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Diversity of larvivorous fish fauna in Lake Kolleru (AP), India

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Abstract
Fish that are predators of the immature stages of mosquitoes are referred to as larvivorous fish. Among all the biological control agents, larvivorous fish are most common and widely used in vector control management. A survey was conducted in Lake Kolleru with an objective to document the larvivorous fish fauna available in the lake which revealed the occurrence of 29 species of larvivorous fish from 6 orders, 14 families and 20 genera. Order mugiliformes was the most dominant group with 9 species and cyprinidae was the dominant family with 8 species. According to the IUCN (2015) red list of threatened species, 89.65% of species are at least concern, 3.44% are at near threatened, 3.44% are not assessed and for 3.44% of species data is deficient. As per the CAMP report (1998), 10 species are at lower risk near threatened, 1 at lower risk least concern, 5 are vulnerable, 12 are not evaluated and for 1 species data is deficient. Out of 29 larvivorous fish, 14 species are very common, 11 are abundant in the lake and 24 varieties of fishes are food fishes of which 14 species are cultivable. 23 species are from both freshwater and brackish water regions and the rest from freshwater region only. Several anthropogenic activities including pollution, habitat loss, human interference, over exploitation and siltation are causing biodiversity loss and seriously affecting the lake resources. The indigenous larvivorous fish species of the lake can be successfully used for integrated vector control management.

Keywords: Indigenous fish, larvivorous fish, biological control, Lake Kolleru.

1. Introduction
Mosquitoes are responsible for the transmission of various life-threatening diseases of mankind such as malaria dengue, chikungunya, etc for which many countries have adopted various chemical, physical and biological means to control the population of mosquitoes in order to reduce the incidence of malaria and other mosquitoes borne diseases. Chemical control measures pollute aquatic ecosystems, expensive and require many skilled persons for constant surveillance of mosquito breeding sites. Physical control measures are also expensive and time consuming. The use of biological agents shows no environmental contamination or mosquito resistance. Their side effects on living things including humans, domestic animals and on wildlife are minimal, if not completely absent. Biological control of mosquito larvae consists of the utilization of selected natural enemies of targeted mosquitoes and of biological toxins to achieve effective vector management for which larvivorous fish, invertebrate predators, nematodes, protozoa, fungi, bacteria, etc. are the better alternatives. Integrated vector management (IVM) efforts are now oriented towards controlling larval stages and/or the adult stages of mosquitoes using biological means, where various concerns at the ecological, environmental, social, and economical levels are highly considered (Beier, 2008) [1]. Among all the biocontrol agents, larvivorous fish are widely used in vector control. Approximately 315 fish species under seven genera are reported to have larvivorous nature and using larvivorous fish in malaria control is a renewed strategy (Ghosh and Dash, 2007) [6].
Many types of mosquito eating fish have been used in control programs across the world (Walton, 2007) [22]. Of which two non-native fish *Gambusia affinis* and *Poecilia reticulata* are extensively introduced into various parts of India for mosquito control program. But introduction of such invasive alien fish species can have negative consequences on the aquatic environment and compete with the indigenous fish fauna for food and space. Native larvivorous fish species are acceptable mosquito control agents and potentiality of these native fishes should be evaluated. Various indigenous fishes have been used for mosquito control which provides dual benefits by reducing the mosquito populations and indirectly augmenting the aquacultural economics (Chandra *et al*., 2008) [4].

Mosquito larval preference of four indigenous larvivorous fishes *Amblypharyngodon mola*, *Colisa lalia*, *Mystus bleekeri* and *Rasbora daniconius* was assessed by Rao *et al*., 2015 [15]. Das (2012) [5]. 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) [8]. 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 which proved the Superiority of panchax minnow over guppy as mosquito biocontrol agent. *Channa gachua*, commonly available snakehead fish is very efficient at mosquito larval control (Phukon and Biswas, 2011) [14]. Manna *et al*., 2011 [12]. Assessed habitat heterogeneity and prey selection of *Aplocheilus panchax* an indigenous larvivorous fish. The suitability of indigenous air-breathing fishes as predators of mosquito larvae was assessed by Bhattacharjee *et al*., 2009 [2]. Ghosh *et al*., 2005 [7]. Reported the efficiency of larvivorous fish as control agents of malaria vector sibling species of the *Anopheles culicifacies* complex in wells of the villages in Karnataka, India. Considering the importance of indigenous fish fauna as mosquito control agents, the present work was initiated aiming at assessment and documentation of the diversity of larvivorous fish fauna of lake Kolleru, and thereby evaluating the conservation status of those fish species, taking into consideration lake health and makes the local people more aware about their indigenous environmental resources and their conservation.

2. Materials and Methods

Monthly survey was conducted from January 2014- December, 2015 and fishes were collected at different sites of the lake with the help of local fishermen. Fishes were also collected from local fish markets. Immediately photographs were taken prior to preservation for the identification. Specimens were preserved in 10% formalin. The fishes were identified using keys for fishes of the Indian subcontinent (Jayaram, 1999; Talwar and Jhingran, 1991) [11, 20]. Classification was carried out on lines of Jayaram (1981) [10]. Identification of the larvivorous fish species was done by gut content analysis. Data on current conservation status was obtained from report of the Conservation, Assessment and Management Plan (CAMP) workshop (Molur and Walker, 1998) [13]. On freshwater fishes of India and IUCN Red List Category of Threatened Species (IUCN, 2015) [9].

3. Results

During the study period we have recorded 29 species of larvivorous fish from 6 orders, 14 families and 20 genera. List of larvivorous fish recorder from the lake, along with their conservation status, abundance and ecological importance was given table 1. Order mugiliformes was the most dominant group contributing 31.03% of the total species followed by cypriniformes with 27.58%, perciformes with 17.24%, siluriformes with 13.79%, cyprinodontiformes with 6.89% and osteoglossiformes with 3.44%. Among the genera, 30% are from mugiliformes, 25% from cypriniformes, 20% from perciformes, 10% each from siluriformes and cyprinodontiformes and 5% from osteoglossiformes. Order mugiliformes contributed 5 families to the total fish species, followed by perciformes each with 3, siluriformes and cyprinodontiformes each with two and cypriniformes and osteoglossiformes each with 1 family. Out of 14 families recorded, cyprinidae with 8 species contributing about 27.58% of the total species, bagridae, belontiidae and channidae each with 3 (10.34%), ambassidae and cichlidae each with 2 (6.89%) and rest of the families each with 1 (3.44%) species (table 2 & figure 1). According to the IUCN (2013) red list of threatened species 26 species are at least concern, 1 at near threatened, 1 is not assessed and for one species data is deficient. As per the CAMP report (1998), 34.48% of species are at lower risk near threatened, 3.44% (1) at lower risk least concern, 17.24% (5) vulnerable, 41.37% (12) are not evaluated and for 3.44% (1) species data is deficient (table 3 & figure 2).

Table 1: Diversity and conservation status of larvivorous fish fauna recorded from Lake Kolleru

Order / Family / Species	Camp	Iucn	Habit	Habitat	Commercial Importance	Frequency	Threats
Order: Osteoglossiformes Family: Notopteridae 1. *Notopterus notopterus*	Lrnt	LC	C, P & SCF	BW & FW	CL, F, MD & OF	A	Hi, Oe, P & T
Order: Cypriniformes Family: Cyprinidae 2. *Puntius sarana*	VU	LC	BCF	BW & FW	F, OF & WF	A	F, Hi, Hl & T
3. *Puntius sophore*	Lrnt	LC	BCF, H & O	BW & FW	CL, F, OF & WF	A	F, P & T
4. *Puntius ticto*	Lrnt	LC	BCF, H & O	BW & FW	CL, F, OF & WF	C	F, Hl & T
5. *Salmostoma phulo phulo*	NE	LC	SF	FW	F & OF	R	Hl & P
6. *Amblypharyngodon mola*	Lrlc	LC	H & SSF	F W	CL, F & OF	C	F & P
7. *Esomus barbatus*	NE	LC	O & SCBF	FW	WF	A	P
8. *Esomus danricus*	Lrnt	LC	O & SCBF	BW & FW	OF & WF	A	Oe
9. *Rasbora daniconius*	Lrnt	LC	H & SSF	BW & FW	OF & WF	C	Hl
Order: Siluriformes Family: Bagridae 10. *Mystus armatus*	NE	LC	BCF, C & P	BW & FW	F	C	Hi & P
11. *Mystus gulio*	NE	LC	BCF, O & P	BW& FW	F & OF	C	Oe & T
12. *Mystus vittatus*	VU	LC	BCF, C & P	BW & FW	CL, F & OF	C	Oe & T
Family: Clariidae	VU	LC	BFSV, C &	BW &	CL, F & OF	C	T

13. *Clarias batrachus*			P	FW			
Order: Cyprinodontiformes Family: Belonidae 14. *Xenentodon cancila*	Lrnt	LC	C, O & SF	BW & FW	CL, F, OF & WF	R	F, P & T
Family: Aplocheilidae 15. *Aplocheilus panchax*	DD	LC	H, O & SF	BW & FW	CL, OF & WF	C	F, Hl, Oe, P, S & T
Order: Perciformes Family: Ambassidae 16. *Chanda nama*	NE	LC	C, SCF & O	BW & FW	F, OF, CL	A	F, Hi, P & T
17. *Parambassis ranga*	NE	LC	C, SCF & O	BW & FW	F & OF	A	Hl & P
Family: Gerreidae 18. *Gerres filamentosus*	NE	LC	C & SF	BW & FW	F	C	No Threats
Family: Cichlidae 19. *Oreochromis mossambica*	NE	NT	BCF & P	BW & FW	F & OF	A	No Threats
20. *Oreochromis niloticus*	NE	NE	BCF, H & P	BW & FW	F	A	No Threats
Order: Mugiliformes Family: Mugilidae 21. *Mugil cephalus*	NE	LC	BCF & O	BW & FW	F & OF	C	Oe & P
Family: Gobiidae 22. *Glossogobius giuris*	Lrnt	LC	BF, C, O & P	BW & FW	CL, F & OF	C	Hi & Hl
Family: Anabantidae 23. *Anabas testudineus*	VU	DD	C, CF & P	BW & FW	F & OF	A	F, Hi, Oe & T
Family: Belontiidae 24. *Macropodus cupanus*	NE	LC	CF, O & P	BW & FW	F	O	Hi, Hl, Oe & P
25. *Colisa fasciatus*	Lrnt	LC	CF & O	FW	CL, F & OF	A	F, Hi, P & T
26. *Colisa lalia*	NE	LC	CF & O	FW	WF & OF	R	Hi, Hl, Oe & P
Family: Channidae 27. *Channa gachua*	VU	LC	BCF & C	FW	CL, F & OF	C	Hi, Hl, Oe & T
28. *Channa punctatus*	Lrnt	LC	BCF, C & P	BW & FW	CL, F & OF	C	F, Hl & Oe
29. *Channa striatus*	Lrnt	LC	BCF, C & P	BW & FW	CL, F & OF	C	F & T

Conservation Status: LC-Least Concern; DD-Data Deficient; NE-Not Evaluated; VU-Vulnerable; LRnt-Lower Risk near threatened, NT-Near threatened, LRlc-Lower Risk least concern. Habit: BF – Bottom feeder; BCF – Bottom columnar feeder; BFSV – Bottom feeder and surface visitor; 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: BW- Brackish water; FW- Freshwater. Commercial Value: CL – Cultivable; F – Food fish; OF – Ornamental fish; MD – Medicinal value; WF – Weed Fish. Abundance: A-Abundant; C-Common; R-Rare. Threats: F – Fishing, HI - Human Interference; HL - Habitat Loss; OE – Overexploitation; P – Pollution;; S – Siltation; T – Trade.

Table 2: Number and percent composition of families, genera and species under various orders

S. No	Order	Families	Genus	Species	% of Families in an order	% of Genera in an order	% of Species in an order
1	Osteoglossiformes	1	1	1	7.14	5	3.44
2	Cypriniformes	1	5	8	7.14	25	27.58
3	Siluriformes	2	2	4	14.28	10	13.79
4	Cyprinodontiformes	2	2	2	14.28	10	6.89
5	Perciformes	3	4	5	21.42	20	17.24
6	Mugiliformes	5	6	9	35.71	30	31.03
Total		14	20	29			

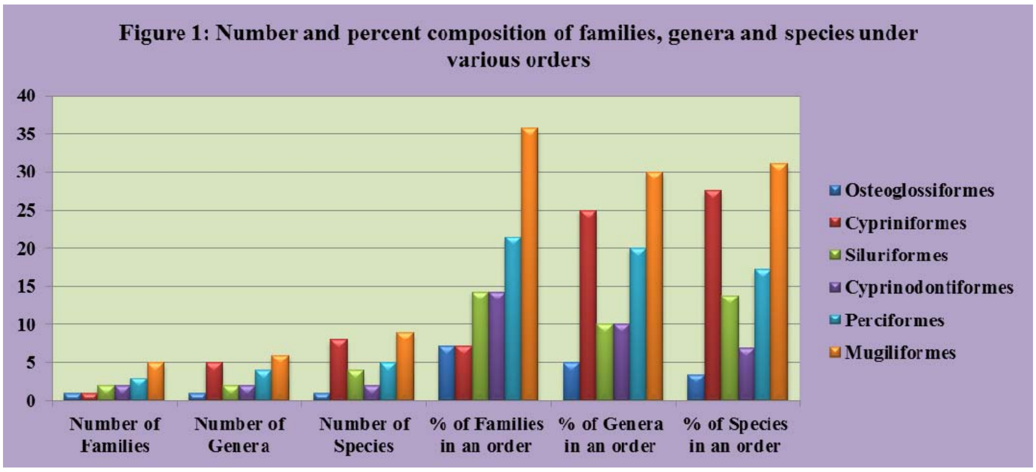
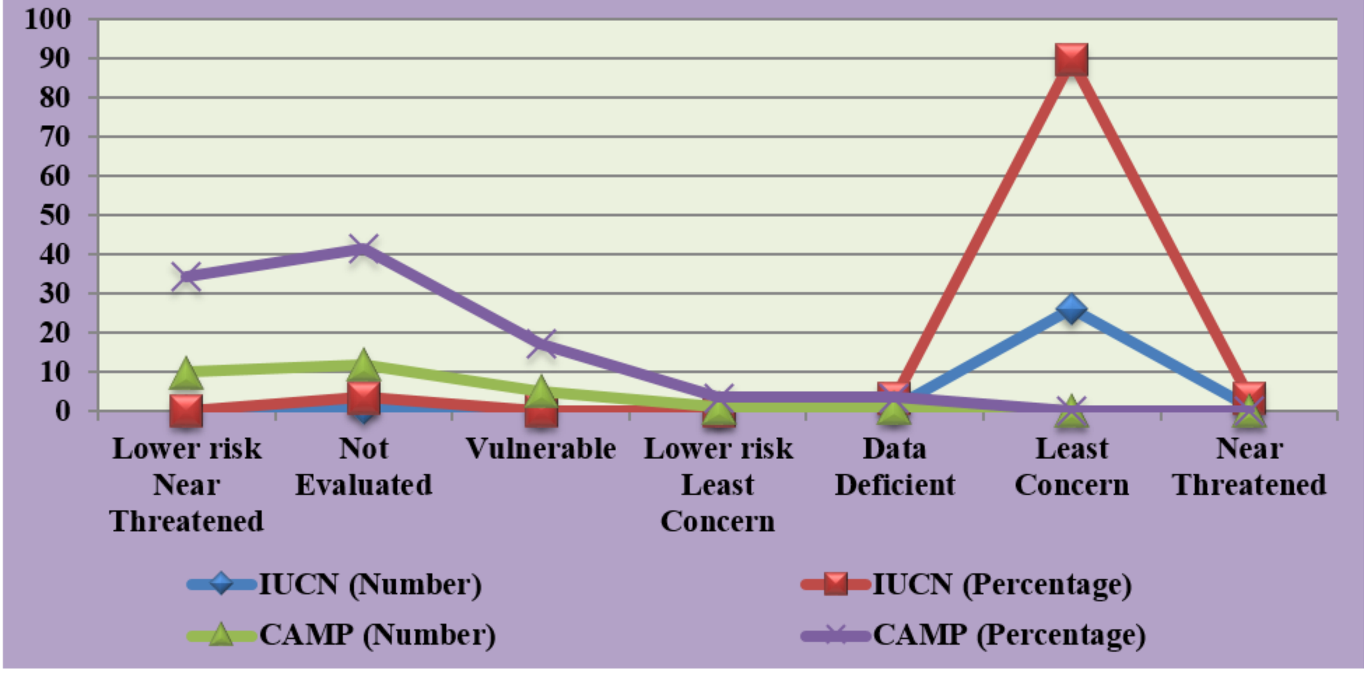


Figure 1: Number and percent composition of families, genera and species under various orders

Table 3: Number and percentage occurrence of fish fauna of Lake Kolleru under the conservation status CAMP, 1998 and IUCN, 2013

S. No	Threat category	CAMP		IUCN	
		Number	Percentage	Number	Percentage
1	Lower risk Near Threatened	10	34.48	--	--
2	Not Evaluated	12	41.37	1	3.44
4	Vulnerable	5	17.24	--	--
5	Lower risk Least Concern	1	3.44	--	--
6	Data Deficient	1	3.44	1	3.44
8	Least Concern	--	--	26	89.65
9	Near Threatened	--	--	1	3.44

Figure 2: Number and percentage occurrence of fish fauna of Lake Kolleru under the conservation status of CAMP (1998) and IUCN (2015)



4. Discussion

In our present study, fishes of the family cyprinidae was the most dominant group among all other families which is in accordance with previous investigations (Rao *et al*., 2013a, 2013b, 2014, Raju *et al*., 2014) [16-19]. Abundance of 11 species and commonness of 14 species are the good indication of sustainability of lake as a resource of larvivorous fish fauna. Larvivorous fish fauna of this lake is augmenting dual benefits by controlling mosquito larval populations and satisfying the needs of nutritional requirements of the local residents. Out of 29 larvivorous fish recorded, 24 varieties of fishes are food fishes of which 14 species are cultivable. Suitability of the ecological characteristics of larvivorous fish with that of mosquito larvae is essential for the development of an integrated vector control approach as suggested by Walker (2002) [21]. Out of 29 larvivorous fish recorded, 23 are inhabiting both freshwater and brackish water regions (upputeru, the only out let of the lake) and the rest of the species are from freshwater region of the lake which indicates the habitat adaptability of the species for different localities with different salinities. Dominance of omnivorous fish (48.27%) followed by carnivores (44.82%) and herbivores (20.68%) observed during the present study is the indication of the suitability of the habitat for larvivorosity of the fish. Commercial value of the ornamental fish fauna of this lake in terms of food value is well known for years. But in terms of ornamental trade, the value of these native ornamental resources is not yet explored (Rao *et al*., 2013a) [16]. Present study also revealed that out of 29 species documented, 24 species are having ornamental value as recorded earlier by Rao *et al*., 2013a [16]. Habitat preference of majority of larvivorous fish (Bottom feeders and surface visitors; columnar feeders, surface feeders, sub-surface feeder; surface columnar feeders) recorded from the present study is a good indication of efficiency of those fishes as potential larval control agents.

Larvivorous fish fauna have the potential to control various mosquito larval populations. Field level research and studies on the efficacy of these fish as potential larval control agents is scanty. Large scale production, transport and storage, higher application rates, initial costs, etc. are some of the major obstacles challenging the usage of this fish. Further investigations to assess the suitability of these fish species at field level need to be contemplated since there is a need to know the kind of water and the kinds of containers that facilitate maximum larval consumption and longest survival of these fish. Studies are also needed on the kind of material, the volume of water and the location of the container (whether inside or outside the house), the physiochemical characteristics of the water, primarily, and also of the chlorine and organic material (Calvacanti *et al*., 2007) [3].

5. Conclusions

Lake Kolleru is harboring sustainable and rich diversity of fish fauna including larvivorous fish which can be integrated in integrated vector control management. There is an increasing pressure on fish fauna of this lake which are facing a severe threat due to several anthropogenic activities. Of the threats identified, pollution, habitat loss, human interference, over exploitation and siltation are causing threat to the fish fauna of this lake. Development and conservation measures must be adopted to develop a concept of sustainable development and utilization of valuable larvivorous fish resources of this lake and for the conservation of the lake fish fauna. However, hindrances related to efficiency under field conditions, feasibility for operational use, persistence under natural environmental conditions, mass-production, application frequency, storage stability, etc. should be addressed too.

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