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Larvicidal efficacy of four indigenous ornamental fish species of lake kolleru, India

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Abstract

A study was conducted to assess the larvivorous potential of the indigenous ornamental fish fauna of Lake Kolleru (Andhra Pradesh, India), a wetland of international importance. Indigenous larvivorous fishes have potential for regulating mosquito larvae. The mosquito larval preference of four indigenous larvivorous fishes (*Amblypharyngodon mola*, *Colisa lalia*, *Mystus bleekeri* and *Rasbora daniconius*) was assessed to highlight their importance in mosquito control management. The fishes consumed a considerable amount of mosquito larvae in laboratory conditions. The consumption rate of mosquito larvae by four different indigenous fish species of ornamental value under laboratory condition revealed that, among the four species, mean consumption of the *Rasbora daniconius* is highly significant ($P<0.01$) followed by *Colisa lalia* and *Amblypharyngodon mola* ($P<0.05$). Overall mean consumption of *Mystus bleekeri* for three hours is not significant but it showed a significant consumption at 2nd and 3rd hour. These fishes can be used as biological control agents in the wetlands and allied mosquito larval habitats.

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Introduction

Among the live feeds that fish consumes, mosquito larvae are one of the most favorite food items for the larvivorous fish. Fish that are predators of the immature stages of mosquitoes are referred to as larvivorous fish. Biological control refers to the introduction or manipulation of animals to suppress the population of vector. A wide range of organisms helps to regulate mosquito populations naturally through predation, parasitism and competition. Among all the biological control agents, larvivorous fish are the most common and widely used in vector control. Biological control using larvivorous fish was important to malaria control programmes in the 20th century, particularly in urban and periurban areas for immediate use in developed and developing countries (Gratz and Pal, 1988). Approximately 315 fish species under 7 genera are reported to have larvivorous nature and using larvivorous fish in malaria control is a renewed strategy (Ghosh and Dash, 2007). As a biological control agent larvivorous fish are being used extensively all over the world since the early 1900s (pre DDT era) (Raghavendra and Subba Rao, 2002). They have been demonstrated to be very effective at reducing larval population of mosquitoes in various parts of the world, in a variety of habitats from small plastic containers (Conor, 1922) to complex natural ecosystems including coastal wetland habitats (Morton *et al*., 1988).

Many types of fish have been used in mosquito control programmes worldwide (Walton, 2007). Various indigenous fish species have been used for mosquito control in different parts of the world (Kim *et al*., 1994). Mosquito control and indirect augmentation of aquaculture economics are the dual benefits provided by these native larvivorous fish (Sharma and Ghosh, 1994). According to Waage and Greathead (1988) selection of biological control agents should be based on their potential for unintended impacts, self-replicating capacity, climatic compatibility, and their capability to maintain very close interactions with target prey populations. Job (1940) explained the characteristic features of the larvivorous fish, according to him fish must be small, hardy and capable of getting about easily in shallow waters among thick weeds where mosquitoes find suitable breeding grounds. They must breed freely and successfully in confined waters. Larvivorous fish should be surface feeders and carnivorous in habit and should have a predilection for mosquito larvae even in the presence of other food materials. Recognizing the high larvivorous potential of *Gambusia affinis*, it was purposely introduced from Southern USA to various countries in the world (Chandra *et al*., 2008). Beginning in 1908, another larvivorous fish, *Poecilia reticulata* from South America was also introduced for malaria control into British India and many other countries (Raghavendra and Subba Rao, 2002). *Gambusia* is a voracious and highly aggressive fish that compete with the native fish very successfully for viable food and space. *Gambusia* essentially depletes all large zooplankton while rotifers and phytoplankton densities increase (Hurlbert and Mulla 1981; Bence 1988). Both *Gambusia* and Guppy being invasive in nature (Rehage *et al*., 2005; Manna *et al*., 2008) may compete with the indigenous fish species as well as other aquatic organisms that use mosquito larvae as food. In a list of studies related to the use of fish for mosquito control, as mentioned by Laird (1970), 719 studies had been carried out during 1901 - 1966. The genera of larvivorous fish studied for their efficacy to prey on mosquitoes include *Aplocheilus*, *Colisa*, *Chanda*, Oryzias, *Danio*, *Macropodus* and *Xenentodon* (Chandra *et al*., 2008).

Haq *et al*. (1993) reported 24 species of larvivorous fish of which *Rasbora daniconius*, *Esomus danricus* and *Colisa fasciatus* are potential larvivorous and play a significant role in controlling mosquito breeding in Shajahanpur district of Uttar Pradesh. Sharma (1994) assessed the larvivorous capacity of six indigenous fish *viz*. *Puntius ticto*, *Colisa fasciatus*, *Aplocheilus panchax*, *Rasbora daniconius*, *Chanda nama* and *Esomus danricus* from Haryana. Das (2013) assessed the larvivorous efficiency of 5 native indigenous fish species from north India *viz*. *Mystus* *bleekeri, Channa stewartii, Rasbora daniconius, Colisa fasciatus* and *Danio aequipinnatus*. Gupta and Banerjee (2013) compared the mosquito biocontrol efficiency of *Poecilia reticulata* and *Aplocheilus panchax,* 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 *Aplocheilus panchax* over *Poecilia reticulata* in all size groups. *Channa gachua*, commonly available snakehead fish is very efficient at mosquito larval control (Phukon and Biswas, 2011). Considering the importance of indigenous fish fauna as mosquito control agents, the present work was initiated to assess the larvivorous potential of the 4 indigenous ornamental fishes commonly available in Lake Kolleru.

Materials and methods

Gut content Analysis

Larvivourous nature of fish was tested depending on the consumption of mosquitoes in their natural habitats. Gastrointestinal content of the selected species was analyzed. For this, fishes were transferred to the laboratory and stored in plastic tubs. Active fishes were transferred to glass aquaria for analyzing their faecal matter. Faecal matter was collected and placed on a watch glass. Excess water was removed with filter paper. Glyserine was added to this material and observed under a steriozoom microscope. After analyzing the gut content and based on the dietary food items recorded, 4 species were selected for the experiment.

Experimental design and Collection of mosquito larvae from natural habitats

Four indigenous larvivorous ornamental fish species from Lake Kolleru *viz. Amblypharyngodon mola*, *Colisa lalia*, *Mystus bleekeri* and *Rasbora daniconius* and size ranging from 6 – 10 cm were selected for the present experiment to assess the efficacy of mosquito larvae control. The experiment was carried out during monsoon season in the month of July in order to obtain adequate number of mosquito larvae. Larvae were collected from the stagnant waters by small plankton net in and around Acharya Nagarjuna University Campus. Fishes selected were reared separately in glass aquaria for week days and fed with pellets of commercial aquarium fish food. Prior to the actual experiment, fishes were starved for 1 day.

Larval culture in Laboratory

Larvae were also reared in the laboratory in a plastic tub of 25 liter capacity. Tub was filled with freshwater and pieces of potato were placed in the tub along with cow dung and it was left undisturbed for 6 days. Attracted to this microhabitat, mosquitoes came and laid eggs and large number of mosquito larvae was found in one week. Larvae were collected by a small scoop net to feed the experimental fish.

Feeding trail

Rate of predation was determined in a glass jar of 3 liters capacity. A total number of 100 larvae were introduced in to the beaker and fish was allowed to predate upon the larvae for 3 hours at a stretch in the glass jar with 5 replicates. Number of larvae consumed by each fish was recorded at one hour interval. Pooled data on larval consumption of fish was statistically analyzed.

Results and discussion

Present study revealed the occurrence of 22 larvivorous fish fauna from 8 orders (Table 1 and Figs. 1-2) out of 60 ornamental fishes recorded by Rao *et al.*, (2013) from lake Kolleru (Fig. 4). After analyzing the faecal contents of major portion of remains of mosquito larvae and pupae, it is evident that faecal matter in the aquarium tank of *Aplochcheilus panchax* contained major part of the mosquito larval remains followed by *Rasbora daniconius*, *Amblypharyngodon mola*, *Colisa lalia*, *Mystus bleekeri* and *Puntius ticto*, *Puntius chola* and *Puntius sophore*. Details about the food item types examined under the in the selected fish species were presented in Table 2. Feeding potential of a larvivorous fish towards immature stages of mosquitoes can be tested depending on the consumption of larvae alone or along with the alternative food material under their natural habitats. Gastrointestinal material food items of a particular fish are the indicators of the larvivorosity and effective biocontrol activity. Out of 22 larvivorous species reported, 17 species were analyzed for the gut content. In the present investigation, even though there is a difference in the percentage of food items collected from the faecal material, most of the fishes feed more on mosquito larvae even in the presence of alternative food in natural habitat.

Table 1. List of Larvivorous fish collected from Lake Kolleru.

S. No	Species	Habit	Habitat	Commercial value	Frequency
1	*Notopterus notopterus*	C, P & SCF	FW & BW	F, CL & MD	A
2	*Puntius sarana*	BCF & C	FW & BW	F	A
3	*Puntius sophore*	BCF, H & O	FW & BW	F	A
4	*Puntius ticto*	BCF, H & O	FW & BW	F	C
5	*Salmostoma phulo*	SF	FW	F	R
6	*Amblypharyngodon mola*	H & SSF	FW	F	C
7	*Esomus danricus*	O & SCBF	FW & BW	WF	C
8	*Rasbora daniconius*	O & SSF	FW & BW	F	C
9	*Mystus gulio*	BCF, O & P	FW & BW	F	C
10	*Mystus vittatus*	BCF, C & P	FW & BW	F	C
11	*Aplocheilus panchax*	H, O & SF	FW & BW	WF	R
12	*Chanda nama*	C, O & SCF	FW & BW	F	A
13	*Parambassis ranga*	C, O & SCF	FW & BW	F	A
14	*Oreochromis mossambica*	BCF & P	FW & BW	F	A
15	*Glossogobius giuris*	BF, C, O & P	FW & BW	F	C
16	*Anabas testudineus*	C, CF & P	FW & BW	F	A
17	*Colisa fasciatus*	CF & O	FW	F	A
18	*Colisa labiosus*	O & SF	FW	WF	C
19	*Colisa lalia*	CF & O	FW	WF	C
20	*Channa gachua*	BCF & C	FW	F	C
21	*Channa punctatus*	BCF, C & P	FW & BW	F	C
22	*Channa striatus*	BCF, C & P	FW & BW	F	C

Habit: BF-Bottom feeder, BCF-Bottom columnar feeder, C-Carnivore, CF-Columnar Feeder, H-Herbivore, O-Omnivore, P-Predatory fish, SF-Surface feeder, SSF-Sub-surface feeder, SCF-Surface columnar feeder, SCBF–Surface column bottom feeder. Habitat: FW-Freshwater, BW-Brackish water. Commercial Importance: F-Food fish, CL-Cultivable, MD-Medicinal value, WF-Weed Fish. Frequency: A-Abundant, C-Common, R-Rare.

Table 2. Details of the gut content of the selected larvivorous fish.

S.No	Name of the Species	Algae	Weeds	Tadpole fish	Larvae/ Pupae	Crustaceans	Insects	Gastropods	Worms	Others
1	*Puntius chola*	53.2	14.5	0	48	3	9.5	0	17.5	3.5
2	*Puntius sophore*	12.75	21	0	41.5	0	47.5	0	23.55	6.55
3	*Puntius ticto*	51.55	15.25	6.3	57.5	5.2	14.5	2.5	16.5	1.75
4	*Amblypharyngodon mola*	11.1	0	0	58.5	0	44.5	0	27.5	3.2
5	*Esomus danricus*	29.5	21.2	1.0	55.0	20	25	1.5	32.5	15.5
6	*Rasbora daniconius*	32.55	41.5	0.5	62.55	25.25	31.5	1.0	21.52	21.5
7	*Mystus bleekeri*	12.5	23.5	18.55	47.55	35.52	67.5	42.15	52.10	75.25
8	*Mystus cavasius*	13.58	22.52	18.5	27.52	33.75	65	41.25	51.32	65.35
9	*Mystus vittatus*	10.52	14.95	6.5	25.3	11.75	34.95	25.5	43.55	52.25
10	*Aplocheilus panchax*	14.5	8.1	0	76.35	24.55	45.25	0	45.95	0
11	*Chanda nama*	9.25	21.15	0	21.52	6.54	32.54	0	31.25	8.1
12	*Glossogobius giuris*	22.54	21.25	0	32.52	6.85	42.15	0	77.52	23.85
13	*Anabas testudineus*	9.5	1502	14.25	14.2	9.25	9.15	25.59	71.25	28.52
14	*Colisa lalia*	11.75	10.55	2.8	57.53	13.55	39.85	15.75	48.95	19.55
15	*Channa gachua*	18.35	19.26	59.52	28.52	47.54	38.52	20.12	36.45	15.24
16	*Channa punctatus*	19.25	21.85	61.25	26.75	45.52	35.35	21.75	38.25	16.45
17	*Channa striatus*	17.5	22.95	62.95	29.35	45.25	52.57	35.2	63.54	12.2

Based on the results obtained, 4 indigenous fish *viz.*, *Rasbora daniconius*, *Colisa lalia*, *Amblypharyngodon mola* and *Mystus bleekeri* were selected for the predation experiment (Fig. 3). The consumption rate of mosquito larvae by four indigenous ornamental fish species under laboratory condition was presented in Table 3.

Table 3. Consumption rate of mosquito larvae by four indigenous ornamental fish species under laboratory condition.

S. NO	Name of the Fish	Size (cm)	Time (hr)	Beaker No 1	2	3	4	5	6	Total (per hr)	Total consumption (per species)
1	*Mystus bleekeri*		I	12	07	09	11	08	10	09.5 ± 1.87	
		7.93±0.52	II	04	08	05	03	04	06	*05.0±2.92	05.86±3.28
			III	04	07	02	03	02	01	*03.1±3.28	
2	*Amblypharyngodon mola*		I	10	12	13	08	06	11	*10.0±2.60	
		6.52±0.39	II	08	10	11	07	05	09	**8.33±2.44	*09.00±2.27
			III	10	12	09	06	05	10	*8.66±2.44	
3	*Colisa lalia*		I	10	10	12	09	10	12	10.5±1.22	*10.00±1.51
		6.91±0.72	II	09	08	10	07	08	10	8.66±1.50	
			III	10	12	11	09	11	13	*11.0±1.58	
4	*Rasbora daniconius*		I	11	15	13	10	12	11	*12.0±1.78	**12.61±2.29
		6.72±0.51	II	17	15	12	9	10	12	*12.5±2.37	
			III	12	10	14	12	14	18	*13.3±2.47	

Results expressed as Mean ± SD; n=6 (B1 to B6); *P<0.05, **P<0.01.

The consumption rate of mosquito larvae by four different indigenous fish species of ornamental value under laboratory condition revealed that, among the four species, mean consumption of the *Rasbora daniconius* is highly significant (P<0.01) followed by *Colisa lalia* and *Amblypharyngodon mola* (P<0.05).

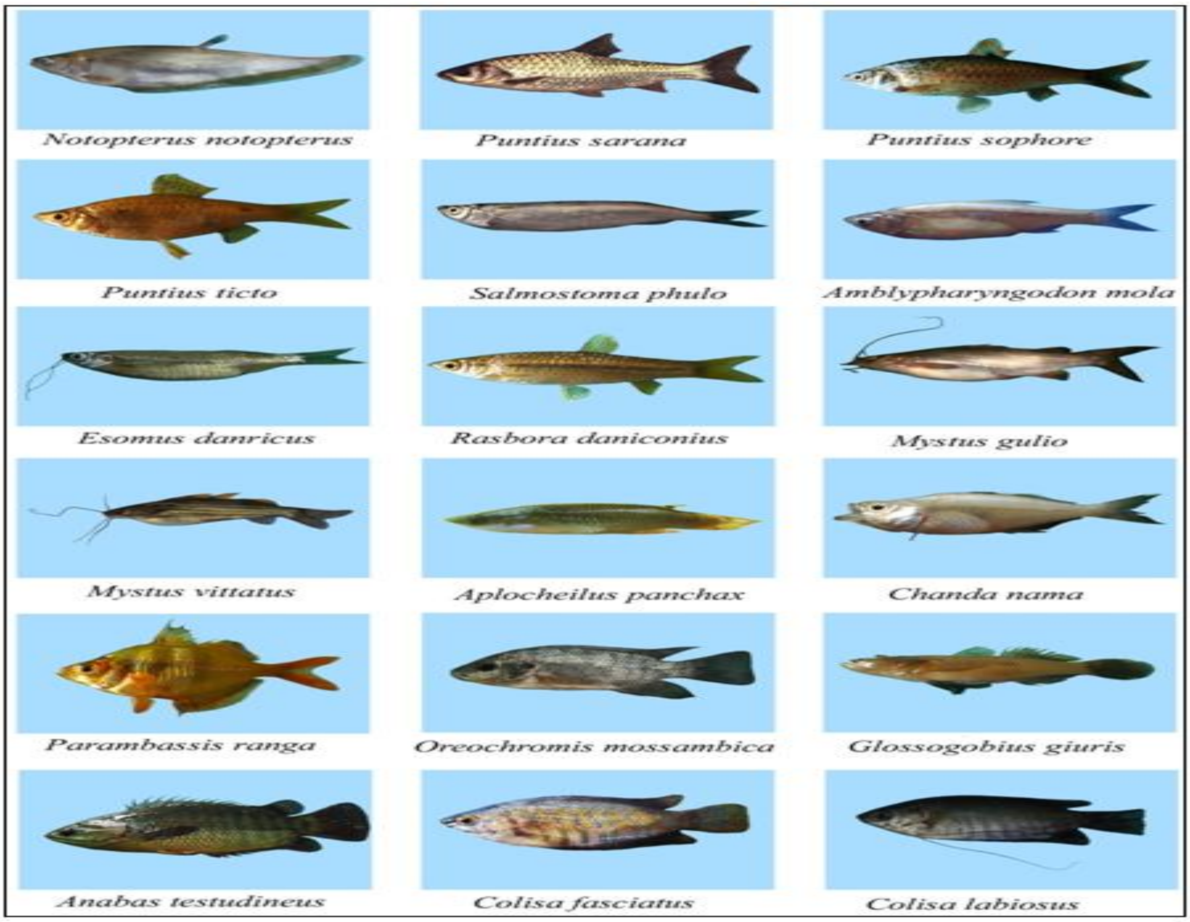

Fig. 1. Larvivorous fish fauna of Lake Kolleru.

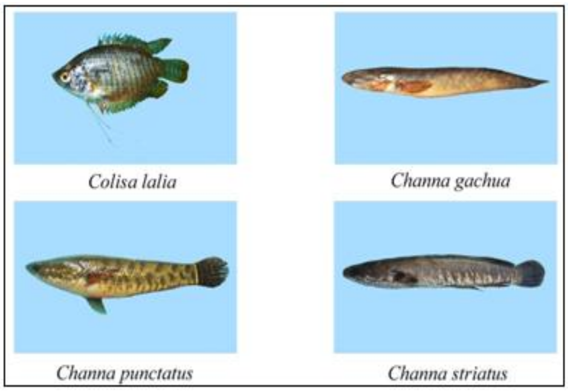

Fig. 2. Larvivorous fish fauna of Lake Kolleru.

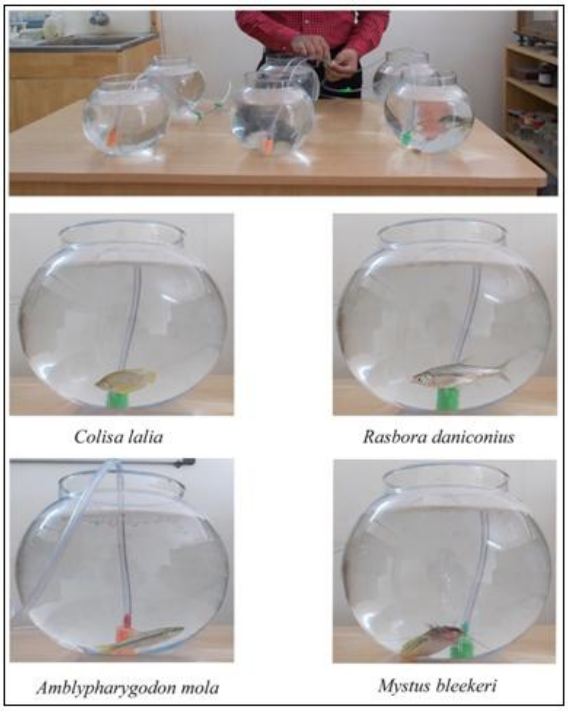

Fig. 2. Experimental design –Mosquito control efficiency of 4 indigenous omamental fish.

Overall mean consumption of *Mystus bleekeri* for three hours is not significant but it showed a significant consumption at 2nd and 3rd hour. In general, predation of mosquito larvae will be influenced by the presence of an alternative prey as evidenced Manna *et al.*, (2008) but some fishes predate more when mosquito larvae alone were offered. Mosquito larval preference of *Gambusia affinis* was reduced when supplemented with *Tubifex tubifex* (Reddy and Shakuntala, 1979). Presence of oligochaete worms reduced the feeding on mosquito larvae in *G. affinis* and *Poecilia reticulata* (Jacob and Nair, 2006). Intake of food in a particular fish is dependent on the gastric evacuation (Windell, 1967). Moreover, soft food items such as dipterans larvae and worms found to be digested more rapidly than the organisms with chitinous exoskeleton (Nikolsky, 1963) and some of the oligocheate worms are reported to have high nutritive content (Galinat, 1960) and easily digestible for fish (Mann, 1935).

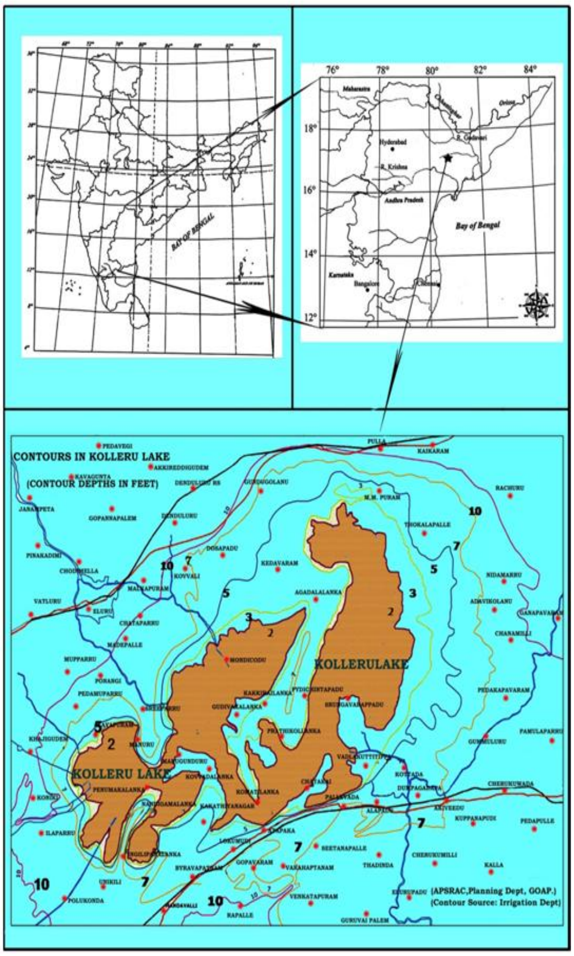

Fig. 4. Geographical location of Lake Kolleru.

Efficacy of a fish as a predator also depends on its weight and sex, among other variables. When compared with the results of their investigations with the results of the present investigation, it is evident that most of the selected fishes predated more on various stages of mosquito larvae even in the presence of alternative food. Present study revealed that the predation was also influenced and decreased with the increasing mosquito larval size. These findings are in accordance with the results of Rojas *et al.*, (2005), Kumar *et al.*, (2008) and Devi and Jauhari (2009).

Conclusion

Lake Kolleru, the only Ramsar site from Andhra Pradesh, India is harboring a rich ichthyofaunal diversity. Lake Kolleru being a wetland of international importance is a rich source of freshwater fish diversity with 93 species of fish including 58 species of ornamental fish and 22 species of larvivorous fish. 17 fish species were analyzed for the gut content and consumption rate of mosquito larvae by four indigenous fish species of ornamental value was conducted under laboratory conditions. Study revealed the potentiality of three fish species *Rasbora daniconius*, *Colisa lalia* and *Amblypharyngodon mola* and their efficiency as mosquito control agents. These can be employed in integrated mosquito control programmes in place of exotic species such as *Gambusia affinis* and *Poecelia reticulta*.

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