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Research Note

Thermo mediated activity of *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) predating on *Rhizoecus amorphophalli* Betren (Hemiptera: Rhizoecidae) on elephant foot yam

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ABSTRACT: Elephant foot yam (*Amorphophallus paeoniifolius* Dennst.) tubers are infested with Oriental mealybug, *Rhizoecus amorphophalli* Betren in storage. The pest sucks and de-saps the cell content of tubers. It causes 10-15% infestation on the tubers leading to reduced vitality. The coccinellid, *Cryptolaemus montrouzieri* Mulsant is a potential predator of *R. amorphophalli*. Studies were carried out to determine the optimum temperature required for *C. montrouzieri* for controlling *R. amorphophalli* in storage. At 30°C, the population of *R. amorphophalli* was found to increase faster than at 20°C and 25°C. The population growth was not favoured at 35°C. The *C. montrouzieri* was found voraciously feeding *R. amorphophalli* at 25°C. Feeding activity of the *C. montrouzieri* declined between 30°C and 35°C. The temperature higher than 30°C was not conducive for survival of the predator and significant mortality was recorded at 35°C ($P< 0.01$). Studies revealed that the temperature range between 25°C and 30°C in storage is most suitable for release of *C. montrouzieri* for successful control of *R. amorphophalli*.

KEY WORDS: Elephant foot yam, feeding potential, temperature, *Cryptolaemus montrouzieri*, *Rhizoecus amorphophalli*

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Elephant foot yam (*Amorphophallus paeoniifolius* Dennst.) is an important tropical and edible tuber crop in India with an estimated production area of 37,000 ha with a yield of 0.67mt and the average tuber yield is 21 t ha^{-1} (CTCRI, 2010) with a production potential of 50-80t/ha (Ravi *et al*., 2009). The tubers are planted during May to June (summer) and harvested during the month of November to December (winter). The tubers after harvest are kept in godowns and there is wide range of variation in temperature while it is being stored during the period from December till their subsequent use during the hot months of the year. The temperature during harvest of the crop is low and it rises as the planting season approaches. During storage, the tubers are infested by Oriental mealybug *Rhizoecus amorphophalli* Betrem (Pseudococcidae: Homoptera). *R. amorphophalli* is a noxious pest infesting the stored tubers of major yams and aroids, especially elephant foot yam (Rajamma *et al*., 2002). They are white, slow-moving, oval, soft bodied insects with a white waxy coating over their body. It causes 10-15% tuber damage in storage in the state of Odisha, India. Williams (1985) reported the presence of *Rhizoecus* sp. in some root crops in India.

The predatory coccinellid, *Cryptolaemus montrouzieri* Mulsant has been observed to feed voraciously upon *R. amorphophalli*. *C. montrouzieri* is a generic predator of mealybug and has been used in over 50 countries for the control of several mealybug species (Solangi *et al*., 2012; Al-khateeb and Asslan 2009; Olivero *et al*., 2003; Rosas-Garcia *et al*., 2009; Srinivasan and Babu, 1989). Release of biological agents in storage houses is adoptable because of controlled and protected environment. The optimum constant temperature for maximal development is 30°C (Ramesh *et al*., 1987). The reproduction rate is a crucial factor in the population growth (Ozgokce *et al*., 2006). The present study was conducted to determine,1) the optimum temperature required for releasing *C. montrouzieri* in elephant foot yam tuber store-house infested with *R. amorphophalli*; 2) the mortality of *C. montrouzieri* depending on temperature; and 3) the number of *C. montrouzieri* required per tuber infested with *R. amorphophalli*.

In vitro studies, simulating the storage conditions were carried to check the effect of temperature on the feeding potential of *C. montrouzieri* on *R. amorphophalli* infesting elephant foot yam at Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India during January to April 2013. The number of mealybugs present in an area of 1cm^2 were quantified as 78±5.0 per cm^2 (10 replications). Elephant foot yam tubers infested with *R. amorphopalli* were collected from tuber store house. Tubers with uniform infestation were selected and kept in plastic jar (2 litre size) and *C. montrouzieri* were released in numbers of 1, 2, 4 and 6 beetles in each jar. The jars were covered with cotton cloth. One of the jars containing the tuber without coccinellid beetle was taken as control. The jars containing the tubers and the coccinellids and also the control were kept inside a BOD incubator at different temperatures i.e. 20°C, 25°C, 30°C and 35°C. At each temperature, the jars were maintained in the BOD incubator for 5 days. The observation on population of *R. amorphophalli* and *C. montrouzieri* was recorded. An *in vitro* study was carried out to find the effect of temperature on the feeding potential of *C. montrouzieri* on *R. amorphophalli* infesting elephant foot yam. The population growth of *R. amorphophalli* was minimum at 20°C. In general, the number of *R. amorphophalli* consumed by *C. montrouzieri* increased with increase in numbers at all temperatures except 35°C.

At 20°C, the activity of *C. montrouzieri* adults was very low. The population of *R. amorphophalli* was also suppressed at 20°C, which is also not favourable for the development of most of the tropical insects. The population of mealybug on tubers taken as control remained constant. Predatory efficiency of 2 beetles at 25°C was equal to the efficiency of 6 beetles at 20°C (41.17%), indicating that at lower temperature, higher number of *C. montrouzieri* are required to control the same population of mealybugs, as in lower number of beetles at higher temperature, upto a certain range of temperature. The adult beetles could only feed on less than 50% of the mealybug population (Table 1). It was observed that the activity and feeding potential was brought down due to the effect of low temperature.

Mild to warm conditions are favourable for survival and development of mealybugs. Temperatures of about 25°C and a high relative humidity are optimum for mealybugs. *C. montrouzieri* requires a minimum temperature of 21°C (Gautam, 1996) for feeding and laying eggs. When the temperature was increased to 25°C, the *C. montrouzieri* population was augmented by 1cm^2 with the change in the temperature. At this temperature, the feeding potential of predator and their multiplication rate was high and also some parasitoids (*Anomalicornia tenuicornis* Mercet (Encyrtidae: Hymenoptera) were found emerging (30±0.8 parasitoids/tuber). Six numbers of adult *C. montrouzieri* fed on 64.70% of initial population of *R. amorphophalli* while 4 adults fed on 52.94% population.

At 30°C, the *C. montrouzieri* adults were torpid. An initial population of 1326 increased to 1482 numbers, which was increased by 89.4% in 5 days. Gradually, the mortality of the coccinellids was observed at this temperature. There was 7.69% of mortality in beetles at this temperature. At 30°C, 6 beetles were able to feed on 52.94% of *R. amorphophalli*. However, the feeding potential of the predator reduced in comparison at 25°C.

When there was rise in temperature from 30°C to 35°C, a mortality of 76.92% of *C. montrouzieri* was observed. There was cessation in the multiplication rate of *R. amorphophalli* with the increase in temperature. Low activity and high mortality of *C. montrouzieri* were recorded at higher temperature along with cessation of feeding. In the jar containing 4 beetles, 75% mortality of the coccinellid was recorded at 35°C within 2 days of release. Again when released on 3rd day, they were found dead on the very next day. Due to continous mortality, the feeding potential was considerably reduced resulting in feeding of 35.29% of inintial population by 4 beetles.

Cryptolaemus montrouzieri is most active in sunny weather; whereas their searching behaviour is unproductive above 33°C (Hussey and Scopes, 1985). There was cessation of feeding by *C. montrouzieri* with the increase in temperature. Even at lower temperatures (20°C), the *C. montrouzieri* was unable to control the target which is in agreement with studies done by Panis and Brun (1971) and Codling (1977). The mortality increased with the increase in temperature. The fecundity of *C. montrouzieri* was higher at 25°C than at 20°C. The development time (from egg to larva) depends strongly on temperature Panis and Brun (1971) and Codling (1977). The optimum temperature for feeding and multiplication of coccinelid beetles was 21°C to 25°C and a minimum temperature of 21°C is required for the predator to feed and lay eggs. It takes about 32 days at a temperature of 24°C. It has been observed that the longevity of adult beetle was reduced at temperatures more than 30°C. Similar results were obtained by Solangi *et al*. (2013) who 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 population survived for 3 to 7 days. At 44°C, only 30% of females survived until the second day whereas the maximum longevity was 4 days. The optimum temperature required by the *C. montrouzieri* for the development was reported as 20-25°C by Cooper (1985) and 30°C by Babu and Azam (1987). Mealybug is a pest that is known to increase its population several folds at high temperature and humidity. The population was higher at 30°C and substantially decreased at 35°C. The fecundity of the mealybug was higher at 25°C.

Though, *C. montrouzieri* survives at temperatures between 16 and 35°C, the present investigations revealed that the optimum temperature for the predator was between 25°C and 30°C. Rise in temperature favoured the augmentation of population of the mealybug, *R. amorphophalli*. Mild to warm conditions are therefore favourable for mealybug development. Temperatures of about 25°C and above are optimum for mealybugs. If temperatures remain elevated for prolonged periods, insect mortality increases rapidly with a consequent crash in population size. Hence, it is recommended to maintain a temperature range between 25°C and 30°C in the elephant foot yam storage houses as this temperature is most congenial for development, activity of *C. montrouzieri* and for successful control of *R. amorphophalli*. Approximately 2 to 3 numbers of *C. montrouzieri* are required for each infested tubers to control *R. amorphophalli*. Accordingly, *C. montrouzieri* can be released in storage godowns.

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