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Relative assessment of diversity of wild ornamental fishes sampled from two river basins of Arunachal Pradesh, India

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Abstract

The present paper attempts to document the potential ornamental fishes (POFs) and assess their diversity in two river basins of Arunachal Pradesh that are still unexplored in such a way. Several diversity indices are computed river-wise and statistically compared. From Dikrong and Ranganadi river basin a total of 52 and 29 POF species are documented respectively. The species compositions are quite different in the two river basins may be because of their altitudinal differences. The computed diversity indices are a little confusing because one river is more diverse while the other has more species richness. Hence, diversity profiles are constructed using Renyi index. The intersecting profiles reveal the two river basins are non-comparable in terms of ornamental fish diversity. The paper concludes with the note that compilation of such information would be of immense value practically to generate a river-wise list of POF of the state to design fish conservation strategies in future.

Keywords: Biodiversity, Dikrong, ornamental fish (OF), potential ornamental fish (POF), Ranganadi

Introduction

North-Eastern region of India is one of the hot spots of freshwater fish biodiversity [1] which possesses great potential to support both food fish (FF) and ornamental fish (OF) industries of the country [2]. Arunachal Pradesh (26° 28'-29° 30' N and 90° 30'-97° 30´ E) is the largest frontier state of North-East India having an area of 83,743 sq. Km that covers almost 60.93% of the Eastern Himalayan hotspot [3]. Being bordered with Bhutan, China, Bangladesh and Myanmar, the state of Arunachal Pradesh uniquely shares their flora and fauna [3]. Topographically the state is comprised of altitudinal zones forming three distinct ecological belts [4]. The northern part is characterized by mountain and sub-mountain terrains, and the southernmost part is gradually slopping towards the plains of the state of Assam, while the part in between constitutes the mid-altitudinal regions which have the greatest diversity [4]. Further this mountainous state is engorged with eleven river basins [5] and numerous streams that harbour enormously rich and diversified piscatorial forms, many of which have ornamental potential but not yet established as OF; these are the potential ornamental fishes (POF) of this state. Thus Arunachal Pradesh is highly promising to be the OF hub of India, only waiting for proper effort.

At present nearly 95% of the total OF supplied from this region is wild fishes that are caught directly from their natural habitat in order to be sold into the aquatics trade [6]. This practice is extremely harmful as it causes over-exploitation and ultimately results dwindling of this immense fish resource. In addition, the introduction of exotic species, pollution, global climate change, indiscriminate fishing for food etc. is making the situation even more critical [7-8]. According to a report of IUCN many of the fish species of Arunachal Pradesh have already become endangered or critically endangered [9], and the list is getting bigger with time. So, there is an urgent need to document the fishes of this state and assess the current status of their diversity so that necessary steps could be taken for their conservation. But such types of studies are lacking except some scattered information in the literature [10-11]. Under this backdrop, the present paper deals with documentation and assessment of the diversity of fishes with ornamental value (*i.e.* OF and POF) in Ranganadi and Dikrong river basins of Arunachal Pradesh, to ascertain the present status of their diversity in this region.

2. Material and methods
2.1 Sampling site
The two selected river basins are divided into four accessible sites on the basis of increasing altitude (Fig. 1). For Dikrong river basin, fishes are sampled from Doimukh (27°08'19" N 93°44'51" E, 120mt asl), Itanagar (27°06'30" N 93°36'27" E, 300mt asl), Sagalee (27°41'38" N 93°29'37" E, 932mt asl), and Dev (27°12'30" N 93°30'24" E, 1083mt asl), while for Ranganadi river basin sampling is done from Kimin (27°21'01" N 93°57'11" E, 193mt asl), Yazali (27°23'04" N 93°45'28" E, 611mt asl), Yachuli (27°25'53" N 93°45'42" E, 797mt asl), and Ziro (27°30'20" N 93°50'00" E, 1617mt asl).

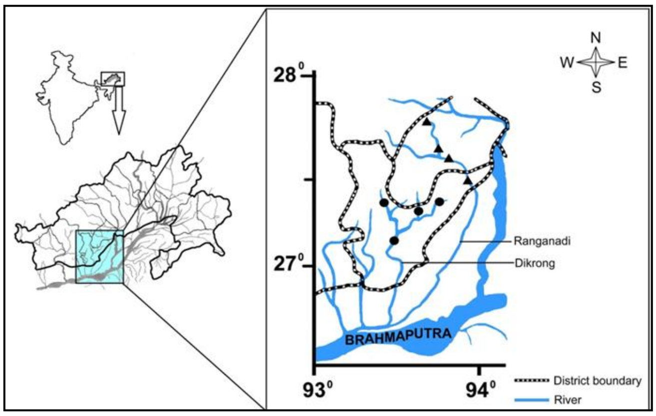


Fig 1: Map showing sampling sites in Dikrong (round black) and Ranganadi (triangle black) river basins of Arunachal Pradesh (map not in scale).

2.2 Field sampling
The fishes are randomly sampled for a period of three years using caste net, electrofisher and other indigenous traps from the rivers and their tributaries starting from July, 2012 till June, 2015. Collected specimens are identified up to species level and their counts are recorded on site, while the unidentified species are kept in 10% formalin and taken to the Rajiv Gandhi University Fisheries Museum (RGU-MF), where identification of the specimens is completed. Valid names of the documented fishes are obtained using the information of Vishwanath et al. and Eschmeyer [12-13]. The lists of the fishes with ornamental potential are then prepared separately for each of the river basins. Later, % relative abundance was calculated using the following formula:

$$\%\,Relative\ abundance = \frac{Number\ of\ individuals\ of\ a\ particular\ species}{Total\ number\ of\ individuals} \times 100$$

2.3 Statistical analyses
Our hypothesis that species compositions within one river basin should be more similar than those from the other basin is tested by one-factorial permutational analysis of variance (PERMANOVA) based on presence/absence data and Bray-Curtis dissimilarities with 9999 permutations, followed by Bonferroni corrected pair-wise permutation test. Assessment of diversity and all the statistical analyses are carried out with the help of PAST software, version 3.02 (University of Oslo, Norway, http://folk.uio.no/ohammer/past).

2.4 Estimation of diversity
From the plethora of diversity indices the following three have been selected for the purpose:

$$Shannon - Wiener\ index = H' = -\sum_i \frac{n_i}{n} \ln \frac{n_i}{n}$$

[Where, n_i= number of individuals of taxon i, n= Total number of individuals]

$$Simpson's\ diversity\ index = D = 1 - \left(\frac{\sum n\,(n-1)}{N(N-1)}\right)$$

[Where, n = total number of organisms of a particular species, N= total number of organisms of all species]

$$Berger - Parker\ index = D = \frac{N_{max}}{N}$$

[Where, N_{max} is the number of individuals in the most abundant species, and N is the total number of individuals in the sample]

Evenness has been measured by the Buzas-Gibson evenness index using the following equation:

$$Buzas - Gibson\ evenness\ index = \frac{eH'}{S}$$

[Where eH' = Shannon-Wiener index, calculated using natural logarithms, S = Number of species]

Species richness has been estimated using Margalef and Menhinick indices by the following equations:

$$Margalef\ index = D_{mg} = \frac{S-1}{lnN}$$

[Where S= Number of species, N= Total number of individuals in the sample]

$$Menhinick\ index = D_{mn} = \frac{S}{\sqrt{N}}$$

[Where S= Number of species, N= Total number of individuals in the sample]

For comparative assessment of the estimated alpha diversity of the two river basins, the diversity indices are subjected to permutation tests. To obtain a complete profile of the OF diversity of the selected river basins, the exponential of Renyi index is used taking different alpha values. The equation is:

$$Renyi\ index = H_\alpha = \left(\frac{1}{1-\alpha} ln \sum_{i=1}^{S} p_i^\alpha\right)$$

[Where S= number of species, p_i = relative abundance of the i^{th} species, α = a scale parameter. According to Hammer, 2014 for α=0, this equation gives the total species number, α=1 gives an index proportional to the Shannon-Wiener index, and α=2 gives the value of Simpson index.]

3. Results and discussion
Central Inland Fisheries Research Institute (CIFRI), Barrackpore, India, has recently made an attempt to collect data from selected sites of the rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari and Krishna. The study reveals all these rivers to be pretty rich in fish fauna where Ganga already harbours the maximum number of species followed by Brahmaputra [14]. This finding is highly significant in the context of the rivers of Arunachal Pradesh being the tributaries of the great river Brahmaputra. Hence it is quite obvious that all the rivers of the state bear high species richness. The present assessment also supports this view as because Dikrong river basin possesses the total of 52 species under 38 genera and 18 families having ornamental value

(Table 1, along with relative abundance and IUCN status). From Ranganadi river basin total of 29 ornamental species are recorded that fall under 22 genera and 14 families (Table 2, along with relative abundance and IUCN status). Members of Cyprinidae family are found to be the most dominant group in both the rivers as reported earlier by many authors from different other parts of Himalayan water bodies [15-16].

Table 1: The list of ornamental and potential ornamental fishes documented from Dikrong River, Arunachal Pradesh, during study period (2012-2015) along with relative abundance (RA) and IUCN status [22].

Family	Species	% RA	IUCN Status
Cyprinidae	*Cabdio Jaya*	0.28	LC
	Barilius bendelisis	24.44	LC
	Barilius vagra	1.11	LC
	Devario assamensis	0.28	VU
	Tor putitora	0.28	EN
	Puntius sophore	5.00	LC
	Cyprinion semiplotum	1.11	VU
	Cirrhinus reba	0.28	LC
	Labeo pangusia	0.83	NT
	Bangana dero	0.55	LC
	Schizothorax richardsonii	3.33	VU
	Crossochilus latius	1.11	LC
	Garra gotyla	10.00	LC
	Garra sp. 1	0.55	NA
	Garra sp. 2	0.83	NA
Psilorhynchidae	*Psilorhynchus homaloptera*	1.66	LC
	Psilorhynchus arunachalensis	0.55	DD
Nemacheilidae	*Paracanthocobitis botia*	5.00	LC
	Schistura sp	0.28	NA
	Physoschistura dikrongensis	0.28	NE
	Aborichthys kempi	1.11	NT
	Aborichthys elongates	5.00	LC
Cobitidae	*Botia dario*	1.39	LC
	Botia rostrata	1.39	VU
	Lepidocephalichthys guntea	5.28	LC
	Canthophrys gongota	0.28	LC
Bagridae	*Mystus cavasius*	1.67	LC
	Mystus tengara	0.28	LC
	Mystus bleekeri	0.83	LC
	Mystus sp	1.94	NA
	Mystus dibrugarensis	0.28	LC
Olyridae	*Olyra longicaudata*	8.05	LC
Siluridae	*Pterocryptis gangelica*	1.67	DD
Amblycipitidae	*Amblyceps* sp	0.28	NA
Sisoridae	*Gogangra viridescens*	0.55	LC
	Nangra assamensis	0.55	LC
	Gagata cenia	1.11	LC
Erethistidae	*Erethistes pussilus*	0.28	LC
	Hara jerdoni	0.28	LC
	Hara hara	0.83	LC
	Hara sp	0.28	NA
Chacidae	*Chaca Chaca*	0.28	LC
Mastacembelidae	*Mastacembelus armatus*	0.55	LC
	Macrognathus aral	0.28	LC
Badidae	*Badis* sp1	0.83	NA
	Badis sp2	0.55	NA
	Badis sp3	0.28	NA
Nandidae	*Nandus nandus*	0.28	LC
Cichlidae	*Oreochromis mossambicus*	2.50	NT
Anabantidae	*Anabas testudineus*	0.28	DD
Osphronemidae	*Trichogaster fasciata*	2.22	LC
Tetraodontidae	*Leiodon cutcutia*	0.83	LC

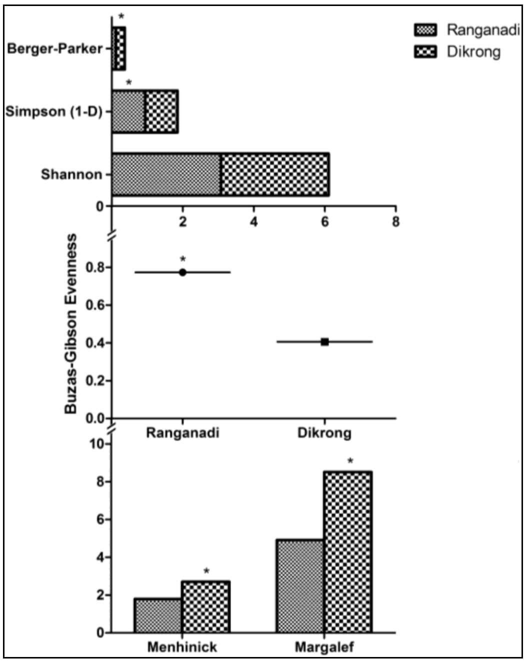
Note: NT= Nearly Threatened, LC= Least Concerned, VU= Vulnerable, NA= Not Applicable, DD= Data Deficient, EN= Endangered

Table 2. The list of ornamental and potential ornamental fishes documented from Ranganadi River, Arunachal Pradesh, during study period (2012-2015) along with relative abundance (RA) and IUCN status [22].

Family	Species	%RA	IUCN Status
Cyprinidae	*Barilius bendelisis*	4.45	LC
	Neolessochilus hexagenolepis	0.41	NT
	Oreichthys sp	11.74	NA
	Pethia chola	6.48	LC
	Labeo gonius	4.45	LC
	Labeo calbasu	1.62	LC
	Schizothorax sp	2.02	NA
	Crossochilus latius	4.86	LC
	Garra annandalei	0.81	LC
	Garra gotyla	6.88	LC
	Garra sp1	1.62	NA
	Garra sp2	5.67	NA
Psilorhynchidae	*Psilorhynchus homaloptera*	4.05	LC
Nemacheilidae	*Aborichthys kempi*	0.41	NT
Cobitidae	*Botia rostrata*	5.67	VU
Siluridae	*Ompok bimaculatus*	0.81	NT
Schilbeidae	*Ailia coila*	2.43	NT
Amblyciptidae	*Amblyceps apangi*	0.41	NT
Erethistidae	*Pseudolaguvia* sp	1.21	NA
Belonidae	*Xenentodon cancilla*	1.62	LC
Mastacembelidae	*Macrognathus aral*	1.62	LC
	Macrognathus pancalus	2.83	LC
	Mastacembelus armatus	1.62	LC
Gobiidae	*Glossogobius giuris*	3.64	LC
Chandidae	*Chanda nama*	4.86	LC
	Pseudambassis ranga	2.43	LC
	Parambasis sp	4.45	NA
Osphronemidae	*Trichogaster chuna*	5.67	LC
Channidae	*Channa gachua*	5.26	LC

Note: NT= Nearly Threatened, LC= Least Concerned, VU= Vulnerable, NA= Not Applicable

Most interestingly it is notable that the species compositions are fairly different in the two river basins. When compared, only ten species (*Barilius bendelisis*, *Garra gotyla*, *Garra* sp.1, *Garra* sp.2, *Psilorhynchus homaloptera*, *Aborichthys kempi*, *Botia rostrata*, *Crossochilus latius*, *Mastacembelus armatus*, *Macrognathus aral*) are found to be common in the samples of both river basins. The fact may be explained from the topographic point of view that the Ranganadi river basin is situated at a relatively higher altitude than the Dikrong basin. The differences in altitudes, physiographic factors, and climatic variables like temperature and rainfall being the determinants of distribution and species richness might have caused variation in the composition of fish species in the two river basins [17-19]. Our hypothesis that the species composition between the two river basins should be dissimilar is proved by statistical analyses ($p<0.0001$, one way PERMANOVA, Bonferroni corrected pair-wise permutation test). Assessment of diversity reveals that Simpson and Berger-Parker indices are significantly higher in Ranganadi (Fig. 2). The third diversity index, *i.e.* Shannon-Wiener index does not show any significant variation between the two data sets, though the mean value is higher in Ranganadi (Fig. 2) confirming Ranganadi to be more diverse than the Dikrong basin.



Note: Asterisk (*) indicates significant difference.

Fig. 2: Measured diversity indices for the fishes sampled from the Dikrong and Ranganadi river basins of Arunachal Pradesh (2012-2015).

On the contrary, Buzas-Gibson evenness index proves that there is more chance to get individuals of same species in two subsequent samplings in Ranganadi (Fig. 2) indicating the possibility of more species richness in the Dikrong river. Menhinick and Margalef indices prove the above inference that Dikrong basin is more species rich (Fig. 2). However, the findings are confusing because one river basin is more diverse, while the other one has more species richness. In a similar situation Kindt and others suggest that studies attempting to compare different communities should not rely on only a single diversity index, or a combination of several indices; but should use techniques that are developed for diversity ordering, such as the Renyi diversity profile which is one of the most useful tools for comparing diversity [20]. Accordingly, the exponential of Renyi index has been used with various alpha values to construct OF diversity profiles of the river basins under this study. The finding shows that the profiles intersect each other, instead of one being constantly higher (Fig. 3). As stated by Hammer and colleagues where the profiles cross each other at any point, they are non-comparable in terms of diversity [21]. Hence it is ultimately concluded that the estimated OF diversity of the two river basins is non-comparable. In other words, both the communities are diverse in terms of OF in their own ways.

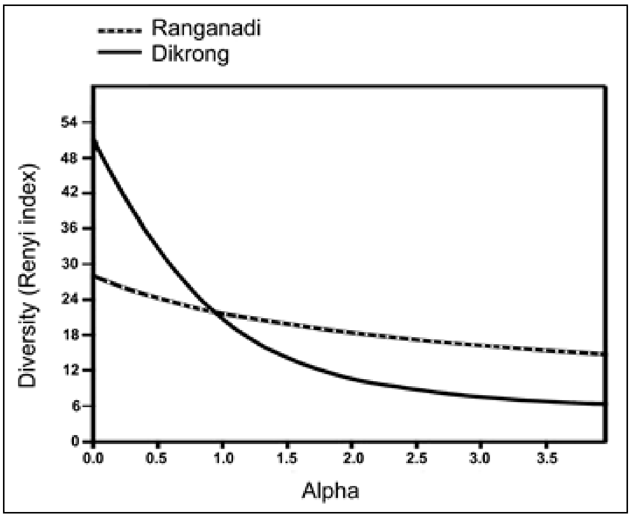


Fig 3: The diversity profile of the fishes sampled from Dikrong and Ranganadi river basins of Arunachal Pradesh (2012-2015).

4. Conclusion

The present study carried out in Dikrong and Ranganadi river basins of Arunachal Pradesh reveals the status of piscatorial diversity in a comparative manner. Similarly, other river basins of this state should also be explored in future. The compilation of such information would be of immense value practically to generate river-wise list of POF of the state. The indigenous people should also be made aware of the prospect of Of business and particularly the importance of fish conservation at least through the practice of fish culture and artificial propagation. The applicability of the finding as a whole being a fundamental ecological knowledge will cater the sustainable R & D activities as well as policy decisions for the highly sensitive mountain ecosystems and human welfare.

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