



Functional response of *Tenagogonus fluviorum* (Fabricius) in its predation of *Culex quinquefasciatus* Say larvae of varied density and size

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ABSTRACT: Male and female *Tenagogonus fluviorum* (Fabricius) were exposed to different size classes (I, II, III, IV and pupa) and different densities (25, 50, 75, 100, 125) of *Culex quinquefasciatus* larvae as prey. Predatory efficiency of the female bug is higher than that of male. However, both the sexes of the predator prefer large sized prey. The size in predatory performance of the bug is directly proportional to the increase in prey density. Attack rate and handling time as two statistical constants were derived from the prey death rate caused by the predator and their significance is discussed.

KEY WORDS: *Culex quinquefasciatus*, functional response, predation, *Tenagogonus fluviorum*

INTRODUCTION

Gerrids are reported to be opportunistic predators dwelling on water surface of freshwater body. They feed on insects trapped on the water surface and those emerging from water (Sih *et al.*, 1990), but are capable of capturing live prey including other gerrids. They show a mechanical preference and not a nutritional one (Jamieson and Scudder, 1977). These gerridomorphans take numerous planthopper pests that fall from rice plants in flooded paddy fields becoming important natural enemies (Samal and Misra, 1982). Several water striders reportedly consume mosquito larvae (Nummelin, 1988), two Indian gerrids prefer to feed on notonectids (Selvanayagam and Rao, 1988) and *Hydrometra australis* seems to specialize on

aquatic collembolans (Lanciani, 1991). Individuals monopolize smaller prey but groups may effectively subdue large preys, which are frequently fed upon concurrently by several bugs (Erlandsson, 1992).

Prey has a direct impact on physiology, behaviour, and population as well as ecosystem levels of the predator (Waldbauer, 1968). Various aspects of the prey have been stressed that cause effective changes in the predator's performance. Predation is highly influenced by the density of the prey to which the predator gets exposed. *Ranatra linearis* increases its selectivity in the presence of high prey population (Blois and Cloarec, 1983). Predatory performance of *Ranatra filiformis* was higher in increased prey density of *Culex quinquefasciatus* mosquito larvae

(Venkatesan *et al.*, 1995). However, such an approach is rarely reported in Gerrids, which are opportunistic polyphagous predators. The present investigation was aimed at the effect of the sex of the predator, determination of handling time and attack rate of the predator, impact of prey density on predator's performance, and effect of prey size on predation in *T. fluviorum*.

MATERIALS AND METHODS

Predator rearing

Adults of *T. fluviorum* were collected from the rearing pond, which lies inside the campus of Loyola College, Chennai. They were maintained in the laboratory with the dipteran larvae as the diet. The female bug deposited the eggs on the wall of the aquarium, which were separated and were maintained in a container till eclosion. The successive nymphal stages that moulted out were periodically separated and maintained. For all the predation experiments, adults that emerged from the fifth nymphal stage of *T. fluviorum* in the laboratory were used.

Prey rearing

Larvae of *C. quinquefasciatus* were chosen as the prey item, since they were found to overlap the predator's habitat. Mosquito larvae collected in the Loyola College campus were brought to the laboratory and were maintained with food (yeast 40% + dog biscuit 60%) following procedure of Fay (1964). Larvae were then classified into five (I, II, III, IV and pupa) groups based on size variations. All the trials were carried out at room temperature ($28 \pm 3^\circ\text{C}$) in containers.

Functional response

Individual male and female predators were exposed to different size classes (I, II, III, IV instars, and pupa) and different densities (25, 50, 75, 100 and 125) of prey in a clean glass trough (20 x 10 cms) with 500ml of water. The number prey killed for one hour and twenty-four hour durations were noted and tabulated. The bugs were pre-starved for a day before the experiment, in order to avoid the effect of satiation.

Attack rate and Handling time

Data thus obtained in all the above treatments were subjected to statistical analyses following the procedure of modified random predator equation of Roger's (1972):

$$N_a = N \{N(1 - \exp) [-a PT - N_a T_h]\}$$

was used to estimate the attack rate and handling time,

where,

N_a = the number of prey killed,

P = the number of predators,

N = the density of the prey,

T = the time duration of exposure,

a = a constant, the attack rate of the predator which is the function or reactive distance of the predator, the speed movement of predator and prey and the proportion of successful attack, and

T_h = a constant, the handling time of the predator that includes the time spent in pursuing, subduing and digesting each prey.

RESULTS AND DISCUSSION

Fixation of prey density

Males and females of *T. fluviorum* were exposed for one hour and 24 hours to various densities and different size classes of prey – *C. quinquefasciatus* larva. Prey densities were fixed as 25, 50, 75, 100 and 125. The increase in predatory potential of *T. fluviorum* was directly proportional to the density of I, II, III, IV and pupal size classes of *C. quinquefasciatus*. Such a performance was similar in males and females when exposed to the pupae of *C. quinquefasciatus*. The number of large sized prey groups killed was higher than the small sized ones in both the sexes. However, the predatory potential of females was always higher than males (Fig 1 & 2).

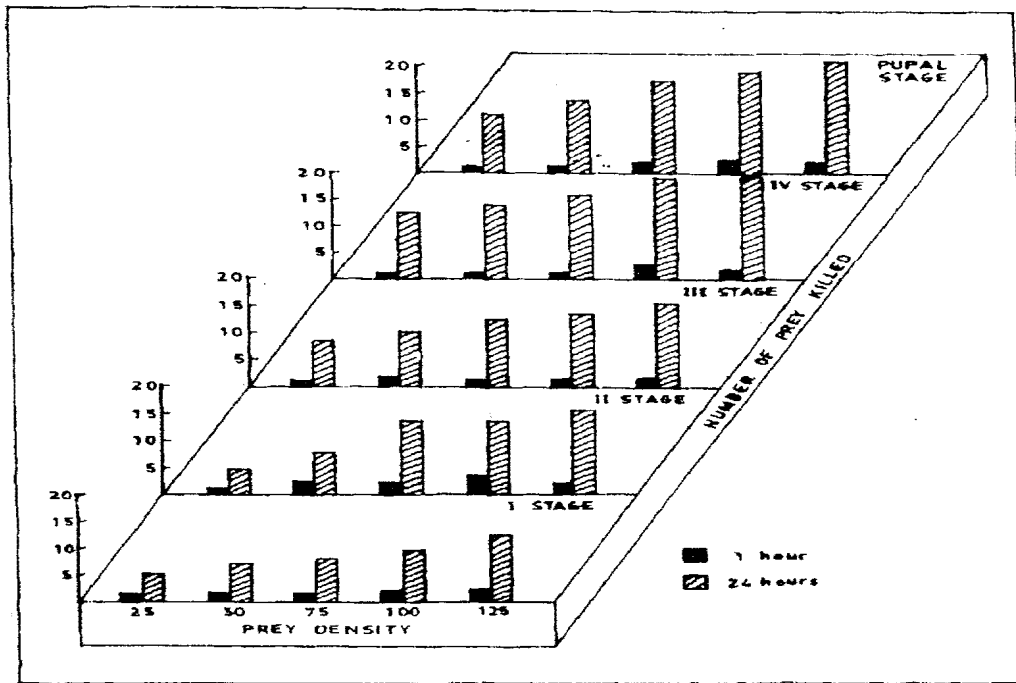


Figure 1: Prey death rate caused by male *T. fluviorum*

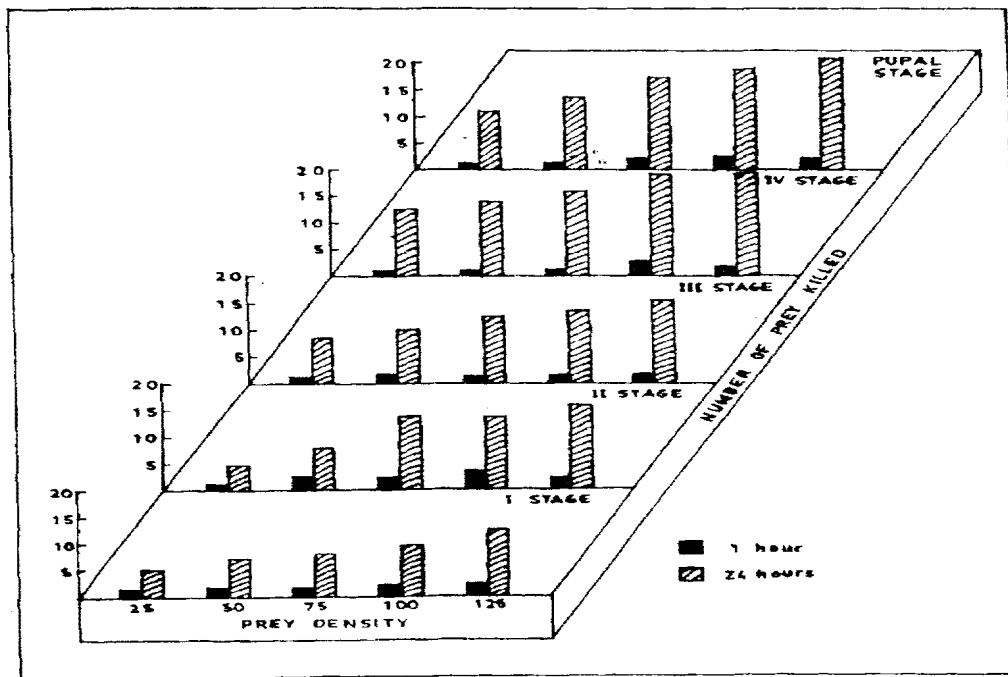


Figure 2: Prey death rate caused by female *T. fluviorum*

Effect of prey density

When male and female predators were maintained in containers separately, with the prey density ranging from 25 to 125, with all prey size groups, the predatory potential of *T. fluviorum* increased with an increase in prey density. Predatory efficiency of male bug exposed to pupal stage of prey was noted to be 11.2 ± 2.15 ; 13.6 ± 3.10 ; 17.1 ± 2.08 ; 19.3 ± 2.91 ; 21.1 ± 3.04 and that of the female bug as 12.7 ± 1.83 ; 14.1 ± 1.91 ; 17.6 ± 2.27 ; 21.3 ± 2.67 ; 22.2 ± 2.10 irrespective of increasing density (25, 50, 75, 100 and 125) for twenty-four hours duration. The findings suggest that a supra-aquatic insect may be efficient in catching the prey that may spend maximum period of time on water surface. Kaitala (1987) reported in *Gerris thoracicus* that the important features of its habitat are their variability with regard to food productivity and environment. Gerrid has a dynamic life history strategy, being a wreckless reproducer when food is abundant but a restrained reproducer when it is scarce. Whereas in aquatic bugs such as belostomatid bugs, their survival in the water column shows an effective predation even at low prey density (Venkatesan *et al.*, 1995). Probably *T. fluviorum* may be a scavenger who may depend upon the dead prey that falls on the water surface.

Predatory efficiency has been well correlated with mating behaviour in gerrids by Rowe *et al.* (1994) who have developed two scenarios, both of them holding good in gerrids. Effects of food availability on mating frequency depend on how feeding *per se* influences mating behaviour and how hunger affects mating behaviour, though there has been some evaluation of the former effect. Effects of food availability on female behaviour and, in particular, female reluctance to mate should depend on the effect of mating on female feeding efficiency. If mating females enjoy higher feeding efficiency than single females, than hungry females should be less reluctant to high mating frequency. If mating females have lower feeding rates than the other then the opposite prediction should hold. The scenarios developed by Rowe *et al.* (1994) and the present findings on higher predatory efficiency of female *T. fluviorum* strongly suggest the occurrence

of first scenario of Rowe *et al.* (1994) in the water strider.

Effect of prey size

The number of prey captured at a given prey density was enormously high with pupal stage than the others. This was observed to be the same at all prey densities. Though data on prey death rate differed at different densities, the pattern of predation with increased performance on pupal stage was distinct than with I, II, III and IV prey size irrespective of the prey density. Predatory potential of male bug was 12.2 ± 1.751 ; 15.1 ± 3.510 ; 15.4 ± 2.836 ; 20.7 ± 2.359 ; 21.1 ± 3.035 and female bug was 13.5 ± 0.972 ; 16.2 ± 3.736 ; 16.9 ± 5.087 ; 21.5 ± 2.461 ; 22.2 ± 2.098 with respect to I, II, III, IV size classes and pupae of *C. quinquefasciatus* larvae for twenty four hours duration at 125 prey density.

With reference to different prey ages, variations in predatory potential of male or female gerrids were noted to be marginal. Specifically the pupal death rate of *C. quinquefasciatus* mosquito was low at lower prey density. It may be suggested that the swift movement of pupae would have caused predatory failure of gerrids at low density, since the pupal stage rise to the surface with its head capsule resting on water surface than the rest of the body. Probably the head capsule of the prey would have prevented the gerrids to pierce and suck the content. Morphological, behavioural and biochemical adaptations for predation may be the limiting factors in gerrids, as is shown in five species of predaceous heteropterans by Cohen (1990) reporting on the nature of mouth parts including the stylets, the receptors and digestive enzymes as the features of feeding adaptations.

Attack rate and handling time

The two statistical constants, namely, attack rate and handling time were derived from the prey death rate caused by the predator. Such values were drawn with every prey size. Results revealed that attack rate was very low, when predator was exposed to early nymphal stages of prey. Whereas handling time was very low in the later stages of prey when such statistical constants were derived

Table 1. Attack rate (\underline{a}) and Handling time (\underline{T}_h) of adult *T. fluviorum* from Roger's random predatory derived equation

Predator's sex	Prey size	Period of exposure			
		One hour		Twenty four hour	
		Attack rate (\underline{a})	Handling time (\underline{T}_h)	Attackrate (\underline{a})	Handling time (\underline{T}_h)
Male	I instar	0.059	0.300	0.252	0.561
	II instar	0.040	0.055	0.235	0.025
	III instar	0.067	0.420	0.639	0.056
	IV instar	0.046	0.183	1.059	0.042
	Pupa	0.079	0.293	0.914	0.039
Female	I instar	0.065	0.361	0.254	0.049
	II instar	0.045	0.045	0.299	0.036
	III instar	0.056	0.353	0.649	0.051
	IV instar	0.043	0.053	1.435	0.041
	Pupa	0.147	0.328	1.044	0.038

for all one hour and twenty-four hour treatments. It may be noted that attack rate and handling time were inversely proportional to each other. Such a trend was noted in the predator in relation to various prey size (Table 1).

In general, the higher rate of attack by the female gerrid may reflect on the rate at which the food ingested is converted and assimilated into the body tissues for the reproductive activity because female gerrids show less willingness to mate when they are in a state of hunger (Rowe *et al.*, 1994). Male hunger had no effect on either frequency or duration of mating (Rowe, 1992). Attack rate and handling time by *T. fluviorum* reveal that attack rate is uniformly low in gerrids irrespective of prey size, predator sex, as well as the duration of the treatment. Whereas values on handling time exhibit a trend which is common in male and female in one - day treatment. That is an increase in handling time is directly proportional to prey size. Such a trend is absent in one-hour treatment. The prolonged exposure of the bug to prey would have caused an experience in the predator to develop the predatory

strategy so that food utilization becomes increasingly higher. *T. fluviorum* has the ability to utilize a prey content at higher level though its attack rate is very low suggesting thereby its possibility to be a sit and wait predator as nepids. Further the bugs show a low attack rate and high handling time. Probably, the bug might have gained individual experience as in other aquatic insects (Resh, 1979). The present investigation highlights the possible interactions of ecological and behavioural aspects of the Indian gerrid *T. fluviorum*. How far wing polymorphism has its effect on such interactions and population diversity is not known. Further investigation on such a study may be of great use in the field of dynamics of supra-aquatic insect communities.

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