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Biology of Oriental Mealybug, *Rhizoecus amorphophalli* Betremand and its Coccinellid Predator, *Cryptolaemus montrouzieri* Mulsant on Elephant Foot Yam

Elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) is an important tropical tuber crop in India.The oriental mealybug, *Rhizoecus amorphophalli* Betrem caused10-15% damage to the corms of elephant foot yam during storage under Bhubaneswar, Odisha conditions.Williams (1985) reported the presence of *Rhizoecus* spp.in some root crops in India, and for the first time, *R. amorphophalli* was reported from Kerala. *R. amorphophalli* are sexually dimorphic. Female mealybugs went through four developmental stages or instars, and adults laid up to approximately 600±23 eggs, in a cottony-like ovisac beneath its body. After hatching (6 to 14 days), the crawlers, moved away from the cocoon and searched for suitable feeding sites in sheltered areas. It was the most fragile and easily controlled stage. The crawlers and adults sucked and de-sapped the cell content of corms which affected the quality of elephant foot yam corms. The juveniles passed through four moults before reaching adult stage. In the case of males, the last juvenile instar pupated in a silk cocoon and emerged as a winged adult.

Females are nymphal; exhibited reduced morphology and are wingless and retained legs. Females do not change completely and are likely to be neotenic. They attach themselves onto the corms and secrete a powdery wax layer for protection. They survive for a day without feeding and once they insert their stylets to feed, they generally remain anchored permanently. The males on the other hand, are pink in colour, and live to fertilize the females. Males are winged and do change completely during their lives.

Most mealybugs have numerous, often overlapping, generations per year. Like all insects, their development is dependent on temperature, there is a threshold temperature for each particular species of mealybug, below which development either ceases totally (dormancy) or is slowed to a greater or lesser degree (quiescence). Amarasekare et al. (2008) reported that approximately 80-90% of eggs of papaya mealybug, *Paracoccus marginatus* survived between 20°C and 30°C. The highest fecundity was at 25°C with each female producing an average of 300 eggs. No eggs hatched at 37°C. Adult longevity and pre-oviposition and oviposition periods increased with decreasing temperature up to 25°C. Mealybug is a pest that is known to build up its population under high temperature and humidity. When the temperature is 30°C, its infestation is severe.

The oriental mealybug is efficiently controlled by the coccinellid, *Cryptolaemus montrouzieri* Mulsant. The biology of both the pest and predator on elephant foot yam is not known. Hence studies are essential to establish suitable protocol for releasing the coccinellid predator to control the mealybug in storage houses. *C. montrouzieri* is a generic predator of mealybugs and has been used in over 50 countries for the control of several mealybug species (Olivero et al., 2003; Al-khateeb and Asslan, 2009; Rosas-Garcia et al., 2009; Solangi et al., 2012). Adult beetles were brought from the Biological Control Laboratory, Department of Entomology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. The beetles are 3.8-4.6 mm in length and 2.7-3.3 mm in breadth having black shining elytra with apices reddish yellow (Fig. 1). Fore-legs in males are reddish yellow and in females completely black. Its head, thorax and abdomen are orange-brown. The *Cryptolaemus* larva reached up to a length of 13 mm and can be recognised by its white downy wax secretion. Due to this secretion, the larva and its prey resemble the same.

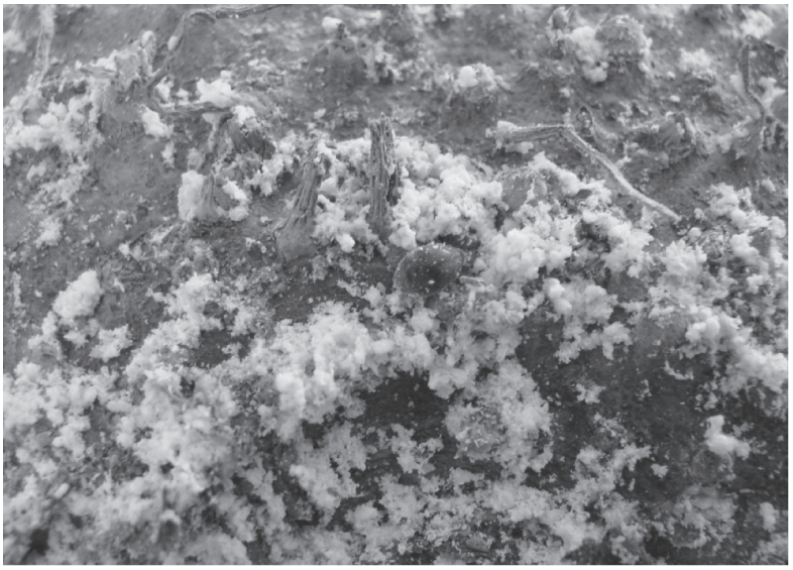

Fig. 1. Adult *Cryptolaemus* beetle

However, the larva of *C. montrouzieri* is longer, more mobile and its wax threads are longer than those of mealybugs (Fig. 2).

The longevity of female beetle was approximately 2 months and laid 10 eggs per day directly into the cottony egg sack of the adult female mealybugs. The fecundity was on an average 500±18. Adult beetles and young larvae feed on mealybug eggs and young stages. *Cryptolaemus* larvae were also found predating on adult mealybugs. The life cycle ranged between 4 to 7 weeks depending on temperature. Incubation period was 5 days at 27°C and the three larval stages lasted for 12 to 17 days, during which, the larvae feed on mealybug eggs, young crawlers and the honeydew produced by mealybugs. Pupation of the predator took place in sheltered places for 7-10 days. The preoviposition period was four days.

Fig. 2. *Cryptolaemus* larvae

The food available to coccinellid larvae and their exposure to predation is influenced by the place of egg laying. The abundance and quality of food in a habitat affects the reproductive output of a female and survival of larvae. Consequently, there is higher retention and oviposition preference for sites with abundant essential prey. *C. montrouzieri* is a voracious feeder of mealybug in both the larval and adult stages-a single larva consumed up to 200 mealybug instar. Although adults and young larvae prefer to feed on mealybug eggs, later instars attacked any stage of mealybug. Kaur and Virk (2012) reported that the adult stage of *C. montrouzieri* was the most efficient predatory stage as compared to other developmental stages of the predator. This is due to the fact that adult beetles have greater longevity than their larval instars. Adults can fly and cover large areas in search of food. Recent studies have shown that adults and larvae spend more time searching for mealybugs in a leaf with honeydew rather than without honeydew (Shelton, 2013).

The fecundity and reproduction periods depends on the species of the prey, the coccinellid beetle feeds upon. The duration of life stages of *C. montrouzieri* is shorter during summer and longer during winter, the optimum constant temperature for maximam development is 30°C (Ramesh Babu and Azam, 1987). The adult longevity is extended at 20°C than at 30°C. They survive at temperatures of 16 to 33°C but does best in temperatures around 28°C. The fecundity of the predator is higher at 25°C than at 20°C. Even though the adults can survive at 10°C, the productive capacity

is impaired. Ozgokce et al. (2006) reported that the mortality rate increases with extended storage period. Longer cooling periods greatly affected the mortality of *C. montrouzieri*. Mortality rates increased with increasing cooling periods, especially those longer than 5 days. Yigit et al. (1994) indicated that the most suitable temperature for storage of *C. montrouzieri* adults was 15°C, with high survival rate at that temperature. This tropical species is inactive at 15-20°C and a minimum temperature of 21°C is needed to feed and lay eggs (Gautam, 1996). The reproduction rate is a crucial factor in the population growth (Ozgokce et al., 2006).

The predator is most active in sunny weather; whereas their searching behaviour is unproductive above 33°C (Hussey and Scopes, 1985). There is cessation of feeding potential of *C.montrouzieri* with the increase in temperature. Even at temperatures lower than 20°C, the coccinellids were unable to control the target pest (Panis and Brun, 1971; Codling, 1977). The mortality increased with the increase in temperature. The fecundity of the predator was higher at 25°C than at 20°C. The development time (from egg to larva) depended strongly on temperature. The optimum temperature for feeding and multiplication of beetles was 21°C (Panis and Brun, 1971; Codling,1977). It has been observed that the longevity of adult beetle reduced at temperatures more than 30°C. Solangi et al. (2013) reported that 50% of population survived for 33 days at 35°C and 50% survived for 11-13 days at 38°C. At 40°C, 50% of the population survived for 3 to 7 days. At 44°C, only 30% of females survived until the second day, whereas the maximum longevity was for 4 days. Our results suggest that optimum temperature for successful growth and reproduction of *C. montrouzieri* on *R. amorphophalli* was 28°C. Hence during storage of elephant foot yam tubers, a temperature gradient of 28°C ± 1 would be the most appropriate for the control of elephant foot yam mealybug using the predator.

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Swagatika Misra[1]
Rajasekhara Rao Korada[1]
Bijoy Kumar Mishra[2]

[1]Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar 751 019, Odisha, India

[2]Department of Entomology, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India

Corresponding author: Rajasekhara Rao Korada,

e-mail:rajasekhararao.korada@gmail.com

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