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Fish Species Inventory in the Rhithron Zone of the Thamirabarani River, Western Ghats, South India

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Thamirabarani River, Endangered fishes, Threatened fishes, Fish faunal diversity, Western Ghats, Conservation

ABSTRACT

This study investigates the fish fauna from the rhithron to the crenon zone of the Thamirabarani River, revealing 58 species across 11 orders and 12 families. It provides valuable insights into fish diversity, distribution, and conservation status, including ornamental and edible species as well as their IUCN status. Various collection methods were employed, including gill nets, cast nets, and scoop nets. The Cypriniformes order was the most prevalent, comprising 64% of the species, followed by Siluriformes and Cichliformes at 8% each, Anabantiformes at 10%, and Anguilliformes, Perciformes, Gobiiformes, Synbranchiformes, and Beloniformes at 2% each. Endangered species include *Dawkinsia tambraparniei*, *Labeo fisheri*, *Hypselobarbus curmuca*, *Hypselobarbus dubius*, *Garra kalakadensis*, and *Etroplus canarensis*, while near-threatened species are *Labeo pangusia*, *Ompak bimaculatus*, *Channa kelaartii*, and *Anguilla bengalensis*. PAleontological STatistics version 4.17 software used to find the species diversity index for various location of the Thamirabarani River.

INTRODUCTION

The Western Ghats region of Peninsular India is renowned for its freshwater biodiversity (Dahanukar *et al*. 2011). It forms a part of the Western Ghats- Sri Lanka biodiversity hotspot. The Thamirabarani River, also known as Porunai Nathi, originates from the summit of the Periyapothigai hills, situated above Papanasam on the eastern slope of the Western Ghats in Tamil Nadu's Tirunelveli district. The Thamirabarani River basin is located between latitudes 08° 82' and 09° 23' N and longitudes 77° 09' and 77° 54' E (Mogalekar, 2019). The river travels for 120 km, passing through the Tirunelveli district for 80 km, including 24 km in the Western Ghats hills and 40 km in Thoothukudi district, before merging at Punnaikayal village in Thoothukudi district and the Bay of Bengal (Mogalekar, 2019). The Thamirabarani River has an extensive network of tributaries (Mogalekar, 2019). The river benefits from two significant rainfall seasons, making it perennial: the southwest monsoon, which occurs from June to September, and the northeast monsoon, which occurs from October to December (Mogalekar, 2019).

Given that most of its catchment regions are situated throughout the Thamirabarani River, various studies have been conducted to identify the fish fauna community. Kannan and Johnson (2020) reported 50 fish species from the streams and rivers of Kalakad-Mundanthurai Tiger Reserve (KMTR) in Tamil Nadu. Mogalekar and Canciyal (2018) identified 226 species from Tamil Nadu's freshwater bodies, including rivers from the eastern side of the Western Ghats region. Devi (1992a, b) reported 19 species from the Pachaiyar, Netterikal, Nambiyar, and Kodumudaiar rivers, as well as Keelmanimuthar and its tributaries, Kulirattiar, and Kusanguliar in the Kalakkad Wildlife Sanctuary, Tirunelveli district. In the Thamirabarani River at the Tirunelveli region, 10 species were identified (Mercy *et al*., 2020). A total of 102 fish species were listed in Western Ghats water bodies at altitudes between 750 and 2000 meters from ten streams in the southern Western Ghats, including the Thamirabarani River (Vishnu *et al*., 2023).

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Johnson and Arunachalam (2009) reported 60 species from four orders, 13 families, and 27 genera. Most recently, 57 species have been reported in the Potamon zone of the Thamirabarani River (Durairaja *et al*., 2022). However, because a large number of new species are identified every year, it is still necessary to evaluate and monitor the river system regarding the distribution of endemic, native, and invasive species. About 11.7% of the fish species known to exist are located in Indian waters (Murugan *et al*., 2012), making India a significant source of biodiversity for endemic fish species. The conservation of biodiversity is dependent on knowledge of the diversity and distribution of species (Bijukumar *et al*., 2013). The biodiversity of freshwater ecosystems is declining faster than in terrestrial or marine systems due to overexploitation, pollution, flow manipulation, species invasion, and habitat degradation, making them some of the most endangered organisms in the world (Postel and Richter, 2012; Lakra *et al*., 2010). Human activities harm many fish and other aquatic animals in rivers (Angeler *et al*., 2014). The Indian Western Ghats Forest, which is heavily fragmented, remains imperilled by mining, industrial agriculture, ongoing deforestation, poaching, human-wildlife conflict, dams, roads, overpopulation, and even tourism (Durairaja *et al*., 2022). Therefore, it is vital to implement appropriate conservation measures to reduce the effects of the pressures imposed by anthropogenic and environmental variables in order to preserve the richness of the native fish species in the Western Ghats and the Thamirabarani River. This study provides information about the Thamirabarani River and its fish species checklist, mainly focusing on the available fish species from the rhithron zone to the crenon zone of the Thamirabarani River.

MATERIALS AND METHODS

Fish were collected with the help of local fishermen using various fishing gears, such as gill nets, cast nets, and scoop nets. The sampling sites spanned from the rhithron zone to the crenon zone of the Thamirabarani riverine system, including locations such as Authoor, Srivaikundam, Tirunelveli, Manimuthar, Ambasamuthram, Papanasam, and Chittar, with their latitudes and longitudes documented (Table I). Fish samples were collected from January 2021 to January 2023. The collected fish were preserved in 10% formaldehyde for further taxonomic investigation. Identification of the fish was carried out using guides by Talwar and Jhingran (1991), Jayaram (1994), Islam *et al*. (2020), Chowdhury *et al*. (2021), the India Biodiversity Portal, and FishBase (Froese and Pauly, 2020). The checklist was created, their conservation status was evaluated using the IUCN Red List (2023) category, and they were divided into food and ornamental categories based on their importance. The total number of fish from the three sample points was recorded monthly. P Aleontological S Tatistics (PAST) version 4.17 software was used to find the fish species diversity index of Dominance (D), Simpson (1-D), Shannon (H), Evenness (e^H/S), Margalef Equitability (J), Fisher_alpha, Chao-1 (Table III).

Table I. Fishing location of the Thamirabarani River.

No	Location	Latitude	Longitude	Number of species	Species (%)
L1	Authoor	8°37'38.7"N	78°04'05.6"E	22	37.93
L2	Srivaikundam	8°37'34.5"N	77°54'45.1"E	32	55.17
L3	Murappanadu	8°42'44.2"N	77°50'12.6"E	33	56.89
L4	Tirunelveli	8°43'41.4"N	77°42'51.1"E	30	51.72
L5	Manimuthar	8°39'21.5"N	77°24'53.0"E	24	41.37
L6	Kalidaikurichi	8°41'03.5"N	77°26'08.7"E	30	51.72
L7	Ambasamudram	8°41'39.1"N	77°27'30.3"E	39	67.24
L8	Sivanthipuram	8°41'49.8"N	77°23'56.1"E	27	46.55
L9	Papanasam	8°42'43.1"N	77°22'03.3"E	18	31.03
L10	Gadana river	8°48'14.3"N	77°18'46.1"E	16	27.58
L11	Sivasailam	8°47'17.3"N	77°20'51.5"E	16	27.58
L12	Alwarkurichi	8°46'13.6"N	77°23'58.4"E	18	31.03
L13	Thenkasi	8°57'01.4"N	77°18'57.2"E	20	34.48
L14	Cittrar	8°54'39.6"N	77°31'39.9"E	33	56.89
L15	Kannupulimedu	8°56'29.5"N	77°12'38.5"E	13	22.41
L16	Padmaneri	8°32'29.6"N	77°33'53.4"E	18	31.03
L17	Pachaiyar	8°31'45.3"N	77°30'41.8"E	23	39.65

RESULTS

The present study documents the diversity of fish species in the Thamirabarani River (Fig. 1), with a total of fifty-eight species identified from January 2021 to January 2023. The Cypriniformes order represented the highest proportion of species at 64%, followed by Siluriformes and Cichliformes, each comprising 8%. The Anabantiformes group accounted for 10% of the species, while anguilliformes, perciformes, gobiiformes, synbranchiformes, and beloniformes each contributed 2% (Fig. 2). Among the collected samples, various conservation statuses were noted (Table II), with approximately 7% of the species classified as near threatened and 10% as endangered.

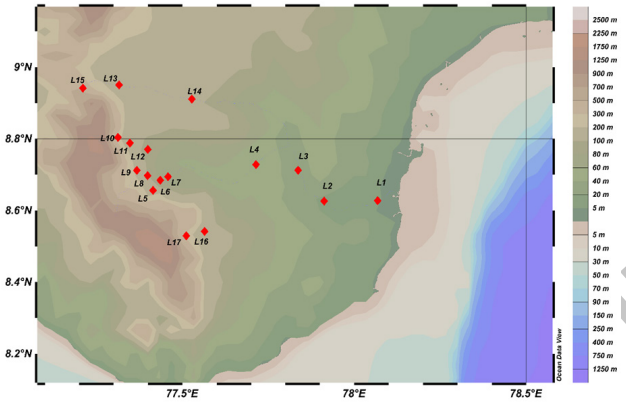

Fig. 1. Sampling location of the Thamirabarani River. L1, Authoor; L2, Srivaikundam; L3, Murappanadu; L4, Tirunelveli; L5, Manimuthar; L6, Kalidaikurichi; L7, Ambasamudram; L8, Sivanthipuram; L9, Papanasam; L10, Gadana river; L11, Sivasailam; L12, Alwarkurichi; L13, Thenkasi; L14, Cittrar; L15, Kannupulimedu; L16, Padmaneri; L17, Pachaiyar.

Four percent of the fish species were not evaluated by the IUCN, while 7% were categorized as vulnerable. The majority of the collected fish, comprising 72%, are classified as least concern (Fig. 3). Specific endangered species listed by the IUCN, such as *D. tambraparniei*, *L. fisheri*, *H. curmuca*, *H. dubius*, *E. canarensis*, and *G. kalakadensis*, are found in the Thamirabarani River. Additionally, species like *H. tamiraparaniei* and *P. stigma* have yet to be evaluated by the IUCN (Fig. 3). Fish classified as near-threatened include *C. kelaartii*, *O. bimaculatus*, *A. bengalensis*, and *L. pangusia*. Vulnerable species in the river include *C. orientalis*, *O. mossambicus*, *C. carpio*, and *C. cirrhosus*. Most of these fish are used for both edible and ornamental purposes, with 50% utilized for human consumption, 36% for ornamental purposes,

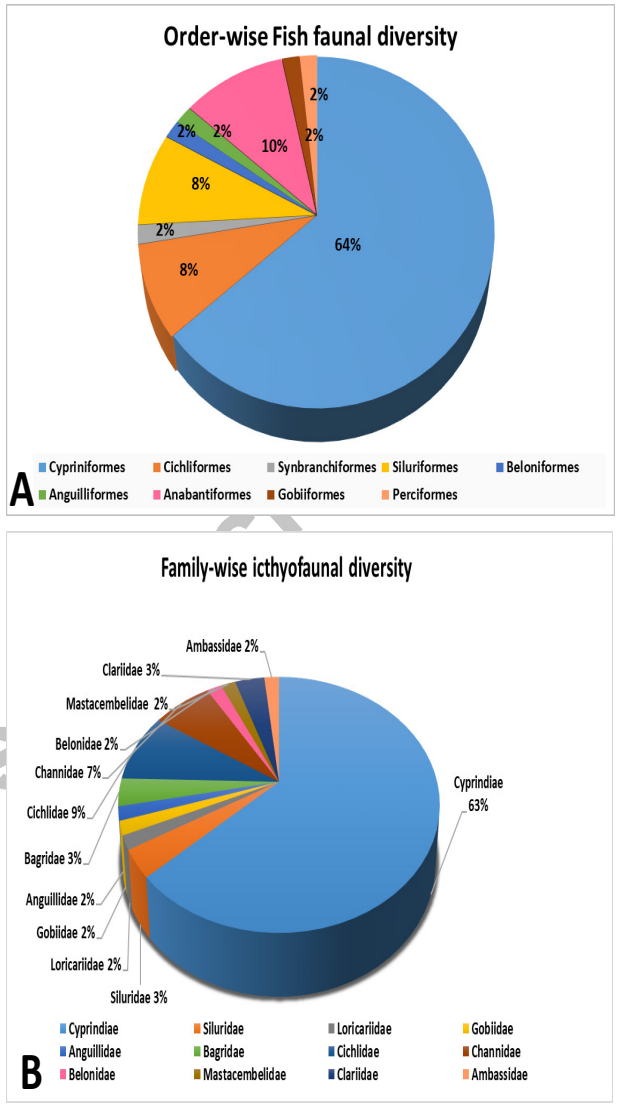

Fig. 2. Order-wise (A) and family-wise (B) fish faunal diversity from Rhithron zone to Crenon zone of the Thamirabarani River.

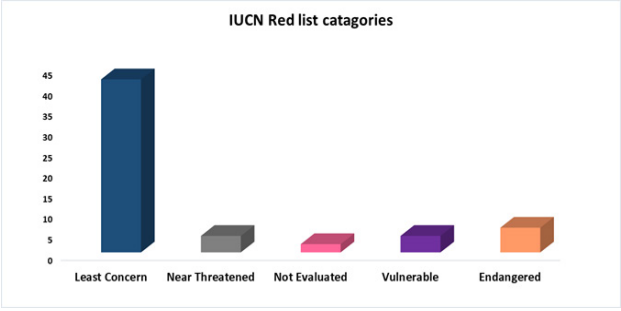

Fig. 3. IUCN Red list status of fishes from Rhithron zone to Crenon zone of the Thamirabarani River.

Table II. Check list of Thamirabarani River.

S. No	Scientific name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L 10	L 11	L 12	L 13	L 14	L 15	L 16	L 17	IUCN status	Edible/ Non edible fish
A	**Order: Cypriniformes Family: Cyprinidae**																			
1	*Systomus sarana* (Hamilton, 1822)	-	-	-	+	+	+	+	+	+	+	-	+	-	+	-	+	+	LC	Edible and Ornamental
2	*Dawkinsia filamentosa* (Valenciennes, 1844)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	LC	Ornamental
3	*Dawkinsia tambraparniei* (Silas, 1954)	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	EN	Ornamental
4	*Puntius sophore* (Hamilton, 1822)	-	-	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	LC	Ornamental
5	*Puntius bimaculatus* (Bleeker, 1863)	-	+	-	-	+	-	+	-	-	-	-	-	+	+	-	-	+	LC	Ornamental
6	*Puntius chola* (Hamilton, 1822)	-	+	-	-	+	-	+	+	+	-	-	-	+	+	-	-	+	LC	Ornamental
7	*Puntius stigma* (Valenciennes, 1844)	-	-	-	-	-	-	+	+	-	+	-	-	+	+	+	-	+	Not evaluated	Ornamental
8	*Puntius parrah* (Day, 1865)	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	+	+	LC	Ornamental
9	*Labeo rohita* (Hamilton, 1822)	+	+	+	+	-	+	+	+	-	-	-	-	+	+	+	-	-	-	LC	Edible
10	*Labeo dyocheilus* (McClelland, 1839)	-	-	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	LC	Edible
11	*Labeo calbasu* (Hamilton, 1822)	+	+	+	+	-	-	+	+	-	-	+	-	+	+	-	+	-	LC	Ornamental
12	*Labeo pangusia* (Hamilton, 1822)	+	+	+	-	-	-	-	+	-	-	-	+	+	-	-	-	-	NT	Edible
13	*Labeo bata* (Day,1878)	-	-	-	+	+	+	-	-	-	-	+	-	+	-	-	-	-	LC	Edible
14	*Labeo dero/ Sinilabeo dero* (Hamilton, 1822)	-	-	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	LC	Edible
15	*Labeo fisheri* (Jordan and Starks, 1917)	-	-	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-	EN	Edible
16	*Hypselobarbus tamiraparaniei* (Arunachalam, Chinnaraja, Chandran and Mayden, 2014)	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	Not Evaluated	Edible
17	*Hypselobarbus curmuca* (Hamilton, 1807)	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	EN	Edible
18	*Hypselobarbus dubius* (Day, 1867)	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	EN	Edible
19	*Aplocheilus lineatus* (Valenciennes, 1846)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	LC	Ornamental
20	*Aplocheilus panchax* (Hamilton 1822)	-	+	+	+	-	-	+	+	+	+	-	+	-	-	-	+	+	LC	Ornamental
21	*Devario malabaricus* (Jerdon, 1849)	-	-	-	+	+	+	+	+	+	+	+	-	-	+	+	+	+	LC	Ornamental

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S. No	Scientific name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L 10	L 11	L 12	L 13	L 14	L 15	L 16	L 17	IUCN status	Edible/ Non edible fish
22	*Devario aequipinnatus* (McClelland, 1839)	-	-	-	+	+	+	+	+	+	+	+	-	-	+	+	+	+	LC	Ornamental
23	*Garra mullya* (Sykes, 1839)	-	-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	LC	Ornamental
24	*Garra kalakadensis* (Rema Devi, 1993)	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	EN	Ornamental
25	*Cyprinus carpio* (Linnaeus, 1758)	+	+	+	+	+	-	+	-	-	-	+	-	+	-	-	-	+	VU	Edible
26	*Cirrhinus cirrhosis* (Bloch, 1795)	-	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-	VU	Edible
27	*Cirrhinus mrigala* (Hamilton, 1822)	+	+	+	+	+	+	-	-	-	-	-	-	-	+	-	-	0	LC	Edible
28	*Catla catla* (Hamilton, 1822)	+	+	+	+	-	+	-	-	-	-	-	-	+	+	-	-	-	LC	Edible
29	*Ctenopharyngodon idella* (Valenciennes, 1844)	+	+	+	+	-	-	-	-	-	-	-	-	-	+	-	-	-	LC	Edible
30	*Lepidocephalichthys thermalis* (Valenciennes, 1846)	-	-	-	-	+	-	+	+	+	+	+	-	+	-	+	+	+	LC	Edible and ornamental
31	*Rasbora daniconius* (Hamilton, 1822)	-	-	-	-	-	-	+	-	-	+	+	+	-	+	+	+	+	LC	Ornamental
32	*Rasbora dandia* (Valenciennes, 1846)	-	-	-	-	-	-	+	-	-	+	+	+	-	+	+	+	+	LC	Ornamental
33	*Esomus thermoicos* (Valenciennes, 1846)	-	-	-	-	-	-	-	-	-	+	+	+	-	+	-	+	+	LC	Ornamental
34	*Esomus danricus* (Hamilton, 1822)	-	-	-	-	-	-	-	-	-	+	+	+	-	+	-	+	+	LC	Ornamental
35	*Salmostoma bacaila* (Hamilton, 1822)	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	LC	Edible
36	*Amblypharyngodon mola* (Hamilton, 1822)	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	LC	Ornamental
B	**Order: Cichliformes Family: Cichlidae**																			
1	*Etroplus suratensis* (Pearl Spot) (Bloch, 1790)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LC	Edible and ornamental
2	*Etroplus maculatus* (Bloch, 1795)	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	LC	Edible and ornamental
3	*Etroplus canarensis* (Day's, 1877)	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	EN	Ornamental
4	*Oreochromis mossambicus* (Peters, 1852)	+	+	+	+	-	-	+	+	-	-	-	-	+	+	-	-	-	VU	Edible
5	*Oreochromis niloticus* (Linnaeus, 1758)	+	+	+	+	-	-	+	-	-	-	-	-	-	+	-	-	-	LC	Edible
C	**Order: Synbranchiformes Family: Mastacembelidae**																			
1	*Mastacembelus armatus* (Lacepede, 1800)	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	LC	Edible and ornamental

Table continued on next page.....

S. No	Scientific name	L1	L2	L3	L4	L5	L6	L7	L8	L9	L 10	L 11	L 12	L 13	L 14	L 15	L 16	L 17	IUCN status	Edible/ Non edible fish
D	**Order: Siluriformes Family: Bagridae**																			
1	*Mystus gulio* (Hamilton, 1822)	+	+	+	+	+	-	+	-	-	-	-	+	-	+	-	+	+	LC	Edible
2	*Mystus bleekeri* (Day's, 1877)	-	+	+	+	-	-	+	+	-	-	-	+	-	+	-	+	+	LC	Edible
	Family: Siluridae																			
3	*Heteropneustes fossilis* (Bloch, 1794)	-	+	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	LC	Edible
4	*Ompok bimaculatus* (Bloch, 1794)	-	-	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	NT	Edible
	Family: Loricariidae																			
5	*Pterygoplichthys pardalis* (Castelnau, 1855)	-	+	+	+	-	+	+	-	-	+	-	-	-	+	-	-	-	LC	Ornamental
	Family: Clariidae																			
6	*Clarias gariepinus* (Burchell, 1822)	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	LC	Edible
7	*Clarius batrachus* (Linneaeus,1758)	+	+	+	+	-	+	+	-	-	-	+	+	+	+	-	+	+	LC	Edible
F	**Order: Beloniformes Family: Belonidae**																			
1	*Xenentodon cancila* (Hamilton, 1822)	-	+	+	+	+	+	+	+	-	-	-	-	+	+	-	-	-	LC	Edible and ornamental
G	**Order: Anguilliformes Family: Anguillidae**																			
1	*Anguila bengalensis bengalensis* (Gray 1831)	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	NT	Edible
H	**Order: Anabantiformes Family: Channidae**																			
1	*Channa striata* (Bloch, 1793)	+	+	+	+	-	+	+	-	-	-	+	+	+	+	-	-	-	LC	Edible
2	*Channa marulius* (Hamilton, 1822)	+	+	+	+	-	+	+	+	-	-	-	-	+	-	-	-	-	LC	Edible
3	*Channa punctata* (Bloch, 1793)	+	+	+	+	+	+	+	+	-	-	-	-	+	-	-	-	-	LC	Edible
4	*Channa orientalis* (Bloch and Schneider, 1801)	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	VU	Edible
5	*Channa kelaartii* (Günther, 1861)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	NT	Edible and ornamental
I	**Order: Gobiiformes Family: Gobiidae**																			
1	*Glossogobius giuris* (Hamilton, 1822)	+	+	+	+	-	+	+	+	-	-	-	+	-	-	-	-	-	LC	Edible and ornamental
J	**Order: Perciformes Family: Ambassidae**																			
1	*Chanda nama* (Hamilton, 1822)	+	+	+	-	+	-	+	+	-	-	-	-	+	+	-	+	+	LC	Edible

LC, Least concern; EN, Endangered; NT, Nearly threatened; VU, Vulnerable.

Table III. Diversity indices of fishes from the Thamirabarani River.

Diversity index	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17
Individuals	58	95	112	108	92	92	120	75	77	57	41	42	51	176	32	74	148
Simpson (1-D)	0.94	0.96	0.96	0.96	0.94	0.9591	0.97	0.95	0.82	0.91	0.91	0.92	0.94	0.95	0.90	0.93	0.92
Shannon (H)	2.99	3.34	3.42	3.3	3.04	3.286	3.53	3.15	2.30	2.62	2.63	2.73	2.95	3.22	2.44	2.77	2.79
Evenness (e^H/S)	0.90	0.88	0.92	0.90	0.87	0.8914	0.88	0.86	0.55	0.86	0.87	0.85	0.95	0.761	0.88	0.89	0.71
Margalef	5.17	6.80	6.78	6.19	5.08	6.413	7.93	6.02	3.91	3.71	4.04	4.55	4.83	6.18	3.46	3.95	4.40
Equitability (J)	0.97	0.96	0.98	0.97	0.96	0.9662	0.96	0.95	0.80	0.94	0.95	0.94	0.98	0.92	0.95	0.96	0.89
Fisher_alpha	12.92	16.95	15.78	13.76	10.56	15.48	20.08	15.13	7.39	7.39	9.65	11.93	12.12	11.99	8.15	7.57	7.62
Chao-1	22.08	32.5	33.13	30	24	30.6	40.25	28.5	18.33	16	16.38	18.5	20.14	33.1	13.11	18	23.14

L1, Authoor; L2, Srivaikundam; L3, Murappanadu; L4, Tirunelveli; L5, Manimuthar; L6, Kalidaikurichi; L7, Ambasamudram; L8, Sivanthipuram; L9, Papanasam; L10, Gadana River; L11, Sivasailam; L12, Alwarkurichi; L13, Thenkasi; L14, Cittrar; L15, Kannupulimedu; L16, Padmaneri; L17, Pachaiyar.

and 14% serving both roles (Fig. 4). This study provides an updated checklist, incorporating the latest taxonomic revisions, covering the rhithron to crenon zones of the Thamirabarani River.

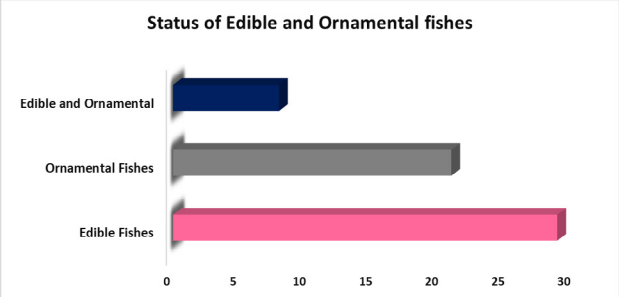

Fig. 4. Status of edible and ornamental fishes from the Thamirabarani River.

The diversity indices were calculated using PAST version 4.17 software. The highest recorded values for the Simpson index and Shannon index (H) were 0.9672 and 3.529, respectively. The Margalef richness index reached a maximum of 7.937, with a minimum value of 3.462. Additionally, high values were observed for other indices, including an equitability (J) of 0.9844, a Fisher's alpha of 20.08, and a Chao-1 index of 40.25 (Table III).

DISCUSSION

The comprehensive fish faunal checklist presented here serves as crucial foundational data for developing fisheries policies and legislation aimed at conservation and management efforts. This checklist includes fish species from various conservation statuses, such as endangered, critically endangered, and least concern, based on the IUCN Red List. Many indigenous fish species of the Thamirabarani River face risks due to industrial pollution, domestic sewage, agricultural pesticides, and waste that contaminate the water system. These pollutants degrade water quality, adversely affecting the fishes' daily lives and breeding activities. In a previous study by Durairaja *et al.* (2022), 57 species were documented in the Potamon region of the Thamirabarani River. Mogalekar (2019) observed 125 species across 73 genera, 44 families, and 13 orders, with 72 species inhabiting the freshwater region and 53 in the brackish water ecosystem. The current study aligns with Mogalekar (2019) findings regarding the upstream region of the Thamirabarani River. Kannan and Johnson (2020) reported 50 fish species across 32 genera, 10 orders, and 15 families in the streams and rivers of the Kalakad-Mundanthurai Tiger Reserve (KMTR) in Tamil Nadu. Endemic species in this protected area include *Garra joshuai*, *G. kalakadensis*, *Haludaria kannikattiensis*, *Hypselobarbus tamiraparaniei*, *Mesonemachilus tambraparniensis*, *Neolissochilus tamiraparaniensis*, and *Dawkinsia tambraparniei*. Additionally, minnows such as *D. aequipinnatus*, *G. mullya*, and *G. kalakadensis* are widely distributed in KMTR streams. In this study shows the diversity indices was higher in Ambasamudram region. In addition to this Simpson index, Shannon, Margalef richness index, Fisher_alpha and Chao-1 index gives the higher values for Ambasamudram region (Table III).

The Gadana River, originating from Alwarkurichi and the Kadayam range of the Western Ghats, has high species diversity, while the Poonkulam area has low species diversity (Kannan and Johnson, 2020). The Gadana River's tributaries, Pampar, Kallar, and Iluppaiyar, all merge with the Thamirabarani River. According to Arunachalam and Sankaranarayanan (1999), cyprinids dominate the streams studied, including Mondai, Phansad, Kigga, Sirkuli, Panniyar, Achankoil, Thalaianai, Gadana, Hanuman Nathi, and Gundar. Most cyprinids were found

in pools with high biodiversity. The current study confirms that the Thamirabarani River exhibits the highest species distribution within the Cypriniformes order (Fig. 2), with the Cyprinidae family showing the greatest diversity (Fig. 4). This is followed by Cichlidae (9%), Channidae (7%), Clariidae and Bagridae (3% each), and other families making up 2% (Fig. 4). Raghavan *et al*. (2008) classified *A. bicolor* as an endangered fish species. However, Mogalekar (2019) suggested it to be near-threatened, while Bijukumar *et al*. (2013) categorized it as least concern. In contrast, this research identifies *C. kelaartii*, *O. bimaculatus*, *A. bengalensis*, and *L. pangusia* as species listed on the IUCN Red List, with the FishBase database indicating their near-threatened status. According to Raghavan *et al*. (2008), *C. marulius*, *C. striata*, *D. malabaricus*, *E. maculatus*, *E. suratensis*, *G. mullya*, *M. gulio*, and *L. thermalis* are categorized as low-risk fish species, while *H. fossilis* and *S. sarana* are considered vulnerable. *O. bimaculatus* is classified as endangered, and *O. mossambicus* is noted as an exotic species.

This study reveals that *D. tambraparniei*, *L. fisheri*, *H. curmuca*, *H. dubius*, *E. canarensis*, and *G. kalakadensis* have low diversity in the Thamirabarani River. According to Bijukumar *et al*. (2013), species such as *D. tambraparniei*, *D. filamentosa*, *D. malabaricus*, *D. aequipinnatus*, *G. mullya*, *L. thermalis*, *M. gulio*, *A. lineatus*, *X. cancila*, *G. giuris*, *C. marulius*, *C. striata*, *L. rohita*, and *S. sarana* are categorized as least concern. According to Arunachalam (2000), smaller *Puntius* species, including *Puntius fasciatus*, *Puntius melanampyx*, *Puntius narayani*, *Puntius sophore*, *Puntius ticto*, and *Puntius vittatus*, are commonly found in shallow backwater ponds and low-flowing pools. Species such as *P. arulius*, *P. tambraparaniei*, *P. amphibius*, *P. bimaculatus*, and *P. filamentosus* were observed near shallow pools with moderate flow. Surface-dwelling species like *D. aequipinnatus*, *R. daniconius*, *Salmostoma*, and *Barilius* were found in deepwater locations with heavy flow. This study supports the conclusions of Arunachalam (2000).

Johnson and Arunachalam (2009) reported 60 species from four orders, 13 families, and 27 genera sampled from 10 selected streams in the southern Western Ghats. The Cyprinidae family was identified as the most dominant, with 39 endemic fish species recorded in the study areas of Agastiyamalai, Anamalai, Cardamom Hills, and Nilgiris, along streams such as Thalayanai, Panniyar, Karaiyar, Kallar, and Achankoil. In the Tirunelveli region of the Thamirabarani River, Mercy *et al*. (2020) identified 10 species belonging to the families Channidae, Anchariidae, Lepisosteidae, Cyprinidae, Anguillidae, Cichlidae, and Lebiasinidae.

The suckermouth sailfin catfish (*Pterygoplichthys pardalis*), indigenous to the rivers, lakes, and marshes of South America, has successfully encroached upon inland water bodies in several nations, including the Philippines (Joshi, 2006; Hubilla *et al*., 2008), Japan (Nakabo, 2002), Taiwan (Wu *et al*., 2011), Vietnam (Zworykin and Budaev, 2013), Sri Lanka (Sumanasinghe and Amarasinghe, 2013), Indonesia, Malaysia, Singapore (Page and Robins, 2006), Israel (Golani and Snovsky, 2013), Turkey (Ozdilek, 2007), Bangladesh (Hossain *et al*., 2008), Mexico (Wakida-Kusunoki *et al*., 2007), Europe (Keszka *et al*., 2008; Piazzini *et al*., 2010; Simonovic *et al*., 2010), the USA (Nico and Martin, 2001), and Brazil (Sergio and Federico, 2019). The invasion of South American armored catfish (*Pterygoplichthys pardalis*), African catfish (*Clarias gariepinus*), and genetically improved farmed tilapia poses major threats to native fish species such as carps, Indian spiny loach (*Lepidocephalichthys thermalis*), *murrel*, species of the *Puntius* group, as well as juveniles and smaller fish from various families. This study also found *P. pardalis* in the Thamirabarani River, indicating its diverse presence. The suckermouth armored catfish, sometimes known as the Devilfish, is a notable invasive species in this ecosystem. The introduction of exotic alien species, water diversions, water pollution, habitat loss, and global climate change are identified as major causes of the decline in fish biodiversity (Gibbs, 2000). The aquatic environment is under significant pressure, affecting ecosystem stability and leading to a decline in biodiversity (Lakra *et al*., 2010). The primary human activities impacting the ecological health and quality of river systems include the rapid growth of agriculture, urbanization, industrial development, and the construction of dams (Schmutz and Sendzimir, 2018). Numerous studies have indicated that fish species are becoming endangered at a rate faster than would be expected from natural biological evolution (Mishra *et al*., 2011).

CONCLUSION

Fish and macrobenthos serve as natural biological indicators for assessing river water quality (Oberdorff *et al*., 2002). To effectively implement a targeted conservation strategy for the diverse freshwater fish species in the Thamirabarani River system, additional surveys are essential. These surveys should focus on evaluating the distribution and population trends of fish species classified as IUCN not evaluated. Given the severe threats faced by many fish species, comprehensive research is needed to assess risks thoroughly and understand their immediate and long-term impacts on ichthyodiversity. Factors contributing to the endangerment of fish species include overexploitation of biological resources, overfishing, deforestation, habitat loss, biodiversity loss, habitat alteration, natural system changes, and the

introduction of invasive alien species (Molur *et al*., 2011; Arijit *et al*., 2017). Legislation plays a critical role in conservation efforts. For example, the Indian Fisheries Act of 1897 prohibits the killing of fish in inland waters through explosion or poisoning. State legislatures can enforce fishing bans in specific inland waters or during certain seasons to protect fish populations. The Kerala government, for instance, has imposed restrictions on harmful fishing gear and overfishing of *Sahyadria denisonii* during spawning seasons to prevent its exploitation in the ornamental fish trade (The Hindu conservation steps for 'Miss Kerala). Additionally, captive breeding programs have been established for several endemic fish species in Tamil Nadu, supported by the Indian Wildlife Protection Act. Notable examples include *D. filamentosa* and *D. tambraparniei* and *Garra mullya* (Mercy, 2009). These initiatives are crucial for the conservation and preservation of endangered fish species.

DECLARATIONS

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Ethical statement

No live specimens were used in the present investigation.

IRB approval

Approved by the Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Institute of Fisheries Post Graduate Studies, Chennai, Tamil Nadu, India.

Statement of conflict of interest

The authors have declared no conflict of interest.

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