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Larvivorous potential of dragonfly nymphs

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Predatory rates of naturally occurring dragonfly nymphs-*Bradinopyga geminata* (Rambur) (tank variety) and *Crocothemis servilia* (Drury) (pond variety) collected from local tanks and ponds were studied under laboratory condition in Health and Disease Control Unit, Mingaladon from January 2002 to 2003. The series of experiment included two to five replicates for different sizes of nymphs. The results showed that medium-sized *B. geminata* consumed 62 ± 22 *Aedes aegypti* larvae (third and fourth instars) per nymph per 24 hours and the same size *C. servilia* 53 ± 21 per 24 hours. When all instars and pupae (equal number of 40 each) were introduced, the predatory rates rose to 137 ± 14 per 24 hours and 128 ± 9 per 24 hours for these varieties respectively. Predatory rates of both varieties were found not to be statistically different ($p > 0.05$). Medium-sized nymphs consumed most *Aedes* larvae followed by large and small-sized ($p<0.005$). The predatory rates increased with increasing number of larvae and pupae introduced and they were well correlated ($r = 0.97 – 1.0$, $p< 0.05$). The nymphs consumed most first instar of *Aedes* larvae and progressively fewer of each of successive stage. The nymphs were also found to be superior to other predators on feeding rate. The study highlighted that due to their advantages and the facts of being locally available, harmless to human and high in predation rate, dragonfly nymphs should be used as bio-control agents in the field by augmentative release, monthly or as necessary, into major water-storage containers especially heavy and irremovable containers such as concrete tanks, concrete and metal drums and earthen glazed jars to suppress *Aedes* mosquito, thereby controlling dengue haemorrhagic fever effectively.

INTRODUCTION

Dragonfly is the common name for large, winged, sun-seeking insect belonging to order Odonata which is widely distributed in the world and the world fauna probably does not greatly exceed the 5,000 species now known. They have been in existence for at least 200 million years as members of the global ecosystem. Dragonflies are predatory insects. Their life cycle consists of three stages - egg, larva or nymph and imago or adult. The former two are aquatic in nature and their habitats are mainly ponds, rivers, streams, tanks and tree holes [1, 2]. During the development from eggs, the dragonfly nymphs molt approximately 8 to 15 times and they feed actively on crustacea and protozoa, midge larvae, aquatic beetles, snails, small fishes, tadpoles and culicid larvae and even nymph of their own kind and other species of Odonata being called cannibalism. Therefore, the nymphs are opportunistic and euryphagous predators in nature and they are very quick in catching preys with the labial strike less than 25 miliseconds [2, 3]. The present study was done with the objectives of: (a) to determine the predatory rates of naturally occurring dragonfly nymphs on *Aedes aegypti* (L.) mosquito larvae within 24 hours, (b) to compare their predatory rates between tank and pond varieties and among different sizes of the predator and (c) to correlate number of mosquito larvae and pupae introduced with predatory rates.

MATERIALS AND METHOD

Study design was a prospective controlled laboratory trial conducted in Health and Disease Control Unit (HDCU), Mingaladon from January, 2002 to 2003. Dragonfly nymph collection areas were Mingaladon, Dagon and Thaketa Townships, Yangon, Myanmar.

Dragonfly nymphs were obtained from domestic water containers like concrete tanks, concrete and metal drums in residential areas of Mingaladon and Thaketa Townships and from the garden pond near Department of Medical Research (Lower Myanmar) in Dagon Township. The dry specimens of nymphs of both tank and pond varieties were sent to Professor PS Corbet, Biologist, Ecologist and Medical Entomologist of United Kingdom and Associate Professor Dr Joan Bryan, Australia Centre for International Tropical Health and Nutrition, the University of Queensland, Australia for species identification and they were all identified as *Bradinopyga geminata* (Rambur) (tank variety) and *Crocothemis servilia* (Drury) (pond variety). Their sizes were small (1.0 ± 0.1cm), medium (1.5 ± 0.2 cm) and large (1.9 ± 0.1cm). *Aedes aegypti* larvae for feeding were collected from domestic water containers in Thaketa Township. Glass bottles were purchased from local markets.

Dragonfly nymph – *B. geminata* collected were kept, for one day for adaptation purposes without any feed, in plastic trays (34.5 cm x 24.5 cm x 6.0 cm) containing rain water admixed with that of larval habitat and some weeds in the laboratory of HDCU. *Ae. aegypti* larvae collected were also kept in the laboratory similarly. Five active medium-sized nymphs were selected and each was placed into each of five clean glass bottles (diameter 7.5 cm and height 17.5 cm) containing 800 ml of rain water. Next, one hundred *Ae. aegypti* larvae (3^{rd} and 4^{th} instars, 50 each) were introduced into each bottle. Larvae in same number in control bottle were monitored to assess the natural mortality. The number of larvae consumed by nymphs was recorded after 24 hours. Each set of experiment was replicated five times.

Similarly medium-sized *C. servilia* nymphs collected were studied for five replicates. Then the small and large-sized of both varieties were tested for predatory rates on third and fourth instars of larvae for two replicates. Then all sizes of both varieties were tested with different number of larvae (all instars) and pupae introduced (50, 100,150 and 200 larvae containing equal number of instars and pupae) for two replicates.

During the experiment period, temperature (25 ± 7 °C) and relative humidity (78 ± 8 %) were recorded. Data analysis was done by Student's t test, the Kruskal-Wallis one-way analysis of variance and Pearson's correlation.

RESULTS

The study results indicated that the predatory rates were satisfactory. The predatory rate of medium-sized *B. geminata* was 62 ± 22 *Aedes* larvae (3^{rd} and 4^{th} instars) per nymph per 24 hours and that of *C. servilia* was 53 ± 21 larvae per 24 hours. The difference between these two predatory rates was found not to be statistically significant ($p > 0.05$). In the control bottle all *Aedes* larvae were alive till 24 hours. Among different sizes of the nymphs, the medium-sized consumed most *Aedes* larvae, followed by the large-and the small-sized. It was statistically significant ($p<0.005$) (Table 1).

Table 1. One-way analysis of variance: differences in mean *Aedes* larvae (third and fourth instars) consumed by *B. geminata* and *C. servilia* of different sizes

Size	No. of nymph tested	Mean larvae consumed		Mean rank		X^2		p value	
		B. geminata	*C. servilia*	*B.geminata*	*C. servilia*	*B.geminata*	*C. servilia*	*B. geminata*	*C. servilia*
Small	10	29.1 ±10.22	21.1± 14.62	7.7	9.5	13.52	12.55	<0.005	<0.005
Medium	10	62.1 ±21.55	53.0± 20.73	22.0	23.2				
Large	10	45.3 ± 9.91	29.2± 10.05	16.8	13.9				

Table 2. Predatory rates of *B. geminata* by size and number of *Aedes* larvae and pupae introduced and larval preference (mean %)

Size	Predatory rates (mean ± SD) by number of *Aedes* larvae (all instars and pupae) introduced				Larval preference by stage (mean %)					r	p
	50	100	150	200	1st	2nd	3rd	4th	pupa		
Small	25.0±5.0	53.5±1.5	73.5±8.5	73.5 ± 3.5	32	25	22	18	3	0.93	>0.05
Medium	39.5±2.5	82.0±5	101.0±15	137.0±14	25	23	22	18	12	0.99	0.01
Large	30.5±1.5	51.0±2	86.5±0.5	93.0± 3	30	25.50	22.50	19	3	0.97	<0.05

Table 3. Predatory rates of *C. servilia* by size and number of *Aedes* larvae and pupae introduced and larval preference (mean %)

Size	Predatory rates (mean ± SD) by number of *Aedes* larvae (all instars and pupae) introduced				Larval preference by stage (mean %)					r	p
	50	100	150	200	1st	2nd	3rd	4th	Pupa		
Small	30.5± 4.5	49.0± 3	66.5±1.5	80.5±7.5	31	28	17	22	2	1	-
Medium	26.5±11.5	57.5± 0.5	93.5±3.5	128.0± 9	27	25	20	15	13	1	-
Large	31.0± 1	33.5± 8.5	57.0±4	96.5±1.5	27.25	25.25	22.25	23	2.25	0.94	>0.05

Another interesting finding was predatory rates associated with number of larvae (all instars) and pupae introduced. It increased with increasing number of prey larvae introduced and these two variables were well-correlated and it was statistically significant (r = 0.97–1.0, p <0.05) except small-sized *B. geminata* (r = 0.93, p>0.05) and large-sized *C. servilia* (r = 0.94, p>0.05) (Table 2 & 3). Predatory rates of the medium-sized on all instars of larvae and pupae of *Aedes* were 137±14 and 128 ± 9 per 24 hours for *B. geminata* and *C. servilia* respectively. Out of different instars and pupae, both varieties of nymphs consumed most first instar (25–32%) and progressively fewer of each successive stage.

DISCUSSION

Dragonflies are popularly supposed to sting, but in reality they are harmless insects and economically they are also of great importance in destroying noxious flies and mosquitoes [3]. Dragonfly nymphs live in aquatic habitats for one to three months or even one to five years in low temperature areas before emergence. They are poly-phagous and can live without food for more than four months. The ability to survive for prolonged period without food may make them touse as valuable biocontrol agents because it allows them to remain viable as predators as the prey is intermittently eliminated. In a comparative study, larval and adult density of *Aedes* mosquito became much more reduced in treated area in Yangon in 1979. In that study medium-sized *C. servilia* nymphs (three weeks old) were used at the rate of four nymphs per a major container every four weeks. Mosquito larvae were reduced more than 85% within 2 weeks and almost eliminated during following 3 months. There was a marked and unequivocal reduction of adult as well. The nymphs are generalized obligate predators and they consume a large number of mosquito larvae and pupae. The nymphs have many advantages for use. They can cling to the side of container and so unlike other predators, are unlikely to be accidentally flushed or scooped out by the householders; their development is relatively slow; and they do not leave the container until emergence [4, 5].

Larval feeding rate in nature varies *inter alia* with predator size and time of year, and is normally less than maximum possible feeding rate determined in captivity. Experiments showed two-half grown dragonfly nymphs (libellulid) could kill all mosquitoes (range 87-780) in 4 to 9 days depending on the number of mosquito larvae initially present. The predatory rate was about 32 mosquito larvae per dragonfly nymph per 24 hours. On the other hand, medium-sized *B. geminata* nymphs consumed on average 133 ± 21 mosquito larvae (all instars) and pupae per 24 hours [5,6]. In the present study, feeding rates of both varieties were found to be satisfactory. Predatory rates of both varieties are not different statistically ($p>0.05$) but the rate of *B. geminata* (tank variety) is a little higher than that of *C. servilia* (pond variety). The reason may be that pond variety was satiated when they live in the pond where food was relatively more abundant than in the tank.

Being the highest predation rate, the medium-sized dragonfly larvae is the most suitable size to use as a biocontrol agent. The large-sized consumed less than the medium because feeding rate decreases with successive stadia. Predatory rates were also well-correlated with the number of prey larvae introduced. This was consistent with the finding that maximum feeding rate of a nymph is capable when food is supplied *ad libitum* [2]. The nymphs consumed most first instar with decreasing number at successive stage. This finding was also compatible with that in one of the studies [6].

Naturally *B. geminata* nymphs are found to be established in a large number in major sources, sometimes attaining about 200 in a concrete tank of 1.9 m^3 volume or 10 per metal drum containing domestic water [4]. *C. servilia* which are naturally found in local ponds in abundance throughout the year and other species like *Orthetrum sabina* (Drury) may be used as predators. The dragonfly adult is also useful because they eat some pests in paddy fields where they occur and about 80% of farmers use no insecticide. A notion persisted in some quarters in North America that the presence of a large anisoptera in flight will repell mosquitoes [2]. Dragonfly nymphs do not produce bacteria when water in which they live was tested bacteriologically on day one, two, three and seven [7].

Table 4. Predatory rates of different predators on *Ae. aegypti* larvae

Predators	Predatory rate (Larvae/predator /24 hr)	References
Dragonfly nymph *B .geminata*	133 ± 2.1	[6]
Larvivorous fish *T. trichopterus* (1.27cm)	30 ± 1.4	[8]
Larvivorous fish *Xi. helleri* (2.5 cm)	228 ± 21	[9]
Larvivorous fish *A. panchax* (2.5 cm)	55.30± 5.5	[10]
Mosquito *Tx. splendens* (full grown)	40±6	[11]
Cyclopoid *Me. pehpeiensis*	28.50 ± 5.9*	[12]
Cyclopoid *Me. thermocyclopoides*	25.45 ± 6.0*	[12]
Dragonfly nymph *B. geminata* (1.5cm)	137 ± 14	present study
Dragonfly nymph *C. servilia* (1.5cm)	128 ± 9	present study

*only 1st and 2nd instars of *Ae. aegypti* larvae

There are also other larvivorous predators (Table 4). By reviewing the nature and predatory rates of different predators, the dragonfly nymphs were found to be superior to other predators. This is the strong supportive point to recommend the dragon-fly nymphs to be used as bio-control agents in the field.

Routine vector control method currently used is effective and cheap. But some people do not follow to carry out these methods due to various reasons like being too busy, difficult to empty heavy and irremovable drums and tanks and lack of cover or lid for water containers. So dragonfly nymphs should be used in the major category containers like metal drum, earthen glazed jars, concrete tanks and concrete drums if there is no proper lid arrangement and regular emptying of water, or in the conditions that whirl formation does not occur in non-circular containers when cotton net sweeper is applied and regular treatment of water with temephos is too expensive and disliked by people due to its particular taste [4].

If an adequate source of supply of nymphs could be assured, for example, by obtaining them from local tanks and ponds by householders, this biological control of *Aedes* mosquito is feasible by using augmentative release of nymphs into domestic water containers monthly or as necessary. Moreover, community should be given health education and motivated and larval control by biocontrol method should be supported by administrative bodies.

It is summarized that dragonfly nymphs which are locally available, harmless to human beings and high in predation rate on *Aedes* larvae should be used in the treatment of domestic water containers especially heavy and irremovable concrete drums, concrete tanks, metal drums and earthen glazed jars to suppress *Aedes* mosquito, the vector of dengue haemorrhagic fever which attacks thousands of children under 15 years in our country annually.

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