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# BIOLOGY OF LADY BIRD BEETLE, *CRYPTOLAEMUS MONTROUZIERI* (MULSANT) ON COTTON MEALY BUG, *PHENACOCCUS SOLENOPSIS* (TINSLEY)

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**ABSTRACT**
Investigation on biology of *Cryptolaemus montrouzieri* (Mulsant) on cotton mealy bug, *Phenacoccus solenopsis* (Tinsley) revealed that it did not lay eggs in the mealy bug colonies under the laboratory conditions when reared on *P. solenopsis*. However, the eggs were laid on the surface of pink hibiscus flowers. The eggs were spindle shaped and pale yellow in colour. The average incubation period and hatching percentage were 5.12 ± 0.87 days and 92.61 ± 3.93 per cents, respectively. The larvae passed through four instars. The average developmental period of first, second, third and fourth instar larva was 3.04 ± 0.28, 2.34 ± 0.48, 3.06 ± 0.24 and 4.18 ± 0.48 days, respectively. The average total larval period was 12.62 ± 1.67 days, while prepupal and pupal period were 1.88 ± 0.39 and 6.98 ± 0.58 days, respectively. The average pre-oviposition, oviposition and post-oviposition period were 5.68 ± 1.10, 41.04 ± 2.26 and 5.26 ± 1.21 days, respectively. The average fecundity of the female was 303.76 ± 17.22 eggs. The average longevity of male and female was 42.32 ± 2.03 and 51.98 ± 2.68 days, respectively. Total life cycle occupied on an average of 68.92 ± 2.37 days by male and 78.58 ± 2.98 days by female. The sizes of various stages of *C. montrouzieri* were also recorded.

## INTRODUCTION

Cotton, *Gossipium hirsutum* L. is an important natural fiber crop cultivated in varying climatic conditions of tropics as well sub-tropic regions over the world. Cotton plays a key role in the national economy in terms of generation of direct and indirect employment in the agricultural and industrial sectors. Due to ready availability of Bt-cotton seeds since 2002 and apparent advantages over non-Bt counterparts, it spread rapidly in India within short span of time. Changes in insect pest complex were evident with changed micro-climate. A new pest, mealybug which was hitherto not familiar earlier started destroying cotton crops caused economic damage, reducing yields up to 40-50% in affected fields since 2006 (Dhara *et al.*, 2008). In a survey conducted by Nagrare *et al*. (2009) showed that two mealybug species, the solenopsis mealybug, *P. solenopsis*, and the pink hibiscus mealybug, *Maconellicoccus hirsutus*, were found to infest cotton plants. However, *P. solenopsis* was found to be the predominant mealybug species, comprising 95% of the samples examined.

The management strategy for each type of pest being different, management operations are complex and highly technical. Among the various methods of pest management, the biological control is a living weapon over chemical control and is prestigious adoption at global level.

Biological control is relatively, permanent, safe, economical and eco-friendly. Parasitoids, predators and pathogens play a great role in the biological suppression of crop pests. Among predators, coccinellids are of great importance, since they have proved their value in checking pest populations *viz*; mealybugs, scales, aphids, coccids, etc. Several predators like *Chrysoperla carnera*, *Micromus*, *Dipha aphidivora*, *Cryptolaemus montrouzieri* Mulsant and *Scymnus coccivora* Mulsant are good examples of Bio-control agent. They are predators of mealybugs and many soft bodied insects like scale insect, aphid, whitefly, woolly aphid, etc (Jalali and Singh, 1989).

*C. montrouzieri* (Coleoptera: Coccinellidae) is a common predator of mealybugs, first reported from Eastern Australia hence, commonly known as Australian ladybird beetle. It was introduced into India in 1898 against coffee green scale, *Coccus viridis* Green and field releases made against coffee mealybug, *Planococcus citri* (Risso) and *P. lilacinus*. The predator was unnoticed in India for many years. In July 1951, it appeared in large scale on Araucaria trees infested with *Eriococcus araucariae* Mask around Bangalore. Later, it was reported as a common predator of many species of mealybugs and to some extent on scales and also known as mealybug destroyer (Mani and Krishnamoorthy, 1997).

In spite of prosperous biodiversity of this important indigenous predator, very scanty information is available on biology of *C. montrouzieri* on the cotton mealybug, *P. solenopsis*. It would

be useful in understanding bioagent behavior and devising ecofriendly management strategies based on the situation to save the cotton and other important crops infested by mealybug. To fill up the lacunae and imminent the knowledge on this aspect, the present study was undertaken.

## MATERIALS AND METHODS

Initial culture of *C. montrouzieri* adults were obtained from Bio-control Laboratory, Department of Agricultural Entomology, N.M. Collage of Agriculture, Navsari Agricultural University, Navsari. The adult beetles were kept in transparent glass jar (25cm in height and 10cm in diameter) and they were provided with mealy bugs (*P. solenopsis*) on cotton shoot and a flower of pink hibiscus for egg laying. A cotton swab soaked in water was placed in the container to maintain humidity. Cotton shoot along with mealy bugs and cotton swab were changed daily. Freshly laid eggs of *C. montrouzieri* laid on flower of pink hibiscus were removed individually with the help of fine camel hair brush and placed in separate petri dishes (75mm) and used for further multiplication. Egg period of *C. montrouzieri* were considered as a period between date of egg lying and date of egg hatching. With a view to determine the number and duration of different larval instars, the newly hatched larva of *C. montrouzieri* were transferred and kept individually in the plastic petri dishes (75mm) and fed with cotton mealy bugs, *P. solenopsis*. Moulting was confirmed by the presence of casted off skin of larva of subsequent instars. The total larval period was calculated from the date of egg hatching to the date of formation of pre-pupa. To know the pre-pupal period of *C. montrouzieri*, observations were taken every day in the morning (8:00 to 10:00am) during the larval development. The duration between formations of pupa to the emergence of adult was considered as pupal period. The colour and shape of eggs, larvae and pupa were observed. The size of egg and larva were measured under microscope with the help of ocular and stage micrometer while in case of pupa it was measured with the help of scale. Adults emerged from pupa were observed for their colour, shape and size. The male and female of *C. montrouzieri* were measured under binocular micrometer. The observations were also recorded on sex ratio, fecundity, pre-oviposition, oviposition and post-oviposition periods at 26.44 ± 0.74ºC temperature and 52.62 ± 2.46 relative humidity.

## RESULTS AND DISCUSSION

The results obtained during the present investigations are presented and discussed here under.

**Eggs:** During the present study, it was observed that *C. montrouzieri* did not laid eggs in the mealy bug colonies. In laboratory condition, the eggs were laid on the surface of pink hibiscus flowers. Earlier, Mani and Krishnamoorthy (1997) who reported that the adult female of *C. montrouzieri* laid its eggs in the mealy bug colonies when it was reared on pink mealy bug, *M. hirsutus*. While in case of present investigation, the colour of *P. solenopsis* was whitish hence females of *C. montrouzieri* preferred the pink coloured hibiscus flower for egg laying under the laboratory condition. This difference might be due to pink colour of hibiscus flower. The eggs were laid singly or in groups of 6 to 10. In past, Mani and Krishnamoorthy (1997) reported similar type of observations on *C. montrouzieri*. The egg laid by *C. montrouzieri* female was small, pale yellowish in colour. It was oval-cylindrical and smoothly rounded at both the ends. A similar description of eggs was also reported by Anonymous (1988) on *C. montrouzieri*. The data on measurement of length and breadth of the eggs presented in Table 1 revealed that the length of eggs varied from 0.69 to 0.77mm with an average of 0.73 ± 0.02mm, whereas the breadth varied from 0.36 to 0.39mm with an average of 0.37 ± 0.01 mm. More or less similar observations in length and breadth of eggs were also recorded by Diraviam and Viraktamath (1991) who reported that length of eggs of *Curinus soeruleus* Mulsant varied from 0.99 to 1.1mm while, breadth varied from 0.3 to 0.4mm. Thus, the report of above workers support the present findings.

The incubation period under laboratory condition varied from 4 to 7 days with an average of 5.12 ± 0.87 days (Table 2). The incubation period reported by various investigators was 4 to 6 days for *C. montrouzieri* (Liotta and Mineo, 1963) and 5 to 6 days for *C. montrouzieri* (Anonymous, 1988). The hatching percentage of eggs of *C. montrouzieri* varied from 81.58 to 98.00 per cent with an average of 92.61 ± 3.93 (Table 2). The present findings are more or less similar with the findings of Anonymous (1988) who reported hatching percentage of *C. montrouzieri* to be 90 to 100 per cent.

**Larva:** In order to study the various larval instars of *C. montrouzieri*, the larvae were reared on mealy bugs, *P. solenopsis* till they pupated. The data obtained on various biological parameters of different larval instars are presented in Table 1 and 2.

During the present studies, *C. montrouzieri* was observed to pass through four larval instars. The tiny grub was pale grayish with white lines across the body along intra segmental regions. These white lines became prominent after few h and white wax strands developed after a day. Freshly moulted second instar larva was oval in shape and grayish in colour. The white wax strands became clearly visible within 2 to 3h. Larvae were flat and somewhat convex dorsally. The third instar larva was similar in general appearance to second instar larva, except larger in size. In third instar larva the white wax strands were little larger then in second instar. The fourth instar larva was similar in general appearance to third instar larva, excluding larger in size. Here also, the white wax strands were little larger than in third instar and when the larva was disturbed, it exudes a yellow fluid from the dorsal surface of the body for defensive purpose. The length of first instar larva ranged from 1.17 to 1.26mm with an average of 1.22 ± 0.02mm, while breadth varied from 0.47 to 0.53mm with an average of 0.50 ± 0.02 mm. Thus, the present findings are in more or less in conformation with findings of Shinde *et al*. (2009) who reported an average length and breadth of first instar of *P. trinotatus* to be 0.76 ± 0.04mm and 0.30 ± 0.04mm, respectively. The length of second instar larva ranged from 3.80 to 5.00 mm (Av. 4.55 ± 0.37mm) while breadth varied from 1.00 to 1.25mm (Av. 1.14 ± 0.07mm). The present findings are more or less in conformation with findings of Shinde *et al*. (2009) who reported that average length of second instar larvae of *P. trinotatus* was 1.32 ± 0.05mm and

**Table 1: Morphometrics of various stages of *C. montrouzieri***

| Sr. No. | Stage | Length (mm) | | | Breadth (mm) | | |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Av. ± S.D. | Min. | Max. | Av. ± S.D. |
| 1 | Eggs | 0.69 | 0.77 | 0.73 ± 0.02 | 0.36 | 0.39 | 0.37 ± 0.01 |
| 2 | Larva | | | | | | |
| | I instar | 1.17 | 1.26 | 1.22 ± 0.03 | 0.47 | 0.53 | 0.50 ± 0.02 |
| | II instar | 3.80 | 5.00 | 4.55 ± 0.37 | 1.00 | 1.25 | 1.14 ± 0.07 |
| | III instar | 5.60 | 6.20 | 5.96 ± 0.16 | 1.70 | 2.20 | 1.97 ± 0.16 |
| | IV instar | 7.80 | 8.30 | 8.08 ± 0.16 | 3.85 | 4.15 | 4.00 ± 0.09 |
| 3 | Pre-pupa | 7.80 | 8.35 | 8.11 ± 0.17 | 3.90 | 4.15 | 4.04 ± 0.07 |
| 4 | Pupa | 7.70 | 4.15 | 8.02 ± 0.17 | 3.85 | 4.10 | 3.98 ± 0.07 |
| 5 | Adults | | | | | | |
| | Male | 3.90 | 4.15 | 4.01 ± 0.07 | 2.85 | 3.11 | 2.98 ± 0.08 |
| | female | 3.70 | 3.90 | 3.80 ± 0.07 | 2.78 | 2.99 | 2.86 ± 0.06 |

* n = 20

**Table 2: Biological parameters of *C. montrouzieri* on *P. solenopsis* under laboratory condition***

| Sr. No. | Particulars | Periods (Days) | | |
|---|---|---|---|---|
| | | Min. | Max. | Av. ± S.D. |
| 1 | Incubation period (Days) | 4 | 7 | 5.12 ± 0.87 |
| 2 | Hatching percentage | 81.58 | 98 | 92.61 ± 3.93 |
| 3 | Larval period (Days) | | | |
| | I instar | 2 | 4 | 3.04 ± 0.28 |
| | II instar | 2 | 3 | 2.34 ± 0.48 |
| | III instar | 3 | 4 | 3.06 ± 0.24 |
| | IV instar | 3 | 5 | 4.18 ± 0.48 |
| | Total larval period (Days) | 11 | 14 | 12.62 ± 1.67 |
| 4 | Pre-pupal (Days) | 1 | 3 | 1.88 ± 0.39 |
| 5 | Pupal period (Days) | 6 | 8 | 6.98 ± 0.58 |
| 6 | Pre-oviposition period (Days) | 4 | 7 | 5.68 ± 1.10 |
| 7 | Oviposition period (Days) | 36 | 45 | 41.04 ± 2.26 |
| 8 | Post-oviposition period (Days) | 3 | 7 | 5.26 ± 1.21 |
| 9 | Adult emergence (%) | 80.00 | 92.86 | 89.32 ± 3.79 |
| 10 | Sex ratio (Male: Female) | 1: 0.66 | 1: 1.40 | 1: 1.00 |
| 11 | Adult longevity (Days) | | | |
| | Male | 37 | 47 | 42.32 ± 2.03 |
| | Female | 45 | 58 | 51.98 ± 2.68 |
| 12 | Total life cycle (Days) | | | |
| | Male | 64 | 74 | 68.92 ± 2.37 |
| | Female | 72 | 84 | 78.58 ± 2.98 |
| 10 | Fecundity | 278 | 348 | 303.76 ±17.22 |
| 11 | Temperature (°C) | 24.9 | 28.0 | 26.44 ± 0.74 |
| 12 | Relative humidity (%) | 65.3 | 74.5 | 70.24 ± 2.08 |

* Based on 50 observations

breadth was 0.76 ± 0.04mm breadth. The length of third instar larva varied from 5.6 to 6.2 mm with an average of 5.96 ± 0.16 mm, while breadth varied from 1.7 to 2.2mm with an average of 1.97 ± 0.16mm. These findings are vary with the findings of Shinde *et al*. (2009) who worked on another coccinellid, *P. trinotatus* and reported that the length and breadth of third instar larva varied from 2.38 to 2.60 mm (Av. 2.48 ± 0.07mm) and 1.28 to 1.40 mm (Av. 1.34 ± 0.03 mm), respectively. The length of fourth instar larva varied from 7.8 to 8.3 mm (Av. 8.08 ± 0.16 mm), while the breadth varied from 3.85 to 4.15 mm (Av. 4.04 ± 0.09 mm). The duration of first instar larva varied from 2 to 4 days with a mean of 3.04 ± 0.28. In past, Anonymous (1983) reported the larval duration of *C. montrouzieri* was 3 to 4 days while, Anonymous (1988) reported the average duration of first instar larva of *C. montrouzieri* was 3.50 days when reared on *Meconellicoccus hirsutus* (Green). Thus, the present findings tallies with the reports of Anonymous (1983) and Anonymous (1988). The duration of second instar larvae varied from 2 to 3 days with an average of 2.34 ± 0.48 days. According to Anonymous (1988), the average duration of second instar larva of *C. montrouzieri* was 2.20 days which are in close agreement with the present findings. The duration of third instar larva varied from 3 to 4 days with an average of 3.06 ± 0.24 days. Previously, it was reported as 4 to 5 by Anonymous (1983) and 4.10 days by Anonymous (1988) which is more or less in support to present findings. The duration of fourth instar larva of *C. Montrouzieri* varied from 3 to 5 days with an average of 4.18 ± 0.48 days. The present findings are more or less in conformation with the reports of Anonymous (1988) who reported it as 4.95 days, where as it vary with the reports of Anonymous (1983) might be due to different rearing condition of particular location or different host insect nutrition.

The total larval developmental period of *C. montrouzieri* varied from 11 to 14 days with an average of 12.62 ± 1.67 days when reared on *P. solenopsis*. The larval period of *C. montrouzieri* was 12 to 17 days when it was reared on *P. citri* (Liotta and Mineo, 1963), while the average duration of larva

of *C. montrouzieri* was 20 days when reared on *M. hirsutus* (Anonymous, 1988).

**Pre-pupa:** The final instar larva stopped feeding and then searched for a suitable place and became stationary. This was the beginning of prepupal stage. The caudal region was firmly attached to the substratum; the body was shrunken during the formation of pre-pupa. Pre-pupa formed by *C. montrouzieri* larva was oval in shape with loose connection of white strands. The colour of pre-pupa was similar to the last larval instar. The length of pre-pupa of *C. montrouzieri* varied from 7.80 to 8.35 mm with a mean of 8.11 ± 0.17 mm, while the breadth ranged from 3.90 to 4.15 mm with an average of 4.04 ± 0.07 mm (Table 1). The duration of prepupal stage varied from 1 to 3 days with an average of 1.88 ± 0.39 days (Table 2). The pre-pupal period of *C. montrouzieri* was reported as 3 to 4 days (Anonymous, 1983); 2 to 4 days (Anonymous, 1988) and 2 days (Mani and Krishnamoorthy, 1997) which more or less in conformation with the present findings.

**Pupa:** When the larva was about to pupate, the white wax strands were separated from the body in the middle, turned orange to grayish in colour and attached itself on dry leaf surface. The pupa measured about 7.70 to 8.25 mm in length with an average of 8.02 ± 0.17 mm and 3.85 to 4.10 mm in breadth with an average of 3.98 ± 0.07 mm (Table 1). The duration of pupal stage varied from 6 to 8 days with an average of 6.98 ± 0.58 days (Table 2). According to Liotta and Mineo (1963), Anonymous (1983) and Anonymous (1988) the pupal duration of *C. montrouzieri* was 6 to 13, 7 to 8.70 and 7 to 9 days, respectively which is more or less similar to present findings (Table 2).

**Adults:** The newly emerged adults were soft, reddish yellow in colour and adult spent about one day in the pupal case before it emerges during which their body hardened and the elytra turned shining black. After coming out from pupal case, it was covered with a white powder like substance for a day. The beetle was small, oval and convex dorsally and flat ventrally. Males were smaller in size than females and the first pair of legs in the case of male beetle was brown, two pairs being black, whereas in the female all the three pairs being black. The last abdominal segment of male beetle was roundish, while in case of female it was pointed. So, by this way the males and females could easily be distinguished. The length of female varied from 3.90 to 4.15 mm with an average of 4.01 ± 0.07 mm and breadth varied from 2.85 to 3.11 mm with an average 2.98 ± 0.08 mm. In case of male, the length varied from 3.72 to 3.90 mm (Av. 3.80 ± 0.07) and breadth varied from 2.78 to 2.99 mm (Av. 2.86 ± 0.06 mm). Mani and Krishnamoorthy (1997) reported the average length of adult of *C. montrouzieri* as 4 mm. Thus, the findings of above workers support the present findings.

The per cent adult emergence varied from 80.00 to 92.86 with a mean of 89.32 ± 3.79. Based on the morphological characters mentioned earlier the adults were differentiated into their Saxes. Out of 320 adults emerged from laboratory mass culture during the period of study, 160 were males 160 were females. The sex ratio (Male: Female) worked out varied from 1: 0.66 to 1: 1.40 with an average of 1: 1.00. The present findings are close agreement with Anonymous (1988) and Mani and Krishnamoorthy (1997) who reported sex ratio (Male: Female) as 1: 1.00 for *C. montrouzieri*. The pre-oviposition period varied from 4 to 7 days with an average of 5.68 ± 1.10 days. The oviposition period varied from 36 to 45 days with an average of 41.04 ± 2.26 days. Earlier, Anonymous (1988) and Mani and Krishnamoorthy (1997) reported the oviposition period of adult of *C. montrouzieri* was varied from 40 to 50 days and 45 to 68 days, respectively. The post-oviposition period varied from 3 to 7 days with a mean duration of 5.26 ± 1.21 days. The egg laying capacity of laboratory reared female beetle varied from 278 to 348 eggs with an average of 303.76 ± 17.22 eggs. In the past, Fisher (1963) reported that the adult female of *C. montrouzieri* laid 194 to 729 eggs at 76 to 78ºF temperature when it reared on *P. citri* while, Anonymous (1988) reported the fecundity of *C. montrouzieri* varied from 200 to 220 eggs per female when fed on *M. hirsutus*. According to Mani and Krishnamoorthy (1997), the rate of fecundity of *C. montrouzieri* was 200 eggs per female while, the fecundity of female adult of *C. montrouzieri* was 150 and 170 eggs per female when it reared on *F. virgata* and *M. hirsutus* (Gautam, 2008). The difference in fecundity might be due to different rearing conditions and the prey on which it was reared. The longevity of male varied from 37 to 47 days with a mean of 42.32 ± 2.03 days, while that of female it was varied from 45 to 58 days with a mean of 51.98 ± 2.68 days. In past, Fisher (1963) observed the adult period of *C. montrouzieri* was 27 to 70 days (with an average of 50.70 days) at 76 to 78ºF temperature when reared on *P. citri* while, the adult of *C. montrouzieri* was lived for about 60 days when it reared on *P. citri* (Liotta and Mineo, 1963). Anonymous (1988) reported longevity of *C. montrouzieri* varied from 50 to 70 days when reared on *M. hirsutus* while, Mani and Krishnamoorthy (1997) reported the longevity of adult *C. monrouziri* varied from 52 to 80 days. Gautam (2008) reported the longevity of male and female was 45 and 50 days on *F. virgata* and 40 and 53 days on *M. hirsutus,* respectively.

The total life cycle of male varied from 64 to 74 days with a mean of 68.92 ± 2.37 days while that of female varied from 72 to 84 days with a mean of 78.58 ± 2.98 days. Liotta and Mineo, (1963) found the total life cycle of *C. montrouzieri* was 82 to 96 days when it was reared on *P. citri*. Babu and Azam, (1987) reported the total developmental period of *C. montrouzieri* was higher at 20ºC than at 30ºC temperature while, Anonymous (1988) reported the total life cycle of *C. montrouzieri* ranged from 79.15 and 99.15 days when reared on *M. hirsutus*. The difference in entire lifespan might be due to difference in rearing condition as well as variation in host nutrition.

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