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Effect of space on the feeding efficiency of dragonfly nymph *Bradynopyga geminata*

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Abstract

Among various predators of mosquito larvae, dragonfly nymphs are efficient, found naturally, safe for human beings, and are also economical in their application. There are many physical, chemical and biological factors like prey species, prey size, prey stage, predator species, predator size, predator stage, aquatic vegetation, quality and quantity of water, illumination, and space affect the feeding efficiency of dragonfly nymphs. These factors serve as a basis for the richness or otherwise biological productivity of any aquatic environment. The present study shows negative correlation where with the increasing space of the basins the feeding efficiency of the nymph decreased. The maximum prey consumption 34.91 ±3.96 was recorded when the circumference of the basin was 4 cm and the water level was 3 cm height and minimum predation 16 ±2.72 was recorded when the circumference of the basin was 64 cm and the water level was 3 cm height.

Keywords: Biological factors, feeding efficiency, functional response, predator – prey relationship

1. Introduction

Mosquito cause a huge medical and financial burden by spreading malaria, yellow fever, dengue, Chikungunya, filarial, Japanese encephalitis, and so on [1]. The incurable filarial, confusing dengue and fatal JE have showed increasing trend of infections and casualties in India [2]. Hence control of mosquito becomes a necessity to control the above diseases. Management of mosquito immatures through biological control is being tried world over [3].

A variety of factors make the Odonata an ideal model taxon for the investigation of the impacts of environmental warming and climate change [4]. Some of the previous studies observed that nymphal odonates are voracious predators of mosquito larvae in controlled settings and small natural habitats [5-8]. Immature Odonata occupy a great diversity of aquatic habitats but are generally most abundant in lowland streams and ponds. The predatory nymphs are an important part of aquatic food webs and the aquatic stages of mosquitoes comprise a significant part of the diet of many immature odonates [9].

The rate at which food is consumed by many organisms is known to increase as local food density rises [10]. In addition to food density, a number of intrinsic and extrinsic factors such as predator sex, predator age, Prey size, prey type, searching behaviour and handling time, direct and indirect competition and feeding method [11-14] affect the feeding efficiency of the predators. This relationship was characterized into three different forms collectively known as the functional response [15]. This relationship is fundamental to ecological studies because it provides the foundation of models that predict the distribution through space and time of organisms across a range of prey densities [16]. Many field studies have shown that those animals presumed to be more susceptible are more clearly separated in space or time from their predators [17].

More recent theoretical work has demonstrated that the feeding rate can influence the distribution of predators through s pace [18]. The objective of this work is to study the effect of space on the feeding efficiency of dragonfly nymph *Bradynopyga geminata.*

2. Material and Methods

2.1. Collection of mosquito larvae

Mosquito larvae were collected from nearby freshwater bodies, stagnant water in domestic settlements using small D-frame nets. The larvae were carefully sorted and allowed into 200 ml plastic beakers. The larvae grown in the laboratory were fed with powdered dog biscuits (Arjunan, 2012). The water in the beakers was renewed daily to keep the larvae healthy. The larvae were segregated as *Aedes* complex, Culicine aggregations and *Anopheles* life stages.

2.2. Collection of *Bradynopyga geminata* naiads

Bradynopyga geminata adults, caught from the Botanical Garden, Scott Christian College, Nagercoil were reared in a wire-netted cage about 18 cu ft in which a large fish tank was placed with about 3 litre water, 1.0 kg of sand and 0.5 kg pebbles. Small twigs were placed in the fish tank which served as moats for the dragonfly adult to settle down while laying eggs. The eggs of *B. geminata* were carefully watched and the egg emerging young ones were initially fed with Paramecium. The larvae were all allowed to develop further for about 20 days. During this period, the larvae were fed with chironomus larvae and fresh earth worm cuts (young larvae). Larvae older than 6 weeks were used to study the effect of space on the feeding efficiency.

2.3. Experimental set up

Basins of different circumferences such as 4, 8, 16, 32 and 64 cm were used with a water height of 3 cm for the experiment. Twenty mosquito larvae were first introduced into the basin and after 10 minutes, a single predator starved for two days was released into each basin. After every hour the number of prey consumed was counted and the prey density was maintained constant by replacing the prey consumed by the predator. Counting was continued at the end of every hour of the experiment (8 hours). Three replicates were maintained. Observations were recorded for each hour and the values were tabulated. The whole experiment was divided in to two halves.

The first half of the experiment consist of first four hours and the second half of the experiment consists of remaining hours. The statistical techniques used in this experiment are mean and standard deviation

3. Results

The effect of space on the feeding efficiency of dragonfly nymph was studied for eight hours. The observation was recorded at the end of each hour till the completion of experiment

3.1. Prey intake at the end of first half of the experiment at different circumference of the basin.

When the circumference of the basin was 4 cm and the height of the water was 3 cm, the feeding efficiency was high and the maximum prey intake was 13.67±1.97 in the first hour and the prey intake was gradually decreased as the time pass on and at the fourth hour the prey intake was abruptly decreased to 2.17±0.89. When the circumference of the basin was 16 cm and the height of the water was 3 cm, the feeding efficiency was high and the maximum prey intake was 9±1.29 in the first hour and the prey intake was gradually decreased as the time pass on and at the fourth hour the prey intake was decreased to 1.67±0.94. When the circumference of the basin was 64 cm and the height of the water was 3 the feeding efficiency was high and the maximum prey intake was 9±1.91 in the first hour and the prey intake was gradually decreased as the time pass on and at the fourth hour the prey intake was abruptly decreased to 1±0.82. The above findings revealed that irrespective of the circumference of the basin the prey intake by the predator was maximum at the end of the first hour. As the time passed on the prey intake was lesser when compared to the first hour. Abrupt change was recorded at the end of the 4th hour. This shows that the predator starved for two days voraciously feed at the beginning and at the later hours, it reached the satiation point and the prey intake was gradually decreased (Table1).

Table 1: Feeding efficiency of dragonfly nymph at different spatial distribution

S. No	Hours	Prey eaten at different circumference of the basin				
		4 cm	8 cm	16 cm	32 cm	64 cm
1	1	13.67±1.97	10.33±1.49	9±1.29	9.5±1.7	9±1.91
2	2	7.5±1.38	7±1	4.83±1.34	4.5±1.38	2.5±1.5
3	3	3.67±0.74	3±1.09	2.8±2.22	2±1	1.17±0.69
4	4	2.17±0.89	1.5±0.87	2±0.81	1.17±0.84	1±0.82
5	5	1.5±0.5	1.5±0.5	1.67±0.94	1±0.58	0.83±0.89
6	6	1.6±0.8	2.17±0.89	1.83±0.68	0.83±0.69	0.33±0.21
7	7	2.5± 0.76	2± 0.58	1.83± 0.89	1.5± 1.25	0.5± 0.34
8	8	2.3± 0.74	1.83± 0.68	2.17± 0.68	1.17±0.68	0.67± 0.47
∑		34.91± 3.96	29.33±3.04	26.1±2.369	21.67±2.79	16±2.72

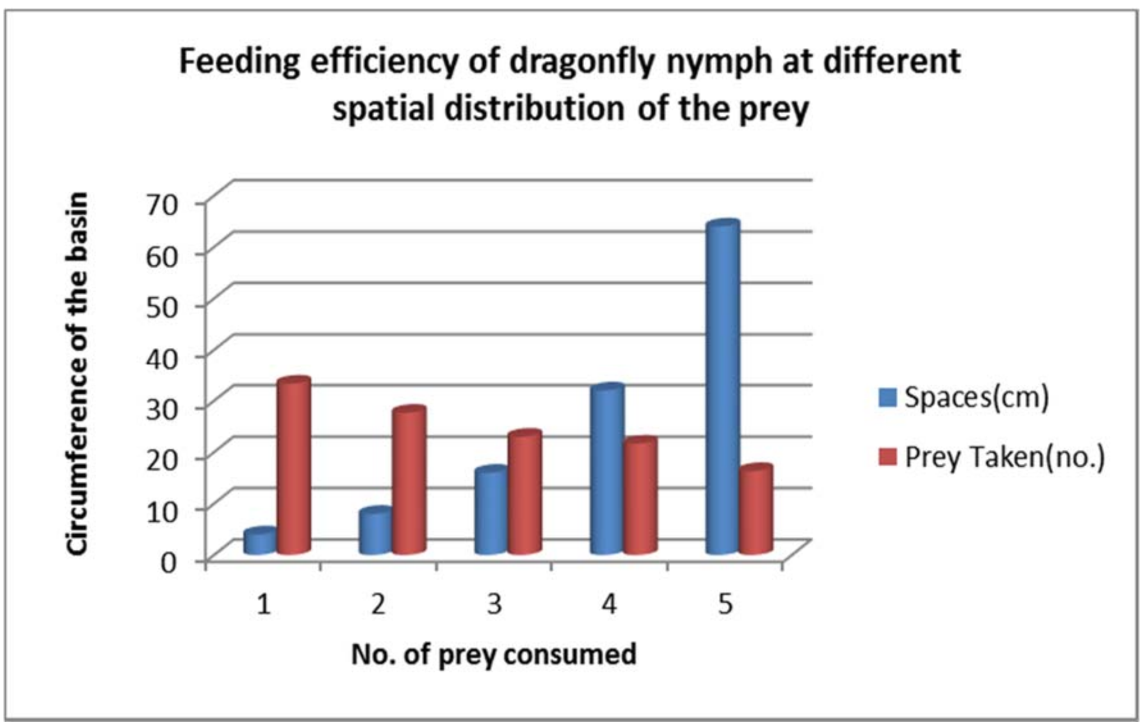

Fig 1

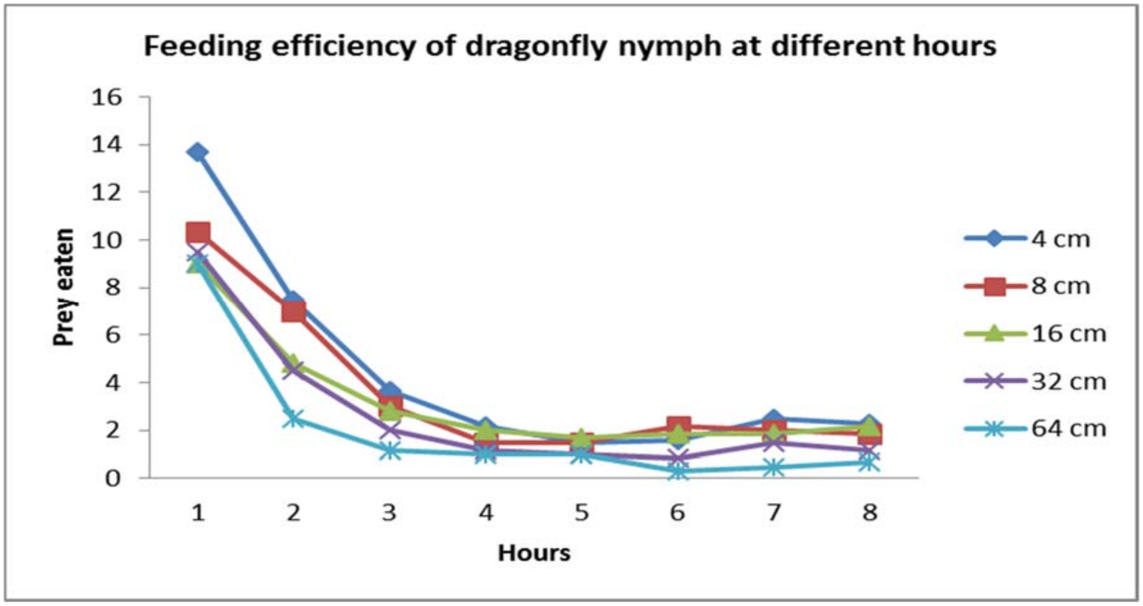

Fig 2

3.2. Prey intake at the end of second half of the experiment at different circumference of the basin.

When the circumference of the basin was 4 cm and the height of the water was 3 cm, the feeding efficiency was further reduced to 1.5±0.5 at the fifth hour. But after that there was a gradual increase in the intake and at the 8th hour it was 2.3±0.74, which is slightly higher than the 6thhour but lower than the 7th hour of the experiment. When the circumference of the basin was 16 cm and the height of the water was 3 cm, the feeding efficiency was further reduced to 1.67±0.94at the fifth hour. But after that there was a gradual increase in the intake and at the 6th and 7th hour it was 1.83±0.68and 1.83± 0.89 and at the 8th hour of the experiment it was 2.17+0.68, which was slightly higher than that of the 6th and 7th hours of the experiment.

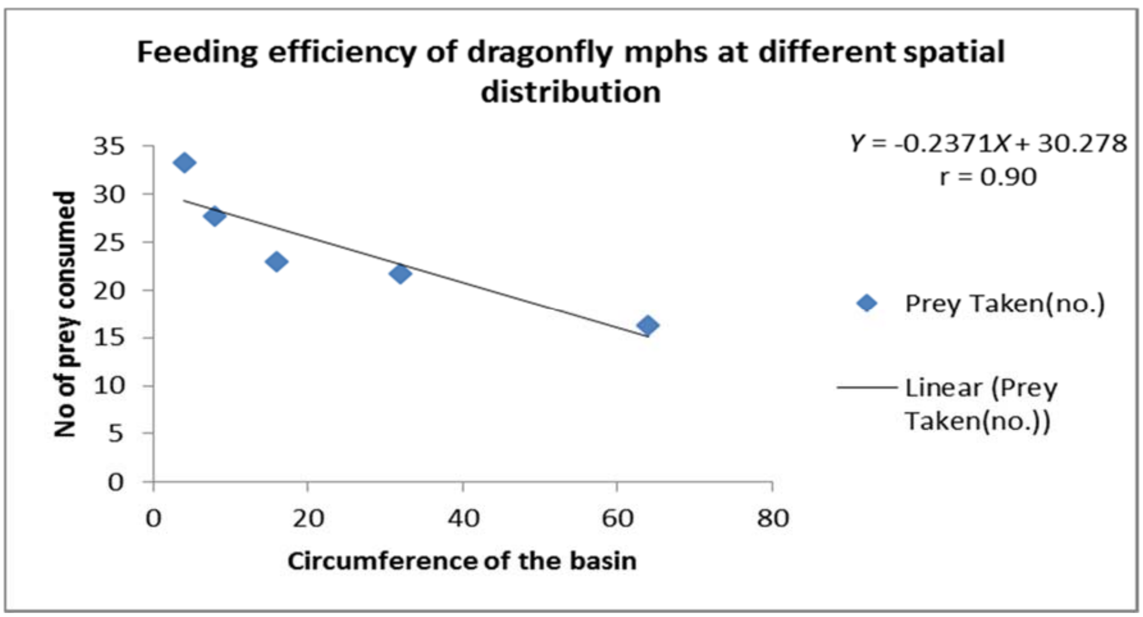

Fig 3: Regression analysis for feeding efficiency of dragonfly nymphs at different spatial distribution

When the circumference of the basin was 64 cm and the height of the water was 3 cm, the feeding efficiency was further reduced to 0.83±0.89at the fifth hour and 0.33±0.21at the sixth hour (Table 1 and Figure 1). But after that there was a slight increase in the intake and it was 0.5± 0.34 at the 7thhour and 0.67+0.47at the 8^{lh} hour of the experiment which was slightly higher than that of the 6th and 7th hours of the experiment. At the second half of the experiment, the prey intake was lesser but at a steady state. As the hours pass by and at end of the eight hour the prey intake was slightly increased than the previous hours of the second half of the experiment.

Two way ANOVA showed that there is significant deviation in the feeding efficiency of dragonfly nymph at different experimental period (hours) ($F=79.86$, $df=7$, $p \leq 0.05$) and at different circumference of the basin ($F=10.46$, $df=4$, $p \leq 0.05$) sins (cm). Linear regression (Figure 3) conveys that there exist a significant negative correlation between the feeding efficiency of dragonfly nymphs with different circumference of the basin ($r= 0.90$).

4. Discussion

There are many physical, chemical and biological factors affect the feeding efficiency of dragonfly nymph. Some of them are prey species, prey size, prey stage, predator species, predator size, predator stage, aquatic vegetation, quality and quantity of water, illumination, space [19]. Each factor plays its own role but at the same time the final effect is the actual result of the interactions of all these factors [20]. Usually the prey discovery was instantaneous with little searching time required. Although the parameter, rate of discovery was theoretically infinite, the predator did spend time in searching for the prey at lower prey density but no time at higher density and the extent of searching was closely related to the degree of satiation [15].

The dragonfly nymph rest at the bottom and wait for the prey to come nearby and when it is in the reachable distance, the starved dragonfly nymph catches it within no time with its extendable labium and engulf it. But when the space or circumference of the basin reduced with the water level of 3 cm height, the prey larvae are forced to be in a limited area that increases the prey density and that ultimately leads to the increasing feeding efficiency of dragonfly nymph. The same observation is made in *Acilius sulcatus* [21]. They studied the prey consumption of the larvae of *A. Sulcatus,* differed significantly with different prey, predator and volume combination. According to them feeding rate decreased with the decreased prey de nsity.

The present study negatively correlated with the increasing circumference of the basin space and decreasing feeding efficiency of dragonfly nymph *B. geminata.* When the circumference of the basin increases, the prey can scatter far away from the predators and so the searching time for predation may be increased, that leads to decline in the feeding efficiency of the predator. The maximum prey consumption 34.91±3.96 was recorded when the circumference of the basin was 4 cm and the water level was 3 cm height and minimum predation 16±2.72 was recorded when the circumference of the basin was 64 cm and the water level was 3 cm height. This study was supported by the study of Mandal *et al.* [22] who reported the prey consumption was inversely related with space and Miura& Takahashi [23] who reported, when density of prey increases the feeding efficiency of the predator will also be increased.

5. Conclusion

In conclusion, the results of the present investigation revealed that with the increasing prey density and when the space of the basin decreased the feeding efficiency of dragonfly nymph *B. geminata* was increased. When the prey density decreased with the increasing space of the basin, the feeding efficiency of dragonfly nymph *B. geminata* was decreased under laboratory condition. But this may vary in the field study because various factors in the environment affect the feeding efficiency of predators. When foods are changed from random to clump in dispersion, the predators increase their total use and feeding efficiency will be increased. By altering the ecological setting over a wide range, we can determine the general trend in the organism's response to single environmental variables and such experiments will prove very informative in the future in determining the effects of ecological change on the general behaviour of organisms.

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