COMPARATIVE ASSESSMENT OF MOSQUITO BIOCONTROL EFFICIENCY BETWEEN GUPPY (*POECILIA RETICULATA*) AND PANCHAX MINNOW (*APLOCHEILUS PANCHAX*)

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ABSTRACT

The present work was designed to compare the mosquito biocontrol efficiency of guppy and panchax minnow, the two popular fish species which so far have been used for mosquito biocontrol here in India. Study of the predation efficiency in relation to fish size and larval size has revealed significant better predation efficiency of panchax minnow over guppy in all size groups except for pupae in small size group fishes. Study of the comparative predation efficiency under vegetative cover has revealed significant ($P<0.01$) higher predation efficiency for panchax minnow over guppy. Study of the comparative predation efficiency under different depth of water has revealed superior predation efficiency of guppy under shallow water depth whereas panchax minnow has shown significantly better predation efficiency with increasing water depth. So, panchax minnow is a better mosquito biocontrol agent in waterbodies with vegetative covering and in comparatively deep water bodies whereas guppy can be used for mosquito control in very shallow water depth. But overall the study has depicted the superiority of panchax minnow over guppy as mosquito biocontrol agent.

Keywords: Biocontrol, Guppy, Larva, Mosquito, Panchax minnow, Predation efficiency, Pupa

INTRODUCTION

Mosquitoes are known vectors for transmission of diseases throughout the world, including the pathogens which are responsible for encephalitis, equine infectious malaria, yellow fever, dengue and filariasis (Homski *et al*., 1994; Walker, 2002). Mosquito borne diseases continue to be a major problem in almost all tropical and subtropical countries (Chandra *et al*., 2008). Chemical and biological approaches have been currently employed in mosquito control in different parts of the world. Chemical insecticides was the most popular solution for mosquito problem in the earlier days; though the growing resistance of mosquitoes to chemical insecticides has now brought about a revival of interest in biological methods (Hass and Pal, 1984) as higher doses of chemical insecticides have adverse environmental consequences to non-target organisms.

The use of larvivorous fishes is presently the most popular biological method for reducing mosquito larvae population (Raghavendra and Subbarao, 2002; Mohamed, 2003; Ghosh *et al.*, 2005; Yildirim and Karacuha, 2007) and more than 253 fish species have been considered for mosquito biocontrol throughout the world (Gerberich and Laird, 1985). In India, mosquito fish (*Gambusia affinis*) and guppy (*Poecilia reticulata*) have been successfully utilized as the mosquito biocontrol agent for a long time (Sharma, 1994; Rajnikant *et al*., 1996; Chatterjee and Chandra, 1997; Singaravelu *et al.*, 1997) and *Aplocheilus sp*. has also been used for this purpose (Kumar *et al.*, 1998; Manna *et al*., 2011) in several cases. Earlier works (Rupp, 1996; Gratz *et al.*, 1996; Morgan and Buttemer, 1996) have revealed the negative impacts of mosquito fish on non-target organisms and on natural ecosystems too. For this reason in present day world, mosquito fish has lost its popularity as mosquito biocontrol agent and now researchers are more concerned on guppy and panchax minnow for mosquito biocontrol. Mosquito biocontrol by larvivorous fishes needs the establishment of the predatory fish species in the mosquito larvae and pupae infested water bodies and the efficiency of these predatory fishes in mosquito biocontrol depends on their prey size preference, predation efficiency under naturally

available variable conditions etc. Detail work on comparative potential between guppy and panchax minnow for mosquito biocontrol in Indian perspective is still lacking. So, the present work was designed to compare the mosquito control efficiency of two most popular mosquito biocontrol agents of India- guppy and panchax minnow.

MATERIALS AND METHODS

Collection and acclimatization of the fishes

Guppies and panchax minnows were collected from a natural habitat, located at Patuly near Bhagajatin railway station. The fishes were then taken to the laboratory and were then kept in 5 L glass tanks at a density of 4 fish/tank with proper aeration, similar photoperiod (12 L: 12 D) and temperature (27 ± 2º C). They were then acclimatized to laboratory condition for one week and were supplied with commercial feed *ad-libitum*. The fish used in the experiments were sorted by total length to the following size groups: Group A (25-30 mm), Group B (30-35 mm) and Group C (35-40 mm). The mouth width of the fishes was also measured. The mouth width of guppy was nearly about 70 percent that of panchax minnow of the same size. The mouth width of panchax minnow varied from 7.41 to 12.5 percent of body length as compared to 5.76 to 7.69 per cent in guppy, for the smallest and largest fish, respectively.

Collection of mosquito larvae

The larvae of *Culex* sp. were collected from sewage drain near the University campus on daily basis. The collected sample was washed thoroughly with tap water and then different instar stages (stage I, stage II, stage III and stage IV) and pupae were obtained from the heterogeneous population. The different stages were then kept separately in enamel trays and supplied with proper amount of food *ad libitum*.

Experimental set up

All the experiments were carried out in 5 L glass tanks keeping one fish/tank (for each size group for each selected fish species) and each of the experiment were conducted in five replicates. The fishes were held in the experimental tanks for 24 hours prior to the commencement of the experiment and were kept without food to standardize the hunger level.

Predation efficiency in relation to fish size and larval size

In this experiment, each size group of fish, of the selected species, was presented with a known number (100 in number) of larvae of a single instar and pupae separately at the same time. The number of larvae and pupae consumed per fish during a 15-minute period was recorded. This specific time period was decided based on an early experiment which revealed that most of the predation occurred within the first 15 minutes of the food presentation.

Comparative predation efficiency under vegetative cover

Four Amazon sword plant (*Echinodorus bleheri*) were planted equidistant in the glass aquarium for the preparation of the vegetative covering. Then each size group of fish, of the selected species, was supplied with a combination of known amount of larval instars and pupae (in total 500; 100 for each of the larval stages and pupae) separately at the same time. Total number of larvae and pupae consumed per fish during a period of 24 hours was recorded.

Prey size selection

Size selective predation was tested by providing each size group of fish, of the selected species, with the combination of known number (in total 500; 100 for each of the larval stages and pupae) of different larval instars and pupae, separately at the same time. The number of larvae of each instar and pupae consumed per fish during a period of 15 minutes was recorded. Selectivity was calculated using Ivlev's index (Crowder, 1990) as follows:

$$S = (r_i - p_i) / (r_i + p_i)$$

where,

S is the degree of selectivity;

r_i is the relative abundance of prey item i among the consumed larvae, and

p_i is the proportion of availability of prey type i in the aquarium

Comparative predation efficiency under different depth of water

In this experiment, individual fishes of all the three size groups of both the selected fish species were kept separately in glass aquariums at three different water depth (5 cm, 10 cm and 15 cm respectively) and then were supplied with a combination of known number

(200 in number) of specific larval instars. Group A of both the fish species was supplied with only Instar I stage, Group B of both the fish species was supplied with a combination of Instar I and Instar II stage (200 in total, 100 for each larval stage) and Group C of both the fish species was supplied with a combination of Instar III and Instar IV stage (200 in total, 100 for each larval stage). Presentation of specific larval instars to specific size group of fishes was based on the results of previous experiment on preference of prey size by fishes. The total number of larvae consumed per fish during a period of 15 minutes was recorded.

RESULTS AND DISCUSSION

Predation efficiency in relation to fish size and larval size

The comparative predation efficiency of guppy and panchax minnow has been represented in Table 1. Both fish species showed increasing consumption of all mosquito larval stages and pupae with increasing fish size. The number of larval stages and pupae consumed by each size group decreased with the progressive larval stages and pupae. Both the fish species showed significant ($P<0.05$) size group wise difference in their predation efficiency of the mosquito larvae and pupae except in case of guppy between Group A and Group B fishes considering Instar III, Instar IV and pupa. Except the predation efficiency for pupae by Group A fishes of both the species, in rest of the cases panchax minnow showed better predation efficiency over guppy at significant level in all the three size groups for the larval and pupal stages.

Comparative predation efficiency under vegetative cover

The comparative predation efficiency of guppy and panchax minnow under vegetative cover has been represented in Figure 1. The total consumption amount in 24 hrs time period for both the fish species increased with increasing fish size and in each size group, panchax minnow showed significantly ($P<0.01$) higher predation efficiency than guppy. In both the fish species, Group A fishes showed significantly ($P<0.05$) higher consumption for Instar I than other stages, Group B fishes showed significant ($P<0.05$) higher consumption for Instar I and Instar II than other stages and Group C fishes showed significant ($P<0.05$) higher consumption for Instar III and Instar IV than other stages.

Prey size selection

Group A fishes of both the fish species showed significantly ($P<0.01$) higher preference for Instar I than other larval stages and pupae and the preference was significantly ($P<0.05$) higher for panchax minnow than in guppy. Group B fishes of both the fish species had significant ($P<0.01$) higher preference for Instar I and Instar II than other larval stages and pupae, though no significant difference was there for the preferences between these two most preferred Instar stages in the two fish species; even no significant difference of preferences for any of the mostly preferred Instar stages has been observed between the two fish species. Group C fishes of both the fish species showed significant ($P<0.01$) higher preference for Instar III and Instar IV than other larval stages and pupae; in case of panchax minnow no significant difference was there for preference between Instar III and Instar IV but guppy showed significant ($P<0.01$) higher preference for Instar IV over Instar III (Figure 2 and Figure 3). Among Group C fishes, panchax minnow showed significant ($P<0.05$) higher preference for Instar III over guppy and vice-versa has been observed for Instar IV preference between the selected fish species.

Comparative predation efficiency under different depth of water

In case of panchax minnow, in each of the three size groups, the total amount of larvae consumption within the specific time period was found to be increased significantly ($P<0.05$) with increasing depth of water, but in case of guppy the situation was reversed i.e. in each size group the maximum amount of larvae consumption was observed at lowest water depth and the amount decreased significantly ($P<0.05$) with increasing water depth (Figure 4, Figure 5 and Figure 6). At lowest water depth in all the three size groups, guppy showed significant ($P<0.01$) higher amount of consumption than that of panchax minnow; in rest of the cases panchax minnow showed significant ($P<0.01$ for all size groups at 15 cm depth and Group C at 10 cm depth; $P<0.05$ for Group A and Group B at 10 cm depth) higher amount of consumption than guppy. Biological control of mosquito larvae has been observed to become successful in waterbodies with high water quality (Ahmed and Isaq, 1982) but problems of mosquito are also associated with polluted waterbodies.

Table 1: Comparative predation efficiency of panchax minnow and guppy on mosquito larvae and pupae

Fish species	Size Group	Instar I Mean ±SD	Instar II Mean ±SD	Instar III Mean ±SD	Instar IV Mean ±SD	Pupa Mean ±SD
Panchax minnow	Group A	60.33 ± 4.50**	38.66 ± 5.03**	18.67 ± 4.51**	12.67 ± 3.78*	3.33 ± 1.53
Guppy	Group A	21.67 ± 3.51	12.66 ± 3.51	6.66 ± 2.52	5.33 ± 2.52	3 ± 1
Panchax minnow	Group B	72.33 ± 3.05**	47.67 ± 5.51**	22.33± 4.72**	16.33± 4.72*	10.33 ± 4.16*
Guppy	Group B	32.33 ± 5.51	19.33 ± 4.51	8.67 ± 3.05	6.67 ± 3.51	4.33 ± 2.30
Panchax minnow	Group C	85.67 ± 5.13**	54.33 ± 4.72**	34.67 ± 3.51**	29.33± 4.51**	19.33 ± 4.51**
Guppy	Group C	46.33 ± 4.04	24.67± 4.04	12.67± 2.52	12 ± 2.64	8.33 ± 2.52

Significantly [* = (P<0.05) and ** = (P<0.01)] different from guppy

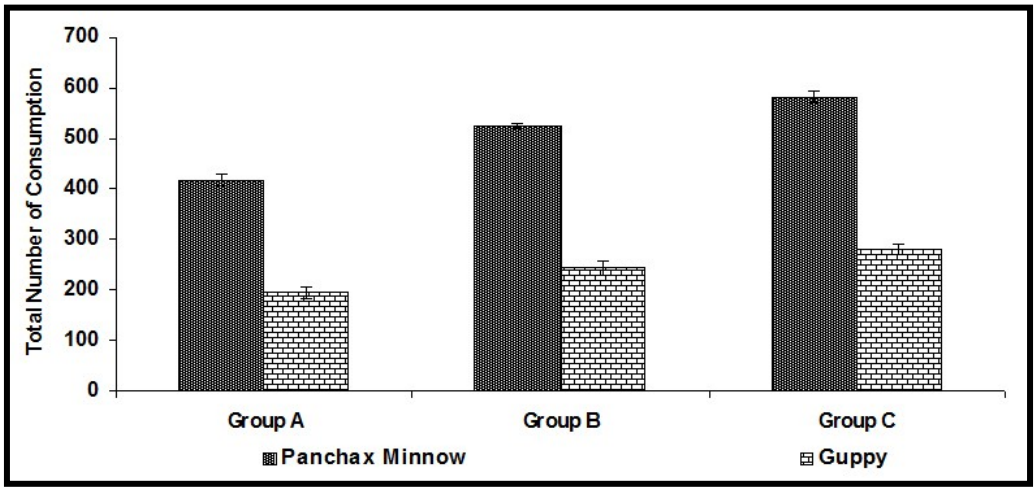

Figure 1: Comparative predation efficiency of panchax minnow and guppy under vegetative cover

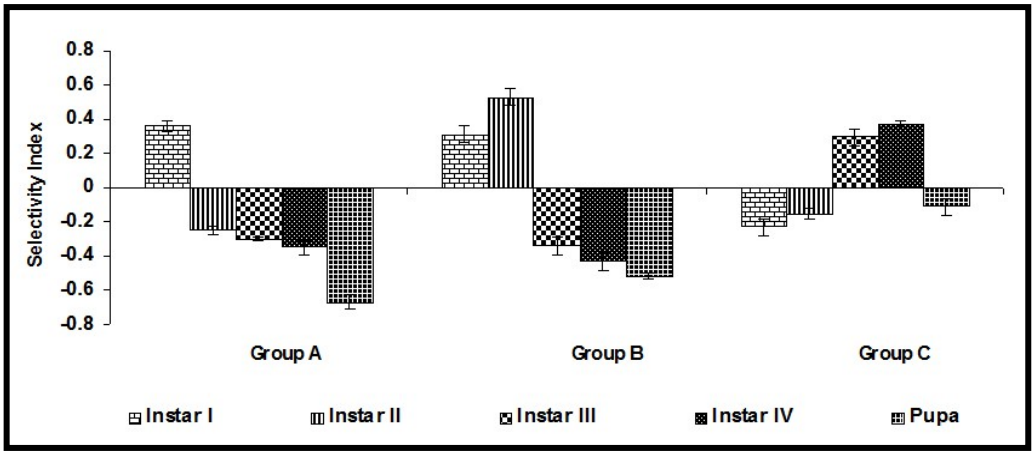

Figure 2: Prey size selection matrix for panchax minnow

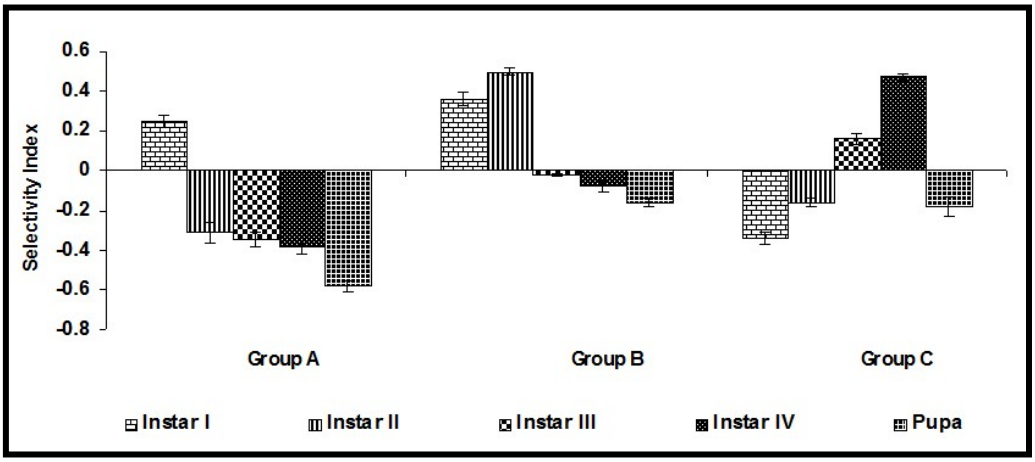

Figure 3: Prey size selection matrix for guppy

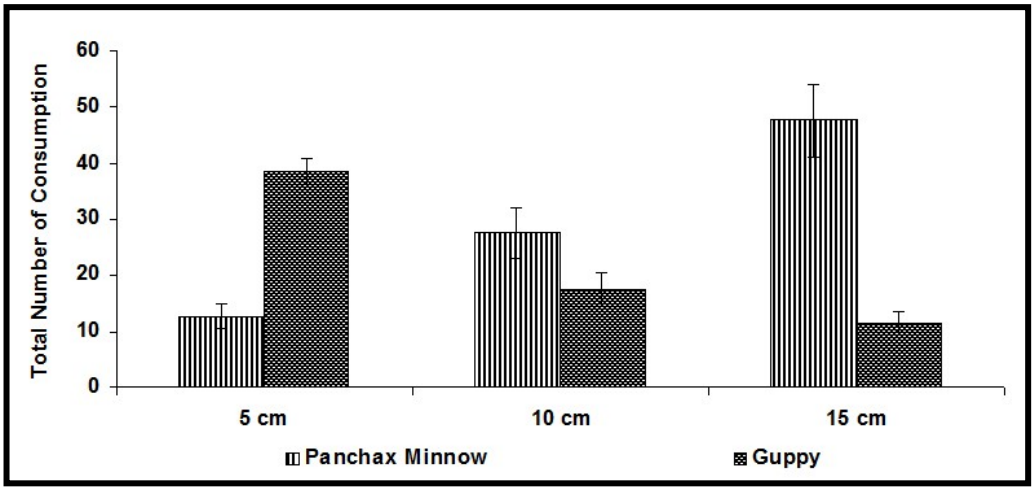

Figure 4: Comparative predation efficiency of panchax minnow and guppy under different depth of water for Group A fishes

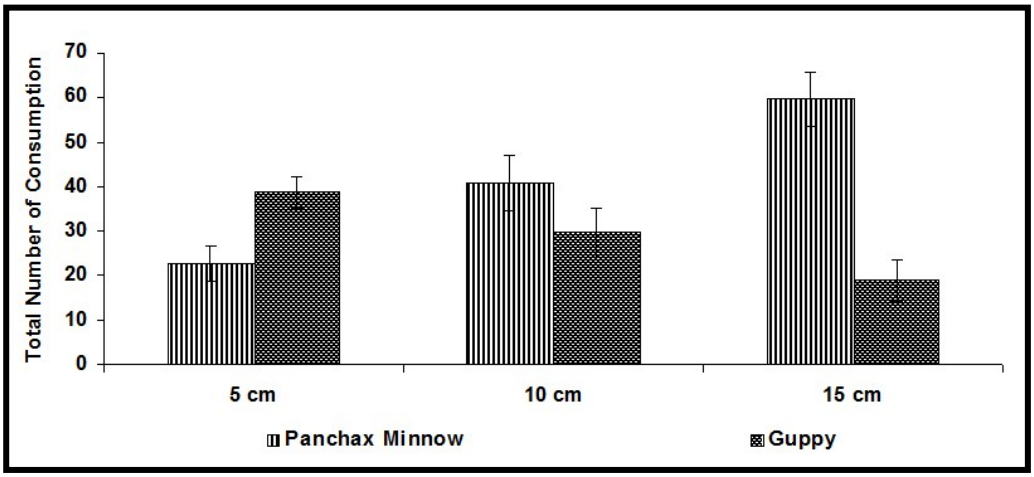

Figure 5: Comparative predation efficiency of panchax minnow and guppy under different depth of water for Group B fishes

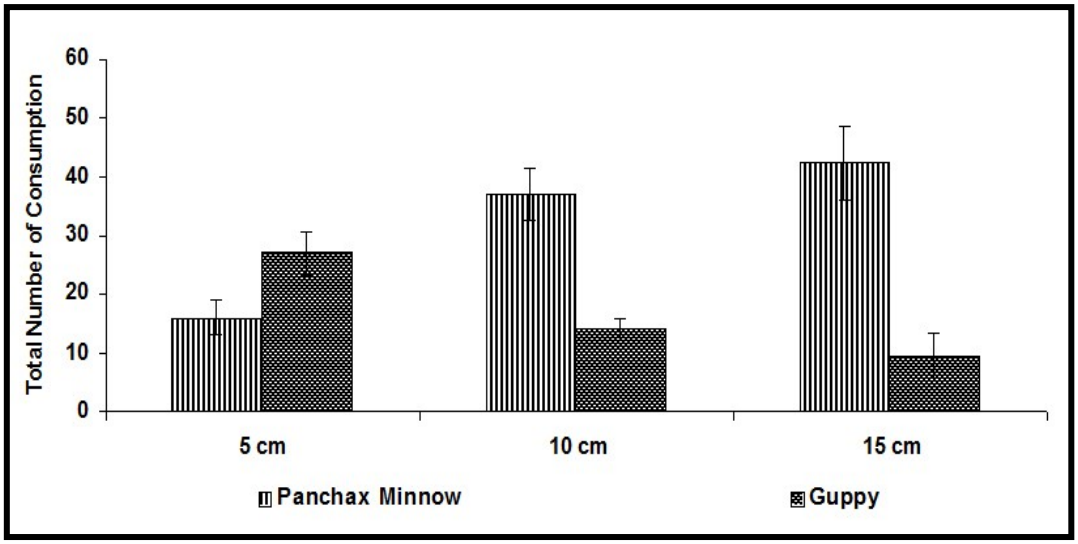

Figure 6: Comparative predation efficiency of panchax minnow and guppy under different depth of water for Group C fishes

So, fishes which can be used for mosquito biocontrol must be at ease with poor water quality condition. On the other hand, they must have to be with high predation efficiency for mosquito larvae in different types of aquatic habitat; be it very shallow or with vegetative covering.

In the present study, the experiment to determine the predation efficiency in relation to fish size and larval size has revealed that panchax minnow is more effective in preying upon almost all the larval stages and pupae of mosquito than guppy except for pupae in Group A fishes; these findings are correlated with the mouth size of the fish, which in panchax minnow is 70% larger than that of similar sized guppy. Results of this experiment thus are conveying the superiority of panchax minnow over guppy as mosquito biocontrol agent. It has also been observed that panchax minnow is a better predator upon mosquito larvae and pupae than guppy under vegetation cover. Experiment to determine the comparative predation efficiency under different depth of water has revealed the superior predation efficiency of guppy under shallow water depth but with increasing water depth its predation efficiency started to decrease; on the other hand panchax minnow showed better predation efficiency with increasing water depth. These results indicate that panchax minnow can be a better mosquito biocontrol agent in waterbodies with vegetative covering and it is also can be a good choice in comparatively deep water bodies whereas guppy can be used for mosquito control in very shallow water depth.

Meanwhile, the experiment on prey size selection has revealed that small size fishes of both species prefer Instar I, medium size fishes prefer Instar I and Instar II and large size groups prefer Instar III and Instar IV. So, it can be concluded that small size fishes can be utilized for controlling Instar I, medium size groups for controlling Instar I and Instar II and large size groups for controlling Instar III and Instar IV stages. But comparison of prey preference between the two fish species has revealed that small size group of panchax minnow can be a better option for controlling Instar I stage; medium size group of both the fish species can be used for controlling Instar I and Instar II; Instar III can be better controlled by large size group of panchax minnow while best option for Instar IV control is large size group of guppy.

So the results of the experiments thus are depicting the suitability of panchax minnow over guppy as a mosquito biocontrol agent. But to get long term success in mosquito control, repeated introduction of these fishes in the infested waterbodies is essential along with measured and careful application of chemical agents.

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