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RESEARCH ARTICLE :

Biology and predatory behaviour of an assassin bug, *Sycanus collaris* (Fabricius) on rice meal moth, *Corcyra cephalonica* (Stainton) and leaf armyworm, *Spodoptera litura* (Fabricius)

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SUMMARY : The effective utilization of any biological control agent relies upon its comprehensive knowledge on bioecology, ecophysiology and behaviour. Hence, in the present study, the biology and predatory behaviour of third, fourth and fifth nymphal instars and adults of an assassin bug, *Sycanuscollaris* (Fabricius) to the larvae of rice meal moth, *Corcyra cephalonica* (Stainton) and leaf armyworm, *Spodoptera litura* (F.) was observed in the laboratory. The eggs were laid in clusters and cemented to each other and the surface of the plastic cylinder. The egg hatched after 11 to 15 days with each cluster having 15 to 70 eggs. Five nymphal instar stages were recorded. The mean longevity of each nymphal stage was 11.38±0.55, 12.24±1.87, 12.58±1.24, 14.62±1.67, 15.42±1.14 days when fed with *C. cephalonica* and 12.54±0.57, 12.24±1.12, 13.26±1.16, 14.42±0.86, 16.58±1.70 days when fed with *S. litura*. The mean longevity of male and female adult fed with *C. cephalonica* was 73.58±2.12 and 80.64±3.40 days, respectively. The mean longevity of male and female adult fed with *S. litura* was 75.82±2.82 and 85.48±3.20 days, respectively. The sequential acts of predatory behaviour and the time taken for each predatory act such as arousal, approach, capturing, paralysing, sucking and postpredatory behaviour and the number of piercing and sucking sites were observed. The predator took less time to predate upon the larvae of *S. litura* than that of *C. cephalonica*.

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BACKGROUND AND OBJECTIVES

The Reduviidae is the largest family of predaceous land Hemiptera and many of its members are found to be potential predators of a number of insect pests (Ambrose, 1999, 2000 and 2003 and Ambrose *et al.*, 2009). Since they are polyphagous predators they may not beuseful as predators on specific pests but they are valuable predators in situations where diverseinsect pest species occur. However, they exhibita certain amount of host as well as stage preferences. Hence, they should be conservedand augmented to be effectively utilized in theIntegrated Pest Management (IPM) programmes (Ambrose, 1999, 2000 and 2003 and Ambrose *et al*., 2003, 2006 and 2007). Conservation andaugmentation of any biological control agent relyupon its comprehensive knowledge onbioecology, ecophysiology and behaviour (Ambrose and Claver, 1996; Ambrose *et al*., 2009 and Das *et al*., 2008). The genus *Sycanus* is apredominant group of harpactorine reduviids in India and its members are very goodpredators with biological control efficiency. The impressive prey record of *Sycanuscollaris* (Fabricius) (Ambrose, 1999; George *et al*., 1998; Singh, 1998 and George, 2000a) prompted the authors to study the feasibility of utilizingthis biological control agent by augmenting and subsequently releasing it into the agro-ecosystem. Though information on predatory behaviour ofmany reduviids is available very littleinformation is documented for *S. collaris*.Hence, an attempt was made to study thebiology and predatory behaviour of *S. collaris*to twolepidopteran prey *viz*., rice meal moth *Corcyrac ephalonica* (Stainton) and leaf armyworm *Spodoptera litura* (F.).

RESOURCES AND METHODS

The adults of *S. collaris*were collected from tomato field, NIPHM, Hyderabad, South India. They were reared in the laboratory in plastic containers (30 x 10 cm) onrice meal moth *C. cephalonica* under laboratory condition (temp. 32±2º C, 75±5 rh and 12±1 hrs photo period). The adults that emerged were allowed to mate. The containers were carefully examined at regular intervels to record the eggs laid as well as spermatophore capsules ejected after succesfull copulation. The eggs laid in the laboratory were allowed to hatching petri dishes (9.2 x 2 cm) with wet cotton swabs for maintaining optimum humidity (85%), separately. The cotton swabs were changed periodically in order to prevent fungal attack. Mated females were maintained individually in order to record the number of batches of eggs and number of eggs in each batch laid by them. Each batch of eggs allowed tohatch in individual containers. The predators were reared in the laboratory for two generation to find out the incubation period, stadial period, fecundity, longevity and sex ratio.

The predatory behaviour was assessed by taking one day preydeprived third, fourth and fifth nymphal instarsand adults were used for the experiment. Eachpredator was placed in a plastic container (16 x7 cm) with the test prey species *i.e*., about 1.5cm long *C. cephalonica* and 2.5 cm long *S. litura* larvae, separately. For each life stage of thepredator six replicates were maintained. The sequential pattern of predatory behaviour and the time taken for each predatory acts such asarousal, approach and capturing, paralysing, sucking, post predatory acts and the number of piercing sites were recorded for each testpredators.

OBSERVATIONS AND ANALYSIS

Sycanus collaris (Fabricius) eggs were brown in colour and laid in clusters. The eggs glued together vertically with substratum. The average fecundity of female on *C. cephalonica* and *S. litura* was 256.58±5.68 and 340.82±3.56 eggs, respectively. The incubation period was 12.42±0.62 and 11.56±0.48 days on *C. cephalonica* and *S. litura*, respectively. The stadial periods of I, II, III, IV and V nymphal instars of *S. collaris*of *C. cephalonica* was comparatively shorter (11.38±0.55, 12.24±1.87, 12.58±1.24, 14.62±1.67 and 15.42±1.14 days, respectively) than those of *S. litura* (12.54±0.57, 12.24±1.12, 13.26±1.16, 14.42±0.86 and 16.58±1.70 days, respectively). The male and female adults fed with *S. litura* had longer life spans with 75.82±2.82 and 85.48±3.20 days. The range was nine to 127 days for the male and twelve to 142 days for the females. The longevity of male and female *S. collaris* adults fed with *C. cephalonica* was 73.58±2.12 and 80.64±3.40 days. Female biased sex ratios of *S. collaris* (male: female) were observed in *S. litura* (0.82:1) and *C. cephalonica* (0.85:1), respectively.

Immaturestages of *S. collaris* attained 92.11 % survival when nymphs were fed with an excess of leaf armyworm *S. litura* larvae. Such better survival was also observed in other reduviids namely *S. dichotomus* on larvae of *S. litura* and *C. cephalonica* (Zulkefli *et al.*, 2004); *R. marginatus* (niger, sanguineous and nigrosanguineous morphs) on cotton leaf worm *S. litura* (George, 1999) and namely *R. kumarii* on larvae of *S. litura*, *Earias vitella* Fab. and *C. cephalonica* (George, 2000b). Nymphal mortality was mainly due to the pronounced cannibalistic tendency among nymphal instars. Newly moulted reduviid nymphs with soft cuticle were main victims of cannibalism (Ambrose, 1980 and 1999; Ambrose and Paniadima, 1988). Abnormalities and natural hazards in hatching, moulting, combat against

Table 1 : Biology of *Sycanuscollaris* reared on larva of rice meal moth, *Corcyra cephalonica* and leaf armyworm, *Spodoptera litura* (n=6; X ± SE)

Particulars	*Corcyra cephalonica*	*Spodoptera litura*
Incubation period	12.42±0.62	11.56±0.48
Nymphal periods		
I nymphal instar	11.38±0.55	12.54±0.57
II nymphal instar	12.24±1.87	12.24±1.12
III nymphal instar	12.58±1.24	13.26±1.16
IV nymphal instar	14.62±1.67	14.42±0.86
V nymphal instar	15.42±1.14	16.58±1.70
Adult longevity		
Male	73.58±2.12	75.82±2.82
Female	80.64±3.40	85.48±3.20
Preovi position period	8.48±1.24	7.86±1.32
Oviposition period	48.52±2.61	53.48±2.14
Postovi position period	15.18.±2.28	12.56±0.93
Total no. of eggs/ female	256.58±5.68	340.82±3.56
Sex ratio (male: female)	0.85:1	0.82:1

powerful prey etc., were a few other causes of nymphal mortality in *Sphedanolestes signatus* Distant and *Velitra sinensis* Walker (Vennison and Ambrose, 1990 a and b).

S. collaris exhibited a pin and jabmode of predation (Ambrose, 1999). The timetaken for the sequential acts such as arousal, approaching, capturing, paralysing, sucking and postpredatory behaviour and the number of piercing sites recorded for third, fourth and fifth nymphal instars and adults of *S. collaris* to the larvae of *C. cephalonica* and *S. litura* are presented in Table 1.The visual stimulus from the moving preyexcited an arousal response in *S. collaris*. The III, IV and V nymphal instars and adults of *S. collaris* took 0.41±0.1, 0.36±0.06, 0.34±0.05 and 0.30±0.2 min for *C. cephalonica* larva and0.45±0.07, 0.45±0.11, 0.43±0.05 and 0.4±0.15 min for *S. litura* larva, respectively. The life stages of *S. collaris* took less time to arouse towards *C. cephalonica* larva than towards *S. litura* larva. The importance of vision inprey location and subsequent arousal responsein predation was proved by eye blinding experiments in many assass in bugs (Ambrose,1999; Ambrose *et al*., 2007; Das and Ambrose, 2008a and b). The moving prey offered a stimulus to the reduviids which lead the reduviid to arouse from a state of akinesis to a high level of excitation. The moving prey offered important stimulus in the primary sensory input for arousalin predation by reduviids (Ambrose, 1999; Haridass and Ananthakrishnan, 1980; Haridass *et al*., 1988; Louis, 1974; Nitin *et al*., 2017; Odhiambo, 1958 and Swadener and Yonke, 1973).

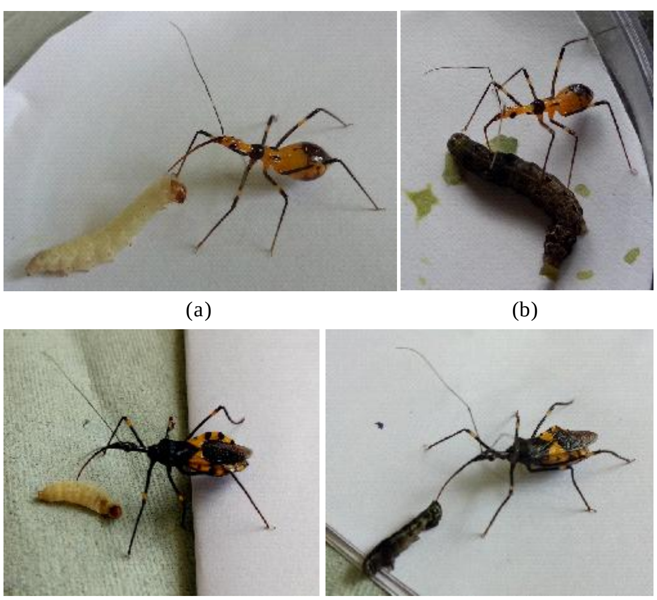
Once the predator got aroused, it turned towards the direction of the prey and approached towards the prey and captured the prey. While approaching and capturing the prey, predator stood in juxta tibial position and extended its antennae towards prey. *S. collaris* took moretime for approaching and capturing a *C. cephalonica* larva (0.14±0.02, 0.12±0.03, 0.12±0.03 and 0.1±0.04 min. for III, IV and Vnymphal instars and adults, respectively) than a *S. litura* larva (0.15±0.04, 0.13±0.03, 0.13±0.03 and 0.12±0.03 min for III, IV and V nymphalinstars and adults, respectively). The time taken for prey approaching and capturing, varied inother harpactorines due to their prey capturing potential, as well as the prey types (Ambrose,1999). Edwards (1962) stated that antennal movement of the *Rhynocoris carmelita* Stål was the key sensory input to approach the prey. Claverand Ambrose (2001) stated that under normal circumstances information was first perceived through the compound eyes before eliciting apredatory movement. The sensory hairs of thefore legs were

Table 2 : The predatory behaviour of life stages of an assassin bug, *Sycanuscollaris* (Fabricius) to larva ofrice meal moth, *Corcyra cephalonica* and leaf armyworm, *Spodoptera litura* (n=6; X ± SE)

Prey species	Predator stage	Predatory acts (in min)					
		Arousal	Approach and capturing	Paralysing	Sucking	Post predatory acts	No. of piercing and sucking sites
Corcyra cephalonica	III nymphal instar	0.41±0.1	0.14±0.02	0.05±0.02	37.07±0.82	0.08±0.02	5.86±1.52
	IV nymphal instar	0.36±0.06	0.12±0.03	0.06±0.02	49.04±4.66	0.09±0.01	8.36±1.61
	V nymphal instar	0.34±0.05	0.12±0.03	0.03±0.01	52.24±3.65	0.08±0.02	8.36±1.40
	Adult	0.30±0.2	0.1±0.04	0.02±0.02	67.09±6.75	0.06±0.02	9.8±1.52
Spodoptera litura	III nymphal instar	0.45±0.07	0.15±0.04	0.06±0.02	47.01±5.76	0.1±0.02	11.27±1.12
	IV nymphal instar	0.45±0.11	0.13±0.03	0.06±0.02	62.05±7.46	0.09±0.02	11.32±2.18
	V nymphal instar	0.43±0.05	0.13±0.03	0.04±0.02	67.24±5.69	0.09±0.05	13.10±1.38
	Adult	0.4±0.15	0.12±0.03	0.03±0.02	75.07±5.53	0.08±0.03	13.32±1.57

responsible for immediate captureof the prey (Putchkova, 1979). Edwards (1962), Ables (1978) and Ambrose (1999) stated that the reduviid predators with tibial pads are betteradapted for capturing the prey. Moreover, antennal perception of kairomones and allomones plays a major role in the prey capturing (Hagen, 1987). Rani and Wakamura (1993) reported that the prey odours were first perceivedby antennal receptors, triggering the approach.

After the successful capturing of the prey the predator paralysed the prey by injecting its toxicsalivary secretion. The predator took more or lesssame time (0.05±0.02, 0.06±0.02, 0.03±0.01 and 0.02±0.02 min for III, IV and V nymphal instars and adults, respectively) for *C. cephalonica* and (0.06±0.02, 0.06±0.02, 0.04±0.02 and 0.03±0.02 min for III, IV and V nymphal instars and adults, respectively) for *S. litura*. Complete paralysis of the prey was determined by the absence of clicking movement of the prey's head. Similar observations were also observed in other reduviids (Ambrose, 1999; Ambrose and Claver,1996; Ambrose and Ambrose, 2001; Ambrose*et al*., 2006, 2007 and 2009; Das and Ambrose, 2008a, b; Das *et al*., 2008 and Nitin, 2017).After paralysing the prey, the predator released its grip over the prey and sucked the predigested body fluid of the prey at ease byinserting the stylets all over the body



(a) (b) (c) (d)

Plate 1 : Pin and jab predation of *Sycanus collaris* Nymph (a. on *C. cephalonica* and b. on *S. litura*) and adult (c. on *C. cephalonica* and d. on *S. litura*)

without preferring a particular site of the prey. In contrary, Claver *et al*. (2004) reported that *S. collaris* preferred to suck around the head region followed by the abdominal region. The III, IVand V nymphal instars and adults (37.07±0.82, 49.04±4.66, 52.24±3.65 and 67.09±6.75 min, respectively) took more time for sucking a *C. cephalonica* larva than a *S. litura* larva (47.01±5.76, 62.05±7.46, 67.24±5.69 and 75.07±5.53 min, respectively).

After sucking the prey at all possible sites, predator started to clean its tibiae, antennae and rostrum. The duration of post predatory activities of III, IV and V nymphal instars and adults were comparatively shorter (0.08±0.02, 0.09±0.01, 0.08±0.02 and 0.06±0.02 min in, respectively) in *C. cephalonica* predation when compared to these in *S. litura* predation (0.1±0.02, 0.09±0.02, 0.09±0.05 and 0.08±0.03 min). In the final actof predation, the empty case of the host wasdragged and left off and the predator cleaned its antennae and rostrum by the foretibial pads (Ambrose, 2002).

The number of piercing and sucking sites also decreased in *C. cephalonica* (5.86±1.52, 8.36±1.61, 8.36±1.40 and 9.8±1.52 in III, IV and Vnymphal instars and adults of the predator, respectively) than in *S. litura* (11.27±1.12,11.32±2.18, 13.10±1.38 and 13.32±1.57) due to the larger size of *S. litura*. Though the sequential acts of predatory behaviour of *S. collaris* on both the larvae of *C. cephalonica* and *S. litura* were similar, the prey type influenced predation. For instance, the life stages of *S. collaris* quickly predate the larvae of *S. litura* than the larvae of *C. cephalonica* by capturing and sucking. Such prey influenced predation as a function of prey predator interaction was reported for several reduviids (Ambrose, 1999). As the life stages grew, the efficiency of predatory acts such ascapturing, paralysing and sucking also increased.This might be attributed to the predators' size governed predatory efficiency and the largerquantum of toxic saliva available for paralysing the prey. Thus, the size of the predator in relationto prey size plays a vital role in prey capturing (Ambrose, 1999; Nitin, 2017). In the present study, *S. collaris* easily handled the natural prey, *S. litura* than the laboratory prey, *C. cephalonica* which reveals the specific prey-predator interaction.

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