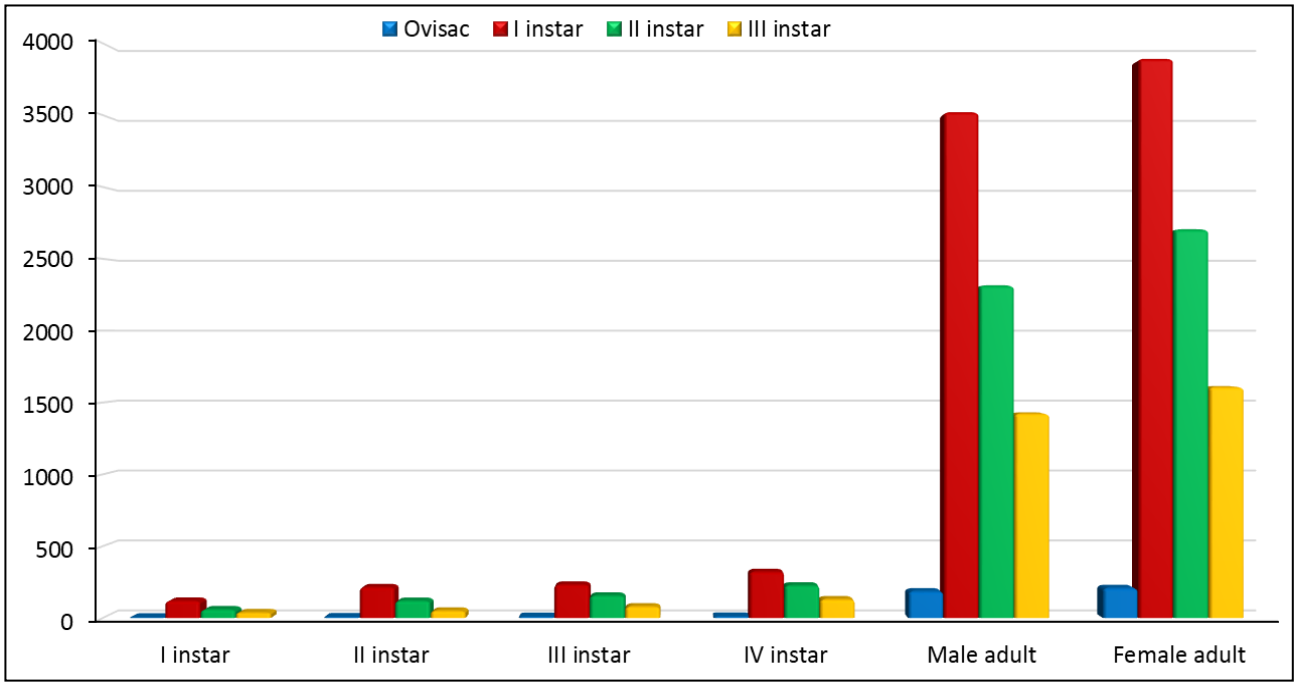

Fig 1: Different stages of predator, *C. montrouzieri*

Conclusion

Among various instars of the predator lady bird beetle, *Cryptolaemus montrouzieri* the third and fourth instar grubs were voracious on different stages of *P. marginatus*. The feeding potential was increased from first instar to fourth instar. Among males and females of the predator, females were voracious feeders when compared to that of males.

The results concluded that *C. montrouzieri* can be effectively utilized as a biocontrol agent in the management of Papaya mealybug. Further, field studies are needed to confirm the predatory potential.

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