



Trade Potential of Indigenous Ornamental Fishes of Arunachal Pradesh, India

SANTOSHKUMAR ABUJAM^{1,*}, LAKPA TAMANG¹, GIBJI NIMASOW², DEBANGSHU NARAYAN DAS¹

¹Department of Zoology, Rajiv Gandhi University, Rono Hills, Doimukh, Itanagar, Arunachal Pradesh 791112, India

²Department of Geography, Rajiv Gandhi University, Rono Hills, Doimukh, Itanagar, Arunachal Pradesh 791112, India

*E-mail: santosh.abujam@gmail.com | Received: 07/05/2021; Accepted: 07/12/2021

© Asian Fisheries Society
Published under a Creative Commons
license
E-ISSN: 2073-3720
<https://doi.org/10.33997/j.afs.2021.34.4.004>

Abstract

Arunachal Pradesh is rich with networks of drainage systems with enormous wild fish diversity due to varied climatic and topographical features. Most of the streams harbour very alluring small indigenous minnows, loaches, catfishes and barbs that have hardly been exploited for the ornamental fish market. If these aquatic resources are sustainably utilised as a trade commodity, then the pattern of livelihood of the local populace may be uplifted economically. The present investigation was undertaken to establish the market potential of certain indigenous ornamental fishes of Arunachal Pradesh. The survey was conducted during 2019–2020 for 6 months (October–March) based on the feasibility of accessible collections. A total of 52 ornamental fish species under 6 orders and 15 families were documented and collected during the surveys in various streams and rivers. The collection showed that 4 species namely *Balitora brucei* Gray, 1830, *Aborichthys kempfi* Chaudhuri, 1913, *Schistura devdevi* Hora, 1935, and *Neolissochilus hexagonolepis* (McClelland, 1839) were recorded under near threatened; *Lepidocephalichthys arunachalensis* (Datta & Barman, 1984) and *Botia rostrata* Günther, 1868, under endangered and vulnerable categories, respectively as per International Union for Conservation of Nature (IUCN) status. The species documented exhibiting natural ornamental features herein considered an indigenous ornamental fish (IOF) for depicting their market demand showing the minimal price of each individual species towards the development of organised trade in Arunachal Pradesh.

Keywords: indigenous ornamental fish, trade, scope, Arunachal Pradesh

Introduction

The Eastern Himalayan region has been identified as one of the 18 mega biodiversity hotspot regions of the world (Myers et al., 2000). The state Arunachal Pradesh, stretching between 26°30' and 29°30'N latitudes and 91°30' and 97°30'E longitudes, falls within the Eastern Himalayan region. The state shares international boundaries with China, Myanmar and Bhutan, and national borders with Assam and Nagaland. Among the North Eastern (NE) states, Arunachal Pradesh is the largest state in geographical area and river drainage area with more than 200 indigenous fish species (Bagra et al., 2009; Darshan et al., 2018). The state is drained by a network of many rivers viz., Siang, Dibang, Bichom, Lohit, Dikrong, Ranganadi, Tirap, Subansiri, Kameng and Siyom, and

mountain lakes viz., Sela, Shungatser, PT sho, Mechuka, Mehao and Ganga, that offers potential resources for mountain fishery based eco-tourism (Figure 1). The favourable climatic conditions, diverse mountain terrain with numerous drainage systems flowing from higher to lower altitudes over the boulders provide highly oxygenated waters to the aquatic life, including the ornamental fishes. For many, ornamental fish keeping and propagation have been enjoyable activities, providing aesthetic pleasure and financial opportunities. The state has enormous potential for ornamental fish trading. Several indigenous fish species of the state have ornamental value due to their unique, fascinating traits like adaptive modification, striking banding patterns and colouration described as indigenous ornamental fish (IOF). Due to rapid growth in

ornamental fish trade worldwide, there is a high demand for IOF from Arunachal Himalayas and other NE states (Subhasis et al., 2007).

Despite rich resources, the fishery resources had not been completely explored due to the inaccessible mountainous terrain with dense forest cover. To date, the studies carried out on fishery resources of Arunachal Pradesh includes Sen (1999), who reported 52 species from Siang and Subansiri districts; Nath and Dey (2000) recorded 131 species with their systematic account; Sen (2006) recorded 143 fish species from the state; Tamang et al. (2007) reported 47 species from Senkhi stream, a tributary of Dikrong River in Papum Pare district; Bagra et al. (2009) listed a total of 213 fish species from 35 rivers of the state; Bagra and Das (2010) reported 44 fish species from Siyom River in West Siang district. Gurumayum et al. (2016) listed 259 species from the state. Darshan et al. (2018) reported 218 valid fish species from different water bodies of the state.

Ornamental fish is gaining popularity across the globe. It is receiving massive attention due to the local and global demand resulting in India's export market and trade growth. Now, India exports fish is worth USD270.80 million yearly, and the share of ornamental fish is around USD40.62 million (Raja et al., 2014). However, reliable information and data on such activities in the state government records and scientific reports in Arunachal Pradesh are lacking. Because of the above, this study attempts to investigate the scope of IOF resources and trade in Arunachal Pradesh, India.

Materials and Methods

The present work involved nine rivers (Lohit, Dibang, Siang, Subansiri, Kamle, Kameng, Bichom, Ranganadi and Dikrong), including the tributaries on a seasonal basis during 2019-2020 (Fig. 1). The fishes were caught randomly from the rivers, streams, and tributaries up to mid-altitude regions (1200 m above sea level). Later some of the specimens were preserved in 5 % formalin and identified with the help of the latest taxonomic keys of Darshan et al. (2018). All animal handlings were performed following the guidelines of the Animal Ethics Committee of the Rajiv Gandhi University. Samplings in the field were conducted, taking permission from the village chief. The IUCN Red List of Threatened species (version 2020-1) was followed to evaluate the current status of recorded fish species. The systematic identification of each family in Figure 2, Tables 1 and 2 followed Eschmeyer's Catalog of Fishes (Fricke et al., 2021).

Basic live fish collection methods and material used in the field

The fishing operation was conducted from October 2019 to March 2020, which is an appropriate time to get all varieties of fish. Besides, water volume and

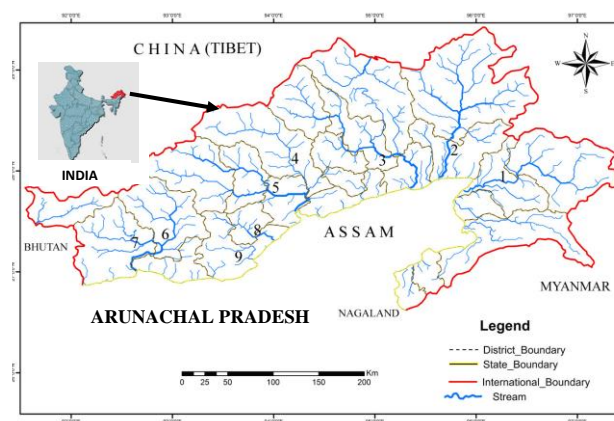


Fig. 1. Map of Arunachal Pradesh (North eastern India), showing collection locality of potential indigenous ornamental fish species in different rivers (indicated by numerical value). (Legends: 1- Lohit River; 2- Dibang River; 3- Siang River; 4- Subansiri River; 5- Kamle River; 6- Kameng River; 7- Bichom River; 8- Ranganadi River; 9- Dikrong River).

temperature in rivers is low, due to which most of the bottom feeder fishes remain hidden under crevices of boulders. The following methods were adopted for the collection of live fish: (1) A 3-meter caste net with 7 mm mesh size for random sampling, (2) barrier construction along one side of diverted streams or drainages, using plastic sheets, boulder and soil or sand, (3) traditional gears and traps, and (4) electrofisher (HailiBao; 2800AV).

Live fish collection and management

The collected fishes were carefully stocked in the netted plastic or bamboo basket, immersed under running water or stocked in riverine pooled water until the completion of the operation.

Packaging for export

The following transportation procedures were adopted: After transportation from the field, the fish were transferred into the stocking cemented cistern with aeration system or raceway tank for 2 days without feeds to remove excreta and urine. This is necessary to keep water in plastic bag clean and safe for fish during long-distance transportation. About 50-60 moderate size fish (12.7-15.24 cm) of the same species were kept in a plastic bag after filling 2/3 water and 1/3 oxygen. On receiving the order, the fish are dispatched to the registered exporter in Guwahati and then exported by the trader to various cities such as Kolkata, Bangalore, or Chennai by flight or train.

Results

A total of 52 fish species belonging to 6 orders and 15 families were collected as potential IOF from the Lohit, Dibang, Siang, Subansiri, Kamle, Kameng, Bichom, Ranganadi and Dikrong Rivers and their

tributaries. The details of the selected fish species, price, status, salient attractive features and feeding nature are given in Table 1. The number of species under different families is shown in Figure 2. The taxonomic analysis showed the family Cyprinidae recorded the highest species composition with 13 species (25.00 %), followed by Nemacheilidae,

Bagridae and Sisoridae with 6 species (11.54 %) each, Danionidae with 5 species (9.61 %), Amblycepsidae with 3 species (5.77 %), Botiidae, Cobitidae Mastacembelidae Channidae, and Badidae were represented by 2 species each. The rest of the families Balitoridae, Osphronemidae and Ambassidae were represented by single species each.

Table 1. List of potential indigenous ornamental fish species of Arunachal Pradesh with images, price, status and salient attractive features.






Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
1.	Cypriniformes Botiidae	<i>Botia rostrata</i> Gunther, 1868 	0.27	VU	Body yellowish with dark brown vertical bars on side decorated with series of yellowish blotches in the middle of each bars; all fins with black bars, and barbels pinkish.	Bottom feeder and TL - 120.2 mm
2.		<i>Botia dario</i> (Hamilton, 1822) 	0.54	LC	Body yellowish with several distinct black transverse bands along flank and fins marked with black bands.	Bottom feeder and TL - 55.9 mm
3.	Cypriniformes Cobitidae	<i>Lepidocephalichthys arunachalensis</i> (Datta & Barman, 1984) 	0.20	EN	Body elongated, almost of parallel profiles and flanks with series of blotches arranged medially; dorsal, pectoral and caudal fins dotted with blackish spots.	Bottom feeder and TL - 84.5 mm
4.		<i>Lepidocephalichthys annandalei</i> Chaudhuri, 1912 	0.20	LC	Body light brownish with series of irregular brown blotches along lateral line; head and snout striped with dark dots; one deep black spot at upper part of caudal base and another at its posterior edge.	Bottom feeder and TL - 62.8 mm
5.	Cypriniformes Balitoridae	<i>Balitora brucei</i> Gray, 1830 	0.47	NT	Body strongly dorsoventrally depressed with series of dark brown mid-dorsal blotches and enlarged pectoral and pelvic fins horizontally placed.	Bottom feeder and TL - 105.8 mm

Table 1. Continued.








Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
6.	Cypriniformes Nemacheilidae	<i>Schistura multifasciata</i> Day, 1878 	0.27	LC	Body light yellowish, elongated and sub cylindrical, marked with series of brown vertical bars along flank.	Bottom feeder and TL - 75.9 mm
7.		<i>Paracanthocobitis botia</i> (Hamilton, 1822) 	0.20	LC	Body light yellowish and moderately elongate with several blackish cross-bands of turns and twists; caudal with 5-7 'S'-shaped black bands.	Bottom feeder and TL - 69.6 mm
8.		<i>Schistura tirapensis</i> Kottelat, 1990 	0.20	LC	Body light yellowish to cream almost parallel profiles with several regular vertical bars along flank.	Bottom feeder and TL - 70.2 mm
9.		<i>Schistura devdevi</i> Hora, 1935 	0.06	NT	Body small and yellowish, with 5-7 broad brown bands across the body.	Bottom feeder and TL - 35.2 mm
10.		<i>Schistura walongensis</i> (Tamang & Sinha, 2016) 	0.13	NE	Body light yellowish and elongated with brown irregular vertical bars on flank, more irregular on anterior portion of the body and basicaudal bar W-shaped;	Bottom feeder and TL - 72.5 mm
11.		<i>Aborichthys kempfi</i> Chaudhuri, 1913 	0.40	NT	Body yellowish to pinkish with series of vertical dark brown bars along flank and head scattered with dark brown spots and irregular marks that overall looks like 'tiger's body; caudal fin rounded with black subdistal margin.	Bottom feeder and TL - 115.7 mm
12.	Cypriniformes Cyprinidae	<i>Esomus danrica</i> (Hamilton, 1822) 	0.13	LC	Body elongate and compressed laterally with a broad midlateral blackish band and sometimes silvery shine; head pointed, mouth small & upturned; maxillary barbel extremely long.	Surface feeder and TL - 52.2 mm

Table 1. Continued.







Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
13.		<i>Opsarius bendelisis</i> (Hamilton, 1807)	0.13	LC	Body silvery and scales with black spots; series of bluish vertical bars present along flank distinctly visible in young specimens.	Column and surface feeder and TL - 95.3 mm
						
14.		<i>Opsarius barna</i> (Hamilton, 1822)	0.13	LC	Body light yellowish to silvery with series of vertical bluish bars along flank.	Column and surface feeder and TL - 80.4 mm
						
15.		<i>Opsarius tileo</i> (Hamilton, 1822)	0.13	LC	Head and body dorsally light bluish and flank silvery with series of blue bars along flank.	Column and surface feeder and TL - 106.2 mm
						
16.		<i>Garra birostris</i> Nebeshwar & Viswanath, 2013	0.47	NE	Body dark brown and snout with a well-developed bilobed proboscis, mouth inferior with a large gular disc behind, paired fins enlarged and horizontally situated.	Bottom feeder and TL - 135.7 mm
						
17.		<i>Garra lissorhynchus</i> (McClelland, 1839)	0.27	NE	Snout smooth without proboscis; mouth inferior with small gular disc behind it. A submarginal black band on dorsal fin & W-shaped band on caudal fin.	Bottom feeder and TL - 89.5 mm
						
18.		<i>Garra annandalei</i> Hora, 1921	0.20	LC	Body greyish, dark grey on dorsum & paler on belly; a black spot present on upper angle of gill-opening; snout smooth without proboscis; mouth inferior with a small gular disc behind it; sometimes pinkish spots present on some of the scales on body.	Bottom feeder and TL - 115.6 mm
						

Table 1. Continued.






Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
19.		<i>Neolissocheilus hexagonolepis</i> (McClelland, 1839)	0.27	NT	Body broad & deep with large eye; scale along flank large and hexagonal shape; scales on dorsal region of body coppery, and flank silvery white.	Column and surface feeder and TL - 140.2 mm
						
20.		<i>Oreichthys cosuatis</i> (Hamilton, 1822)	0.20	LC	Body short, dorsal fin bright-yellow with a large black mark covering the distal margin of the dorsal fin.	Column feeder and TL - 42.4 mm
						
21.		<i>Pethia ticto</i> (Hamilton, 1822)	0.20	LC	Dorsal part of body greyish and flank silvery with two black spots on lateral line: one just posterior to opercle and another above last ray of anal fin.	Bottom and column feeder and TL - 55.3 mm
						
22.		<i>Puntius terio</i> (Hamilton, 1822)	0.13	LC	Body metallic green above and whitish below with a fairly weak reddish or violet lustre and green-silvery on flank; a large round black blotch with golden margin over anal fin.	Bottom and column feeder and TL - 80.6 mm
						
23.		<i>Pethia conchonius</i> (Hamilton, 1822)	0.13	LC	Body silvery, back shining olive-green; fins reddish; a black blotch on caudal peduncle above anal fin.	Bottom and column feeder and TL - 57.8 mm
						

Table 1. Continued.

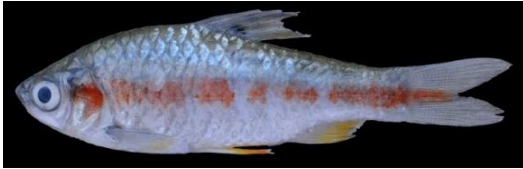





Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
24.		<i>Puntius sophore</i> (Hamilton, 1822)	0.13	LC	A black spot present on mid of dorsal fin just above the base and another spot at caudal fin base. During breeding season an orange streak passes through mid lateral body.	Bottom and column feeder and TL - 75.2 mm
						
25.	Cypriniformes Danionidae	<i>Danio dangila</i> (Hamilton, 1822)	0.40	LC	Olive in the back, sides and abdomen silvery with several alternate bluish and light yellowish silvery lines on posterior part of body and chain like patterns on anterior part.	Surface feeder and TL - 63.4 mm
						
26.		<i>Danio assamila</i> Kullander, 2015	0.40	NE	A chain like pattern along flank and an alternate bluish and light yellowish to cream streak on caudal peduncle and a longer maxillary barbels.	Surface feeder and TL - 62.4 mm
						
27.		<i>Devario aequipinnatus</i> (McClelland, 1839)	0.40	LC	Four alternate bluish & yellowish stripes running along flank; a broad black stripe on median rays of caudal fin.	Surface feeder and TL - 74.0 mm
						
28.		<i>Devario devario</i> (Hamilton, 1822)	0.40	LC	Body rhomboidal shaped and compressed; colour greenish and silvery dorsally, and mixture of irregular bluish and white marks along flank; a bluish streak along caudal peduncle, extending to median rays of caudal fin; fins tinged with golden yellowish colour.	Column and surface feeder and TL - 64.5 mm
						
29.		<i>Danio rerio</i> (Hamilton, 1822)	0.06	LC	Body with uniformly and alternatively arranged white to yellowish and bluish longitudinal stripes along the flank, anal and caudal fins with distinct alternate bluish and white striped.	Column and surface feeder and TL - 24.8 mm
						

Table 1. Continued







Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
30.	Siluriformes Bagridae	<i>Batasio batasio</i> (Hamilton, 1822)	0.20	LC	Body yellowish with a series of black blotches or streak along lateral line and a black patch just below the dorsal fin.	Bottom and column feeder and TL - 107.4 mm
						
31.		<i>Batasio merianensis</i> (Chaudhuri, 1913)	0.20	NE	Body and head light greyish brown, with oblique dark brown vertical bars along flank; dorsal fin hyaline, with a dark brown subdistal ovoid patch.	Bottom and column feeder and TL - 105.8 mm
						
32.		<i>Mystus dibrugarensis</i> (Chaudhuri, 1913)	0.20	LC	Dorsum of head and body greyish; body with two conspicuous black blotches—one on shoulder and another on caudal fin base; a black streak passing through lateral line.	Bottom and column feeder and TL - 135.9 mm
						
33.		<i>Mystus prabini</i> Darshan et al. 2019	0.20	NE	Body with narrow blackish mid-lateral stripe running above lateral line on the flank; adipose fin long, spanning most of postdorsal distance.	Bottom and column feeder and TL - 140.2 mm
						
34.		<i>Mystus tengara</i> (Hamilton, 1822)	0.20	LC	Body with alternate longitudinal brown and creamy streak along the flank, and a dark blotch on shoulder.	Bottom and column feeder and TL - 85.5 mm
						
35.	Siluriformes Bagridae	<i>Olyra longicaudata</i> McClelland, 1842	0.20	LC	Body slender; color brownish to pinkish in life; three alternate blackish and creamy lateral streaks along the flank.	Bottom feeder and TL - 124.4 mm
						

Table 1. Continued.

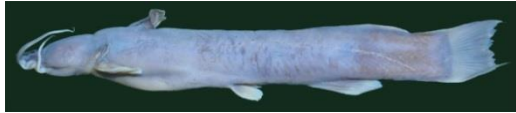





Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL - mm)
36.	Siluriformes Amblycipitidae	<i>Amblyceps apangi</i> Nath & Dey, 1989 	0.27	LC	Body slender, plain and brownish grey; eye small, head dorso-ventrally depressed and caudal fin truncate.	Bottom feeder and TL - 120.4 mm
37.		<i>Amblyceps arunachalensis</i> Nath & Dey, 1989 	0.27	NE	Body slender, skin smooth and color light greyish to dark brownish; eye small, caudal fin deeply forked, upper lobe broader and longer than lower.	Bottom feeder and TL - 115.2 mm
38.		<i>Amblyceps mangois</i> (Hamilton, 1822) 	0.27	LC	Body short and robust; eye very small, caudal fin deeply forked; body dorso-laterally brownish and ventrally creamy.	Bottom feeder and TL - 45.7 mm
39.	Siluriformes Sisoridae	<i>Erethistes hara</i> (Hamilton, 1822) 	0.13	LC	Body short, spindle shaped and yellowish-brown; ventral side flattened; eyes small, dorsal and pectoral fins with strong spine; two creamy vertical bands on side.	Bottom feeder and TL - 50.2 mm
40.		<i>Erethistes jerdoni</i> Day, 1870 	0.13	NE	Body short, deep and brownish with two creamy vertical bands on side of the body; ventral side flattened; eyes small, all fins marked with dark brown patches.	Bottom feeder and TL - 55.4 mm
41.	Siluriformes Sisoridae	<i>Pseudecheneis serinica</i> Viswanath & Darshan, 2007 	0.40	NE	Spindle shaped body with paired fins enlarge and horizontally placed; dorsal & lateral surface of body brown & light brown below; caudal peduncle thin & rounded; series of pale patches on body; all fins marked with dark brown patches and yellowish band in the middle.	Bottom feeder and TL - 130.6 mm

Table 1. Continued.












Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
42.	Siluriformes Sisoridae	<i>Pseudolaugiva shawi</i> (Hora, 1921)	0.20	NE	Body dark grayish-yellow on back and dull whitish below; two broad creamy bands on body; black bands on fins; maxillary barbels annulated with brown marks.	Bottom feeder and TL - 36.5 mm
						
43.		<i>Pseudolaugiva jyaensis</i> Tamang & Sinha, 2014	0.20	NE	Body brownish with creamy vertical bands and fins with black or dark brown bands.	Bottom feeder and TL - 35.3 mm
						
44.		<i>Pseudolaugiva magna</i> Tamang & Sinha, 2014	0.20	NE	Body with two pale-brown to cream patches straddling the mid-dorsal region: one rectangular to elliptical patch on mid-interdorsal region, & another indistinct elliptical patch in between the adipose and caudal fins; a broader rhomboidal thoracic adhesive apparatus.	Bottom feeder and TL - 50.8 mm
						
45.	Synbranchiformes Mastacembelidae	<i>Macrogathus aral</i> (Bloch & Schneider, 1801)	0.13	LC	Body elongated; snout pointed; dorsal fin long decorated with series of 3-5 blackish ocelli at base of dorsal fin and caudal fin rounded.	Bottom feeder and TL - 154.3 mm
						
46.		<i>Macrogathus pancalus</i> (Hamilton, 1822)	0.13	LC	Body elongated; snout pointed; body greenish or olive-green dorsally, white irregular marks on flank and whitish below; yellowish fins with numerous black spots; dorsal & anal fins long, and caudal fin rounded.	Bottom feeder and TL - 116.4 mm
						
47.	Anabantiformes Osphronemidae	<i>Trichogaster fasciata</i> Bloch & Schneider, 1801	0.20	LC	Colour greenish with oblique orange or bluish bars along flank; longer dorsal and anal fins consists of spines and soft rays; caudal fin and dorsal soft rays scattered with white spots, and a long filamentous structure present.	Column and surface feeder and TL - 72.7 mm
						

Table 1. Continued.

Sl. No.	Order and Family	Name of species	Price per piece (USD)	IUCN Status 2020-1	Salient attractive features	Feeding nature and Total length (TL-mm)
48.	Anabantiformes Channidae	<i>Channa pomanensis</i> Gurumayum & Tamang, 2016	0.67	NE	Body elongated with 7-8 oblique black bands on side and black spots scattered over body; dorsal, anal and caudal fins bluish when expanded and orange subdistal margin on caudal fin.	column and surface feeder and TL - 122.4 mm
						
49.		<i>Channa stewartii</i> (Playfair, 1867)	0.67	LC	Body with alternating blackish and pale greyish transverse bars on side, black spots scattered throughout the flank; dorsal, anal & caudal fin bluish with blackish submarginal band and whitish distal margin.	column and surface feeder and TL - 158.8 mm
						
50.	Perciformes Badidae	<i>Badis singenensis</i> Geetakumari & Kadu, 2011	0.27	NE	A conspicuous black blotches on soft rays of dorsal and anal fins and also 3 black blotches along the dorsal fin base.	Bottom and surface feeder and TL - 55.9 mm
						
51.		<i>Badis assamensis</i> Ahl, 1937	0.27	DD	A prominent black blotch posterodorsally on opercle and some blackish blotches scattered on flanks; flanks with 10 vertical bars expressed chiefly as small, contrasting black spots; a dark blotch on caudal fin base.	Surface feeder and TL - 59.4 mm
						
52.	Perciformes Ambassidae	<i>Parambassis ranga</i> (Hamilton, 1822)	0.13	LC	Body short, deep and highly compressed; eye large, occiput concave; body transparent, skeleton can be visible in live.	Column and surface feeder and TL - 68.0 mm
						

NE- Not Evaluated; DD- Data Deficient; LC- Least Concern; VU- Vulnerable; EN- Endangered; NT- Near Threatened;

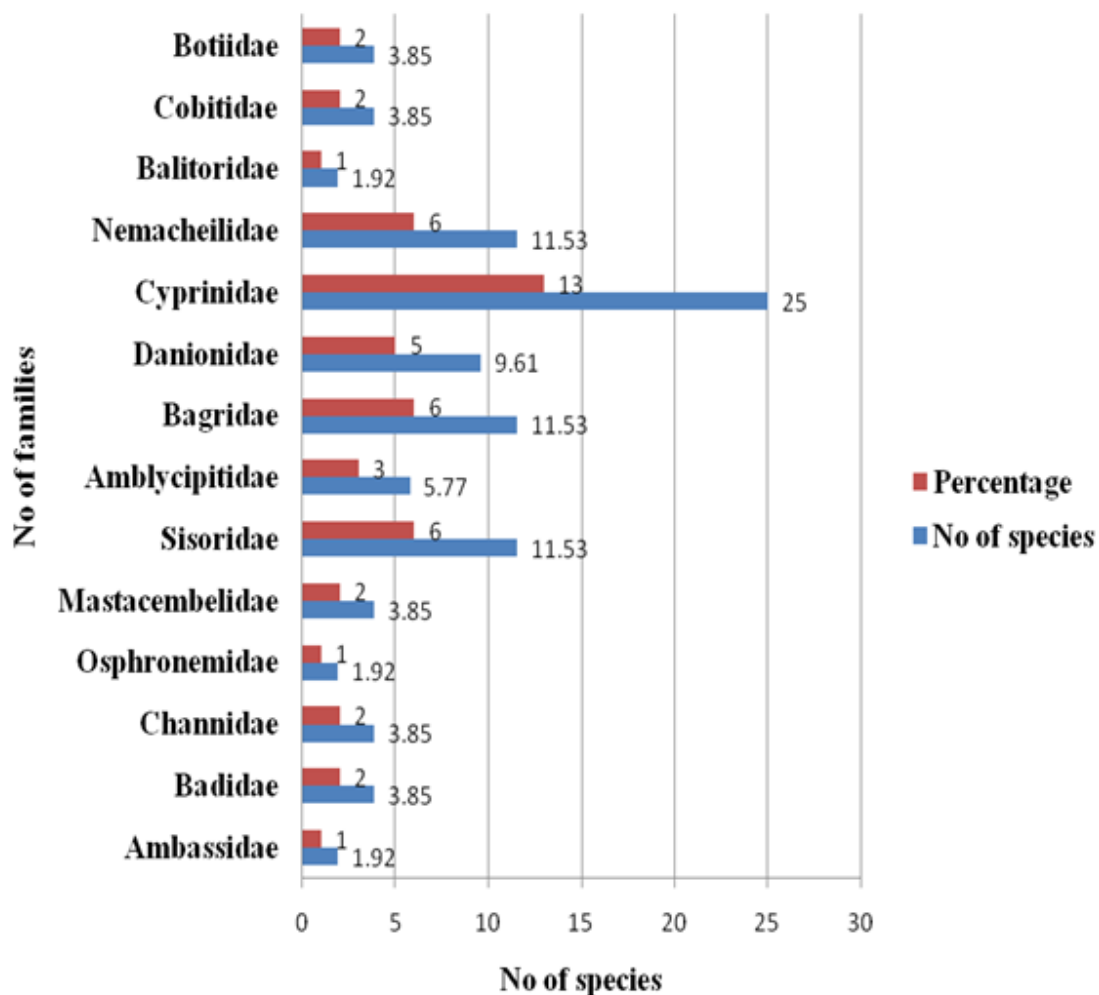


Fig. 2. Family wise taxonomic distribution of indigenous ornamental fish species in Arunachal Pradesh.

According to IUCN red list status, out of the selected potential fish species, 1 species each (total of 5.77 %) was found respectively under endangered (EN), vulnerable (VU) and data deficient (DD) respectively; 4 species (7.69 %) under near threatened (NT); 31 species (59.62 %) under least concern (LC); and 14 species (26.92 %) under not evaluated (NE) categories.

Among the above listed fishes, *Botia rostrata* Günther, 1868, *Botia dario* (Hamilton, 1822), *Devario aequipinnatus* (McClelland, 1839), *Danio assamila* Kullander, 2015, *Danio dangila* (Hamilton, 1822), *Danio rerio* (Hamilton, 1822), *Aborichthys kempi* Chaudhuri, 1913, *Channa pomanensis* Gurumayum & Tamang, 2016, *Balitora Brucei* Gray, 1830, and *Paracanthocobitis botia* (Hamilton, 1822) have higher demand as potential ornamental fish. Due to hardy and stress-tolerant, these tropical ornamental fish can be easily transported. Besides, the mid-altitude IOF are mainly found above 1200 m above sea level, like catfishes belonging to genus *Creteuchiloglanis*, *Oreoglanis*, *Exostoma*, *Glyptothorax* and *Psilorhynchus*, are striking and worthy for trade. However, these species are well adapted to cold and high oxygenated water and are at risk during transportation through the warm climatic zone. Moreover, they are highly

sensitive to decomposed matters in aquaria and vulnerable to diseases. In addition to the 52 potential IOF, the surveys encountered 23 species of indigenous small fishes that require further verification for viability as ornamental candidates (Table 2).

Discussion

The present observation on the trends of family dominance was similar to the findings of Das et al. (2015), Kumar et al. (2016), Gurumayum et al. (2016) and Abujam et al. (2017), where the family Cyprinidae dominated in the different rivers of the state. However, the diversity of fish species may vary from river to river due to the topographical variations. During the survey, it was realised that collecting fish from the wild requires expertise in fishing and knowledge about microhabitat of different fish species. It was usually observed that the water bodies in urban or city areas remain disturbed throughout the year due to developmental activities, overfishing and replacement of riparian vegetation by human settlement, posing a threat to fish population and diversity. So, the abundance of live fish collection in such areas was relatively lower than in undisturbed rural regions. However, collections from the latter are

Table 2. Some other viable potential ornamental fishes of Arunachal Pradesh.

Family	Name of species	IUCN Status	Feeding nature
Cobitidae	<i>Pangio pangia</i> (Hamilton, 1822)	LC	Bottom feeder
Psilorhynchidae	<i>Psilorhynchus arunachalensis</i> (Nebeshwar, Bagra & Das, 2007)	DD	Bottom feeder
Cyprinidae	<i>Garra arunachalensis</i> Nebeshwar & Viswanath 2013	NE	Bottom feeder
Cyprinidae	<i>Laubuka laubuca</i> (Hamilton, 1822)	LC	Surface feeder
Cyprinidae	<i>Rasbora daniconius</i> (Hamilton, 1822)	LC	Column feeder
Cyprinidae	<i>Rasbora rasbora</i> (Hamilton, 1822)	LC	Column feeder
Cyprinidae	<i>Barilius vagra</i> (Hamilton, 1822)	LC	Column and surface feeder
Cyprinidae	<i>Chela cachius</i> (Hamilton, 1822)	LC	Surface feeder
Cyprinidae	<i>Raiamas bola</i> (Hamilton, 1822)	LC	Column and surface feeder
Chacidae	<i>Chaca chaca</i> (Hamilton, 1822)	LC	Bottom feeder
Bagridae	<i>Chandramara chandramara</i> (Hamilton, 1822)	LC	Bottom and column feeder
Bagridae	<i>Mystus carcio</i> (Hamilton, 1822)	LC	Bottom and column feeder
Sisoridae	<i>Conta pectinata</i> (Hamilton, 1822)	DD	Bottom feeder
Sisoridae	<i>Glyptothorax pantherinus</i> Anganthoibi & Vishwanath, 2013	NE	Bottom feeder
Sisoridae	<i>Glyptothorax telchitta</i> (Hamilton, 1822)	LC	Bottom feeder
Sisoridae	<i>Exostoma labiatum</i> (McClelland, 1842)	LC	Bottom feeder
Sisoridae	<i>Exostoma tenuicaudata</i> Tamang et al., 2015	NE	Bottom feeder
Sisoridae	<i>Creteuchiloglanis arunachalensis</i> Sinha & Tamang, 2014	NE	Bottom feeder
Sisoridae	<i>Oreoglanis pangenensis</i> Sinha & Tamang, 2014	NE	Bottom feeder
Siluridae	<i>Pterocryptis indicus</i> (Dutta, Barman & Jayaram, 1987)	DD	Bottom and column feeder
Channidae	<i>Channa gachua</i> (Hamilton, 1822)	LC	Column and surface feeder
Nandidae	<i>Nandus nandus</i> (Hamilton, 1822)	LC	Bottom, column and surface feeder
Badidae	<i>Badis badis</i> (Hamilton, 1822)	LC	Bottom and surface feeder

NE- Not Evaluated; DD- Data Deficient; LC- Least Concern.

more expensive than the former, especially manpower and transportation, which is somewhat higher in Arunachal Pradesh than in other states. Despite the laborious work performed by the fish collectors and expenses incurred, the price quoted by exporters from Guwahati is relatively low.

The present investigation indicates that the identified 52 IOF species possess values as ornamental fish candidates for trade due to unique alluring traits like adaptive modification, body shape, behaviour, beautiful banding patterns and pigmentation. Besides, its non-occurrence in other states, especially in central and southern India, is also a prime factor for their demand.

Despite rich resources in the state, the native people are not aware of the potential of this trade market, particularly the export opportunities outside the state. Moreover, there is no appropriate information and data of such activities in the state government records. The local people catch fish primarily for consumption and sometimes for traditional festivals. In certain places of the state, the local people sell the fish in the local markets from time to time. The

increasing number of fish collectors from various corners of the state may lead to depletion of wild stock and extinction of rare species and ultimately threaten the viability of the trade.

Hence, these IOF may be utilised and developed through culture and propagation for commercial exploitation in the state and NE region of India. Once this possibility is successfully explored, it would generate additional employment opportunities and boost up the economy of the tribal population of this area. The respective state governments of the entire NE region have not yet initiated the culture and propagation of the IOF with immense export potential, except for some commercial fish. So, there is a need for intensive efforts from the government and other key institutions to increase IOF production in a sustainable manner.

Conclusion

The current status indicates that most of the streams in Arunachal Pradesh harbours very alluring small indigenous minnows, loaches, catfishes and barbs that have hardly been exploited for the ornamental

fish market. A total of 52 fish species belonging to 6 orders and 15 families were collected as potential indigenous ornamental fishes from 9 rivers and their tributaries. These freshwater ornamental fishes have high demand in the national and international markets. So the resources documented in Arunachal Pradesh will be of immense use for income and employment generation if it is appropriately planned towards marketing in future. The outcome of the investigation also revealed the importance of indigenous ornamental fishes and their market demand despite the higher cost of trained manpower and transportation due to the remote and terrain topography of Arunachal Pradesh. Therefore, a policy may be framed by involving the state government and all the stakeholders, including the local people, for effective trade and more extensive export of ornamental fishes in long-term sustainable ways. Further, subject experts, researchers, exporters, fish farmers, and aquarists may organise the trade to achieve the target. Besides, the preparation of the database and effective conservation in scientific lines are highly recommended.

Acknowledgements

Authors acknowledge the authorities of Rajiv Gandhi University Museum of Fishes (RGUMF), Department of Zoology for providing necessary facilities. All the photographs have been taken by Santoshkumar Abujam and Lakpa Tamang.

Conflict of interest: The authors declare that they have no conflict of interest.

References

- Abujam, S.K., Kumar, R., Darshan, A., Gogoi, B., Das, D.N. 2017. Enumeration of fish and alimentation of fisherman at Tezu River in Lohit District of Arunachal Pradesh, India. *Journal of FisheriesSciences.com* 11:55–63. <https://doi.org/10.21767/1307-234X.1000130>
- Bagra, K., Das, D.N. 2010. Fish diversity from river Siyom of Arunachal Pradesh, India: A case study. *Our Nature* 8:164–169. <https://doi.org/10.3126/on.v8i1.4324>
- Bagra, K., Kadu, K., Nebeshwar, K.S., Laskar, B.A., Sarkar, U.K., Das, D.N. 2009. Ichthyological survey and review of the checklist of fish fauna of Arunachal Pradesh, India. *Check List* 5:330–350. <https://doi.org/10.15560/5.2.330>
- Darshan, A., Abujam, S.K., Das, D.N. 2018. Biodiversity of fishes in Arunachal Himalaya, Academic Press, Elsevier. 284 pp.
- Das, B.K., Boruah, P., Kar, D. 2015. Ichthyofaunal diversity of Siang River in Arunachal Pradesh, India. *Proceedings of the Zoological Society* 70:52–60. <https://doi.org/10.1007/s12595-015-0155-6>
- Fricke, R., Eschmeyer, W.N., Van der Laan, R. 2021. Eschmeyer's catalog of fishes: Genera, species, references. <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp> (Accessed 20 October 2021).
- Gurumayum, S.D., Kosygin, L., Tamang, L. 2016. Ichthyofaunal diversity of Arunachal Pradesh, India: A part of Himalaya biodiversity hotspot. *International Journal of Fisheries and Aquatic Studies* 4:337–346.
- IUCN. 2020-1. Red list of threatened species, Version 2020-1 <http://www.iucnredlist.org/apps/redlist/search> (Accessed 30 April 2021).
- Kumar, R., Abujam, S.K., Ganguly, A., Das, D.N. 2016. Fish and fisheries of Sinkin tributary with emphasis on the people's socio-economic dependence in Dibang River basin of Arunachal Pradesh, India. *Journal of FisheriesSciences.com* 10:070–075.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853–858. <https://doi.org/10.1038/35002501>
- Nath, P., Dey, S.C. 2000. Fish and fisheries of North Eastern India (Arunachal Pradesh). Narendra Publishing House, New Delhi. 201 pp.
- Raja, S., Babu, T.D., Nammalwar, P., Jacob T.C., Dinesh, K.P.B. 2014. Potential of ornamental fish culture and marketing strategies for future prospects in India. *International Journal of Biosciences and Nanosciences* 1:119–125.
- Sen, N. 1999. On a collection of fishes from Subansiri and Siang districts of Arunachal Pradesh. *Records of the Zoological Survey of India* 97:141–144.
- Sen, T.K. 2006. Pisces. In: *Fauna of Arunachal Pradesh. State fauna series 13 (Part 1)*. Zoological Survey of India, pp. 317–396.
- Subhasis, M., Mahapatra, B.K., Tripathi, A.K., Verma, M.R., Datta, K.K., Ngachan, S.V. 2007. Agribusiness opportunities of ornamental fisheries in North-Eastern region of India. *Agricultural Economics Research Review* 20:471–488.
- Tamang, L., Chaudhry, S., Choudhury, D. 2007. Ichthyofaunal contribution to the state and comparison of habitat contiguity on taxonomic diversity in Senkhi stream, Arunachal Pradesh, India. *Journal of Bombay Natural History Society* 104:170–177.