



Research Article

Biology and functional Response of *Andrallus spinidens* (F) to the rice army worm *Spodoptera mauritia* (Boisduval)

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ABSTRACT: The pentatomid bug, *Andrallus spinidens* (F.), is a polyphagous predator on lepidopteran larvae in rice fields in India. The basic biology and predatory potential of the bug was studied under laboratory conditions. The nymphs were reared in petri dishes and were fed 3rd to 5th instar *Spodoptera mauritia* (Boisduval) larvae. The mean development period from egg to adult was 21 days. Eggs were laid in batches of 45 to 95 and the mean total number of eggs laid by each female was 259. The second, third and fourth stage nymphs fed on 7.99, 8.32, 26.33 number of third instar larvae of *S. mauritia*, respectively. The predator exhibited a type II functional response to *S. mauritia* larvae with a disc equation of $Y' = 0.41(5 - 0.74)x$ to the increasing density of *S. mauritia*. This study provides important life history information for using the predator *A. spinidens* as a possible biological control agent for army worm management in rice.

KEY WORDS: Spiny soldier bug, attack ratio, handling time, searching time, predatory potential

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INTRODUCTION

Rice swarming caterpillar or armyworm, *Spodoptera mauritia* (Boisduval) (Lepidoptera: Noctuidae) is polyphagous and infests various graminaceous crops and weeds with worldwide distribution. During the last few years it has emerged as a major pest in eastern India and caused severe losses to wet season rice production in many parts of the country. An armyworm invasion on paddy fields was recorded in 22 districts of Assam in an unprecedented manner due to some unidentified reasons, besides possible aberrations in climatic conditions besides changes in traditional agricultural practices during the *kharif* season of 2016-17. (<http://timesofindia.indiatimes.com/city/guwahati/Crop-lands-in-Assam-hit-by-large-scale-armyworms-attack/articleshows/54295377.cms>). Similar outbreaks have also been reported from Odisha, Kerala and many parts of the world. Changing climate may be one of the factors to have caused an upsurge of this pest. Presently, the farmers depend on chemical control measures for the management of *S. mauritia*. However, in order to overcome the limitations of sole reliance on use of chemicals for the safety to human health and environment, it is imperative to develop holistic sustainable pest management strategies that may prevent the outbreak of this pest. There is tremendous potential for exploiting the role of predatory bugs such as *Andrallus* (F)

for managing insect pests in rice. In India, the indigenous predatory spiny soldier bug, *A. spinidens* (Hemiptera: Pentatomidae) belonging to the Asopinae group is a potential biological agent of lepidopteran larvae (Rao, 1965) with a wide distribution around the world in many crops including rice. It can be easily mass multiplied in the laboratory (Manley, 1982). Ebadi and Ghaninia, (2003) studied the mass rearing feasibility of *A. spinidens* in the laboratory on *Galleria melonella* Linnaeus. Mohaghegh and Amir-Maafi, (2007) further studied the effect of live or frozen larvae of *Ephestia kuehniella* and *Galleria mellonella* and found the latter to be more suitable in both forms. In India no work has been undertaken to mass produce this predator. In order to quantify its pest suppression efficacy for armyworm, it is imperative to assess its functional response to pest density. Therefore, the biology and functional response of *A. spinidens* was studied on the army worm *S. mauritia* under laboratory conditions.

MATERIALS AND METHODS

Insect culture and biology of predator

The army worm *S. mauritia* egg masses and adults were collected from rice field in Maruteru, Andhra Pradesh and maintained in the laboratory on baby corn and modified *Sopdoptera litura* diet. Adults of *A. spinidens* were col-

lected from rice fields at Kampasagar in Nalgonda district of Telangana and reared in the laboratory under controlled conditions at the ICAR - Indian Institute of Rice Research (IIRR), Hyderabad. The culture was maintained on the facultitious laboratory host *Corcyra cephalonica* (*S*) larvae. The second generation adults were released in plastic containers provided with wet cotton plugs and *S. mauritia* larvae as prey. Eggs laid on the paper strips and plastic containers were removed and kept for incubation. The neonates on hatching were maintained with water soaked cotton balls and after moulting the second to fifth instar nymphs were provided with *S. mauritia* as prey. The biological parameters like developmental period, prey consumed per day by nymphs and adults were recorded on fifteen *S. mauritia* larvae replicated thrice.

Functional response

The functional response experiments were conducted with 24 hours starved adult males and females of *A. spinidens* in plastic containers with *S. mauritia* as prey to determine the relationship between the prey density and the number of prey consumed, searching time, attack ratio and handling time of the predator. *S. mauritia* was first introduced into the container and allowed to settle. After 10 minutes, a predator was introduced into the container and the functional response was observed at varying prey densities, viz., 3, 5 and 10 third instar larvae of *S. mauritia* as prey / predator for 3 days with female and male predators separately. The experiment was replicated six times with three males and three females to represent both the sexes. After every 24 hours, the number of prey consumed was monitored and the prey number was kept constant by replacing them with fresh prey throughout the experiment. In the present study various parameters in the ‘disc’ equation of Holling (1959) were analysed to describe the functional response of *A. spinidens* as per the following formula:

$$Y^l = a (Tt - by) x$$

Where

- x* = prey density
- y* = total number of prey killed in given period of time
- y/x* = the attack ratio
- Tt* = total time in days when prey was exposed to the predator
- k* = maximum predation; handling each prey by the predator (*Tt/k*) and
- a* = rate of discovery per unit of searching time [(*y/x*)/*Ts*].

The parameters ‘*b*’, ‘*k*’, and ‘*a*’ were directly measured in the present study where the handling time ‘*b*’ was estimated as the time spent for pursuing, subduing, feeding

and digesting each prey. The maximum predation was represented by the ‘*k*’ value and it was restricted to the higher prey density. Another parameter ‘*a*’, the rate of discovery, was defined as the proportion of the prey attacked successfully by the predator per unit of searching time.

Assuming the predatory efficiency is proportional to the prey density and to the time spent by the predator in searching the prey (*Ts*), the expression of relationship is:

$$y = a Ts x \dots\dots\dots (1)$$

Since, time available for searching is not a constant it is deducted from the total time (*Tt*) by the time spent for handling the prey. If one presumes that each prey requires a constant amount of time ‘*b*’ for consumption, then

$$Ts = Tt - by \dots\dots\dots (2)$$

Substituting (2) in (1), Holling’s ‘disc’ equation is

$$Y^l = a (Tt - by) x \dots\dots\dots (3)$$

RESULTS AND DISCUSSION

Eggs were laid in batches of three to four rows. Each batch consisted of 45 to 95 eggs. The percent hatchability was 59.70 to 79.38% with an incubation period of 6 to 10 days. Freshly laid eggs were creamy white turning black as they harden. The eggs nearly ready to hatch became increasingly reddish. The nymphal stage had five instars and the average nymphal development period was of 18.54 days, which is in accordance to the earlier report of Manley (1982). The first instar nymphs were gregarious and tended to congregate on the eggs. No feeding was observed in the first instar but water was taken readily from damp cotton. The first instar nymphal period ranged from 3.0 to 4.0 days with a mean of 3.53± 0.51 (Table1), however, Manley (1982) reported the shorter period of 2.6 days. The fifth instar had the longest development period with a range of 5.0 to 6.0 and a mean of 5.71± 0.48 days, which was in agreement to the observations of Manley (1982). The younger instars hunted and fed gregariously, while fourth to fifth instar nymphs were mostly solitary and became cannibalistic, if confined in small space. Sometimes different stages were found feeding together. The second, third and fourth stage nymphs fed on 7.99, 8.32, 26.33 numbers of early third instar *S. mauritia* larvae, respectively, while Khodaverdi *et al.* (2012) recorded feeding of 12.22, 26.22 and 41.28 larvae of *S. littoralis*. Longevity of adult female was longer and ranged from 12.0 to 16.0, with a mean of 14.2± 1.64 days as compared to male, where it was 10 to 11 days with a mean of 10.5±0.70 days. Total life cycle of

A. spinidens from egg to death of adult male and female was 35.09±2.79 and 38.79±4.06 days, respectively. Rao *et al* (1979) recorded total developmental period of 24.2 days on *Parnara mathias* and other lepidopterans, while a mean development of 32 days was recorded on *S. litura* in Japan (Uematsu, 2006).

The response of *A. spinidens* to the increasing density of *S. mauritia* was of type II curvilinear functional response as advocated by Holling (1959) with a disc equation of $Y' = 0.41(5 - 0.74y)x$ indicating killing of more number of prey at higher densities than at lower prey densities (Table 2; Fig 1). Type II functional response is most typical of many predators and corresponds to where search rate is constant and the plateau represents predator saturation. Predators of this type cause maximum mortality even at low prey density. At high prey density, less time was spent in searching; therefore more time was available for handling, whereas at low prey density the searching time always dominated over handling time. The probability of the predator to come in contact with prey at higher prey density would have enhanced the searching ability per unit area. Ambrose and Claver (1997) obtained similar response for *R. fuscipes* to *S. litura*, *i.e.*, handling time decreased as the prey density was increased. The searching time decreased with increase in prey density. It is presumed that the predators spent less time on searching activities, which in turn might have caused perceptive decline in the attack rate until the hunger was established. Such indirectly proportional relationship between the attack ratio and prey density was also reported in other asopinae bugs *Podisus maculiventris*

(Say) and *P. nigrispinus* (Dallas) (Mohaghegh *et al.*, 2001).

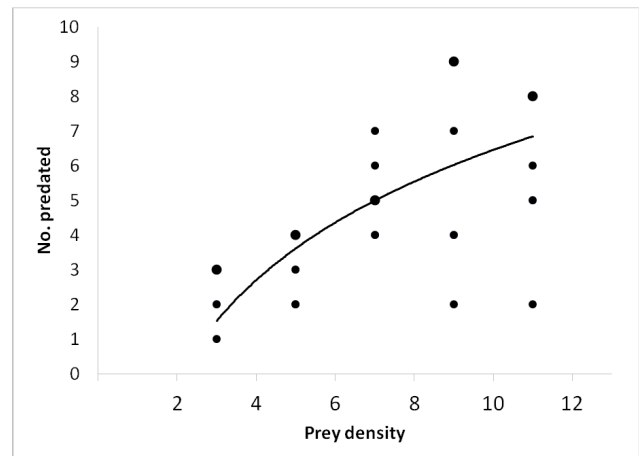


Fig. 1. Hollings Type II response of *Andrallus spinidens* (Each density is a mean of five replications).

Manley, (1982) concluded from his study that *A. spinidens* though limited in importance at low host densities will have greater value at outbreak or moderate to high host densities because of its short life-cycle and continuous feeding habit. The predator has also been successfully reared in the laboratory for many generations on the factitious host, *C. cephalonica* at IIRR. Similarly the insect has been reared on many other hosts in Iran and Japan. The ease of rearing of *A. spinidens* in the laboratory on *C. cephalonica*, *E. kuhnella* and *S. litura* and its positive response to higher densities makes it a potential biocontrol agent for developing mass multiplication strategies and field release

Table 1. Biology and predatory potential of *Andrallus spinidens* on *Spodoptera mauritia*

Stadium	Developmental duration (Mean±SD)	Range	Predated prey per day (Mean±SD)	Total prey	% Survival
I	3.53±0.51	3-4	-	-	100.00
II	4.44±0.50	4-5	01.80±0.44	07.99±0.47	100.00
III	2.50±0.51	2-3	03.33±0.57	08.32±0.54	93.33
IV	2.45±0.52	2-3	07.18±1.76	26.33±9.86	73.33
V	5.71±0.48	5-6	19.25±5.67	27.6±12.19	46.66

Table 2. Functional Response of adults of *Andrallus spinidens* to *Spodoptera mauritia* larva

Prey density (x)	Prey attacked (y)	Max 'Y (k)	Days/Y b= Tt/K	All y's Days (by)	Searching days Ts=Tt-by	Attack ratio (y/x)	Rate of Discovery (y/x)/Ts=(a)	Disc equation Y'=a (Tt-by) x
3	2.4	6.8	0.74	1.76	3.24	0.80	0.25	0.41(5-0.74y)x
5	2.4			1.76	3.24	0.48	0.15	
7	3.6			2.65	2.35	0.51	0.22	
9	5.2			3.82	1.18	0.58	0.49	
10	5			3.68	1.32	0.50	0.38	
11	6.8			5.00	0.00	0.62	1.00	
Mean				3.11	1.89		0.41	

and for conserving in the field, for management of army worms.

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