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N Lalitha

(1). Eri Silkworm Seed Production Centre, Central Silk Board, Guwahati, Assam, India
(2). Study Conducted at Central Sericultural Research & Training Institute, Berhampore, West Bengal, India
(3). PhD Scholar, Visvabharathi University, Santiniketan, West Bengal, India

Hirak Chatterjee

Professor and Head, Palli Siksha Bhavana, Visva-Bharathi University, Santiniketan, West Bengal, India

MV Santhakumar

Associate Professor, Shivaji University, Kohlapur, Maharashtra, India

S Nirmal Kumar

Retd. Director of Central Sericultural Research & Training Institute, Berhampore, West Bengal, India

Correspondence**N Lalitha**

(1). Eri Silkworm Seed Production Centre, Central Silk Board, Guwahati, Assam, India
(2). Study Conducted at Central Sericultural Research & Training Institute, Berhampore, West Bengal, India
(3). PhD Scholar, Visvabharathi University, Santiniketan, West Bengal, India

Predatory potential of new species of *Scymnus* Kugelann, *Scymnus latifolius* Poorani sp. nov. (Coleoptera, Coccinellidae) on papaya mealybug *Paracoccus marginatus* infesting mulberry

N Lalitha, Hirak Chatterjee, MV Santhakumar and S Nirmal Kumar

Abstract

A new species of *Scymnus* Kugelann, *Scymnus (Pullus) latifolius* Poorani sp. nov., (Coleoptera: Coccinellidae) was collected from mealybug infested mulberry shoots in West Bengal. The new predator was found preying on the life stages of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in mulberry gardens. The life stages of the predator were collected from the mulberry gardens and acclimatized in the laboratory for further studies. Feeding efficacy studies conducted in the laboratory at 25-28 °C and 65-70% RH established that the grubs and adults of the *Scymnus latifolius* sp. nov. were found to feed on all the stages of the mealy bugs. Each grub of the predator devoured a mean of 1775.67 ± 28.80 eggs or 225.42 ± 6.31 crawlers or 33.33 ± 1.56 adults of *P. marginatus* during its entire larval feeding period. An adult female preyed on 2316.33 ± 62.78 eggs or 302.50 ± 8.50 nymphs or 59.75 ± 1.45 adults of host *P. marginatus* whereas an adult male devoured 1815.08 ± 27.99 eggs or 239.50 ± 8.85 nymphs or 54.25 ± 1.16 adults during its entire adult feeding period. The studies indicated the scope of utilizing the promising native predator in biocontrol of mealybugs.

Keywords: *Scymnus latifolius*, *Paracoccus marginatus*, mealybug, Mulberry, West Bengal

1. Introduction

Mulberry ecosystem of Eastern India is invaded by many polyphagous pests due to which crop losses are being recorded up to 25%. Pest outbreaks often result in non-availability of quality mulberry leaves to silkworm crops. The major pests of mulberry are thrips, mealy bug, whitefly, root mealy bug and leaf webber. The Indo-gangetic plains of West Bengal harbour rich fauna of coccinellid predators associated with the major pests of mulberry. The reported native predators from the mulberry ecosystem on mealy bug populations in West Bengal includes *Scymnus nubilus* Mulsant, *Scymnus (Pullus) bourdilloni* Kapur, *Scymnus coccivora* Ayyar, *Scymnus brunnescens* Mots., *Scymnus fuscatus* Bohem, *Scymnus apiciflavus*, Mots., *Scymnus pyrocheilus* Mulsant, *Scymnus ceylonicus* (Mots.), *Scymnus quadrillus* (Mots.), *Pharoscymnus* sp. ^[14], *Nephus* sp. near *roepkei*, *Nephus* sp. ^[2], *Nephus tagiapatus* (Kamiya), *Stethorus indira* Kapur, *Stethorus tetranychii* Kapur ^[9] and *Brumoides suturalis* (Fabricius) ^[16]. Intensive surveys for predators in mealybug infested shoots of mulberry grown in West Bengal during 2014-15 revealed eighteen predators that were consistently associated with the sucking pests of mulberry ^[6]. Among them, one new species of *Scymnus* Kugelann was collected from papaya mealybug infested mulberry shoots. The classification and accurate species identification of *Scymnus* genus belonging to Scymnini tribe turn out to be tough due to their small size and depends on examination of male genitalia ^[18, 8]. The new predator species was described as *Scymnus latifolius* Poorani sp. nov. for the first time with species identification characters and detailed morphological description ^[10].

The objective of the present work was to evaluate the predatory potential of this new coccinellid *Scymnus latifolius* on papaya mealybug in laboratory condition.

2. Materials and methods

Survey was conducted in the mulberry fields of Central Sericultural Research and Training Institute, Berhampore, farmers' fields of four districts namely Murshidabad, Nadia, Birbhum and Malda during 2014-15. The mealy bug infested shoots along with their natural enemies were collected from the selected fields at fortnightly intervals. It was found difficult to identify

and sort out the coccinellids at the immature stages. Therefore, they are reared in the same mulberry shoot without disturbing the host colonies up to adult emergence. The newly emerged adults of *Scymnus latifolius* was collected and kept in vials for mating. From the field collection, nucleus culture of *Scymnus latifolius* sp.nov were maintained as per standard methods [3]. Every copulated female predator was released separately in a cavity block and provided with host mealybug eggs and allowed for oviposition. The predator eggs were sorted out carefully and kept individually in cavity block and provided with a known number of prey.

Experiments were conducted to determine the feeding efficacy of grubs and adults of *Scymnus latifolius* on different developmental stages of *P. marginatus* (eggs, nymphs and female adults) under laboratory conditions at 25-28 °C and 65-70% RH. The host developmental stages of *P. marginatus* were reared on sprouted potatoes to provide the appropriate life stages as per the timely requirement for the experiments.

Day wise feeding potential of the predatory grubs/ adult beetles were recorded in laboratory conditions throughout the developmental period of grubs and longevity of the adults. Known number of fresh preys were provided (host eggs in multiples of 50, host nymphs/adult females in multiples of 10) every day. Observations were taken on the number of preys devoured (fully/partially) at every 24 hours. Surviving preys were counted and deducted from the total number provided to estimate the predation rate. Number of prey consumed by every predatory grub (n=12) instar-wise and during the total larval feeding period was worked out. The developmental time, instar-wise when fed with each host developmental stage was calculated.

After sex determination, the teneral adults were also subjected

to feeding efficacy studies individually for males (n=12) and females (n=12) providing each developmental stage of host mealybugs (eggs, nymphs and adults). Observations on the number of preys devoured at every 24 hours during the entire longevity of the adults were recorded. The longevity of the male and female predator when fed with each host developmental stage was also recorded.

Each grub/adult confined in a cavity block was considered as one replicate. A dissecting microscope was used to facilitate an accurate count of the number of eggs, nymphs, and adults of host species before and after exposure to predating stages of *Scymnus latifolius* sp.nov. to determine the predation rate.

The data were subjected to one-way ANOVA at $\alpha=0.05$ and means were separated using the Tukey-Kramer honestly significant difference (HSD) test at $P < 0.05\%$.

3. Results and discussion

The results of predatory potential studies of *Scymnus latifolius* on different developmental stages of *P. marginatus* (eggs, nymphs and female adults) (Plate 9a-c) are presented in Table 1. Early instars of predator beetles are relatively inactive fed more preferably on mealybug egg masses as compared to other developmental stages. The grubs of late instar stage are active crawlers with voracious feeding habits. They catch the prey and suck the body fluid of all the developmental stages of mealybugs leaving behind empty skin (Plate 9d-9f). The adult mealybugs and nymphal stages were often partially devoured. This observation is similar to the feeding habits of other coccinellid beetles studied earlier [1]. Unlike the grubs, the adults chewed and devoured the mealybug stages completely (Plate 9g-9i). Adult beetles are found to attack and feed on all the developmental stages of host mealybugs.

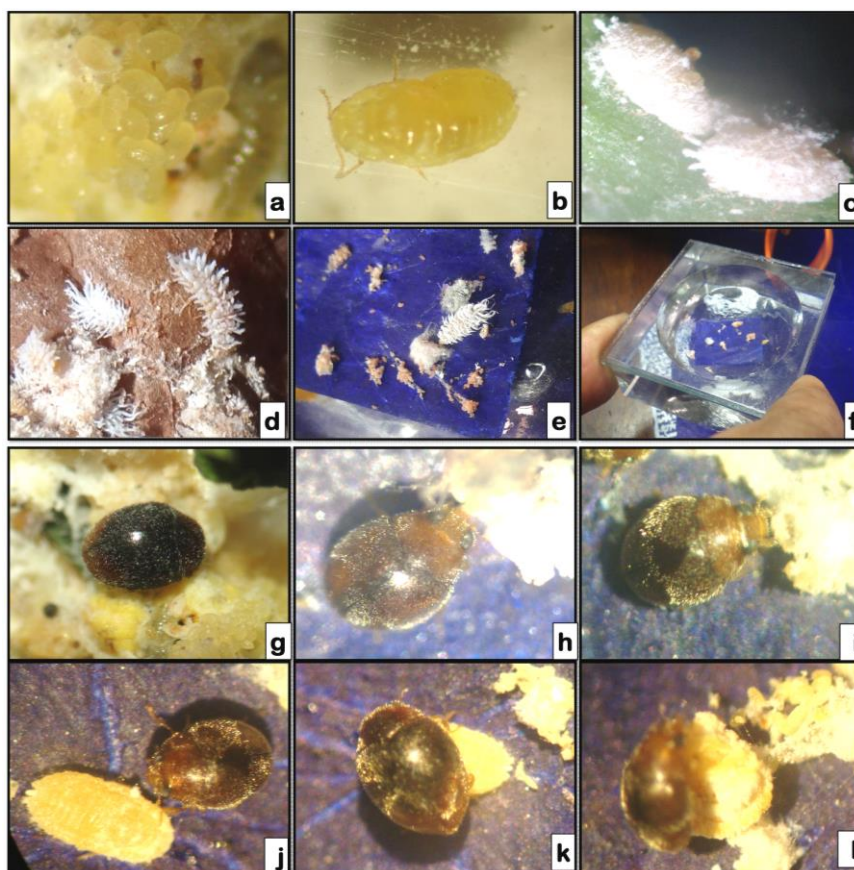


Plate 1: Feeding of *Scymnus latifolius* sp. nov. a) eggs of *P. marginatus* b) Nymphal stage of *P. marginatus* c) adult females of *P. marginatus* d-f) grubs of *S. latifolius* feeding on stages of *P. marginatus* g-i) adult beetle of *S. latifolius* feeding on eggs of *P. marginatus* j-l) adult beetle of *S. latifolius* devouring the nymphal stage of *P. marginatus*

During the first instar development, the grub consumed 44.92 ± 2.01 eggs or 14.67 ± 0.67 crawlers or 2.17 ± 0.21 adults of hosts while the second instar devoured 80.75 ± 2.18 eggs or 30.92 ± 1.66 crawlers or 4.75 ± 0.33 adults (Table 1). During the third instar development, the grub consumed 374.67 ± 7.25 eggs or 54.67 ± 1.32 crawlers or 9.08 ± 0.53 adults while

the fourth instar devoured 1275.33 ± 25.72 eggs or 125.17 ± 3.83 crawlers or 4.75 ± 0.33 adults of *P. marginatus*. This increased trend of feeding rate of grubs with age was comparable in other coccinellids of Scymnini tribe, *S. marginicollis* [1], *S. nubilus* [13], *S. brunescens* [17, 13] and *S. coccivora* [7].

Table 1: Feeding potential of *Scymnus latifolius* sp. nov. on different life stages of *Paracoccus marginatus* at 28 ± 2 °C and $75 \pm 5\%$ RH in laboratory.

Life stages of predator	Various life stages of mealy bug consumed (nos)					
	Eggs		Nymphs		Adults	
	Total feeding in the stadium	Average Intake per day	Total feeding in the stadium	Average Intake per day	Total feeding in the stadium	Average Intake per day
1 st instar	$44.92 \pm 2.01b$	$22.46 \pm 1.00b$	$14.67 \pm 0.67b$	$7.33 \pm 0.33b$	$2.17 \pm 0.21a$	$1.08 \pm 0.10a$
2 nd instar	$80.75 \pm 2.18b$	$26.92 \pm 0.73b$	$30.92 \pm 1.66c$	$10.31 \pm 0.55c$	$4.75 \pm 0.33a$	$1.61 \pm 0.10b$
3 rd instar	$374.67 \pm 7.25a$	$74.93 \pm 1.45a$	$54.67 \pm 1.32a$	$10.93 \pm 0.26c$	$9.08 \pm 0.53b$	$1.82 \pm 0.11b$
4 th instar	$1275.33 \pm 25.72c$	$255.07 \pm 5.14c$	$125.17 \pm 3.83d$	$25.03 \pm 0.77a$	$17.33 \pm 0.91c$	$3.47 \pm 0.18c$
Total larval	$1775.67 \pm 28.80d$	$118.38 \pm 1.92d$	$225.42 \pm 6.31e$	$15.03 \pm 0.42d$	$33.33 \pm 1.56d$	$2.22 \pm 0.10d$
Adult female	$2316.33 \pm 62.78e$	$33.05 \pm 1.14e$	$302.50 \pm 8.50f$	$4.42 \pm 0.10e$	$59.75 \pm 1.45e$	$0.94 \pm 0.02e$
Adult male	$1815.08 \pm 27.99d$	$30.74 \pm 0.55e$	$239.50 \pm 8.85e$	$4.31 \pm 0.13e$	$54.25 \pm 1.16f$	$0.95 \pm 0.02e$

Each value represents pooled data of 12 replications. Means \pm SEM within the column followed by the same letter do not differ significantly.

Each grub of the predator devoured 118.38 ± 1.92 eggs or 15.03 ± 0.42 nymphs or 2.22 ± 0.10 adults per day during the total larval feeding period. The average consumption rate of the fourth instar predator grub is the highest followed by third instar grub which lasted for about 5 days each (Fig 1). In the

present study 50-72% of the total larval nutritional requirement is met by the voracious intake of host stages during fourth larval instar. Similar observations were made in other beetles of Scymninae [4, 12].

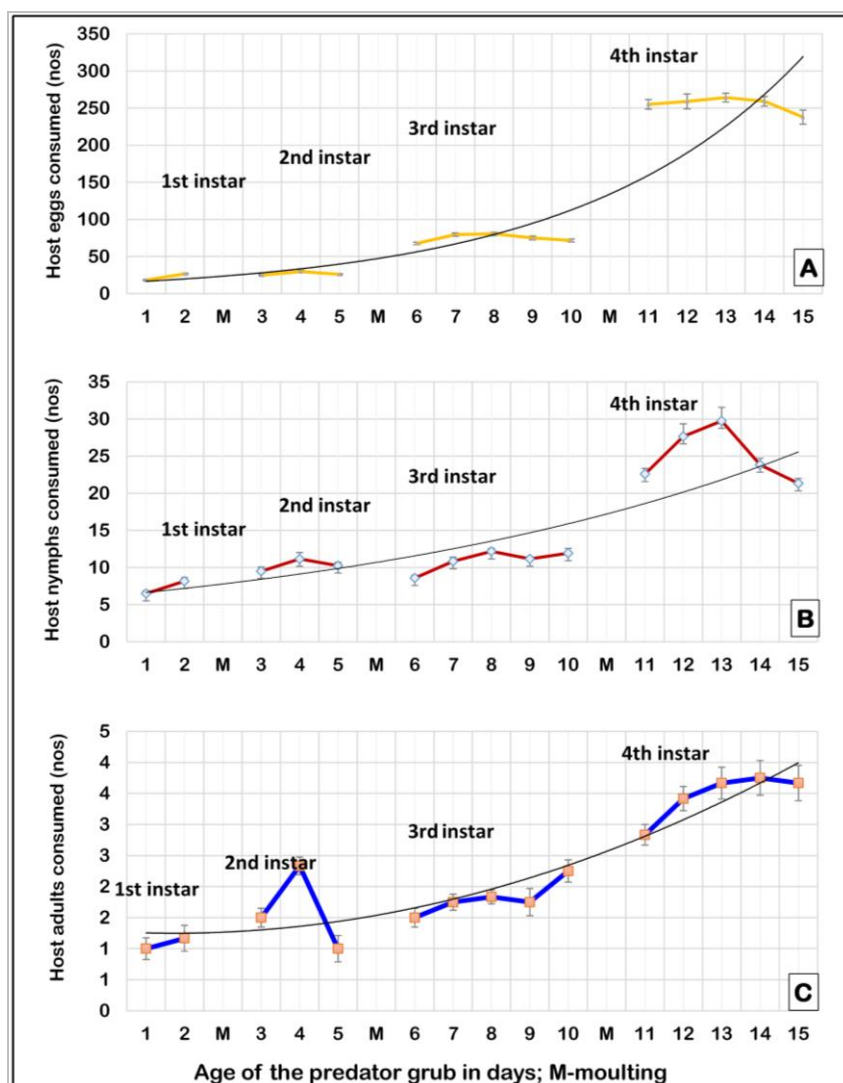


Fig 1: Day-wise feeding potential of *Scymnus latifolius* sp. nov. grubs on eggs (A), nymphs (B) and adults (C) of host *P. marginatus*

During the development of one predatory grub, a mean of 1775.67 ± 28.80 eggs or 225.42 ± 6.31 crawlers or 33.33 ± 1.56 adults of *P. marginatus* were consumed during development period ranging from 13-15 days (Table 2). These observations are in close proximity with the feeding potential studies conducted earlier on *S. nubilus*,^[13] *S. brunnescens*^[17] and *S. coccivora*,^[7] feeding on *Maconellicoccus hirsutus*. However the feeding rate of *C. montrouzeuri* was higher^[5] as compared to the values observed in the present study.

The total developmental period of the grub when fed with *P. marginatus* eggs, crawlers and adults did not differ significantly during four instars. However, eggs were more preferred host stages when compared to nymphal and adult stages of the host. Hence the developmental duration of larva is significantly shorter when only host eggs/ nymphs are fed when compared to adults in the total larval developmental period.

Table 2: Developmental period and longevity of different life stages of *Scymnus latifolius* sp. nov. reared on eggs, nymphs and adults of *P. marginatus* at 28 ± 2 °C and $75 \pm 5\%$ RH in laboratory.

Larval Instars	Duration/ longevity (days)		
	Eggs fed	Nymphs fed	Adults fed
1 st instar	$1.75 \pm 0.09a$	$1.94 \pm 0.03a$	$2.02 \pm 0.04a$
2 nd instar	$2.60 \pm 0.09a$	$2.88 \pm 0.05a$	$3.02 \pm 0.0a$
3 rd instar	$4.04 \pm 0.09a$	$4.25 \pm 0.08a$	$4.77 \pm 0.11a$
4 th instar	$4.88 \pm 0.05a$	$4.96 \pm 0.06a$	$5.23 \pm 0.06a$
Total larval	$13.27 \pm 0.19a$	$14.02 \pm 0.11a$	$15.04 \pm 0.13b$
Adult female	$70.33 \pm 0.92a$	$68.42 \pm 1.12b$	$63.92 \pm 0.75c$
Adult male	$59.17 \pm 1.02a$	$55.58 \pm 0.38b$	$57.33 \pm 0.51c$

Means \pm SEM within the same row followed by the same letter do not differ significantly.

Each female predator devoured 33.05 ± 1.14 eggs or 4.42 ± 0.10 nymphs or 0.94 ± 0.02 adults per day during its life span ranging from 64 -72 days while a male predator consumed 30.74 ± 0.55 eggs or 4.31 ± 0.13 nymphs or 0.94 ± 0.02 adults per day during its life span of 55-60 days (Table-2). An adult female preyed on 2316.33 ± 62.78 eggs or 302.50 ± 8.50 nymphs or 59.75 ± 1.45 adults of *P. marginatus* whereas an adult male devoured 1815.08 ± 27.99 eggs or 239.50 ± 8.85 nymphs or 54.25 ± 1.16 adults of *P. marginatus* during its entire adult feeding period. Female beetles consumed significantly higher number of mealybug stages as compared to male. Similar trends were reported in *Scymnus nubilus*^[13], and *Scymnus coccivora*^[7].

The longevity of the female predator beetle was 70.33 ± 0.92 , 68.42 ± 1.12 , 63.92 ± 0.75 days when fed with *P. marginatus* eggs, crawlers and adults respectively. The longevity of male predator beetles was 59.17 ± 1.02 , 55.58 ± 0.38 , 57.33 ± 0.51 days when fed with host eggs, nymphs and adults respectively (Table 2). The longevity of the adult predator beetles both male and female differed significantly when fed with eggs, nymphs and adults of host mealybugs. The average longevity of male and female adults were significantly higher when fed with only host eggs when compared to nymphs and adults of *P. marginatus*. The variation in the developmental period of grubs and longevity of adults reared on different stages of the mealybugs may be due to the varied nutritional sufficiency. The results are in agreement with the feeding efficacy studies on *C. montrouzieri* reared on different stages of *M. hirsutus*^[11]. Day-wise predatory potential of both female and male predator increased with the age from 1 to 15 days and remained constant in the age of 15 to 45 days and declined with the age from 45-75 days (Fig. 2).

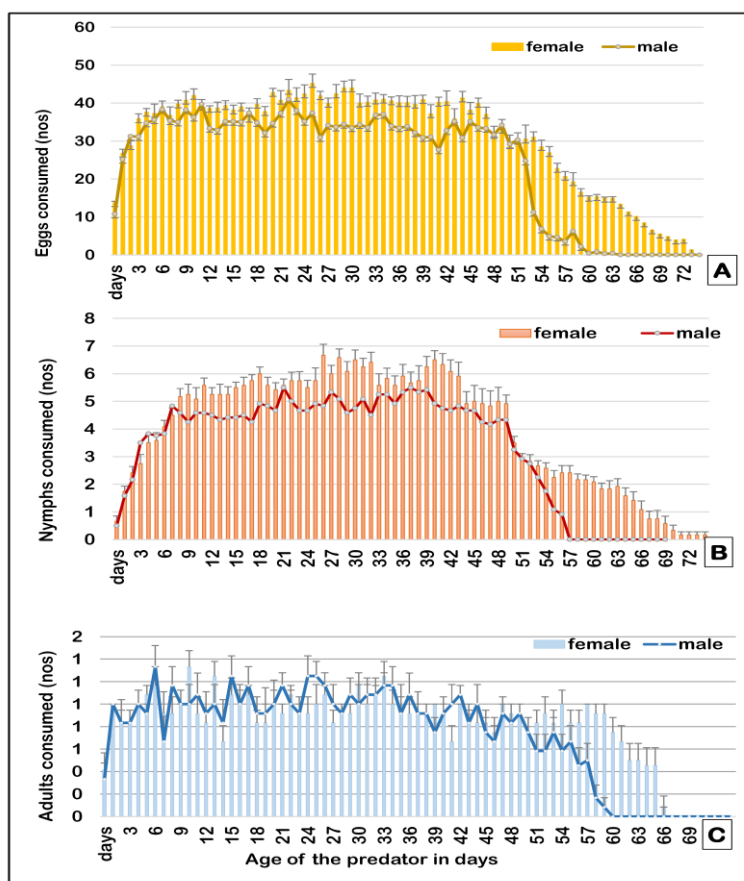


Fig 2: Day-wise feeding potential of *Scymnus latifolius* sp. nov. female and male adult beetles on eggs (A), nymphs (B) and adults (C) of host *P. marginatus*

Predatory adult beetles consumed a maximum number of *P. marginatus* stages through the entire life span as compared to the total consumption of predator grub. Similar results were reported earlier in *C. montrouzieri* [12]. The adult stage was the most efficient predatory stage as compared with the other development stages of the predator. The total feeding potential of adult beetles were high due to the greater longevity of the adult beetles than their larval instars.

4. Conclusion

The predatory potential studies evidently indicate that *Scymnus latifolius* could be a promising predator of papaya mealybug. Keeping in view the feeding efficacy of this native predator it could be concluded that it can additively contribute along with other natural enemies to suppress mealybug populations in mulberry gardens maintained for sericulture without insecticide cover. However, the laboratory studies cannot mimic the natural situations in the field. The present study can be utilized to infer basic mechanisms underlying predator-prey interactions and develop mass multiplication protocols for this promising predator. Being native to the Eastern zone of India the predator survives the adverse climatic conditions especially high temperature and high humid conditions. The present study envisages the scope of this native predator in biocontrol of mealybugs in mulberry.

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