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Research Article

STUDY ON THE BIOLOGY, FEEDING BEHAVIOUR AND PREDATORY POTENTIAL OF *Sycanus* collaris (FABRICIUS) (HETEROPTERA: REDUVIIDAE), A NEW PREDATOR OF *Hyposidra talaca* (WALK.) (LEPIDOPTERA: GEOMETRIDAE), A MAJOR TEA PEST AND MASS REARING ON *Corcyra cephalonica* (STAINTON) IN LABORATORY

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A B S T R A C T

The sustainable utilization of biological control agents in agro-ecosystems depend on the data on biology, bio-ecology and feeding behaviour of that biological control agents on their main or alternative host. In the present study, the biology, feeding behavior and predatory potential of a newly recorded reduviid predator *Sycanus collaris*, from tea ecosystem found predating on one of the major tea pests *Hyposidra talaca,* have been observed under laboratory conditions. The incubation period, duration of the nyphal stages and longevity of adult stages were observed both on *Corcyra cephalonica* (rice meal moth) and on *H. talaca.* The incubation period was recorded as 13.6±1.1 and 11.8±2.3, duration of nymphal stages as 58.4 ±3.9 and 64.8±4.1, adult longevity 99.8±3.5 and 108.6±2.8 days respectively on rice meal moth and tea looper respectively. The fecundity (total number of eggs laid /female) was found to be 282.0± 23.9 and 320.4± 44.2 eggs/female when feed on larvae of *C. cephalonica* and *H. talaca* respectively. Predatory potential of the reduviid bug *S. collaris,* has been studied by providing larvae of tea looper, *H. talaca* in laboratory. The predator *S. collaris* attacked more prey to satiate itself at a given point of time. In the case of free choice feeding condition, wherein the adult males consumed a 4.6±1.8 fifth instar larvae of *H. talaca* while the adult female consumed 5.0±1.6per day. However, the nymphal consumption varied between 3.2±1.3 on third instar and 2.2±0.8 fifth instar of looper. The feeding behaviour of the predator such as the time taken for approach and attacking, paralyzing, sucking on the prey were also recorded. The adult female could paralyze a grown-up looper within 5-8 seconds and sucked the body sap within 119-121 seconds. First instar nymph of the reduviid bug preferred only second instar larvae of looper and group feeding was observed whereas, with the advancement of the nymphal instar they prefer to predate on later stages of looper (fourth and fifth instars) when compared to the early instars.

INTRODUCTION

Reduviidae a large family belongs to the order Hemiptera, found to be efficient predators of different insect pest, preferably lepidopteran larvae (Ambrose *et al*., 2009). *Sycanus collaris*, known as assassin bug, all of its life stage efficiently feed on the target insect. Depending on the feeding on different insect the developmental period and fecundity rate is also different when fed on different hosts (George, 2000).The perennial monoculture crop tea (*Camellia sinensis* L.), provides a stable shelter, food and microenvironment for breeding for divers species of arthropod throughout the year (Babu *et al.,* 2014). Among them, some arthropods are considered as pest and some are considered as biological control agents. In the tea ecosystem of Dooars and Darjeeling regions of West Bengal among different *Sycanus* species of Reduviidae family of order Hemiptera only *Sycanus croceovittatus* (Dohrn) have been reported (Das *et al.,* 2010 and Mitra *et al*., 2018). The sequential predatory behaviour of the Genus *Sycanus* on its prey is very active (Ambrose, 1999). Sahayaraj, (2012) developed a rearing technique of reduviids using meat-based artificial diets which couldbe useful for mass rearing and pest management programme. There is no information available on *Sycanus collaris* as a predator of *H. talaca* in tea ecosystem of West Bengal and North East India

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as on today. Among the pest population H.talaca, has been reported as a major tea pest causing considerable crop loss in tea. Use of chemical pesticides having residual problem in made tea besides the negative impact on the environments a concern for tea growers. Researchers developed nuclear polyhedrosis virus (Nguyen *et al.*, 2018) which is an efficient bio-formulation. Apart from these, biological control agents play a vital role in controlling tea pests, which are available in tea ecosystem (Das *et al.,* 2010; Barua *et al.,* 2016; Perumalsamy *et al*., 2009; and Sinu *et al*., 2011). In the present study, we have evaluated the biology, feeding behavior and predatory potential of *Sycanus* collaris on the tea looper *H.talaca* and the possibility of mass rearing on *C.cephalonica* under laboratory conditions.

MATERIALS AND METHOD

Study area and sampling: Three different tea gardens of Dooars region of West Bengal, in India were selected for the study namely Ambari Tea Estate (TE) (26.8732°N 88.0538°E), Banarghat TE (26.7995°N 89.0418°E) and experimental plot (26.8809°N 88.9079°E) Tea Research Association for the collection of *H. talaca* and *S. collaris*.

***Maintenance of hosts and predators:* (*H. talaca*, C.cephalonica and *S. collaris*):** Gravid healthy male and female moths of *H. talaca* were collected from the selected fields, put them into mating and egg laying chamber (glass chimney) and provided 10% honey solution as food source. After hatching of the eggs, larvae were reared on susceptible selected tea clone TV1 (Tocklai Vegetative 1) under the laboratory conditions (27± 2^{o}C, 70-80% RH and 16:10 LD photoperiod), followed the methodology developed by Babu *et al.,* (2014) with minor modifications. Rice meal moth of *Corcyra cephalonica* were reared under the same laboratory conditions on maize powder in a plastic container for the mass rearing of *S. collaris,* methodology followed by Rashmi (2009) with modifications. In the same laboratory conditions the collected adult of *S. collaris* were kept into glass chimney for mating and laying eggs, larvae of *H. talaca* and *C. cephalonica* were provided for feeding, methodology followed by Rajan *et al.,*(2017) in slight modifications. Shade tree barks were kept inside the chamber for egg laying and the egg masses were collected. A piece of wet cotton was put into the chamber for maintaining the moisture. The moist cotton pieces were changed every day to prevent the fungal infection. After hatching of eggs, the first and second nymphal instars of the predator were reared in group until molted into third instar stage, fourth, fifth and adult stages were put into separate Tarson sample container (Diameter 4.3cm height 5.4cm) to avoid cannibalism, methodology was followed by Sahayaraj (2012) with slight modifications. The reduviid predator were reared in laboratory for two generations to record the incubation period, nyphal stages, longevity of adult stages, number of eggs laid when feeding on the larvae of *H. talaca* and *C. cephalonica*.

Predatory Efficiency of s. Collaris

No-choice Feeding

The feeding efficiency of *S. collaris* was studied in no-choice condition, wherein different larval instars of *H. talaca* like second, third, fourth and fifth respectively were provided individually along with some tea shoots. For the assessment of prey consumption known number of larval instars of looper were provided to each nymphal instar (first, second, third, fourth and fifth) and adult (male and female) in separate containers (Diameter 4.3cm height 5.4cm). Prey consumption was recorded at 24h intervals. Fresh larvae of *H. talaca* were provided daily in order to maintain the constant prey density (Barua *et al.,* 2016).

Free-choice feeding

In free-choice condition of feeding different larval stages of *H. talaca* were provided together to different life stages of *S. collaris*. Known number of larval instars (second, third, fourth and fifth) were provided into the container containing single nymph or adult of *S. collaris* with few tea shoots as food. Daily prey consumption and preference of different life stages of *S. collaris* were recorded and tabulated. Cleaning of containers, providing of prey and tea shoots were maintained daily basis (Barua *et al.,* 2016).

Predatory behaviour of life stages of S.collaris: To record the predatory behaviour like the time taken in approach attacking, paralyzing and sucking the prey of different life stages of *S. collaris*, an experiment was conducted using large petridish (14.5cm in diameter). Each life stage of *S. collaris* were maintained under starved condition for 1.5h and then placed into that petridish with different larval instars of *H. talaca.* The sequential pattern of predatory behaviours were assessed and recorded the time taken by each stage of *S. collars* (Rajan *et al.,* 2017).

Stage specific predation: Stage specific predation of different life stage *S. collaris* were also studied under the same laboratory conditions. Different larval instars of *H. talaca* were provided to the individual stages (except first and second instar nymphs) of *S. collaris* and the maximum number of prey consumption and type of feeding were observed at 24h interval.

Statistical analysis

Data on the predatory potential and biology *S. collaris* on two host were subjected to analysis of variance (ANOVA) and means were separated by Tukey's multiple comparison test at p=0.05 and CD=1.103. Data on predatory behaviour were calculated by Tukey-Kramer HSD Post-Hoc Test and the means were significant at p<0.05.

Table 1 Biology of *Sycanus collaris* reared on larva of rice meal moth, *Corcyra cephalonica* and tea looper *Hyposidra talaca*:

Parameters	Developmental stages (in days) on	
	Corcyra cephalonica	***Hyposidra talaca***
Incubation period	13.6 ± 1.1^{d}	11.8 ± 2.3^{d}
I instar	9.6 ± 2.1^{d}	10.4 ± 0.9^{d}
II instar	11.2 ± 0.8^{d}	12.8 ± 3.3^{d}
III instar	11.6 ± 2.1^{d}	12.6 ± 2.4^{d}
IV instar	12.6 ± 0.5^{d}	14.0 ± 2.5^{d}
V instar	13.4 ± 2.3^{d}	15.0 ± 1.2^{d}
Total nymphal period	58.4 ± 3.9^{b}	64.8 ± 4.1^{b}
Male	41.6 ± 1.5^{c}	42.4 ± 2.1^{c}
Preovipositional period	9.2 ± 0.8^{d}	9.6 ± 2.1^{d}
Ovipositional period	39.6 ± 2.3^{c}	42.0 ± 2.9^{c}
Postovipositional period	9.4 ± 0.9^{d}	9.0 ± 0.7^{d}
Female	58.2 ± 2.0^{b}	59.4 ± 3.4^{b}
Eggs	282 ± 23.9^{a}	320.4 ± 44.2^{a}

Means followed by the same letter in a column do not differ significantly at p = 0.05 according to Tukey's multiple comparison test.

Table 2 Predatory efficiency of *S. collaris* on different larval stages of *H. talaca* in No-choice feeding condition

Stages of *S. collaris*	Feeding on larval stages of *H. talaca*			
	II	III	IV	V
I	2.2±0.8[d]	2.0±1.0[d]	-	-
II	3.6±1.5[cd]	2.2±0.8[d]	-	-
III	5.0±1.2[bc]	3.6±1.5[cd]	3.0±1.0[d]	1.8±0.8[c]
IV	6.6±2.1[b]	4.2±0.8[cd]	4.0±1.6[cd]	2.6±0.9[c]
V	7.0±1.2[b]	5.8±1.5[c]	5.0±1.6[c]	5.4±1.1[b]
Male	9.8±1.9[a]	8.8±1.9[b]	9.6±1.8[b]	9.0±1.0[a]
Female	11.8±2.6[a]	11.4± 4.0[a]	11.8±2.5[a]	10.2±1.9[a]

Means followed by the same letter in a column do not differ significantly at p = 0.05 according to Tukey's multiple comparison test.

Table 3 Predatory efficiency of *S. collaris* on different larval stages of *H. talaca* in Free-choice feeding condition

Stages of *S. collaris*	Larval stages of *H. talaca*			
	II	III	IV	V
I	1.4±0.5[c]	1.2±0.4[c]	-	-
II	1.6±0.9[c]	1.4±0.5[c]	-	-
III	1.8±0.8[c]	2.0±0.7[bc]	1.8±0.8[b]	1.2±0.4[b]
IV	2.2±0.8[bc]	2.4±0.5[bc]	3.6±0.5[a]	2.0±0.7[b]
V	3.0±0.7[ab]	3.2±1.3[ab]	4.0±1.2[a]	2.2±0.8[b]
Male	3.2±0.8[ab]	3.6±1.1[a]	4.2±0.8[a]	4.6±1.8[a]
Female	3.4±1.1[a]	3.8±0.8[a]	4.6±1.1[a]	5.0±1.6[a]

Means followed by the same letter in a column do not differ significantly at p = 0.05 according to Tukey's multiple comparison test.

RESULTS AND DISCUSSION

Biology: After 9-11 days of mating, the females of *Sycanus collaris* after started to lay the first clutch of eggs. A healthy female laid 4-6 clutches of eggs containing 60-68eggs/clutch when, fed on larvae of *H. talaca* whereas, a only 3-5 clutches containing 55- 63eggs/clutch of eggs were laid by the female feeding on larvae of *C. cephalonica*. The incubation period was longer13.6±1.1days when reared on *C. cephalonica* and it was shorter11.8±2.3 days when reared on *H. talaca*. Eggs were brown in colour, cemented together in vertical position on a smooth surface. Total nymphal period of I, II, III, IV and V instars of *S. collaris* was shorter (58.4±3.9 days) on *C. cephalonica* and longer (64.8±4.1days) on *H. talaca.* Ovipositional period of *S. collaris* was recorded as (42.0±2.9 days) when reared on *H. talaca* when compared to that of on *C. cephalonica* (39.6±2.3 days). Longevity of male and female of *S. collaris* are not significantly different when reared on the two hosts (Table 1) which are in line with studies by earlier researchers on other reduviid species (Rajan *et al.,* 2017; Vennison and Ambrose, 1990 & Zulkefli *et al*., 2004). Nitin *et al.,*(2017) reported the durations of *S. galbanus* I and V instar 9.24±0.18 and 16.04±0.19 days respectively when reared on larvae of *Galleria mellonella.*

The fecundity of *S. collaris* reared on *C. cephalonica* was 282±23.9 eggs/female and 320.4±44.2 eggs/female reared on *H. talaca* which are similar to the other reduviid bugs (Rajan *et al.,* 2017; Sahid *et al*., 2018). For mass multiplication of reduviid bug in laboratory conditions alternative host like *C. cephalonica* has been recommended through extensive studies by earlier workers (Rajan *et al.,* 2017 and George, 2000)

Predatory Efficiency of S. collaris: The predatory potential of the nymphs and adult of *S. collaris* assessed by recording the total number of *H. talaca* larvae consumed. The results revealed its potential on various life stages of looper. The feeding efficiency of *S. collaris* increased gradually with the development of life stages. In a no-choice condition of feeding, the first instar nymph of *S. collaris* fed 2.2±0.8second instar larvae in 24h which was found increase with the advancement of instars.(p=0.05, Table 2). Adult females voraciously consumed maximum fourth and fifth instar larvae of *H. talaca* per day.

In free-choice condition of feeding, the first and second instar nymph of *S. collariss* howed more preference towards the second and third instar larvae of *H. talaca* (Table 3). The third instar nymph consumed more (2.0±0.7) on second instar larvae of *H. talaca* per day whereas fourth and fifth instar nymph consumed 3.6±0.5 and 4.0±1.2 larvae of *H. talaca* per day respectively than other larval instars of *H. talaca.* In the current investigation, under both feeding conditions, *S. collaris* showed its potentiality to consume maximum number of larvae of *H. talaca* under laboratory conditions. Vennison and Ambrose (1992) reported that adults of *Sycanus reclinatus* consume 2-4 big size *Heliothis armigera* larvae per day. Srikumar *et al*., (2017) reported the maximum predation of adult *S. collaris* on *Spodoptera litura* was 3.77 per day. Extensive work has been done on the effective pest control by several species of reduviid bugs in agriculture fields (Grundy and Mealzer, 2000; Sahayaraj, 2000).

Predatory behavior of life stages of S.collaris: Movement of larvae of *H.talaca*, offered a visual stimulus which lead to arouse, erect posture and extension of antennae and rostrum of *S. collaris* towards the prey. Time taken by the different stages of *S. collaris* for approach and attacking, paralyzing and feeding and presented in Table 4. In excited condition, the predator pin the roustrum, on the body of the host larvae and inject the venom within 6.3±1.5second to paralyse the same. Depending on the developmental stages of *S.collaris* and the stages of host larvae the feeding time varied (Table 4).

The sequential predatory behaviour of *S. collaris* mediated on the stimuli- response proceedings initiated by the prey (Haridas and Ananthakrishnan, 1980). Depending on the prey size and its movement the approach attacking time and behavior of the predator varied (Edwards, 1962; Ambrose,1999). In the present study time taken by reduviid bug *S. collaris* for the paralyzing and sucking on the different larval instar were found to be longer than the time reported by Rajan *et al.,* (2017).Similarly, predatory behavioral work of different reduviid bug has been worked out on different pest (Das *et al*., 2008; Nitin *et al.,* 2017 & Venniso and Ambrose, 1992).

Stage specific predation: Depending on the life stage, nutritional requirement and availability of prey, larvae of *H. talaca* the reduviid bug *S. collaris* choose on specific prey stage. Data represented in the table 4 represents that first and second instar nymph of *S. collaris* preferred on second instar larva of *H. talaca*, indicated the group feeding behaviour. After molting into third instar nymph to the adult all stages preferred third to later stages (fourth & fifth instars) larvae of *H. talaca*.

Table 4 Predatory behaviour of life stages of *S.collaris*

Stages of *S. collaris*	Predatory activities (in second)					
	Approach attacking	Paralyzing	Sucking (Stages of *H. talaca*)			
			II	III	IV	V
I	24.0±1.0	12.0±2.0	74.7±3.5	87.7±1.5	-	-
II	22.0±1.0	11.3±1.5	73.0±2.6	86.0±4.4	-	-
III	19.3±1.2	11.0±1.0	71.0±2.6	84.0±4.0	95.3±2.1	124.0±3.6
IV	17.0±1.0	9.7±0.6	69.0±5.5	81.7±2.1	94.0±2.0	123.0±4.6
V	14.0±1.0	9.0±1.0	68.3±1.5	80.7±6.7	93.3±3.5	120.0±4.4
Male	11.7±1.5	6.7±0.6	65.7±2.1	78.3±1.5	90.0±4.4	119.3±8.0
Female	9.7±0.6	6.3±1.5	64.3±5.9	77.3±3.8	88.0±4.6	118.3±3.1

Means were calculated byTukey-Kramer HSD Post-Hoc Test significant at p<0.05.

Table 5 Stage specific predation of *S. collaris* on larvae of *H. talaca*

Stages of *S. collaris*	Stage specificity	Type of feeding	Feeding preference
I	II& III instars	Group feeding	II Instar
II	II & III instars	Group feeding and starting of individual feeding	II instar
III	II, III & IV instars	Individual feeding	III &IV instars
IV	II, III, IV & V instars	Individual feeding	IV instar
V	II, III, IV & V instars	Individual feeding	IV & V instars
Male	II, III, IV & V instars	Individual feeding	IV &V instars
Female	II, III, IV & V instars	Individual feeding	IV &V instars

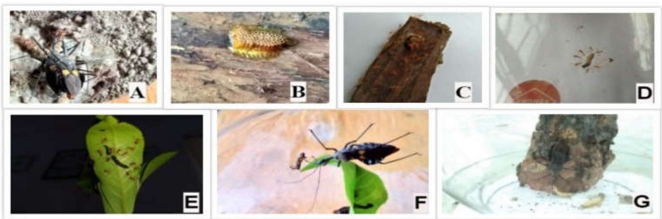

Fig 1 Different stage and feeding position of *Sycanus collaris nymph* and adult (A. mating pair, B. egg clutch, C. Newly hatched I instar nymphs, D. group feeding of I instar nymphs on larva of *C. cephalonica,* E. group feeding of I instar nymphs on larva of *H. talaca*, F, adult female feeding on larva of *H. talaca*, G. adult female feeding on larva of *C. cephalonica.*).

CONCLUSION

The predatory efficiency of *S. collaris* on the II, III, IV and V instar larvae of *H. talaca* has reconfirmed that, bigger size of life stage *S. collaris* preferred later stages of (IV and V instar larvae) morefor fulfilling the nutritional requirement.The performance of *S. collaris* on *C. cephalonica* confirmed that, mass multiplication under laboratory rearing of *S. collaris* is possible. The results on predatory behaviour, of feeding preference highlighted the vital role of this predator as an efficient biological control agent in tea ecosystem. Conservation of this predator in plantation belt wouldbe useful in developing a biocontrol-based looper pest management strategy in tea ecosystem.

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