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Cover: A female Javan Leopard *Panthera pardus melas* in rehabilitation phase at Cikananga Wildlife Center. © Yayasan Cikananga Konservasi Terpadu.

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ARTICLE

Ichthyofaunal diversity of Senkhi stream, Itanagar, Arunachal Pradesh: a comparative status between 2004–05 and 2018–19

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Abstract: An investigation was conducted during 2018–19 after a time span of 13 years in the Senkhi stream, an important hill stream that flows through western corner of the capital city, Itanagar. The present study aims to compare decadal changes in ichthyofaunal diversity, status, and abundance with reference to the impact of increasing urbanization in the capital city. The ichthyofaunal diversity assessed presently is restricted to 37 species spreading over 30 genera under 13 families which include four species more, not reported in the past. Thus, of the 37 species recorded, 33 species only could be compared, and noticeably resulted ultimate reduction of 14 species belonging to 11 genera under 10 families from the study area. It indicated that nearly 64% decline in fish abundance within stream zone under urban area and about 46% reduction in undisturbed area. The present study hitherto revealed the alarming rate of decline in fish diversity and also unfolded key factors responsible for crucial decline of fish diversity along with the possible mitigation measures.

Keywords: Catch frequency, diversity loss, electrofishing, habitat degradation, restoration, urbanization.

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Author contributions: Authors have equally contributed in the study.

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INTRODUCTION

Biodiversity is essential for stabilization of ecosystems and protection of overall environmental quality (Ehrlich & Wilson 1991). Freshwater fish are one of the most threatened taxonomic groups (Darwall & Vie 2005) because of their high sensitivity to the quantitative and qualitative alteration of aquatic habits (Laffaille et al. 2005; Sarkar et al. 2008; Kang et al. 2009). Conservation of fish diversity and associated habitats is a great challenge (Dudgeon et al. 2006). Conservation measures to mitigate the impact of the pressures have largely been slow and inadequate and as a result populations of many of the species are declining rapidly. The Himalayan region in India has been identified as one of the 36 biodiversity 'hotspot' areas of the world (https://www.conservation.org) where the state of Arunachal Pradesh (26.28–29.30 °N & 91.30– 97.30 °E) constitutes 60.93% of the region and is characterized in having varied topographical features that forms a huge watershed network provided with numerous aquatic habitats. There are 2,500 species of freshwater fishes that have been recognized in the Indian subcontinent out of which 930 are categorized as freshwater species (Jayaram 2010) and 1,570 are marine (Kar 2003; Vijaykumar et al. 2008). Fishing is a common recreational activity and fish is a good source of protein required for a good health. The tribal populace of the state of Arunachal Pradesh are fond of fish and practice fishing and harvesting seasonally from streams and rivers by employing traditional fishing gears and traps as common property resource. However, depletion of the aquatic biodiversity is gradually increasing due to use of modern contraptions in most of the streams and rivers of Arunachal Pradesh (Chaudhry & Tamang 2007; Tamang & Shivaji 2012). A glimpse of such non-conventional methods of fishing using inverter and battery had once been highlighted in the local news (Arunachal24. dated 24 September 2020) operating within D'Ering Wildlife Sanctuary (DEWS).

Senkhi is an important and lonely hill stream, one of the tributary of upper Brahmaputra River and is the prime source of water for people inhabiting Itanagar that caters about 70% of drinking water to urban populace. The stream originates from about 7 km inside dense forest fed by merging various small drainages, before entering a beautiful valley popularly known as 'Senkhi Valley' in the north. The freshwater stream moves downwards traversing urban areas like Chandranagar, Police colony, IRBN colony and subsequently meets with Chimpu stream near IRBN firing ground. Thereafter, it forms a contiguous water body with Pachin and eventually confluences with Dikrong river at RCC bridge, Doimukh, covering about 30 km towards east. It consists of varied microhabitats ranging from deep water to fast-flowing riffles. The substratum comprised of medium to large boulders, pebbles, cobbles, and sand. Density of medium to large boulders are higher upstream than downstream. Sand and mixture of various colored gravels are dense towards lower reaches after Jullang village and density of sand increases thereafter up to Doimukh, through twin capital Naharlagun. On account of having varied physiographic features, the stream harbours a good number of fish diversity.

As far as ichthyofauna of the state is concerned, McClelland (1839) seemed to be the earliest pioneer worker followed by Chaudhuri (1913), Hora (1921), Jayaram (1963), Jayaram & Mazumdar (1964), Srivastava (1966), Dutta & Sen (1977), Dutta & Barman (1984, 1985), and Sen (1999). The first compilation of fish fauna of the state was made by Nath & Dey (2000) who listed a total of 131 species, followed by Bagra et al. (2009) who added 82 more totalling to 213 species. Finally, Darshan et al. (2019) listed 218 species, based on field surveys and available literatures.

Tamang et al. (2007b) earlier reported 47 species belonging to 35 genera and 17 families from Senkhi stream. Tamang et al. (2006; 2007a; 2008) had also reported first distributional record of three fish species: *Pseudolaguvia shawi, Balitora brucei*, *Glyptothorax telchitta* for the state and one new species *Erethistoides senkhiensis* from this stream. Therefore, the stream also acts as an important habitat for ichthyological research. Chaudhry & Tamang (2006) had also reported practicing of non-conventional method of fishing like using of chemicals, electrocution and it has been being continued by many people since long time. Thus to validate the current status of ichthyofaunal diversity of the stream, the present study has been conducted, so that the information may be used for restoration of the ongoing situation. Besides, the paper aims to highlight the major key factors responsible for rapid depletion of fish population in the Senkhi stream along with necessary policy decision to be taken for conservation and mitigation of the stream.

MATERIAL AND METHODS

The reinvestigations were conducted after a time span of 13 years from 02 September 2018 to 22 September 2019. Two sampling sites were selected in Senkhi stream with a gap of about 3 km in between

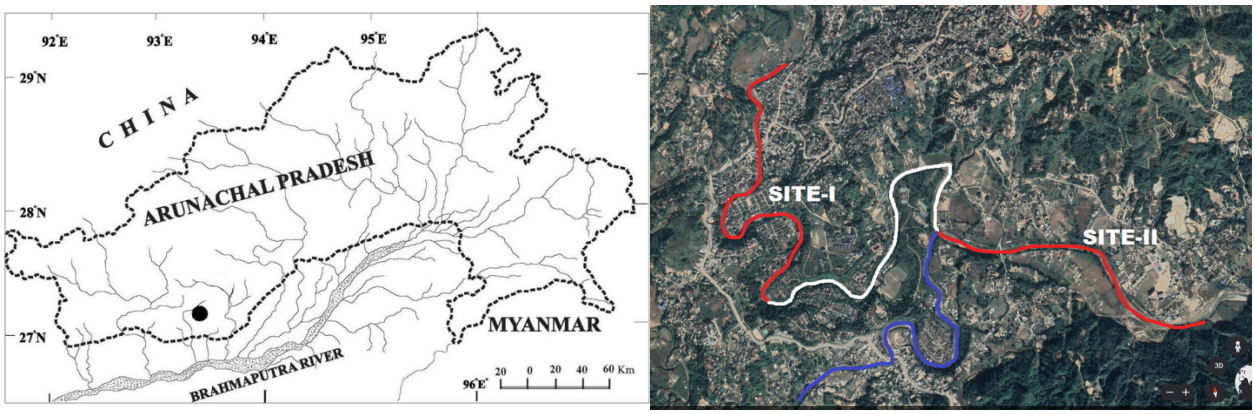

Image 1. Drainage and satellite map view of Itanagar city, showing study sites (Site-I and Site-II) indicated by red lines, gap in between two sites (white line) and Chimpu stream (blue line).

Site-I and Site-II. The site-I extends from Chandranagar - hanging bridge downwards to D.N.G. College, (27.088^{0}N & 93.601^{0}E) covering a total distance of about 3 km and is entirely situated within urban disturbed area. Site-II was selected as control condition (outside urban area) in order to have a comparison with Site-I. Site-II extends from confluence point of Senkhi and Chimpu stream (27.08 °N & 93.60 °E) near IRBN firing ground to Jullang village (27.06 °N & 93.63 °E) about 3 km downstream (Image 1). Habitat pattern: Site-I consists of large to medium sized boulders, pebbles and cobles with low quantity of sand deposit, width of stream narrow causing high pressure water during monsoon. Site-II: Stream gradually becoming wider towards downstream, and stream bed consists of large number of pebbles, cobbles, gravels, and sand, but few numbers of large boulders, placed collectively at beginning, middle and end of the site. Overall, it somewhat resembles with plain stream of Assam. However, both the sites mostly share gravelly bed which characterized true hill stream habitat. Random sampling was carried out weekly after dusk from 1800 to 2200 h using a cast net with radius of 2.30 m and 7 x 7 mm mesh size. Sampling in site-II was done in other alternate day. Weekly samplings were restricted to four weeks in a month. The frequency of occurrence of each species was calculated based on the numbers of occasions the species were collected during the samplings. Finally the data of total catch frequencies (%) of species encountered from two respective sites were compared and each result was compared with data of 47 species of the past record (Tamang et al. 2007b), prior to total number of species encountered in each site. Samplings were carried out covering various microhabitats such as shallow to deep and moderate to torrential flowing water. The collected samples were brought to laboratory of Rajiv Gandhi University for identification. The identification of fishes was confirmed following Talwar & Jhingran (1991), Nath & Dey (2000), and Darshan et al. (2019) and subsequently deposited in Rajiv Gandhi University Museum of Fishes (RGUMF). Trophic niche model may be useful for assessing altered as well as less altered fish habitat of the tropical rivers. Trophic niche of the species were recognized examining morphology of mouth, body shape and paired fins. Species having inferior mouth, cylindrical or dorso ventrally flattened body or horizontally situated paired fins are considered as bottom feeder, whereas terminal to sub-terminal mouth with compressed body are categorized as column feeder and upturned mouth with compressed body as surface feeder. The five previously misidentified species were rectified and fourteen name of species were revised and upgraded (indicated by symbol # and ** respectively in Table 1) following "Eschmeyer's Catalogue of Fishes, 2019. The catch frequency of common (91–100%) and abundant (81–90%) as per Tamang et al. (2007b) were used as standard norms of frequency scale (Table 2). Thus, % catch frequency with respect to species richness is computed as Abundant: 91–100%, Common: 81–90%, Frequent: 61–80%, Occasional: 31–60%, Sporadic: 15–30%, Rare: 05–14%, Extremely rare <05%. The conservation status of the encountered species were categorized following IUCN Red List of Threatened Species (2019-3).

RESULTS AND DISCUSSION

The ichthyofaunal diversity in the present study is restricted to 37 species belonging to 30 genera under 13 families, including additional four species

(not recorded in the past study). While comparing present data (excluding 4 additional species) with that of the past (Tamang et al. 2007b) presented in Table 2, revealed disappearance of 14 species, viz., *Glyptothorax pectinopterus, Glyptothorax brevipinnis, Glyptothorax telchitta, Glyptothorax cavia, Botia dario, Heteropneustes fossilis,Channa orientalis, Oreichthys cosuatis, Clarias magur, Labeo gonius, Mystus montanus, Oreochromis mossambica, Mastacembalus armatus, Badis badis* belonging to 11 genera under 10 families and identified as mostly bottom feeder (10 species), rarely column (4 species). Among all, the family cyprinidae was found to be highly dominant represented by 13 species (35%), followed by danionidae represented by nine species (24%). Other rarely diversified families are: Nemacheilidae, three species (8%), Ambassidae & Amblycipitidae, two species (5%) each, and Anguillidae, Balitoridae, Botiidae, Cobitidae, Erethistidae, Bagridae, Psilorhynchidae, and Sisoridae with one species (3%) each (Figure 3). With regard to 14 disappeared species, presently it is unwise to consider them as extinct as they may be existing in undisturbed upstream habitat far beyond study sites inside Senkhi valley or other drainage system within the vicinity of Itanagar Wildlife Sanctuary. Therefore, at present, species diversity is raised to 50 species excluding one exotic species *Oreochromis mosssambica,* which had been reported earlier.

Comparative analysis between two sites (Site-I: urban area) and (Site-II: undisturbed area): Of the total 37 species collectively encountered, distribution of 31 species were common in both sites except for six species. The comparative analysis of total catch frequency obtained from 37 species, showed 467.1 and 682.2 in site I and site II respectively, resulting deduction of 215.1, i.e., 31.5% catch frequency in Site-I than Site-II. This is the point in fact which shows that % catch frequency in Site-I is lower, since it is being situated in urban disturbed area compared to Site-II (Table 2). Of the remaining six species, four species—*Danio rerio, Bangana dero, Chanda nama,* and *Parambassis ranga*—were only caught in Site-II and two species—*Opsarius tileo* and *Anguilla bengalensis*—in Site-I. This may be due to habitat preferences, as *Danio rerio*, *Chanda nama* and *Parambassis ranga* are typically occurs in slow moving water of the plain, characteristics somewhat familiar with Site-II. However, *Bangana dero* occurs in plain as well as upstream. So, may be due to water contamination, it migrated to lower reaches. The occurrence of *Opsarius tileo* and *Anguilla bengalensis* in Site-I is genuine as *Opsarius tileo* occurs in both the habitat in hill streams. This may be due to low population density, occasionally caught in the past study too. So, *Opsarius tileo* might not have caught during sampling in Site-II. *Anguilla bengalensis* was accidentally caught during flood.

The comparative analysis of 33 species (excluding 4 additional species) with those of 47 species of Tamang et al. (2007b) showed respectively 1295.9 and 457.5 total catch frequencies resulting in deduction of 838.4, i.e., 64.7% in Site-I and similarly total catch frequencies 1295.9 and 697.6 respectively which depicts decline of total catch frequency 598.3, i.e., 46.2% in Site-II. This clearly indicates drastic decline of abundance of fish fauna in the study sites. Further, the data of comparative analysis between two sites also revealed 64.7–46.2% = 18.5% relatively more decline in urban area than undisturbed area, except *Neolissochilus hexagonolepis, Botia rostrata* and *Tariqilabeo latius* which showed 5.8%, 11.6%, 1.9% higher, respectively (Table 2 and Figure 1). Only one species *Opsarius bendelisis* showed cent percent catch frequencies in both sites as well as in the past. This indicates that *Opsarius bendelisis* is the most dominant and adoptive species in the stream.

The percent declining trend of each species in descending order are as follows (Table 2): Site-I (29 out of 47 species earlier study): *Tor tor* and *Garra birostris* declined to 65.4% each*, Aborichthys kempi* and *Garra annandalei* 61.5%, *Neolissochilus hexagonolepis* 48.1%, *Psilorhynchus balitora* 44.2%, *Schistura devdevi* and *Botia rostrata* 42.3% each, *Opsarius tileo* 40.4%, *Cyprinion semiplotum* 30.8%, *Balitora brucei* 28.9%, *Devario aequipinnatus* 26.9%, *Tariqilabeo latius* 25%, *Chagunius chagunio* 23.1%, *Opsarius barna* 19.2%, *Danio dangila* 17.4%, *Pseudolaguvia shawi* 13.4%, *Pethia conchonius* 11.5%, *Paracanthocobitis botia* 9.6%, *Devario devario, Puntius sophore*, & *Lepidocephalichthys guntea* 5.8% each, *Pethia ticto*, *Raiamas bola*, & *Puntius chola* 3.9% each, and *Cabdio jaya, Olyra longicaudata*, & *Amblyceps arunachalensis* 1.9% each. Out of 29, only one species, *Opsarius bendelisis* showed 100% abundance and hence considered as highly dominant species. Overall, it is clearly indicated that out of 47 earlier reported species, i.e., 18 species were not retraced in Site-I in present study. With regard to Site-II (32 out of 47 species earlier reported), 19 species had declined: *Tor putitora* declined to 59.7%, *Garra birostris* 57.7%, *Neolissochilus hexagonolepis* and *Botia rostrata* 53.9% each, *Aborichthys uniobarensis* (53.8%), *Garra annandalei* (48%), *Schistura devdevi* (40.4%), *Balitora brucei* (26.9%), *Tariqilabeo latius* (26.9%), *Psilorhynchus balitora* (25%), *Devario aequipinnatus* (25%), *Danio dangila* (11.6%), *Pseudolaguvia shawi* (9.6%), *Opsarius barna* (7.7%), *Paracanthocobitis botia* (5.8%),

Table 1. The revised and updated list of fish species encountered during past study (Tamang et al. 2007b) including four additional species in present study (2018–19), trophic niche and IUCN conservation status.

	Family	Species name listed in Tamang et al. 2007b	Species name (valid)	Trophic niche	IUCN Red List status
1	Nemacheilidae	*Aborichthys elongatus*	*Aborichthys uniobarensis#*	Bottom	NE
2	Nemacheilidae	*Acanthocobitis botia*	*Paracanthocobitis botia***	Bottom	LC
3	Cyprinidae	*Acrossocheilus hexagonolepis*	*Neolissochilus hexagonolepis ***	Column	NT
4	Amblycipitidae	*Amblyceps arunachalensis*	*Amblyceps arunachalensis*	Bottom	EN
5	Cyprinidae	*Aspidoparia jaya*	*Cabdio jaya***	Column	LC
6	Badidae	*Badis badis*	*Badis badis*	Bottom	LC
7	Balitoridae	*Balitora brucei*	*Balitora brucei*	Bottom	NT
8	Danionidae	*Barilius barna*	*Opsarius barna***	Column	LC
9	Danionidae	*Barilius bendelisis*	*Opsarius bendelisis***	Column	LC
10	Danionidae	*Barilius bola*	*Raiamas bola*	Column	LC
11	Danionidae	*Barilius tileo*	*Opsarius tileo ***	Column	LC
12	Botiidae	*Botia dario*	*Botia dario*	Bottom	LC
13	Botiidae	*Botia rostrata*	*Botia rostrata*	Bottom	VU
14	Danionidae	*Brachydanio rerio**	*Danio rerio***	Column	LC
15	Cyprinidae	*Chagunius chagunio*	*Chagunius chagunio*	Bottom	LC
16	Ambassidae	*Chanda nama**	*Chanda nama*	Column	LC
17	Channidae	*Channa orientalis*	*Channa orientalis*	Column	NE
18	Claridae	*Clarias batrachus**	*Clarias magur#*	Bottom	LC
19	Cyprinidae	*Crossocheilus latius latius*	*Tariqilabeo latius***	Bottom	LC
20	Danionidae	*Danio aequipinnatus*	*Devario aequipinnatus***	Surface	LC
21	Danionidae	*Danio dangila**	*Danio dangila*	Surface	LC
22	Danionidae	*Danio devario**	*Devario devario***	Surface	LC
23	Cyprinidae	*Garra annandalei*	*Garra annandalei*	Bottom	LC
24	Cyprinidae	*Garra gotyla*	*Garra birostris #*	Bottom	NE
25	Sisoridae	*Glyptothorax brevipinnis*	*Glyptothorax brevipinnis*	Bottom	DD
26	Sisoridae	*Glyptothorax cavia*	*Glyptothorax cavia*	Bottom	LC
27	Sisoridae	*Glyptothorax pectinopterus*	*Glyptothorax pectinopterus*	Bottom	LC
28	Sisoridae	*Glyptothorax telchitta*	*Glyptothorax telchitta*	Bottom	LC
29	Sisoridae	*Hara hara*	*Pseudolaguvia shawi#*	Bottom	LC
30	Heteropneustidae	*Heteropneustes fossilis*	*Heteropneustes fossilis*	Bottom	LC
31	Cyprinidae	*Labeo dero**	*Bangana dero***	Bottom	LC
32	Cyprinidiae	*Labeo gonius*	*Labeo gonius*	Bottom	LC
33	Cobitidae	*Lepidocephalichthys guntea**	*Lepidocephalichthys guntea*	Bottom	LC
34	Mastacembelidae	*Mastacembalus armatus**	*Mastacembalus armatus*	Bottom	LC
35	Bagridae	*Mystus montanus*	*Mystus montanus*	Column	LC
36	Bagridae	*Olyra longicaudata**	*Olyra longicaudata*	Bottom	LC
37	Cyprinidae	*Oreichthys cosuatis*	*Oreichthys cosuatis*	Column	LC
38	Cichlidae	*Oreochromis mossambica*	*Oreochromis mossambica*	Column	NT
39	Ambassidae	*Parambassis ranga**	*Parambassis ranga*	Column	LC
40	Psilorhynchidae	*Psilorhynchus balitora*	*Psilorhynchus balitora*	Bottom	LC
41	Cyprinidae	*Puntius chola*	*Puntius chola*	Column	LC
42	Cyprinidae	*Puntius conchonius*	*Pethia conchonius***	Column	LC
43	Cyprinidae	*Puntius sophore**	*Puntius sophore*	Column	LC

	Family	Species name listed in Tamang et al. 2007b	Species name (valid)	Trophic niche	IUCN Red List status
44	Cyprinidae	*Puntius ticto*	*Pethia ticto***	Column	LC
45	Nemacheilidae	*Schistura devdevi*	*Schistura devdevi*	Bottom	NT
46	Cyprinidae	*Semiplotus semiplotus*	*Cyprinion semiplotum* **	Bottom	VU
47	Cyprinidae	*Tor tor*	*Tor putitora#*	Column	EN
	Additional species				
48	Erethistidae	-	*Erethistoide senkhiensis*	Bottom	DD
49	Danionidae	-	*Barilius vagra*	Column	LC
50	Anguillidae	-	*Anguilla bengalensis*	Bottom	NT
51	Amblycipitidae	-	*Amblyceps apangi*	Bottom	LC

*—fish caught outside regular sampling site in the past study by Tamang et al. (2007b) | **— revised name of the species | #—corrected name of the species previously misidentified.

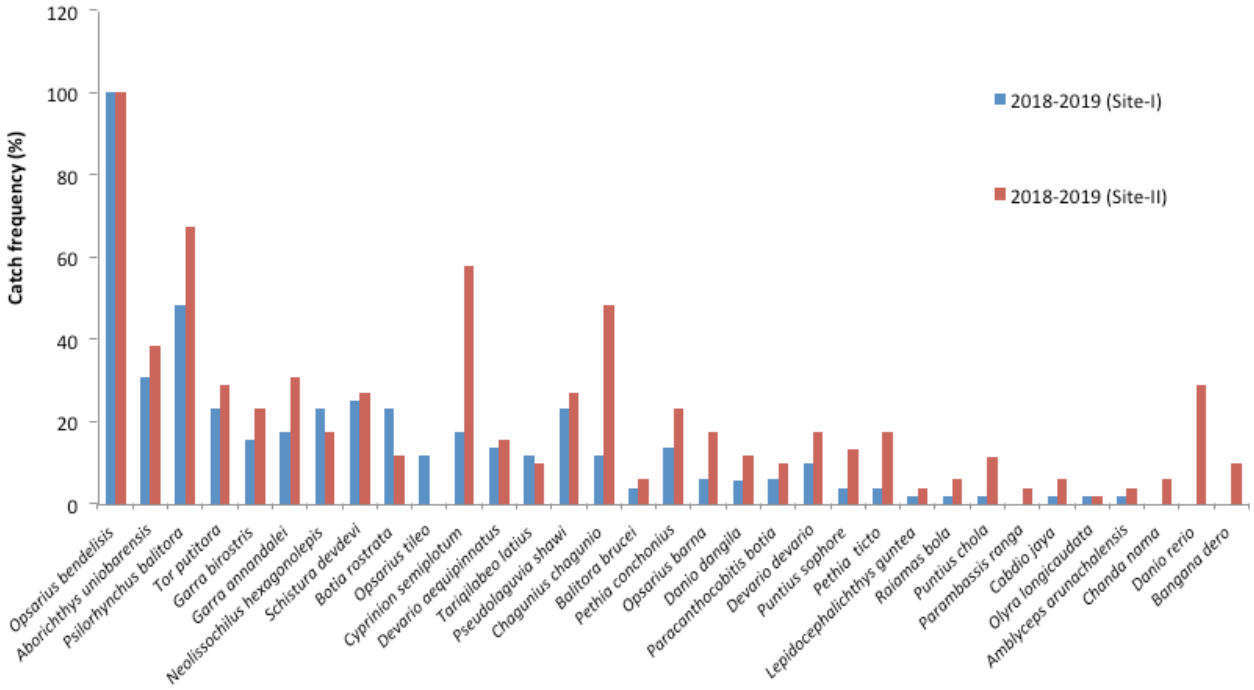

Figure 1. Comparative analysis of catch frequency (%) 33 species (including uncommon 5 species) of both (SITE-I and SITE-II). The graph showed that frequencies of catch is higher in Site-II compared to Site-I except *Neolissochilus hexagonolepis, Botia rostrata*, and *Tariqilabeo latius. Opsarius bendelisis* showed cent percent catch frequency and considered highly dominant species among all.

Lepidocephalichthys guntea (3.9%), *Parambassis ranga* (2%), *Olyra longicaudata* (1.9%), *Pethia conchonius* (1.9%), whereas, 10 species showed increase in catch frequency, viz., *Devario devario* (1.9%), *Cabdio jaya* and *Chanda nama* (2%), *Puntius sophore* (3.7), *Puntius chola* (5.6%), *Bangana dero* (7.7), *Cyprinion semiplotum* & *Pethia ticto* (9.6%), *Chagunius chagunio* (13.5%), *Danio rerio* (26.9%), and two species, namely, *Raiamas bola* & *Amblyceps arunachalensis* showed neither decline nor increase (Table 2). In this case too *Opsarius bendelisis* showed 100% abundance, and rest of the remaining 15 species were not retracted. Overall result indicates that Site-I (urban area) is more disturbed area than that of Site-II (outside urban area) for which there is severe decline in catch frequency in Site-I (64.7%) whereas moderate in Site-II (46.2%).

The conservation status of 37 fishes as per IUCN Red list (2019-3) revealed that majority (70%) of fish fauna are listed as Least Concern (LC), followed by 11% of them as Near Threatened (NT), 5% Vulnerable (VU), and

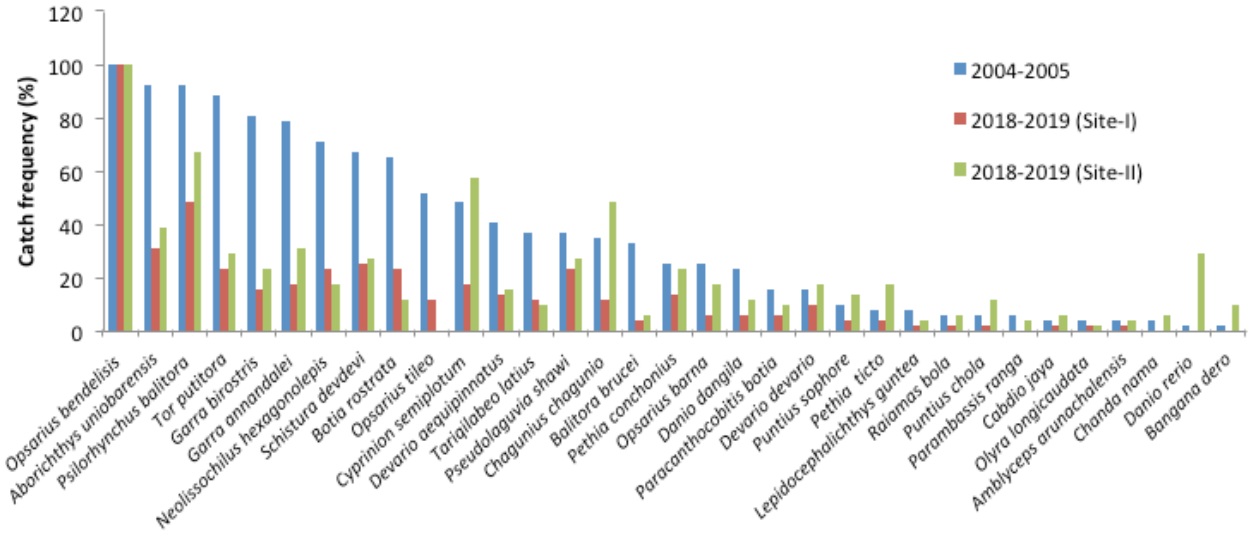

Figure 2. Graph showing comparative analysis of catch frequency (%) of 33 species, during present (2018–2019; SITE-I and SITE-II) and past (2004–2005; Tamang et al. 2007b) studies. The graph depicts overall drastic declining of catch frequency except first one species *Opsarius bendelisis* that showed cent percent abundance.

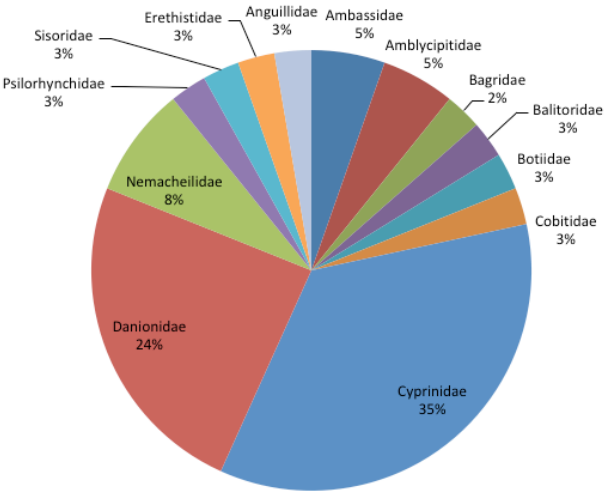

Figure 3. Percentage of species composition under 13 families in the present study (Site-I and Site-II).

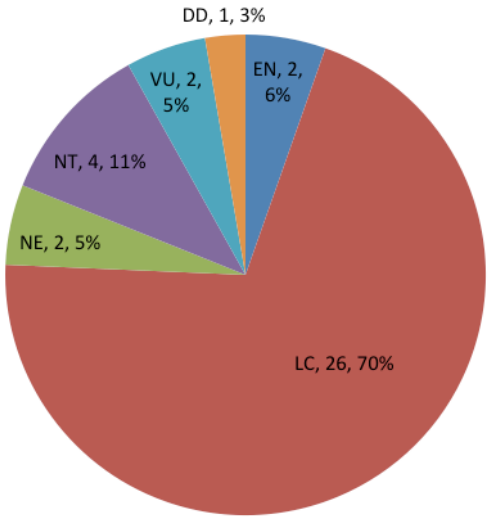

Figure 4. Combined IUCN conservation status of both Sites (I &II).

3% are Data Deficient (DD), 5% Not Evaluated (NE), and Endangered (EN) each (Figure 4). The 14 disappeared species mostly belong to LC category, i.e., 11 species and 1 species to NT, DD, and NE (Table 1). However, in case of local abundance, these species fall under extremely rare (8), rare (4) and occasional (2) categories (Table 2).

In the case of ecological trophic niche is concern, it is found that majority of the species are belong to bottom feeder represented by 19 species (51%), followed by 14 (38%) column feeders and four (11%) surface feeders (Figure 5). The percent catch frequencies of each species and availability status are presented in Table 2. The species under extreme threats are: *Amblyceps arunachalensis* recognized as 'Endangered' among all, followed by *Neolissochilus hexagonolepis, Schistura devdevi, Balitora brucei*, & *Anguilla bengalensis* as 'Near Threatened', and *Botia rostrata* & *Cyprinion semiplotum* as 'Vulnerable'. In the present study four species—*Erethistoides senkhiensis*, *Barilius vagra, Anguilla bengalensis,* and *Amblyceps apangi*—were additionally caught. *Erethistoides senkhiensis* was doubted to be a new species in the past study and not included in Tamang et al. (2007), and later published as a new species (Tamang et al. 2008). Though, as per

Table 2. Comparative percentage of catch frequencies and species abundance status of past study (Tamang et al. 2007b) and present study (Site-I and Site-II) conducted during 2018–19.

	Scientific name	Catch frequency (%) (2004–2005)		Catch frequency (%) (2018–2019)			
			Status	SITE-I	Status	SITE-II	Status
1	2	3	4	5	6	7	8
1	*Opsarius bendelisis* (Hamilton, 1822)	100	Abundant	100	Abundant	100	Abundant
2	*Aborichthys uniobarensis* Nanda et al., 2021	92.3	Abundant	30.8	Sporadic	38.5	Occasional
3	*Psilorhynchus balitora* (Hamilton, 1822)	92.3	Abundant	48.1	Occasional	67.3	Occasional
4	*Tor tor* (Hamilton, 1822)	88.5	Common	23.1	Sporadic	28.8	Sporadic
5	*Garra birostris* Nebeshwar & Vishwanath, 2014	80.8	Common	15.4	Sporadic	23.1	Sporadic
6	*Garra annandalei* (Hora, 1921)	78.8	Frequent	17.3	Sporadic	30.8	Occasional
7	*Neolissochilus hexagonolepis* (McClelland, 1839)	71.2	Frequent	23.1	Sporadic	17.3	Sporadic
8	*Schistura devdevi* (Hora, 1935)	67.3	Frequent	25.0	Sporadic	26.9	Sporadic
9	*Botia rostrata* Gunther, 1868	65.4	Occasional	23.1	Sporadic	11.5	Rare
10	*Opsarius tileo* (Hamilton, 1822)	51.9	Occasional	11.5	Rare	-	-
11	*Cyprinion semiplotum* (McClelland, 1839)	48.1	Occasional	17.3	Sporadic	57.7	Occasional
12	*Devario aequipinnatus* (McClelland, 1839)	40.4	Occasional	13.5	Rare	15.4	Sporadic
13	*Tariqilabeo latius* (Hamilton, 1822)	36.5	Occasional	11.5	Rare	9.6	Rare
14	*Pseudolaguvia shawi* (Hora, 1921)	36.5	Occasional	23.1	Sporadic	26.9	Sporadic
15	*Glyptothorax pectinopterus* (McClelland, 1842)	34.6	Occasional	-	-	-	-
16	*Chagunius chagunio* (Hamilton, 1822)	34.6	Occasional	11.5	Rare	48.1	Occasional
17	*Balitora brucei* (Gray, 1830)	32.7	Occasional	3.8	Extremely rare	5.8	Rare
18	*Botia dario* (Hamilton, 1822)	30.8	Occasional	-	-	-	-
19	*Pethia conchonius* (Hamilton, 1822)	25	Occasional	13.5	Rare	23.1	Sporadic
20	*Opsarius barna* (Hamilton, 1822)	25	Sporadic	5.8	Rare	17.3	Sporadic
21	*Danio dangila* (Hamilton, 1822)	23.1	Sporadic	5.7	Rare	11.5	Rare
22	*Acanthocobitis botia* (Hamilton, 1822)	15.4	Sporadic	5.8	Rare	9.6	Rare
23	*Devario devario* (Hamilton, 1822)	15.4	Sporadic	9.6	Rare	17.3	Sporadic
24	*Glyptothorax brevipinnis* Hora, 1923	11.5	Rare	-	-	-	-
25	*Heteropneustes fossilis* (Bloch, 1794)	9.6	Rare	-	-	-	-
26	*Puntius sophore* (Hamilton, 1822)	9.6	Rare	3.8	Extremely rare	13.3	Rare
27	*Pethia ticto* (Hamilton, 1822)	7.7	Rare	3.8	Extremely rare	17.3	Sporadic
28	*Lepidocephalichthys guntea* (Hamilton, 1822)	7.7	Rare	1.9	Extremely rare	3.8	Extremely rare
29	*Channa orientalis* Bloch & Schneider, 1801	5.8	Rare	-	-	-	-
30	*Oreichthys cosuatis* (Hamilton, 1822)	5.8	Rare	-	-	-	-
31	*Raiamas bola* (Hamilton, 1822)	5.8	Rare	1.9	Extremely rare	5.8	Rare
32	*Puntius chola* (Hamilton, 1822)	5.8	Rare	1.9	Extremely rare	11.4	Rare
33	*Parambassis ranga* (Hamilton, 1822)	5.8	Rare	-	-	3.8	Extremely rare
34	*Cabdio jaya* (Hamilton, 1822)	3.8	Extremely rare	1.9	Extremely rare	5.8	Rare
35	*Olyra longicaudata* McClelland, 1842	3.8	Extremely rare	1.9	Extremely rare	1.9	Extremely rare
36	*Amblyceps arunachalensis* Nath & Dey, 1989	3.8	Extremely rare	1.9	Extremely rare	3.8	Extremely rare
37	*Chanda nama* (Hamilton, 1822)	3.8	Extremely rare	-	-	5.8	Rare
38	*Clarias magur* (Linnaeus, 1758)	1.9	Extremely rare	-	-	-	-

	Scientific name	Catch frequency (%) (2004–2005)		Catch frequency (%) (2018–2019)			
			Status	SITE-I	Status	SITE-II	Status
1	2	3	4	5	6	7	8
39	*Labeo gonius* (Hamilton, 1822)	1.9	Extremely rare	-	-	-	-
40	*Mystus montanus* (Jerdon, 1849)	1.9	Extremely rare	-	-	-	-
41	*Oreochromis mossambica* (Peters, 1852)	1.9	Extremely rare	-	-	-	-
42	*Glyptothorax telchitta* (Hamilton, 1822)	1.9	Extremely rare	-	-	-	-
43	*Mastacembalus armatus* (Lecepede, 1800)	1.9	Extremely rare	-	-	-	-
44	*Badis badis* (Hamilton, 1822)	1.9	Extremely rare	-	-	-	-
45	*Glyptothorax cavia* (Hamilton, 1822)	1.9	Extremely rare	-	-	-	-
46	*Danio rerio* (Hamilton, 1822)	1.9	Extremely rare	-	-	28.8	Sporadic
47	*Bangana dero* (Heckel, 1822)	1.9	Extremely rare	-	-	9.6	Rare
	Additional species encountered						
48	*Erethistoides senkhiensis* Tamang, Chaudhry & Choudhury, 2008)	-	-	9.6	Rare	11.5	Rare
49	*Barilius vagra* (Hamilton, 1822)	-	-	9.6	Rare	17.3	Sporadic
50	*Anguilla bengalensis* (Gray, 1831)	-	-	1.9	Extremely rare	-	-
51	*Amblyceps apangi* Nath & Dey, 1989	-	-	1.9	Extremely rare	3.8	Extremely rare
Total of catch frequency (%)		**1295.9**		**467.1**		**682.2**	

Abundant—91–100% | Common—81–90% | Frequent—61–80% | Occasional—31–60% | Sporadic—15–30% | Rare—05–14% | Extremely rare—<05% | (-)—indicated in catch frequency (%) (2018–19) denotes species disappeared.

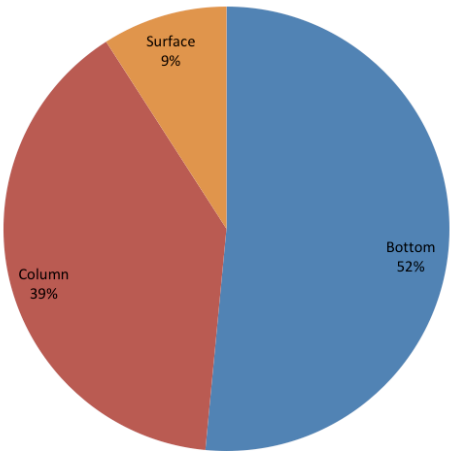

Figure 5. Ecological niche of different fish species encountered in the present study (2018–2019), showing maximum species as bottom feeders.

present study it seems to be locally a rare species and consequently considered Data Deficient in IUCN Red List of Threatened Species. The population density of *Barilius vagra* seems to be very low and might not have caught in the past study. Even in the present sampling its catch frequency is rare in upstream (Site-I) and sporadic in downstream (Site-II). *Anguilla bengalensis* was accidentally caught during flood. Moreover, its population seems to be very low as they mostly lives under hollow gaps of large boulders or rocks which is rarely seen in the study sites and is usually inappropriate and difficult to catch by castnet because of its robust and slippery body. *Amblyceps apangi* mostly hide beneath pebbles and cobbles and usually not comes in castnet, but sometime occasionally entangle, which may be the reason it could not be sampled in the past study.

Altogether the result of the present reinvestigation prior to disappearance of 14 species and drastic decline in catch frequencies within a time span of thirteen years broadly revealed rapid dwindling of existing fish fauna in the study sites primarily due to human intervention on various aspects.

On the backdrop of human interaction in the stream we gathered the information from dwelling people using unstructured questionnaire along with physical observation throughout the study sites. In fact the major key factors that has seriously jeopardized the stream ecosystems leading to sharp declination of fish fauna

Image 2. Organic and inorganic wastes accumulated in the study site-I, near Police colony, Itanagar, Arunachal Pradesh. © Lakpa Tamang.

Image 4. Electro-fishing in the study site-I, at Police Colony, Itanagar, Arunachal Pradesh. © Lakpa Tamang.

Image 3. a—Habitat degradation by mining activities near Jullang village | b—Earth work by JCB machine for construction of wall at Police colony, Itanagar, Arunachal Pradesh. © Lakpa Tamang.

may be as follows:

1. Electro-fishing: Electric fishing was frequently observed in the study site-I and rarely in Site-II. Chaudhry & Tamang (2006) had already reported the practicing of nonconventional method of fishing like using of chemicals (lime and bleaching power) and electrofishing in the Senkhi stream. This is basically operated during winter season (November–February) when water level comes down and intensity of current becomes more effective. Electro fishing is mostly dreadful to bottom dwelling fishes like species belonging to genera *Glyptothorax*, *Garra*, *Schistura*, *Aborichthys*, *Channa*, *Anguilla*, *Mastacembelus*, *Pseudolaguvia*, *Olyra* and *Amblyceps* as members of these genera live inside boulders and cannot escape or run away immediately when electric rod is run over the boulders. Besides, eggs, fish larva, juveniles, crustacean (crab and shrimp), various aquatic insects, and zooplankton which are prime food for growing larval fishes are also destroyed. Such fishing technique enables easy and more collection in short time with less effort (Image 4). However, using of chemicals was not observed as reported earlier, mainly due to siltation of organic wastes.

2. Water contamination: Being a solvent the water gets polluted very easily and causes various water borne internal and external diseases. Water contamination has been observed mostly in urban area within study site-I which covers Police colony, Chandranagar, and IRBN colony. Discharge of untreated domestic savage into the stream is one of the key factors responsible for water contamination and habitat degradation in Senkhi stream.

3. Sewage disposal: The study site is primarily fed by a major perennial drainage that brings all sorts of organic and inorganic wastes far off Ganga market places (ca 3 km) and other surrounding areas during heavy floods (June-August). Our field observation throughout

the study sites and at the time of sampling, has led to identification of the following sewage wastes mostly in Site-I (urban area): (i) Organic wastes (vegetable): cabbage, cauliflower, tomato, peels of potato, onion, long guard, and pumpkin; radish, green lettuce, french bean, soya bean, bitter guard, brinjal, ladies finger etc.; fruits: spoiled apple, banana, orange, lemon, pineapple and its peels; dead animal: pig, dog, cat, poultry bird were occasionally seen entrapped between boulders and sometime on marginal area of the stream, and intestine, skull, bony jaws of commercial cattle were frequently seen in the stream bed; (ii) Inorganic wastes: all sorts of cold drink plastic bottles and packets were seen densely accumulating among the boulders towards banks and middle section of the stream; footwear: plastic, foam, rubber, nylon and leather shoes and slippers; other items include large number of wrapped polythene bag, commercial fish thermocol box, plates, plastic sheets, vinyl carpet, cement bags, rubber pipe, pieces of tin sheet, umbrella, helmet, vehicle tyre, blanket, plastic sheets, plastic ball etc. Siltation of organic and inorganic debris over stream bed seen till premonsoon season; (iii) Human waste: typically human faecal matter is known to spread many water borne diseases to human like diarrhoea, typhoid, cholera, polio, hepatitis, and skin borne diseases. Some direct disposal of wastes have been seen within study Site-I as well as along the main drainage mentioned above.

4. Habitat degradation and disruption of riparian vegetation: Habitat alteration was more commonly seen in the lower reaches of the stream near Jullang village and beyond it. This was extraction of bed materials like boulders, cobbles, pebbles, gravels, and sand for developmental activities (Image 3a). This mining operation seems increasing due to increase in demand for developmental activities within capital city and its vicinity. Ecologically viable riparian vegetation have been replaced by residential houses and walls creating fish habitat congested, unsuitable and threatening mostly in Site-I (Image 3b). Habitat loss is also seen by displacing heavy boulders towards stream banks by JCB machine to protect from flash flood devastation. Moreover, due to disruption of aquatic ecosystem, one sustainable recreational angling, practiced especially for *Cyprinion semiplotum* using bamboo rod, nylon line and loops were entirely disappeared which was popular in the year 1995–1998 (personal observation).

CONCLUSION

In modern days management of fish diversity and its relevant habitats is a great issue and challenges (Dudgeon et al. 2006). Fresh water fish are one of the most threatened taxonomic groups (Darwall & Vie 2005) because of their high sensitivity to the quantitative and qualitative alteration of aquatic habits (Laffaille et al. 2005). One of the regular visible sign of development efforts in Itanagar, the capital, is the rapid urbanization and spreading of settlements which have adverse effect on stream ecosystem and its fauna. Much of the upstream areas near by Senkhi valley have already low vegetation cover consequences to low water discharge in the stream. Therefore, adoption of all above mentioned activities would only aggravate the already existing problems, first by destruction of the minimal viable population and secondly, by the destruction of the habitat itself. It has been observed that Senkhi stream harbors a good number of fish diversity. However, most of the fish fauna are freshwater bottom feeders which are very sensitive to ecosystem alteration. It was observed that anthropogenic activities may be the sole reasons responsible for the worsening condition of the Senkhi stream ecosystem. Hence, this might have resulted serious fish stock depletion and disappearance of 14 species in the present catch.

The fish are staple diet of the tribal folklore and an important source of protein required for the hardworking tribal communities of the state. Hence, sustainability of fish harvesting must continue for future generations. One can emulate examples from the state itself, where the tribal customary laws protect the flora and fauna in their own village area.

Keeping in view all above mentioned issues and overall result of the present study suggests urgent adoption and implementation of the following conservation strategies and mitigation measures by the concerned state government departments/ non-government agencies/ local volunteer organizations:

i. Disposal of organic and inorganic wastes into the stream should be banned.

ii. Disposal of human wastes directly into the stream should be replaced by safety tank.

iii. Illegal and unscientific methods of fishing should be strictly band.

iv. Construction of residential houses and walls closely attached to stream banks should be avoided by laws. Moreover, the hilly regions are prone to flash flood and land slide which is risky to life.

v. Creation of awareness campaign among

the local communities relating to importance of fish biodiversity, ecosystem and water source.

If urgent steps are not taken in appropriate time, the serious irreparable damage may cause to stream in near future. Therefore, the documentation of available present fish species and its rapid declining trend status is utmost important for conservationist, researcher, planner, relevant government department/ institution/ non-government agencies and local volunteer organization so that immediate necessary conservation strategies and mitigation measures could be implemented for restoration of aquatic fauna, its habitat and water resource.

REFERENCES

Bagra, K., K. Kadu, K. Nebeshwar-Sharma, B.A. Laskar, U.K. Sarkar & D.N. Das (2009). Ichthyological survey and review of the checklist of fish fauna of Arunachal Pradesh, India. *Checklist* 5(2): 330–350.

Chaudhary, S. & L. Tamang (2007). Need to adopt traditional fishing gears in Senkhi. *Current Science* 93(12): 1647.

Choudhuri, B.L. (1913). Zoological results of the Abor Expedition. 1911-1912 XVIII. Fish. *Records of the Indian Museum* 8: 243–258.

Darshan, A., S.K. Abujam & D.N. Das (2019). *Biodiversity of Fishes in Arunachal Himalaya-Systematics, Classification, and Taxonomic identification*. 1st Edition, Elsevier, Academic Press, London, UK, 270 pp.

Darwall, W.R.T. & J.C. Vie (2005). Identifying important sites for conservation of freshwater biodiversity: extending the species based approach. *Fisheries Management and Ecology* 12(5): 287–293. https://doi.org/10.1111/j.1365-2400.2005.00449.x

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler, C. Leveque, R.J. Naiman, A.H. Prieur-Richard, D. Soto, M.L.J. Stiassny & C.A. Sullivan (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews* 81: 163–82.

Dutta, A.K. & R.P. Barman (1984). On a new species of the genus Garra Hamilton (Pisces: Cyprinidae) from Namdapha Wildlife Sanctuary, Arunachal Pradesh, India. *Bulletin of the Zoological Survey of India* 6(1–3): 283–287.

Dutta, A.K. & R.P. Barman (1985). Fauna of Namdapha, Arunachal Pradesh (Pisces). *Records of the Indian Museum* 6(1–3): 275–277.

Dutta, A.K. & T.K. Sen (1977). *Schizopygopsis stoliczkae* Steindachner-First record from Arunachal Pradesh, India, with observation on geographical range. *Newsletter Zoological Survey of India* 3(4): 143–144.

Ehrlich, P.R. & E.O. Wilson (1991). Biodiversity Studies: Science and Policy. *Science* 253: 758–762.

Fricke, R., W.N. Eschmeyer & R. van der Laan (eds) (2019). Eschmeyer's Catalog of Fishes: genera, species, references. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed on 05 November 2019.

Hora, S.L. (1921). On some new record and rare species of fishes from Eastern Himalayas. *Records of the Indian Museum* 22(5): 731–744.

IUCN 2019. The IUCN Red List of Threatened Species. Version 2019-3. https://www.iucnredlist.org. Accessed on 15 November 2019).

Jayaram, K.C. & N. Mazumdar (1964). On a collection of fish from Kameng frontier division, NEFA. *Journal of the Bombay Natural History Society* 6(2): 264–280.

Jayaram, K.C. (1963). A new species of sisorid from Kameng Frontier Division (NEFA). *Journal of the Zoological Society of India* 15(1): 85–87.

Jayaram, K.C. (2010). *The Freshwater Fishes of the Indian Region*. *2nd Ed.* Narendra Publishing House, Delhi, 616 pp.

Kang, B., D. He, L. Perrett, H. Wang, W. Hu, W. Deng & Y. Wu (2009). Fish and fisheries in the Upper Mekong: current assessment of the fish community, threats and conservation. *Reviews in Fish Biology and Fish* 19: 465–480.

Kar, D. (2003). Fishes of Barak drainage, Mizoram and Tripura, pp. 203–211. In: Kumar, A., C. Bohra & L.K. Singh (eds.). *Environment, Pollution and Management*. APH Publishing Corporation, New Delhi, 604 pp.

Laffaille, P., A. Acou, J. Guillouet & A. Legult (2005). Temporal change in European eel, *Anguilla anguilla*, stock in a small catchment after installation of fish passes. *Fisheries Management* and *Ecology* 12: 123–129.

McClelland, J. (1839). Indian Cyprinidae. *Asiatic Research* 19(2): 217–471.

Nath, P. & S.C. Dey (2000). *Fish and Fisheries of North Eastern India (Arunachal Pradesh)*. Narendra Publishing House, Delhi.

Sen, N. (1999). On a collection of fishes from Subansiri and Siang districts of Arunachal Pradesh. *Records of the Zoological Survey of India* 97(1): 141–144.

Sen, T.K. (1985). Fish fauna of Assam and neighbouring North Eastern states of India. *Records of the Zoological Survey of India, Occasional paper* 64: 1–216.

Srivastava, C.B. (1966). On a collection of fishes from Tirap Frontier Division (NEFA), India. *Journal of the Zoological Society of India* 18: 122–128.

Talwar, P.K. & A.K. Jhingran (1991). *Inland fishes of India and adjacent countries*. Oxford and IBH Publishing Co Pvt Ltd, New Delhi, 1158 pp.

Tamang, L. & S. Chaudhry (2012). Range extension of *Conta pectinata* Ng, 2005 (Teleostei: Sisoridae) in upper Brahmaputra River drainage in Arunachal Pradesh, India. *Journal of Threatened Taxa* 4(2): 2402–2405. https://doi.org/10.11609/JoTT.o2933.2402-5

Tamang, L., S. Chaudhry & D. Choudhury (2006). On a new record of freshwater fish, *Pseudolaguvia shawi* (Hora) from Arunachal Pradesh, India (Teleostomi: Erethistidae). *Zoos Print Journal* 21(11): 2443–2446. https://doi.org/10.11609/JoTT.ZPJ.1511.2443-6

Tamang, L., S. Chaudhry & D. Choudhury (2007a). *Balitora brucei* (Gray) and *Glyptothorax telchitta* (Hamilton), two new reports for Arunachal Pradesh, India. *Journal of the Bombay Natural History Society* 104: 229–230.

Tamang, L., S. Chaudhry & D. Choudhury (2007b). Ichthyofaunal contribution to the state and comparison of habitat contiguity on taxonomic diversity in Senkhi stream, Arunachal Pradesh, India. *Journal of the Bombay Natural History Society* 104(2): 170–177.

Tamang, L., S. Chaudhry & D. Choudhury (2008). *Erethistoides senkhiensis*, a new catfish (Teleostei: Erethistidae) from India. *Ichthyological Exploration of Freshwaters* 19(2): 185–191.

Vijaykumar, K., C. Vijaylaxmi & Z. Parveen (2008). Ichthyofaunal diversity of Kagina River in Gulbarga district of Karnataka. *The Ecoscan* 2(2): 161–163.

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