Poll Res. 41 (2) : 625-630 (2022)

ISSN 0257–8050
DOI No.: http://doi.org/10.53550/PR.2022.v41i02.033

IMPACT OF HABITAT QUALITY VARIATIONS ON SOME BEHAVIOURAL ASPECTS OF LARVIVOROUS FISH

KULKARNI RAJENDER RAO*, JULIANA SILVEIRA, SHEENA PAUL, NANDADEEP PHALDESSAI, SHAILESH NAIR, CLARA RODRIGUES AND PRIYANKA NAIK

Department of Zoology, Government College of Arts, Science and Commerce, Quepem, Goa, India

(Received 15 October, 2021; Accepted 20 November, 2021)

ABSTRACT

Over 85 per cent of all known animal species belong to Arthropoda which includes the vectors of most important diseases. They affect our health either directly by bites, stings or indirectly through disease transmission. Several genera of Arthropods like mosquitoes, flies, ticks and mites play an important role in human disease transmission. The most significant vector borne disease transmission is by blood feeding insects. Utilization of larvivorous fish in vector borne disease control programme is gaining momentum. *Poecilia reticulata* survives in all types of water bodies and can tolerate high degree of pollution. It a prolific breeder and surface feeder, carnivorous, thus efficient larvivorous fish. Present investigation reveals that low oxygen content in sewage water and surface feeding nature make it to stay at surface waters for longer time as compared to pond water.

KEY WORDS : Carnivorous**,** Guppies**,** *Poecilia reticulata,* Sewage,Surface feeders,

INTRODUCTION

Three different factors crucial in the vector borne disease transmission are the parasite, the vector and the human host. Some animals act as reservoir hosts (intermediary) for the pathogens these parasites exposed to susceptible human host. Pathogens received from an infected host by the vectors are transmitted, either to reservoir host or directly to the primary host. The life cycle of the pathogens completes during this process and is closely associated with the availability of the suitable vectors and hosts (Rufalco-Moutinho *et al.,* 2021)

Vector borne diseases are widespread in the tropic and subtropic zones. Many vector borne diseases, particularly malaria, Japanese encephalitis dengue fever, occur in epidemic form. Most of these are emerging every year seasonally with severe morbidity and mortality. Dengue is spreading rapidly to newer areas, with more frequent and explosive outbreaks. Chikunguniya has re-emerged in the country affecting many states. Most significant causes are unplanned urbanization, increased slum areas associated with the rapidly growing cities, degrading sanitary conditions. It is urgently needed to address these challenges to fight against vector borne diseases in the country.

Mosquito population can be destroyed by using a number of methods. Several reports are available on the use of pesticides, insecticides, adulticides as the common methods for mosquito population eradication (Prasad *et al.,* 1993; Milam *et al.,* 2000; Choi *et al.,* 2019), To kill the mosquito larvae and pupae regular application of chemical or microbial insecticides to water bodies was advocated (Choi *et al.,* 2019). The most successfully and widely used biological control agents against mosquito larvae are the top water minnow or mosquito fish *Gambusia affinis* and common guppy *Poecilia reticulata* (Chandra *et al*., 2008). Gambusia is an voracious feeder and its food includes both phyto and zooplanktons, aquatic insects and its eggs and larvae (Garcia *et al.*, 1991),

Sewage water is a dynamic fluid whose concentration varies from place to place and even community to community. One of the very conducive ambiances for mosquito breeding in urban areas is sewage water. In fact, in urban areas other than sewage waters mosquitoes hardly finds any other area to complete their life cycle. Information on different larvivorous fish species and the status of their use in mosquito control was provided by Chandra *et al*. (2008) among which very few can tolerate the sewage water pollutions (Garaccia *et al.*, 1991).

Poecilia reticulata can easily survive in saline water and can withstand salinity level up to 150% (Takahito Shikano *et al.*, 2001). Guppies are generally peaceful but sometimes predatory behaviour is seen during breeding season. It can breed in both marine as well as fresh water. Laboratory experiments have shown that it can survive in most of the water bodies but cannot survive in cold waters. It can tolerate high degree of pollution. It can tolerate a pH range of 6.5 - 9.0. They are surface feeders and a single fish can eat 80-100 mosquito larvae in 24 hours (Chatterjee and Chandra, 1996). It is highly carnivorous and matured or old fish can eat their young ones, thus enough amount of feed is required in water bodies so that the young can hide and survive. Guppies can easily survive and reproduce when introduced in new water bodies. Once well-established it can be found even after years.

The sequence of physiological and behavioural alterations that occur as the fishes attempt to maintain in the short and long term stressful environmental changes was reported by Wedemeyer, and McLeay, (1981). Several reports are available indicating individual guppies often differ in their behaviour associated with physiology in response to variations in the physico chemical parameters of the immediate environment. (Biro and Stamps 2016; Brian *et al.,* 2010; White *et al.*, 2016.).

In Goan vector bio control programme *Poecilia reticulata* is given priority due to its adaptability and great larvivorous efficiency. A good number of reports on mosquito larval feeding efficiency and its tolerance to sewage pollution are known. However, very meagre information is available with respect to behavioural and physiological aspects of larvivorous fish. *P. reticulata* and its efficiency in sewage water in Goa, hence present investigation is carried out to understand the behavioural aspects of larvivorous guppy fish in sewage water (Unnatural habitat) and pond water (natural habitat).

MATERIALS AND METHODS

The larvivorous fish *P. reticulata were* collected from Government Hospital Sanvordem and Sub Health centre, Quepem, Goa and acclimatized to the laboratory conditions. Young and healthy fish of 2 to 3 cm in size were used in the present investigation. Fish were divided into two groups and were placed in ten large glass jars, i.e. first group of five jars for pond water and second group of five jars for sewage water, one fish in each beaker. The experiment was set up for five days. Daily observations were made for five hours to obtain the behavioural traits of the test animal. Only one person recorded behavioural observations per day for five hours from approximately 1 m awayto eliminate variations in observations. Proper care was taken not to cause disturbance to the fish

The behavioural traits such as, surface stay, bottom stay, vertical and horizontal migration in pond water and sewage water, was recorded and percentage of the coefficient of variation calculated by the following formula.

Coefficient of Variation for x = Std.deviation / $\bar{x}$ X 100.

Where; Standard deviation σ_x = $\sqrt{(\sum u2/n \;-\; (\sum u/n)2}$

n = number of observations;

$\bar{x}$ = Mean of x

u = x-a

a = minimum value in a given range.

Similarly for y Coefficient of Variation for y = Std. deviation / $\bar{y}$ X 100.

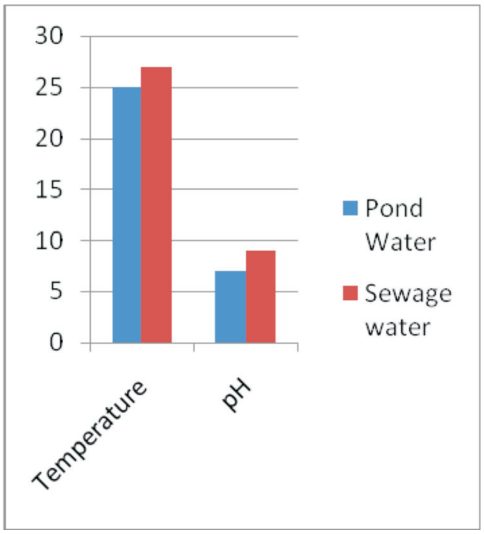
Computing the differences of behavioural traits performed as coefficient of variation an attempt was made to evaluate the behavioural aspects of the test animal.

Physico-chemical parameters of the pond water and sewage water were estimated using the standard Procedures.

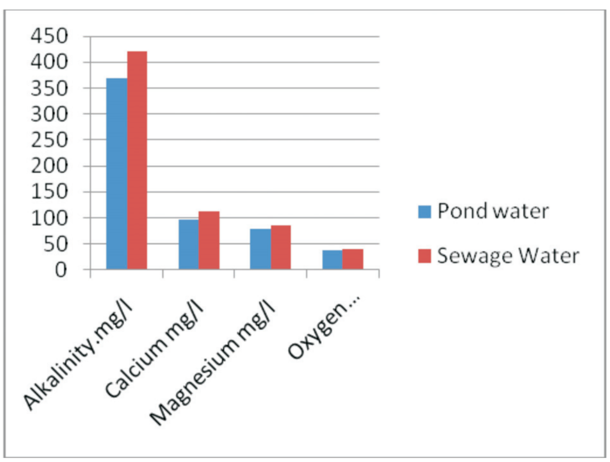
RESULTS AND DISCUSSION

In the present investigation it is found that pH was neutral (07) in pond water and alkaline (09) in sewage water. Temperature recorded in pond water is low in comparison with sewage water. Calcium content is 96.19 mg/l in pond water and 112.22 mg/l in sewage water similarly magnesium content was 77.96 mg/l in pond water and 85.52 mg/l in sewage water, indicating maximum values of above mentioned parameters in sewage water collected from the experimental site. As a result of such extreme conditions in sewage water the fish tend to consume more oxygen as compared to pond water. It is found that fish consumed 39.32/g body wt./hour of oxygen in pond water whereas 40.89 mg/g body wt./hour of oxygen in sewage water, which is more in sewage water (Table 1).

It was observed that the fish showed a significant difference in behavioural traits (Table 2).



Graph 1. Showing physical parameters



Graph 2. Showing Chemical parameters of Pond water and Sewage water of Pond water and Sewage water

Pondwater

In pond water it is observed fish prefers to stay at the bottom and horizontal migration. The fish showed coefficient of variation 56.38% surface stay, 14.41% bottom stay. 12.19% horizontal migration and 67.37% vertical migration.

Sewage water

From data it reveals that in sewage water the fish preferred surface stay and vertical migration. After releasing the fish in the sewage water the fish dispersed in different directions and very soon they all moved up to surface zone and most of them remained in vertical position. The fish showed coefficient of variation 11.80% surface stay, 20.85% bottom stay, 28.60% horizontal migration and 10.52% vertical migration.

This reveals that the behaviour of the fish changes when moved from pond water to sewage water. (Table 3).

Mosquito problem for mankind is ever known and their prevalence is increasing day by day. There are many kinds of mosquitoes and each of which has different habitat, among which sewage water in the urban areas is predominant. In addition to sewage water the most common mosquito breeding places are underground cement tanks, ground level tanks, fountains, elevator chambers (Lift wells), cattle troughs and ponds (Collins and Blackwell, 2000). Mosquitoes transmit dreadful diseases and produce intense annoyance and distress to human beings, which is considered as major health problem in the country. Using larvivorous fish is gaining very much importance in the country. The efficacy of fish depends on its ability to feed on mosquito larvae and its adaptability to the new environment of the introduced water body, i.e. the breeding centre of mosquito.

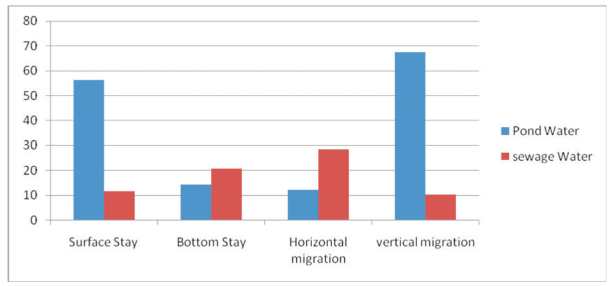
Recently, use of larvivorous fish for eliminating mosquito larvae has been increased enormously. This is due to the reasons well known such as

Table 1. Physico-chemical parameters of pond water and sewage water.

Parameters	Pond water	Sewage water
Temperature	25	27
pH	07	09
Alkalinity	370 mg/l	420 mg/l
Calcium	96.19 mg/l	112.22 mg/l
Magnesium	77.96 mg/l	85.52 mg/l
Oxygen consumption	39.32/g body wt./hour	40.89/g body wt./hour

environmental protection agencies have banned or placed severe restrictions on the use of many pesticides, which were used earlier and there are now very limited adulticides available for mosquito control programmes (Collins and Blackwell, 2000). The eradication of mosquito using adulticides is not a prudent strategy, as the adult stage occurs alongside human habitation, and they can easily escape remedial measures (Sekhara Rao *et al.*, 2015). As per the existing restrictions several manufacturers stopped production of these chemicals and it is the fact that the production of crop pesticides for the agricultural market is much more lucrative (Prasad *et al.*, 1993). Recent resurgence of different mosquito borne diseases, the harmful effects of chemicals in non-target populations and the development of resistance to these chemicals in mosquitoes was reported by Milam *et al.* (2000).

The mosquito control efficiency of larvivorous fish varies with environmental conditions. It is essential to analyse the efficacy of several indigenous larvivorous fish, their role in the trophic structure of the communityin seasonal wetlands and larger water bodies (Blaustein and Jonathan, 2007). Impact of introducing larvivorous fish on the density of Anopheles larvae and pupae is evaluated by Walshe *et al.*, (2017). Role of larvivorous fish as biological control agent and their diversity was reported by Das *et al.* (2018).



Graph 3. Coefficient of variation of larvivorous fish *P. reticulata* for pond water and sewage water

Table 2. Showing behavioural aspects of larvivorous fish *P. reticulata*

Days	Hours.	surface Stay in Pond Water (in%)	bottom Stay in Pond Water (in%)	surface Stay in sewage Water (in%)	bottom Stay in sewage Water (in%)	horizontal migration in Pond Water (in%)	Vertical migration in Pond Water (in%)	horizontal migration in sewage Water (in%)	vertical migration in sewage Water (in%)
1	1	05	95	60	40	95	05	30	70
	2	20	80	65	35	80	20	40	60
	3	15	85	50	50	98	02	20	80
	4	10	90	60	40	90	10	18	82
	5	30	70	65	35	85	15	25	75
2	1	20	80	70	30	90	10	25	75
	2	30	70	75	25	88	12	20	80
	3	45	55	60	40	80	20	22	78
	4	25	75	70	30	60	40	20	80
	5	30	70	50	50	75	25	40	60
3	1	20	80	63	37	98	02	25	75
	2	15	85	68	32	95	15	20	80
	3	10	90	60	40	80	20	35	65
	4	05	95	64	36	80	20	45	55
	5	40	60	70	30	90	10	30	70
4	1	40	60	75	25	60	40	35	65
	2	27	73	78	22	75	25	20	80
	3	18	82	60	40	98	02	30	70
	4	45	55	59	41	80	20	25	75
	5	30	70	50	50	75	25	22	78
5	1	20	80	55	45	85	15	30	70
	2	05	95	70	30	92	08	20	80
	3	05	95	68	32	70	30	25	75
	4	10	90	68	32	90	10	35	65
	5	20	80	60	40	95	05	15	85

Table 3. Coefficient of variation of larvivorous fish *P. reticulata* for pond water and sewage water

Pond water.	$\bar{x}$	Σu	Σu2	σx	C.V for x
1.surface stay in Pond water(in %)(x-)	21.6	415	10603	12.18	56.38
2.Bottom stay in Pond water(in %)(x-)	78.4	600	17678	11.42	14.41
3.Horizontal migration in Pond water(x)	84.16	614	177740	10.31	12.19
4.Vertical migration in Pond water(x)	15.84	346	7636	10.67	67.37
Sewage water.	$\bar{y}$	Σu	Σu2	σy	C.V for y
1.Surface stay in sewage water(in%) (y-)	63.72	343	6121	07.52	11.80
2.Bottom stay in sewage water(in%) (y-)	36.28	355	6467	07.55	20.85
3.Horizontal migration in Sewage water(y)	26.88	297	5007	07.69	28.60
4.Vertical migration in Sewage water(y)	73.12	453	9687	07.69	10.52

To extirpate the mosquito problems from targeted water body, its chemical analysis has to be evaluated in terms of its pollution quantity, to establish tolerance threshold of a larvivorous fish in sewage water, as the sewage water quality significantly varies from place to place and community to community (Wedemeyer *et al.,* 1990). The water analysis for pH, Temperature, alkalinity, calcium, magnesium and oxygen consumption rate was performed. Present investigation show significant variation in pond water and sewage water due to the presence of organic and other chemical pollutants. In the present study Larvivorous fish *Poecilia reticulata* were selected, as it is used in Vector borne disease control programme of the Goa state. Reddya Naik and Reddy (2005) evaluated the effectiveness of *Poecila* in bio control of mosquito larvae in municipal sewage water.

A positive correlation between behaviour and social attitude of guppy fish the new environment is established by Budaev (1997). In a feral guppy population individual personality traits have tremendous influence on community behaviour of the habitat (Bell, 2005). Advantages of larval control for African malaria vectors were reported by low mobility and behavioural responsiveness of immature mosquito stages (Killeen *et al*., 2002).

Behavioural and physiological responses to the new environment play crucial role in efficiency of larvivorous fish (Lewis *et al*., 2006; Heimpel and Cock, 2018). Differences in foraging behaviour and relevance to both the efficacy and the ecological impact of introduced guppies have been documented by Bassar *et al.* (2010). Body colour patterns and predation among guppies was reported by Godin and Donough (2003). Behaviour and intricate impact on feeding nature and metabolism was analysed by White *et al.* (2016).

In the present investigation. *P. reticulata* preferred to stay at the bottom of the pond water and only for feeding they come to the surface (Larvivorous). It is well established that mosquitoes prefer sewage water for laying eggs hence in sewage water larvivorous fish predominantly move to the surface to feed on larvae in addition to breathing.

CONCLUSION

From the present investigation it is clear that *P. reticulata* compelled to stay at the surface in sewage water due to low oxygen level in contrast to the pond water. It is being surface feeder frequently visit surface for food collection and showed positive correlations between surface stay and feeding habit. Though significant variations were reported in the normal behavioural traits, still it is capable enough to adjust the new environment and survive successfully. *P. reticulata* can tolerate handling and transportation very well, having great larvivorous efficiency and highly acclimatized to Goan conditions.

ACKNOWLEDGEMENTS

Authors express gratitude to Dr.Joydeep Bhattacharjee, Principal for constant motivation, Dr. Mamata kakodkar, I/C. PHC, Quepem Shri, Vasudev Naik, sanitary inspector, PHC, Quepem for providing guppies and training us in handling and releasing the test animals. Shri. Ehlrich Barretto, Associate professor in Mathematics and Shri. Rahul kulkarni for their help during the study period.

REFERENCES

Bassar, R.D., Marshall, M.C., López-Sepulcre, A., Zandonà, E., Auer, S.K., Travis, J., Pringle, C.M., Flecker, A.S., Thomas, S.A., Fraser, D.F. and Reznick, D.N. 2010. Local adaptation in Trinidadian guppies alters ecosystem processes. *Proceedings of the National Academy of Sciences.* 107 : 3616-3621,

Bell, A.M. 2005. Behavioural differences between individuals and two populations of stickleback (*Gasterosteus aculeatus*). *J Evol Biol.* 18 : 464-473.

Biro, P.A., Fanson, K.V. and Santostefano, F. 2016. Stress-induced peak (but not resting) metabolism correlates with mating display intensity in male guppies. *Ecol Evol.* 6 : 6537-6545.

Blaustein, L1, and Jonathan, M. Chase 2007. Interactions between mosquito larvae and species that share the same trophic level. *Annu Rev Entomol.* 52 : 489-507.

Brian, R., Smith, Daniel T. Blumstein 2010. Behavioral types as predictors of survival in Trinidadian guppies (*Poecilia reticulata*). *Behavioral Ecology.* 21(5) : 919-926.

Brown, C. and Irving, E. 2014. Individual personality traits influence group exploration in a feral guppy population. *Behav Ecol.* 25 : 95-101.

Budaev, S.V. 1997. Personality" in the guppy (*Poecilia reticulata*): a correlational study of exploratory behavior and social tendency. *J Comp Psychol.* 111 : 399-411.

Chandra, I.G.,, Bhattacharjee, S.N., Chatterjee and Ghosh, A. 2008. Mosquito control by larvivorous fish. *Indian J Med Res.* 127 : 13-27.

Chatterjee, S.N. and Chandra, G. 1996. Laboratory trials on the feedingpattern of *Anopheles subpictus, Culex quinquefasciatus* and *Armigeres subalbatus* by *Xenentodon cancila* fry. *Env Ecol.* 14 : 173-4.

Choi, L., Majambere, S. and Wilson, A.L. 2019. Larviciding to prevent malaria transmission. *Cochrane Database Syst Rev.* 14: 8 (8).

Collins Larissa, E. and Blackwell, A. 2000. The biology of Toxorhynchites mosquitoes and their potential as biocontrol agents. *Biocontrol News and Information.* 21(4): 105N – 116N.

Das, M.K., Rao, M. R. and Kulsreshtha, A. K. 2018. Native larvivorous fish diversity as a biological control agent against mosquito larvae in an endemic malarious region of Ranchi district in Jharkhand, India. *J Vector Borne Dis.* 55 : 34-41.

García Avila, L., Koldenkova, A., Santamarina Mijares, R. and González Broche, 1991. The introduction of the larvivorous fish *Poecilia reticulata* (Peters, 1895) (Cyprinodontiformes: Poeciliidae), a bioregulator of culicids in oxidation ponds and contaminated drainage ditches on the Isla de la Juventud. *Rev Cubana Med Trop.* 43(1) : 45-49.

Godin, J.G., J. Mc Donough, H.E. 2003. Predator preference for brightly colored males in the guppy: a viability cost for a sexually selected trait. *Behav Ecol.* 14 : 194-200.

Heimpel, G.E. and Cock, M.J. 2018. Shifting paradigms in the history of classical biological control. *Bio Control* 63 : 27-37.

J. Chandra Sekhara Rao, K. Govinda Rao, Ch. Sebastian Raju, G. Simhachalam. 2015. Larvicidal efficacy of four indigenous ornamental fish species of lake kolleru, India. *Journal of Biodiversity and Environmental Sciences (JBES).* 7(1) : 164-172.

Killeen, G.F., Fillinger, U. and Knols, B.G. 2002. Advantages of larval control for African malaria vectors: Low mobility and behavioural responsiveness of immature mosquito stages allow high effective coverage. *Malar J.* 1 : 8.

Lewis, E.E., Campbell, J., Griffin, C., Kaya, H., Peters, A. 2006. Behavioral ecology of entomopathogenic nematodes. *Biological Control.* 38 : 66-79.

Milam, C.D., Farris, J.L., Wilhide, J.D. 2000. Evaluating mosquito control pesticides for effect on target and nontarget organisms. *Arch Environ Contam Toxicol.* 39(3) : 324-328.

Prasad, H., Prasad, R.N. and Haq, S. 1993. Role ofbiological agents for the control of mosquito breeding through *Gambusia affinis* in ricefields. *Indian Journal of Malariology.* 30 : 57-65.

Reddya Naik, B. amd Umamaheshwara Reddy, P. 2005. Survival ability of larvivorous fish (*Poecilia reticulata*), in Hyderabad municipal sewage water. *J. of Theoretical and Exp. biol. Elias. Aced. Pub.* 2(1) : 1-4.

Rufalco-Moutinho, P., Moura Kadri, S., Peres Alonso, D., Moreno, M., Carrasco-Escobar, G., Prussing, C., Gamboa, D., Vinetz, J.M., Mureb Sallum, M.A., Conn, J.E. and Martins Ribolla, P.E. 2021. Ecology and larval population dynamics of the primary malaria vector *Nyssorhynchus darlingi* in a high transmission setting dominated by fish farming in western Amazonian Brazil. *PLoS One.* 8; 16(4):

Takahito Shikano, Takashi Chiyokubo and Nobuhiko Taniguchi. 2001. Effect of inbreeding on salinity tolerance in the guppy / *Poecilia reticula. Aquaculture.* 202 : 45-55.

Walshe, D.P., Garner, P., Adeel, A.A., Pyke, G.H. and Burkot T.R. 2017. Larvivorous fish for preventing malaria transmission. *Cochrane Database Syst Rev.* 11: 12(12):

Wedemeyer, G. A., Barton, B. A. and J.McLeay, D. 1990. Stress and acclimation. In C. B. Schreck and P.B. Moyle (eds.), *Methods for Fish Biology*, pp. 451-489. *American Fisheries Society, Bethesda, Maryland.*

White, S., Kells, T.J. and Wilson, A.J. 2016. Metabolism, personality and pace of life in the Trinidadian guppy, *Poecilia reticulata. Behaviour.* 153 : 1517-1543.