THE BIOLOGY AND PREDATORY POTENTIAL OF NOTONECTID BUG, *ENITHARES INDICA* (FABR) AGAINST MOSQUITO LARVAE

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Abstract. The biology of a notonectid bug *Enithares indica* against immatures of Anopheline, Culicine and Aedine mosquitos was studied in the laboratory. The life cycle of the bug consists of the egg and five nymphal stages and takes about 64 ± 1.54 days for completion. All stages of *E. indica* have good predatory potential. It can be used as a biological control agent in an integrated disease vector control program.

INTRODUCTION

Mosquito control in India relies basically on the spraying of residual insecticides which has resulted in resistance in vector mosquitos, environmental pollution and other deleterious effects. As a result there is more emphasis on non-insecticidal methods of control and one of the methods receiving emphasis is the use of biological control agents (Sharma, 1989). Larvivorous fishes, bacilli, nematodes, fungi, have been tested and applied to mosquito aquatic stages in the field (WHO, 1982; Gerberich and Laird, 1985; Gajanana, 1978; Mulla, 1985; Starnes *et al*, 1993). In spite of the fact that various species of the genus *Notonecta* are known predators of mosquito larvae (Ellis and Borden, 1970; Wolda, 1961; Gracia *et al*, 1974; Sih, 1981) little attention has been paid to these bugs as biological control agents in India. This paper reports the biology and predatory potential of a Notonectid bug, *Enithares indica* (Fabr) studied in laboratory conditions to find out its suitability for biological control of immature stages of mosquitos.

MATERIALS AND METHODS

The notonectid bugs, *Enithares indica* (Family: Notonectidae) were collected from district Nainital, Uttar Pradesh, where the bugs are found commonly in ponds, pools, pits, rice fields and tanks. In natural conditions these bugs consume many types of prey including immature mosquitos. Laboratory studies on the biology and predatory potential of *E. indica* were carried out in Delhi.

All studies were carried out in an insectary maintained at 28 ± 2°C. Twenty-five adult bugs of each sex were released in one plastic tub of 60 cm diameter for mass rearing. Sponge pieces were provided as substratum in the tub for egg laying. Different immature stages of *Anopheles stephensi, Culex quinquefasciatus* and *Aedes aegypti* from the laboratory colony were provided as food while rearing. Fecundity was studied by holding one pair of male and female bugs (ten replicates) in a plastic bowl. Incubation period of eggs, egg hatchability and duration of nymphal instars were also studied. Eggs were removed and counted daily and the duration of different nymphal instars was recorded by observing the moulting time lag between different nymphal stages (four replicates). Size of each immature stage was measured from 20 samples and expressed as mean ± SE.

For assessing predatory potential of *E. indica* two sets of experiments were performed. Plastic bowls of 500 ml capacity containing 400 ml of water were used. Observations on prey mortality were made every 24 hours for five consecutive days by counting the dead prey whose hemolymph had been sucked out. All prey were replenished after recording the mortality.

The first set of experiments was performed to assess the feeding rate of nymphal and adult stages of *E. indica* against immature stages of Anopheline and Culicine mosquitos. *An. stephensi* and *Cx. quinquefasciatus* were used as prey. One hundred prey of a particular stage were provided to one predator (four replicates). Thus each stage of *E. indica* (first through adult) was studied seperately for predation against each mosquito stage and species. During the experiment, predation on *Culex* larvae was found quite high, therefore, 500 mos-

quito immatures were provided to one bug instead of 100.

The second set of experiment was performed (three replicates) to study the comparative prey-preference by *E. indica*, when *An. stephensi, Cx. quinquefasciatus* and *Ae. aegypti* were offered together. One bug of each stage (first through adult) was offered 10 prey of each stage (first instar larvae through pupae) of the three mosquito species (150 larvae/pupae altogether).

RESULTS

Biology

E. indica is a backswimmer. A single female lays 1-13 eggs in one oviposition. Eggs are rod shaped, blackish brown in color measuring 1.39 ± 0.31 mm. Incubation period lasts for 15.5 ± 1.89 days. *E. indica* passes through five nymphal stages before moulting into adult form. Duration between successive nymphal instars ranges from 6 to 8.29 ± 1.28 days and size ranges from 1.8 ± 0.24 mm to 7.5 ± 0.26 mm (Table 1). All nymphal stages look alike except for the difference in their size. Maturation of adult bugs takes 10-12 days after fifth moult. The male and female bugs measure 9.31 ± 0.35 mm and 8.45 ± 0.35 mm respectively. The total duration of life cycle from egg to adult is about 64 ± 1.54 days. The male bugs can be distinguished from females by the presence of deeply pigmented patch at subterminal end on ventral side covering 2/3 part (Fig 1). They are bigger in size than females and have a tapering posterior end, which is rounded

Table 1

Developmental stages of *Enithares indica*.

Immature stages	Duration (in days)	Size (in mm) (n = 20)
Egg	15.5 ± 1.89	1.39 ± 0.31
1st Instar Nymph	6 ± 0	1.8 ± 0.24
2nd Instar Nymph	6.45 ± 1.38	2.49 ± 0.28
3rd Instar Nymph	8.0 ± 1.16	3.5 ± 0.28
4th Instar Nymph	8.06 ± 1.20	5.5 ± 0.23
5th Instar Nymph	8.29 ± 1.28	7.5 ± 0.26

Figs are in mean ± SE.

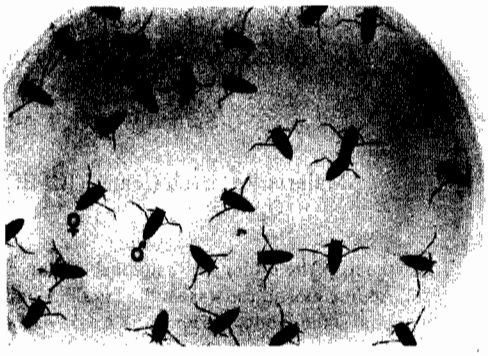

Fig 1–Adult male and female bugs.

in case of females. However, sex is not distinguishable in nymphal stages. It may be mentioned that in the absence of adequate food a high degree of cannibalism is observed in *E. indica*. It is, therefore, desirable to culture different stages of the bug separately for mass culture.

Predatory potential

Result of feeding rate of *E. indica* on immature stages of *An. stephensi* and *Cx. quinquefasciatus* indicate that maximum predation was of first instar larvae (85.66 ± 8.26 and 411.92 ± 102.05 while minimum (3.65 ± 4.33 and 6.83 ± 2.92 respectively) of pupal stage (Table 2). The predation rate decreased with increase in mosquito larval stage. There was no marked difference in predation by I, II, III and IV nymphal instars. However, the predation by fifth nymphal stage and adult bugs on first instar larvae of *An. stephensi* was noticeably low (19.15 ± 10.9 and 9.03 ± 8.32 respectively) while it was quite high in *Cx. quinquefasciatus* (356.12 ± 16.76 and 74.71 ± 45.13 respectively).

The results of prey selection amongst different stages of *An. stephensi, Cx. quinquefasciatus* and *Ae. aegypti* when provided together (Table 3) indicate that *E. indica* prefers *An. stephensi* followed by *Cx. quinquefasciatus* and *Ae. aegypti*. There was no marked difference in predation by different nymphal instars of bugs except that predation by the first instar bug was the least (total 26 larvae of all species). Early nymphal stages seemed to prefer early larval instars while predation on advanced stages of larvae increased with the increase in the nymphal stage. However, pupae were least preferred by all stages of *E. indica*.

Table 2

Predatory potential of *Enithares indica* on *Anopheles stephensi* and *Culex quinquefasciatus* (in 24 hours).

i) *Anopheles stephensi*

Stage of bug	Larvae/pupae consumed in 24 hours				
	I	II	III	IV	Pupae
1st	61.79 ± 12.08	42.58 ± 21.41	40.70 ± 19.94	33.34 ± 19.68	3.65 ± 4.33
2nd	82.80 ± 11.07	51.22 ± 22.49	49.37 ± 23.84	39.45 ± 26.20	11.37 ± 8.79
3rd	85.66 ± 8.26	63.58 ± 12.74	44.95 ± 14.53	36.12 ± 19.41	9.34 ± 3.1
4th	76.19 ± 10.83	71.87 ± 17.39	42.73 ± 10.44	41.87 ± 11.92	11.04 ± 4.56
5th	19.15 ± 19.9	80.66 ± 15.39	58.58 ± 14.71	50.54 ± 14.96	17.31 ± 6.48
Adult	9.03 ± 8.32	70.63 ± 10.71	76.07 ± 12.48	44 ± 17.21	13.18 ± 4.81

ii) *Culex quinquefasciatus*

Stage of bug	Larvae/pupae consumed in 24 hours				
	I	II	III	IV	Pupae
1st	86.59 ± 56.04	32.42 ± 17.74	33 ± 25.8	23.94 ± 18.21	8.28 ± 5.74
2nd	411.92 ± 102.05	95.93 ± 30.25	48.15 ± 18.98	29.62 ± 24.02	12.2 ± 6.97
3rd	304.4 ± 191.18	80.46 ± 58.62	33.12 ± 10.19	29.5 ± 2.66	6.83 ± 2.92
4th	374.6 ± 145.42	117.64 ± 62.53	37.18 ± 16.47	26.35 ± 12.39	9.84 ± 4.04
5th	356.12 ± 160.76	159.23 ± 57.03	75.65 ± 40.13	31.57 ± 16.77	15.25 ± 5.24
Adult	74.71 ± 45.13	75.95 ± 30.91	33.66 ± 18.01	25.73 ± 16.09	12.34 ± 10.08

Figs are in mean ± SD
* Bugs died eventually

Table 3

Predation of *Enithares indica* on different mosquito species when offered together in 24 hours.

Stage of bug	Predation of larval instar and pupae of mosquitos																		Grand total
	An. stephensi						*Cx. quinquefasciatus*						*Ae. aegypti*						
	I	II	III	IV	P	Total	I	II	III	IV	P	Total	I	II	III	IV	P	Total	
1st	6	4	1	0	0	11	5	4	1	1	0	11	3	1	0	0	0	4	26
2nd	7	7	5	2	0	21	6	4	3	1	0	14	4	4	1	0	0	9	44
3rd	7	6	4	4	1	22	4	5	3	2	1	15	4	3	2	1	0	10	47
4th	6	7	7	7	1	28	5	5	3	2	1	16	4	4	3	1	0	12	56
5th	4	5	5	5	2	21	3	4	4	3	2	16	2	3	8	3	1	17	54
Adult	3	4	5	7	2	21	2	4	5	5	2	18	2	4	4	5	1	16	55

DISCUSSION

The overall results of this study indicate that *E. indica* has predatory potential against immature stages of *Anopheles, Culex* and *Aedes* mosquitos. It became apparent from the experiments that the size of prey in relation to the stage of predator is important in influencing the predation rate by bug. Low preference for first instar larvae of *An. stephensi* (when offered exclusively) by V stage nymph and adult bugs may be attributed to the very small size of these larvae and the resting behavior of larvae to remain on margins where the bugs cannot reach owing to their long legs. On the other hand it is not so with *Cx. quinquefasciatus* larvae as they are usually found scattered all over the water surface. The reason of decreasing predation with increase in size of immature mosquitos is due to increase in size of the prey, which provides more quantity of hemolymph resulting in reduction in number of prey to be preyed. When the immature mosquitos of three species were offered together, maximum predation was observed against *An. stephensi*, while it was minimal against *Ae. aegypti*, probably due to the differences in feeding behavior and resting posture of two species (*An. stephensi* larvae remain parallel to the water surface while *Culex* and *Aedes* larvae remain vertical).

Laboratory studies on the biology and predatory potential of *E. indica* against different mosquito species clearly suggest that this bug can be used effectively as a biological control agent against aquatic stages of different mosquitos.

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