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Influence of prey on the development and reproduction of *Endochus inornatus* Stal

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ABSTRACT

The relative importance of three types of prey viz. termites (*Odontotermes obesus* Rambur), larvae of rice moth (*Corcyra cephalonica* Stainton) and tobacco caterpillar (*Spodoptera litura* Fabricius) in mass rearing, conservation and augmentation of the biological control agent, *Endochus inornatus* Stal has been analyzed under laboratory conditions for two generations. *S. litura* was found to be the most suitable prey among all the three prey types for the mass rearing of this biocontrol agent.

Key words: *Odontotermes obesus, Corcyra cephalonica, Spodoptera litura, Endochus inornatus,*biocontrol

INTRODUCTION

In a majority of insect species development, growth and reproduction are influenced by a variety of external and internal factors, and nutrition seems to be the most crucial single factor affecting the total development and total egg output. Nutrition is a factor of great importance which regulates animal growth, reproduction and diversity of animals (White 1970). Ambrose and Livingstone (1979, 1987) pointed out that food is the limiting factor controlling distribution and abundance of assassin bugs in any ecosystem.

Reduviids have been documented as important natural enemies, suppressing several pests, especially lepidopteran insect pests (Ambrose, 1996). Conservation and augmentation of natural enemies, their mass rearing and release at the appropriate stage and conditions are the major components in Integrated Pest Management (IPM) (Rabb *et al*., 1976). The prey quality and quantity not only influence the growth and survival rates of the predator but also the fecundity and life table characteristic such as generation time and intrinsic rate of population increase (Awadallah *et al.*, 1986; George *et al.*, 1998b).

Prey species influence the development, survival and reproductive potential of insects which ultimately determines the rate of population growth. *E. inornatus* a predatory a land heteroptera was found to feed upon *Achaea janata*, *C. cephalonica*, *Helicoverpa armigera* Hubner, *Mylabris pustulata* (Thunb) and *Poecilocerus sp.* Investigation on the nutritional influence on development, growth and reproduction of predatory bugs was scanty except the works on *Acanthaspis pedestris* Stal (Ambrose and Subburasu, 1988), *Rhynocoris marginatus* Fabricius (Ambrose *et al.*, 1990), *Cydnocoris gilvus* Burmeister (Venkatesan *et al.*, 1997), *Rhynocoris longifrons* Stal (Ambrose *et al.*, 2003), *Sphedanolestes minusculus* (Chandral *et al.*, 2005). The objective of this study was to find out the most suitable prey among the three different prey types *viz.*, *O. obesus*, *C. cephalonica* and *S. litura* for the mass culture of *E. inornatus*, a potential biocontrol agent.

MATERIALS AND METHODS

Adults of *E. inornatus* were collected from the semiarid zone of Kalluvilai village of Kanyakumari district Tamil Nadu. They were reared in plastic containers (6.5cm x 6 cm) and fed on *O. obesus* Rambur and caterpillars of *C. cephalonica* Stainton in the laboratory (temperature range of 30-32ºC, relative humidity of 75-85% and photoperiod of 11-13 hours). Laboratory emerged adults were allowed to mate (single female x single male kept throughout in container). Eggs laid were allowed to hatch with moist cotton swab to maintain optimum humidity (85%) for hatching. The cotton swabs were changed periodically to prevent fungal attack. After noting egg hatchability, all the newly hatched nymphs were reared individually.

Nymphal instars hatched from the laboratory laid eggs were reared on four different types of preys such as termite (*O.obesus)*, larvae of rice moth, *Corcyra cephalonica*, tobacco caterpillar *(S. litura)* and a combination of the selected species of three preys. Fifteen nymphs were taken in each category and reared in small containers with each type of prey separately. The dead nymphs were replaced with newly hatched ones and throughout the experiment the population density was maintained. Thus four sets of experiments were used for observation, larvae of rice moth *(C. cephalonica)* larvae of cotton bug *(Spodoptera litura)* and a combination of the selected species of three preys. Fifteen nymphs were taken in each catagory and reared in small containers with each type of prey separately. The dead nymphs were replaced with newly hatched ones and throughout the experiment the population density was maintained. Thus eight sets of experiments were used for observation, *E. inornatus* fed with *O.obesus, C. cephalonica* larvae, *S. litura* and *E. inornatus* fed with mixture of prey. Observations on stadial period and nymphal mortality were recorded.

The second generation adults that emerged from each category were allowed to mate. Biological parameters like incubation period, oviposition pattern, hatchability, hatching percentage, adult longevity and sex ratio were studied. An index of oviposition days was calculated as percentage of egg laying days in the female adult longevity.

All observations outlined were adequately replicated. Differences in biological parameters for the four sets of experiments of each predator was analysed by one way ANOVA (SAS institute, 1988) and Tukey's test (Tukey, 1953).

RESULT

Incubation and stadial period

The incubation period was the shortest for the test individuals fed with *S. litura* and *C. cephalonica* and the longest for the individuals maintained on *O. obesus* followed by the mixture of prey fed group. The shortest stadial period was observed in the nymphal instars reared on *S. litura*. The longest stadial period was recorded among the nymphal instars reared on mixture of prey followed by those fed with *C. cephalonica*. The fifth stadial period was not completed for the tested individuals fed with *O. obesus* and they were completely dead with shrinkled abdomen without metamorphosis. So next generation could not be raised (Table 1).

Nymphal mortality

The highest and total mortality was observed in the test individuals fed with *O. obesus* followed by *C. cephalonica*. The lowest nymphal mortality was noticed among the nymphal instars fed with *S. litura* followed by mixture of prey. The highest percentage of death was observed in the V stadial period of the nymphal instar fed with *O. obesus*, hence next generation was not raised for the test individuals fed with *O. obesus* (Table 2).

Adult longevity and sex ratio

In all the three categories, the females lived longer than the males. The adult longevity of both male and female was the longest in *S. litura* fed group. The lowest adult longevity was observed in *C. cephalonica* reared test individuals and followed by the mixture of prey fed group. The laboratory raised progeny was skewed towards the female biased population rather than to male population in all the three categories (Table 3).

Oviposition pattern and hatchability

Pre oviposition period was short almost equal among the individuals fed with *C. cephalonica* and the mixture of prey. The longest pre oviposition period was noticed for the tested individuals maintained on *S. litura*.

Oviposition period was long for the individuals maintained on *S.litura* and short for the tested individuals reared on *C. cephalonica*. The oviposition index was lesser for those individuals fed with *S. litura* and greater for the individuals reared on *C. cephalonica*.

Table 1. Prey influence on the incubation and stadial period (days) in *Endochus inornatus* (n = 15; x ± SD)

Prey	Incubation period	Stadial period					Total (days)
		I-II	II-III	III-IV	IV-V	V- male	
O.obesus	11.33 ± 0.47^{a}	7.53 ± 0.72^{a}	5.367 ± 0.70^{a}	7.53 ± 0.81^{a}	8.47 ± 0.88^{a}	-	-
C.cephalonica	8.0 ± 0^{b}	7.20 ± 0.47^{ab}	5.60 ± 0.49^{a}	5.87 ± 0.81^{b}	7.47 ± 0.88^{b}	13.75 ± 1.09^{a}	16.86 ± 1.96^{a}
S. litura	$8.0\pm0.^{b}$	6.80 ± 0.75^{b}	5.20 ± 0.83^{a}	5.40 ± 0.80^{b}	5.93 ± 0.68^{c}	11.63 ± 0.99^{b}	15.71 ± 1.28^{a}
Mixture	9.20 ± 0.75^{c}	7.53 ± 0.72^{a}	5.53 ± 0.62^{a}	7.53 ± 0.88^{a}	8.13 ± 0.81^{ab}	11.75 ± 1.49^{b}	18.71 ± 1.28^{b}
O.obesus	11.33 ± 0.47^{a}	7.53 ± 0.72^{a}	5.367 ± 0.70^{a}	7.53 ± 0.81^{a}	8.47 ± 0.88^{a}	-	-

Values followed by similar superscripts "across a column" are not statistically significant at 0.05% level

Table 2. Prey influence on the nymphal mortality (%) of *Endochus inornatus*

Prey	Mortality of instars					Total (%)
	I	II	III	IV	V	
O.obesus	6.67	6.67	0	0	100	100
C. cephalonica	19.99	13.33	6.67	6.67	13.33	40.91
S. litura	13.33	6.67	6.67	0	6.67	26.32
Mixture	13.33	6.67	0	0	13.33	27.78

Table 3. Prey influence on the adult longevity (days) and sex ratio in *Endochus inornatus* (n = 15; x ± SD)

Values followed by similar superscripts "across a column" are not statistically significant at 0.05% level

Maximum number of eggs were laid by the females fed with *S. litura* with the maximum number of 33.2 ± 6.3 eggs/ batch followed by the females fed with a mixture of prey. Lesser number of 87.17±12.63 eggs with a maximum of 17.2 ± 1.8 eggs/ batch was noticed in the females fed with *C. cephalonia*. But the number of batches of eggs was less for those females fed with *S. litura* and mixture of prey. Females fed with *C. cephalonia* laid more batches of eggs with lesser number of eggs/batch.

Similar to fecundity, adults fed with *S. litura* laid maximum number of fertile eggs. The hatching percentage was highest for the individuals fed with *S. litura*. Lowest hatching percentage of 41.35 ± 5.03% was noticed for those individuals fed with *C. cephalonica* (Table 4).

DISCUSSION

Incubation and stadial period

The shortest incubation and stadial periods were noticed among the nymphal instars fed with *S. litura*. It might be the consequence of better nutrition obtained by the predator with the minimum expenditure of energy and minimum stress developed during predation on less number of large sized, less agile prey with high nutritive value. This finding agreed with the concept of Slansky (1982) which established a correlation between prey preference and accelerated developmental rate of predators.

The longest stadial period was recorded among nymphal instars fed with *O.obesus* and mixture of prey. This might be due to the feeding stress developed by the small size of the prey and the formic acid secreted by the prey. Due to the smaller size and the lesser mass of the prey the predator was compelled to capture a higher number of prey to satiate itself which resulted in more stress on the predator. Similar type of feeding stress was reported in *A. pedestris* (Ambrose and Subburasu, 1988), *Rhynocoris marginatus* (Ambrose *et al.*, 1990), *R. kumarii* (Ambrose and Sahayaraj, 1991) and *C. gilvus* (Venkatesan *et al.*, 1997).

Table 4. Prey influence on the oviposition pattern and hatchability in *Endochus inornatus* (n = 6; mean ± SD)

Oviposition pattern and hatchability	Prey type		
	C. cephalonica	*S. litura*	Mixture
Adult female longevity in days	45.17 ± 5.31[a]	59.17 ± 5.98[b]	54.67 ± 5.79[b]
Pre oviposition period in days	10.33 ± 2.75[a]	12.83 ± 2.03[a]	10.50 ±2.50[a]
Oviposition period in days	19.67 ± 2.29[a]	28.50±2.81[b]	25.00±3.74 [b]
Post oviposition period in days	14.17 ±2.97[a]	17.83 ± 4.88[ab]	19.17±4.71[b]
Oviposition index	15.26 ±2.28[a]	9.26±1.94[b]	10.61 ±1.80[b]
Number of eggs laid	87.17±12.63[a]	150.67±20.49[b]	108.50±19.23[a]
Number of batches of eggs	6.83±0.90[a]	5.50±1.26[a]	5.83±1.34[a]
Minimum number of eggs / batch	10.67±1.97[a]	19.17±3.98[b]	14.00±2.77[a]
Maximum number of eggs/ batch	17.17±1.77[a]	33.17±6.34[b]	23.83±4.49[a]
Average number of eggs / batch	12.81±1.96[a]	28.14±3.70[b]	18.80±1.08[c]
Number of nymphs hatched	35.67±4.42[a]	124.33±12.18[b]	55.50±9.93[c]
Hatching percentage	41.35±5.03[a]	82.87±4.08[b]	52.14±3.29[c]
Frequency of 100% hatching	0.33±0.47[a]	3.17±0.69[b]	1.83±0.69[c]
Frequency of 0% hatching	1.83±0.90[a]	0.33±0.47[b]	0.83±0.69[c]

Values followed by similar superscripts “across a row” are not statistically significant at 0.05% level

Adult longevity and reproduction

Pre reproductive delay and reproductive potential such as fecundity, percentage hatchability of the insect predators were determined by the nutrient composition of the prey species (Fuller, 1988). Egg laying potential, hatching success and longevity of adults were maximum with *S. litura* rather than with other prey species. It appeared to be a reflection of the superior nutritional quality of the prey. It might also be due to the minimum stress developed during predation on lesser number of prey because of the comparatively larger size with richer body tissue. This conclusion concured with the inference drawn by Venkatesan *et al.* (1997), George *et al.*(1998), Chandral *et. al.* (2005) and George (1999,2000a).

Nymphal mortality

The highest nymphal mortality was observed in the nymphal instars fed with *O. obesus.* Among the five instars, hundred per cent mortality was observed in the 5th instar, and in all the other instars nymphal mortality was found to be negligible. The total mortality in the 5th instar might be due to the high feeding stress developed by the predator. Due to the small sized nature of the prey and poor content of the total body tissue, the fifth instar was forced to capture higher number of small sized *O.obesus* with more expenditure of energy and it created a high feeding stress. Due to the high feeding stress, the energy obtained from the prey was not sufficient for growth and metamorphosis. It is correlated with the findings of Chandral *et. al.*(2005) in *S. minusculus* in which small sized predator depends upon small sized prey.

Similar result was obtained by De Clercq and Degheela (1994) in *Podidus maculiventris* in which eggs and the first two larval instars of the beet armyworm proved to be inadequate food for this pentatomid predator, however fourth instar larva provided adequate nutrients for completing the life cycle of the predator.

The fifth instar of *E. inornatus* was found to be normal during early days, but as days passed, the middle region of the abdomen became shrunken, the posterior part curved and the individuals died off without moulting and metamorphosis. Some chemical inhibitors in *O.obesus* might have disrupted metamorphosis, because when supplimentary feed was given to the fifth instar normal metamorphosis occured. The adults emerged from this category was found to be normal, fertile and oviposited when fed with *O.obesus*. Furthur investigation is necessary to find out the real mechanism behind this abnormality.The largest size of the adults and eggs were noticed is *S. litura* fed individuals followed by mixture prey fed group. It concurred with the findings of Ambrose *et al.*(1990) in *R. marginatus* in which tested individuals were larger in size when fed with *Chrotogonus* sp. which formed the most suitable prey for the laboratory rearing of *R. marginatus*.

In *E. inornatus* maximum longevity, highest fecundity and highest hatching percentage were noticed in individuals fed on the larvae of *S. litura*. This conclusion concurred with the inference of Venkatesan *et al.* (1997), George *et al.* (1998), George (2000), in which high egg output and maximum longevity were observed in reduviids *C. gilvus*, *A. siva, R. marginatus* and *R. kumarii* fed with *S. litura*. Hence from the present study, larvae of *S. litura* was found to be the highly preferred prey of *E. inornatus* since it seemed to promote faster development, higher longevity, fecundity and higher percentage of hatching. Considerable attention is needed to select the appropriate prey species for augmenting (mass rearing) the predators in Pest Management Programme.

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