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V Veena

PSGR Krishnammal College for
Women, Coimbatore, Tamil
Nadu, India

G Sasikala

PSGR Krishnammal College for
Women, Coimbatore, Tamil
Nadu, India

Selvaraju Raja

Kongunadu Arts and Science
College, Coimbatore, Tamil
Nadu, India

Occurrence of South American suckered armoured catfish (*Pterygoplichthys pardalis*) in the Gayathripuzha River, Palakkad, Kerala

V Veena, G Sasikala and Selvaraju Raja

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Abstract

An intensive survey was undertaken and reported the existence of an invasive armoured sailfin catfish *Pterygoplichthys pardalis* from the Bharathapuzha River, Palakkad, Kerala, India, and its invasion as one of the foremost threats to the endemic aquatic biodiversity of Kerala. It belongs to the Genus *Pterygoplichthys* (Siluriformes: Loricariidae) which is known as popular aquarium fish that constitutes one of the most successful aquatic freshwaters invasive taxa, having achieved global distribution. The invasion occurred through aquarium fish culture and trading and is intensified by the distribution through rainstorm flooding and irrigation canal. The fish were identified based on morphological tests, identified fishes ranged in length (9.50-31.75cm) and weight (8.16-129.80 g). Distribution leads to understanding the changes and disturbances in fish species composition and the negative impact on the riverine ecosystem.

Keywords: Freshwater, invasive fish, *Pterygoplichthys pardalis*, Bharathapuzha River

1. Introduction

The *Pterygoplichthys pardalis* American suckermouth armoured catfishes (Loricariidae) are native to the Amazon River of Brazil and Peru and placed under the largest family of the order Siluriformes, of over 700 species with about 80 genera are placed and occurring naturally in south-central American water (Nelson, 2006) [45]. The synonym genus of *Pterygoplichthys liposarcus* (Siluriformes: Loricariidae) characteristically has nine dorsal fin rays or more and is popularly identified as sailfin catfishes (Weber, 1992; Fuller 1999; Nelson, 2006; Ferraris, 2007) [66, 19, 45, 17]. The sailfin catfish belongs to the genus *Pterygoplichthys* spp. of the Loricariidae family is one of the invasive fish groups most extremely dangerous to the tropical and subtropical freshwater ecosystem (Page, 1994; Liang *et al.* 2005; Chavez *et al.* 2006; Nico, 2010) [52, 37, 13, 48] have been introduced all around the world from South America by the aquarium trade (Wakida-Kusunoki *et al.* 2007) [64] because of the feeding activities being an excellent algae grazer and detritus (Li-Wei *et al.* 2011; Ozedilek, 2007) [38, 50] they also may ingest young insect, and its larvae fish eggs and other bottommost dwellers but the vast majority of diet includes the detritus algae and numerous plant matters (Mendoza *et al.* 2009) [39]. The wild sympatric distribution of both *Pterygoplichthys disjunctivus* and *Pterygoplichthys pardalis* were recorded in Singapore Indonesia and the Philippines (Kottelat and Whitten 1993; Chavez *et al.* 2006; Page and Robins, 2006) [13, 32, 53]. Members of the genus *Pterygoplichthys*, or *Liposarcus sensulato*, have four phylogenetically close *Pterygoplichthys* spp. with very similar morphology and biology in the Amazon River basins and the Orinoco are (Weber, 1992) [66] *Pterygoplichthys pardalis* (Castelnau, 1855) [11], *Pterygoplichthys multiraditus* (Hancock, 1828) [21], *Pterygoplichthys disjunctivus* (Weber, 1991) [65] *Pterygoplichthys anisitsi* (Eigenmann and Kennedy, 1903; Weber, 1991; Weber, 1992; Montoya-Burgos *et al.* 2002; Armbruster *et al.* 2004) [4, 16, 42, 65, 66].

The genus *Pterygoplichthys* spp. is a fast-dispersing invasive aquatic species invading the aquatic habitat globally, commercialized primarily through uncontrolled pet trafficking by the aquaculturists attack of these fishes on natural freshwater bodies results in serious economic and environmental consequences (Nico, 2012) [49]. The evolving foreign trade of ornamental

Corresponding Author:

G Sasikala

PSGR Krishnammal College for
Women, Coimbatore, Tamil
Nadu, India

fish is prime significant and has little evidence found on the pathways for the aquatic biological invasion (Rixon *et al.* 2005; Raghavan *et al.* 2013) ^[55, 58] approximately thirty-three percent of the ornamental fish population in the world's worst aquatic invasive species (AIS) (Padilla and Williams, 2004) ^[51]. The non-indigenous species become predators and competitors to native species (Hill and Lodge, 1999) ^[23], leading to the decline and elimination of indigenous freshwater fishes in the aquatic environment (Lever, 1996; Peh, 2010) ^[35, 55]. Latest studies from southern parts of India have reported the existence of numerous ornamental fishes in inland freshwater bodies, including the environmentally sensitive area such as the Chalakudy River in the Western Ghats (Bhachan, 2003) ^[7], a biodiversity hot spot that harbors 16 endangered and 4 critically endangered species. So far, 27 ornamental species have been confirmed in the inland wetlands of India. Amongst, 15 species have already recognized high tolerance and good breeding population and occurred as a hazard to the innate species.

South American suckermouth armoured catfishes (Loricariidae), are popular aquarium fishes for more than 55 years throughout the world as aquarium pets for their distinctive appearance and "use" in the aquarium as a "cleaner" to remove the algae (Wu *et al.* 2011) ^[68]. It is one of several species commonly referred to as the common pleco or "leopard pleco" by aquaculturists (ITIS, 2005). People in the Native Amazon and Orinoco drainages traditionally consumed and marketed sailfin catfishes (Mohammad *et al.* 2018) ^[40] triggering high demand for the ornamental aquarium fish trade which also encourage the cultivation of fishes beyond their natural ranges (Fuller *et al.* 1999; CEC, 2009; Krishnakumar *et al.* 2009) ^[12, 19, 33].

The natural affluence of *Pterygoplichthys pardalis* in varied aquatic habitats is due to the capability of tolerating extreme conditions breeding and also the shortage of potential predators such as large fish-eating (Laurenti, 1768) ^[34] birds and Asian water monitor (*Varanus Salvator*) have struggled in controlling and consuming the adult *P. pardalis* (Bunkley-Williams *et al.* 1994; Karunarathna *et al.* 2008) ^[10, 29].

Effective invasion of non-native Ichthyofauna is predominantly observed as an anthropogenically and ecologically disrupted atmosphere (Hobbs, 2009) ^[24].

The armoured catfishes have an upraised concern about exotic fishes which could affect the indigenous population through egg predation (Ratcha and Sirapat 2012) ^[57]. Habitat adaptations such as water velocity and food supply play an important role in influencing the distribution of species at different life stages. In India, limited data is available about the environmental and economic impacts of introduced *P. pardalis*. Non-native fish introduction causes a potential threat to native species in the Western Ghats (Molur *et al.* 2011) ^[41]. This study reported the existence of *P. pardalis* in the native freshwater Ichthyofauna Gayathripuzha riverine, in Palakkad, Kerala, India, and identified the invasion of *P. pardalis* (Castelnau, 1855) ^[11], an Amazon sailfin catfish (Loricariidae, Siluriformes), a newly discovered fish species observed in Gayathripuzha River.

2. Materials and methods

2.1 Study area

Bharathapuzha River is recognized by the name 'Nila' as the lifeline of central Kerala and a few parts of Tamil Nadu. This river measuring of 209 km in length and had a catchment surface area of 6186 km², before merging with the Arabian Sea near Ponnani (CWRDM, 1995). The drainage network of the Bharathapuzha River is comprised essentially of four major tributaries, namely Chitturpuzha (Basin Area: 1347 km²), Kalpathipuzha (1400 km²), Gayathripuzha (1057 km²), and Thuthapuzha (1030 km²). Gayathripuzha River originates from Anammalalai hills traversing through Kollengode 10°37'4.15"N 76°41'23.76"E, Pallasena 10°37'27.19"N 76°39'57.47"E, Alathur 10°37'30.64"N 76°35'9.02"E, and Pazhayannur 10°39'59.45"N 76°30'9.55"E, joins Bharathapuzha at Mayannur 10°44'48.00"N 76°23'37.01"E. This tributary has five main sub-tributaries; viz., Mangala River, Ayalurpuzha River, Vandzhipuzha River, Meenkarapuzha River, and Chulliyar River.



Fig 1 a, b): Sampling site of Gayathripuzha River

2.2 Distribution mapping

The Occurrence of *Pterygoplichthys pardalis* in the Gayathripuzha River was mapped. The map is generated by

using Arc GIS 10.51- DSAS version 5 (Alexander and Daniel, 2018) ^[3]. Species occurrence in different geographical areas is displayed with multicolor patterns (Fig. 3).

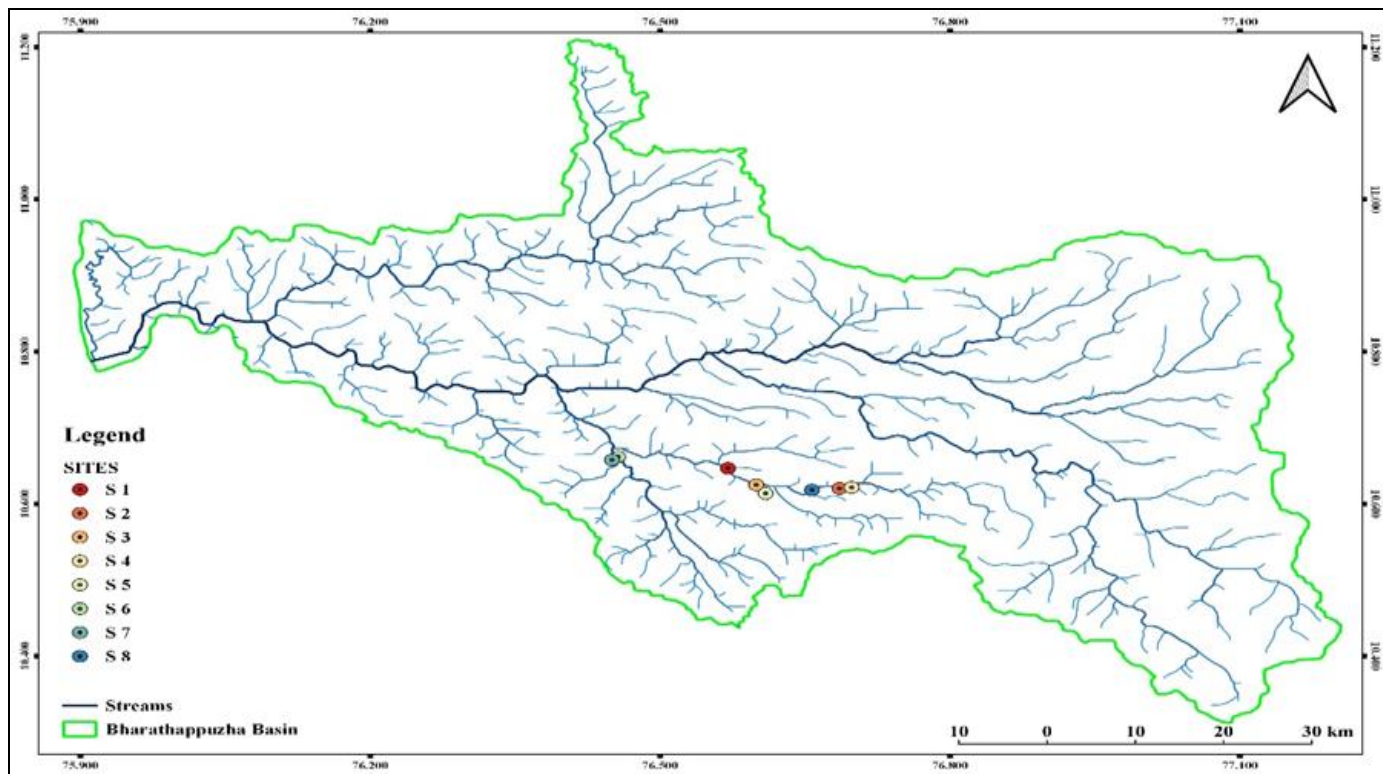


Fig 2: Map showing of Bharathapuzha river basin and sampling site are marked with different colors

2.3 Sample collection and identification

There is a paucity of information available about the taxonomic status of the alien invasive *Pterygoplichthys* spp. in this river, an intensive survey was conducted from December (2018) to May (2021) on the Gayathripuzha tributary of Bharathapuzha river, Kerala, India (Fig. 1, 2). The species *Pterygoplichthys pardalis* were collected, recorded its length (9.5-31.75 cm) and weight (8.16-129.8g) and taken to the laboratory, preserved in 10% formaldehyde solution. Sampling frequency was determined according to the information from local fishers to meet research objectives. Fish were caught using fixed gill nets (22-40 mm mesh size) in the morning from 2018 to 2021. An average of eight to ten hauls per sampling were conducted with a total sampling distance of 10 km per stretch. Twenty sailfin catfish were

collected from Gayathripuzha River 10°37'30.4" N, 76°35'54.5" E Palakkad. All species were marked and categorized in the field, preserved in 10% formalin solution, and transported to the lab. Taxonomic identification was carried out using the previously published descriptions of species. Morphometric data were used to make a comparison with the newly collected specimens. Specimens were identified based on the nature of their abdominal patterns in existing available keys provided by Weber (1991; 1992) [65,66], for characteristic peculiarities and photographs of specimens. Armbruster and Page, (2006) [6] presented a revised key of the species in the genus *Pterygoplichthys* spp. except for *Pterygoplichthys ambrosetti*. The fishes were preserved and maintained in the Zoology laboratory.

2.3 *Pterygoplichthys pardalis*

Table 1: Scientific classification of *Pterygoplichthys pardalis*

Meristic Characters	Number
Kingdom	Animalia
Subkingdom	Bilateria
Infrakingdom	Deuterostomia
Phylum	Chordata
Subphylum	Vertebrata
Infraphylum	Gnathostomata
Super class	Actinopterygii
Class	Teleostei
Super Order	Ostariophysi
Order	Siluriformes
Family	Loricariidae
Subfamily	Hypostominae
Genus	<i>Pterygoplichthys</i>
Species	<i>P. pardalis</i> (Castelnau, 1855)

The armoured catfish *Pterygoplichthys pardalis* inhabits the Gayathripuzha River, and belongs to the family Loricariidae

is an extremely large and diverse group of American freshwater fish have sucker mouth distinguished by a

depressed body surrounded by dermal plates, dark spots on its sidelong and caudal peduncle coalescing or forming chevrons; with mostly discrete ventral spots. The collected fish species *Pterygoplichthys pardalis* size ranges from 9.5-31.75 cm.

2.4 Morphometric analysis

Morphometric dimensions were recorded following the standard methods of Armbruster (2003)^[4] and measurements were carried out using digital slide calipers (0.1mm). Other external characters were also examined.

3. Result

The examination of fishes established on coloration, morphometric, and meristic attributes reported (Tables 1 and 2) and revealed the occurrence of species *P. pardalis* (Castelnaud, 1855)^[11] (Fig 2) in the Gayathripuzha river. The scientific classification of *P. pardalis* is provided in Table 3. Twenty specimens of *Pterygoplichthys pardalis* were observed and recorded in the morphometric characters (Table 2). The number of fishes gathered while conducting the cast net process varied from 3-10 (average 6-7), implying their plentifulness in the aquatic ecosystem (Fig. 4, 5). Juvenile fishes were found throughout the year from the river, indicating their successful invasion.

The fin formula is Dorsal fin spines 12, Caudal fin rays 16, Pectoral fin rays 6, Pelvic fin rays 6, and anal fin rays 4.5. The mean standard deviation of 29 morphometric characters is shown, Total Length 24.33 ± 12.85 cm, Fork Length 22.17 ± 11.66 cm, Standard Length 19.33 ± 10.50 cm, Pre Dorsal Length 7 ± 3.46 cm, Pre Adipose Length 115.8 ± 8.31 cm, Pre Pectoral Length 4 ± 1.90 cm, Pre Pelvic Length 8.8 ± 4.68 cm, Pre Anal Length 13 ± 6.93 cm, First Dorsal Fin Length $4.1 \pm$

1.96cm, Adipose Dorsal Fin Length 1.47 ± 0.92 cm, Pectoral Fin Length 5.43 ± 3.06 cm, Pelvic Fin Length 4.2 ± 2.25 cm, Anal Fin Length 3.10 ± 1.62 cm, Caudal Fin Length 5.5 ± 2.94 cm, Dorsal Fin Base Length 6.47 ± 3.52 cm, Adipose Dorsal Fin Base 1.1 ± 0.52 cm, Pectoral Fin Base 1.3 ± 0.69 cm, Anal Fin Base 1.13 ± 0.81 cm, Caudal Fin Base 1.27 ± 2.27 cm, Caudal Peduncle Depth 3.23 ± 2.19 cm, Head Length 4.07 ± 1.79 cm, Eye Diameter 1.3 ± 0.87 cm, Body Depth 3.5 ± 1.73 cm, Snout Length 2.73 ± 1.33 cm, Upper Jaw Length 2.43 ± 1.33 cm, Lower Jaw Length 2.6 ± 1.56 cm, Maxillary Labial Length 1.27 ± 0.75 cm and Head Width 2.67 ± 1.10 cm respectively. All the morphometric and meristic characters are represented in Tables 2 and 3.

The specimen is recognized as *Pterygoplichthys pardalis* thanks to the distinct black spots on its lateral and caudal peduncle with a pattern of un-coalesced light background covered by dark dots, strong pectoral fins with rough surfaces, and inferior disc-like protrusible mouth. (Fig. 3, 4). The triangular-shaped sucker mouth is present on the ventral side, it contains smooth tubular denticles and many numbers of tubercles are noticed (Fig. 5). The dorsal fin had one spine and 11 branched rays (Fig. 3). The pectoral fin had one spine and six branched rays, the pelvic fin had one spine and five branched rays, (Fig. 3, 4). The presence of sucking lips (Fig. 5, 8) and the pectoral fin semi-circular gill arch were noticed (Fig. 6). The ventral side of the body is smooth and covered by bony plates and spines (Fig. 5).

The lateral side is enclosed by large bony plates and spines in five rows, finally, it reaches the caudal portion of the peduncle base. The first dorsal fin contains twelve numbers of spines and the second dorsal fin is replaced as adipose.

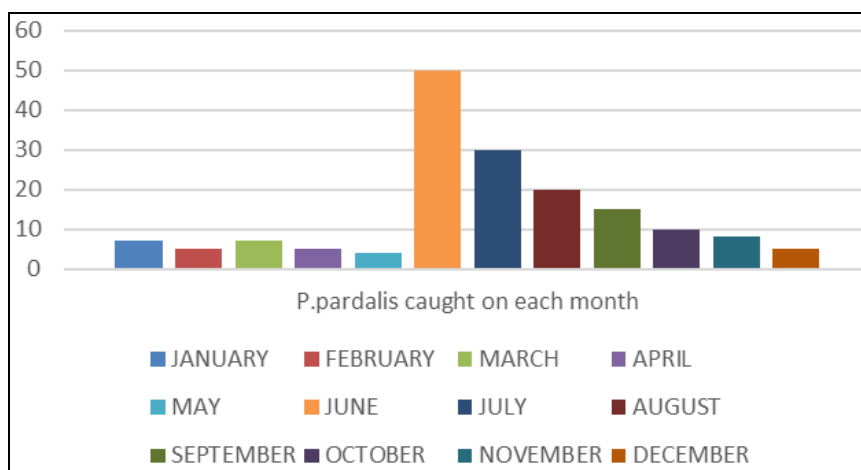


Fig 3: Shows the number of *Pterygoplichthys pardalis* caught in the year 2021 January-2021 December

Table 2: Morphometric characteristics of *Pterygoplichthys pardalis*

Sl. No.	Morphometry	Range N=20	Mean \pm SD
1.	Total Length (in cm)	9.50 - 31.75	24.33 \pm 12.85
2.	Weight (W) (in g)	8.16 - 129.80	89.25 \pm 70.23
3.	Fork Length (FL)	8.70 - 28.9	22.17 \pm 11.66
4.	Standard Length (SL)	7.20 - 25.4	19.33 \pm 10.50
5.	Pre-Dorsal Length (PrDoL)	3.00 - 9.00	7 \pm 3.46
6.	Pre-Adipose Length (PrAL)	6.20 - 20.60	115.8 \pm 8.31
7.	Pre-Pectoral Length (PrPL)	1.80 - 5.10	4 \pm 1.90
8.	Pre-Pelvic Length (PrPeL)	3.40 - 11.5	8.8 \pm 4.68
9.	Pre-Anal Length (PrAnL)	5.00 - 17.00	13 \pm 6.93
10.	First Dorsal Fin Length (FDoFL)	1.80 - 5.20	4.1 \pm 1.96
11.	Adipose Dorsal Fin Length (ADoFL)	0.40 - 2.00	1.47 \pm 0.92
12.	Pectoral Fin Length (PcFL)	1.90 - 7.20	5.43 \pm 3.06

13.	Pelvic Fin Length (PvFL)	1.60 - 5.50	4.2 ± 2.25
14.	Anal Fin Length (AnFL)	1.20- 4.00	3.10 ± 1.62
15.	Caudal Fin Length (CFL)	2.10 - 7.20	5.5 ± 2.94
16.	Dorsal Fin Base Length (DoFBL)	2.40 - 8.50	6.47 ± 3.52
17.	Adipose Dorsal Fin Base (ADoFL)	0.50 - 1.40	1.1 ± 0.52
18.	Pectoral Fin Base (PFB)	0.4- 1.90	1.3 ± 0.69
19.	Anal Fin Base (AFB)	0.20 - 1.60	1.13 ± 0.81
20.	Caudal Fin Base (CFB)	0.80 - 3.00	1.27 ± 2.27
21.	Caudal Peduncle Depth (CPD)	0.7- 4.50	3.23 ± 2.19
22.	Head Length (HL)	2.00 - 5.10	4.07 ± 1.79
23.	Eye Diameter (ED)	0.3- 1.80	1.3 ± 0.87
24.	Body Depth (BD)	1.50 - 4.50	3.5 ± 1.73
25.	Snout Length (SnL)	1.20 - 3.50	2.73 ± 1.33
26.	Upper Jaw Length (UpJL)	0.9- 3.20	2.43 ± 1.33
27.	Lower Jaw Length (LoJL)	0.8 - 3.50	2.6 ± 1.56
28.	Maxillary Labial Length (MaLL)	0.4- 1.70	1.27 ± 0.75
29.	Head Width (HW)	1.40 - 3.30	2.67 ± 1.10

*Abbreviations of meristic counts: Do-dorsal, An-anal, P-pectoral, V-ventral, C-caudal.

Table 3: Meristic characteristics of *Pterygoplichthys pardalis*

Sl. No.	Meristic Characters	Number
1.	Dorsal Fin Spines (DFS)	12
2.	Caudal Fin Rays (CFR)	16
3.	Pectoral Fin Rays (PeFR)	6
4.	Pelvic Fin Rays (PvFR)	6
5.	Anal Fin Rays (AFR)	4



Fig 3: Shows the *P. pardalis*



Fig 4: Lateral view of *P. pardalis*

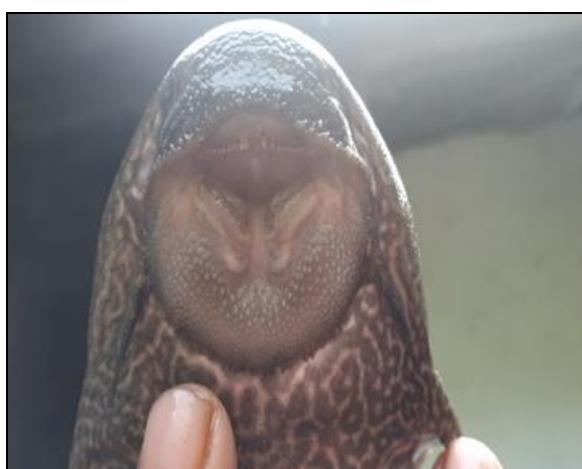


Fig 5: Triangular mouth with denticles of *P. pardalis*



Fig 6: Gill arch and eyes of *P. pardalis*



Fig 7: Snout region of *P. pardalis*



Fig 8: Ventral view of *P. pardalis*

4. Discussion

The present study revealed the occurrence of *Pterygoplichthys pardalis*, a non-native invasive facultative air-breathing fish (AIS) in the Gayathripuzha River, Kerala. The sample was recognized as *Pterygoplichthys pardalis* based on the morphometric and meristic measurements (Weber, 1991)^[65], Bijukumar *et al.* (2015)^[19] and Muralidharan *et al.* (2015)^[43], sailfin catfishes into the rivers have led to their visible naturalization and threats to native ichthyofauna diversity.

Several researchers recorded the invasion of species *Pterygoplichthys* have successfully arriving territorial water bodies of several countries worldwide, USA (Nico and Martin, 2001)^[46], Europe (Keszka *et al.* 2008)^[30], Philippines (Joshi 2006; Hubilla *et al.* 2007)^[27, 28] Vietnam (Zworykin and Budaev 2013)^[69], Israel (Golani and Snovsky 2013)^[20] Japan (Nakabo 2002)^[44], Taiwan (Wu *et al.* 2011)^[68], Turkey (Ozdilek, 2007)^[50], Singapore, Indonesia Malaysia and (Robins and Page 2006)^[53], Bangladesh (Hossain *et al.* 2008)^[26], Mexico (Armando *et al.* 2007; Piazzini *et al.* 2010; Simonovic *et al.* 2010)^[1, 59, 60] and Sri Lanka (Amarasinghe and Sumanasinghe, 2013)^[63]. Weber (1991)^[65] noticed the established populations of *Pterygoplichthys disjunctivus* in Philippine waters and *Pterygoplichthys pardalis* by Chavez and his colleagues (2006)^[13], Page and Robins (2006)^[53] reported invasion of Genus *Pterygoplichthys* spp. in Singapore waterways.

In America, 150 species were reported that belong to the genus *Pterygoplichthys* spp., out of the four species were recorded in India implying the invasion in Indian aquatic habitats (Rama and Venugopal, 2017)^[56] West Bengal, Bihar, and Uttar Pradesh (Singh 2004)^[61]. *Pterygoplichthys pardalis* is reported in the coastal regions of West Bengal, Bihar, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, and Kerala in India also documented. Four species of the suckermouth armoured catfishes viz., *Pterygoplichthys anisitsi* found in Bihar (Sinha *et al.* 2010)^[62], *P. multiradiatus* found in Kerala and Tamil Nadu (Ajithkumar *et al.*, 1998; Daniels, 2006; Krishnakumar *et al.*, 2009; Knight, 2010)^[2, 14, 33, 31] *Pterygoplichthys disjunctivus* and *P. pardalis* from Uttar Pradesh, Bihar, Andhra Pradesh and West Bengal (Singh, 2004; Sinha *et al.* 2010)^[61, 62] were reported. Similarly, *Pterygoplichthys pardalis* existence has been reported in the current study as one of the main tributaries of River Bharathapuzha, Kerala. The findings of Daniels (2006)^[14] and Krishnakumar *et al.* (2009)^[33] supported the occurrence of another species *Pterygoplichthys multiradiatus* of the genus in Vylathur and the Chackai Canal, Kerala, and wetlands of Chennai,

Tamilnadu by Knight (2010)^[31]. Similar reports by Muralidharan (2015)^[43] in the Cauvery basin of Mettur, Tamil Nadu also supported the invasion. The prevalence of Genus *Pterygoplichthys* issues is emerging worldwide (Devick, 1989; Hoover *et al.*, 2004; Page and Robins, 2006)^[15, 25, 53] reported adversely in the USA, causing disturbances in the aquatic food chain and a decline in abundance of native fishes in this current scenario.

P. pardalis increased the size almost gradually as they grew from juvenile to the adult stage. They are moderately large catfish, with adults ranging from about 30 to 55 cm in total length (Liang *et al.* 2005; Nico *et al.* 2009a)^[37, 47] although maximum size can reach nearly 50 cm (Froese and Pauly 2016)^[18]. *Pterygoplichthys pardalis* measurements in Vietnam are standard length (mm) 189.4, head length 54.3, and snout length 23.5 (Levin *et al.* 2008)^[36]. In Colombia, the morphometrics of *P. pardalis* standard length ranges from 209.89-252 and 76.1-422.9, head length 58.3-75.55 and 26.7-35.1 and snout length 32.17-40.45 and 26.4-57.2 in Cauca River and Laguna Bay respectively (Henry *et al.* 2021)^[22]. The *P. pardalis* collected from the Gayathripuzha river, Kerala shows similar morphometric traits.

In India, Ichthyology studies propose the occurrence of Alligator Gar an invasive species of North American fish which is predatory and grows to an average of 8 feet in length, in the city's Pawna dam, Pune (Bijukumar *et al.* 2018)^[8] and revision of the list of invasive fish existing which is being imported in India further studies warrants to protect its local varieties from alien, alien species filling an ecological niche in the aquatic environment.

The aquaculturists of the southern state of Kerala, India is culturing the cultivable commercial fish either in the natural water bodies or in man-made ponds/tanks. The aquaculturist introduces aquarium fishes into the natural water bodies to culture *Pterygoplichthys* spp., which supports the evidence of Daniels (2006)^[14] culture of *Pterygoplichthys multiradiatus* in the natural freshwater canal, Kerala. The present investigation confirmed the existence of *Pterygoplichthys pardalis* species invasion in the Bharathapuzha River Kerala which is rapidly introduced into the freshwater ecosystem of Kerala by the aquaculturists accidentally. The freshwater riverine system is highly rich in diversity with a variety of species, which is ecologically sensitive due to the introduction of invasive species that will disturb and destroy the biodiversity of native species in this ecosystem.

Moreover, the present study reported the existence of *Pterygoplichthys pardalis* in the freshwater ecosystem of

Gayathripuzha River, Palakkad, Kerala which is away from the coastal region. Bijukumar *et al.* (2015) ^[9] reported the invasion of Amazon Sailfin suckermouth armoured Catfishes *Pterygoplichthys* spp. from the Trivandrum, a coastal region of Kerala. The presence of this species indicates that could have either migrated through Ponnani estuaries into the Bharathapuzha River or by aquaculturists. The Palakkad district is located in the middle of the Kerala state and is blessed with many freshwater rivers namely Bharathapuzha (Nila), Shiruvani, Bhavani, Thuthapuzha, Kalpathy, Kannadi, Chitturpuzha, Kollengode, and Gayathripuzha (District Environment Plan-Palakkad) indicating the invasion in the inland riverine system.

The collected fishes from the Gayathripuzha River were examined identified and confirmed the presence of *Pterygoplichthys pardalis* that exhibited dark spots in the white background abdominal region. Similar findings were reported by Nico *et al.* (2012) ^[49] for the occurrence of four closely related species *Pterygoplichthys anisitsi*, *Pterygoplichthys multiradiatus*, *Pterygoplichthys pardalis*, and *Pterygoplichthys disjunctivus* based on the abdominal patterns, further confirmed by Bijukumar *et al.* (2015) ^[9] among the ornamental fish traders and hobbyists in Thiruvananthapuram.

Interestingly, the sailfin catfishes have been found in rice fields in Northeast Thailand for at least the past 10 years (Welcomme and Vidthayanom, 2003) ^[67]. In the present study, the occurrence of *Pterygoplichthys* spp. in six out of fifteen farms surveyed reported paddy farms during the summer season near the Gayathripuzha River. However, scientists from other countries have also reported the presence of *P. pardalis* on agricultural farms.

Pterygoplichthys species are adapted by their external body plates, which can help them from native predators even in mainstream habitation (Liang *et al.* 2005, Özdilek *et al.* 2007, Wakida-Kusunoki *et al.* 2007) ^[35, 50, 64] the profusion cannot be controlled effortlessly (CEC, 2009., Nico *et al.* 2012) ^[12, 49]. *Pterygoplichthys disjunctivus* (Weber, 1991) ^[65] and *P. pardalis* are known to be high fecundity. There are possibilities for hybridization in the aquatic habitats, aquariums, and farms which warrants further detailed studies. Findings of the said literature together with the results of the current study suggest that the sucker armour mouth catfish is existing in the paddy farms of Gayathripuzha River.

5. Conclusion

The present study documented the occurrence of *Pterygoplichthys pardalis* in the river of Gayathripuzha, Kerala State, which is an invader species. This might have occurred by aquaculturists either introducing fish unintentionally into the water bodies through accidents causing many ecological impacts including disturbance to food chains by overgrazing benthic algae and competing with endemic freshwater fishes. Small fishes (8-10 cm long) are found in the cast net during night fishing by fishermen, confirming that the breeding of *Pterygoplichthys pardalis* has occurred in the riverine ecosystem. The existence of *Pterygoplichthys pardalis* in Gayathripuzha River requires in the forthcoming aquatic management and conservation plan. These findings help fishery managers to map out the distribution of *Pterygoplichthys* spp. in this region as well as to sensitize on the hazards of releasing aquarium pets. Hence, continuous investigations are necessary to evaluate the current distribution pattern and to understand the biological habitat

loss by the wide spreading of exotic species on the already threatened fish accumulation in Palakkad, Kerala. There is an urgent need for a legislature to prevent the discharge of ornamental fish and potentially damaging cultivable alien species into the natural bodies. This provides preliminary information on the occurrence of *Pterygoplichthys* spp., and possibilities of invasion to the neighboring water system. A continuous survey is needed to expand the search into other tributaries to characterize their dispersal ability in the entire riverine system.

Author contributions

All authors contributed to material preparation, data collection, analysis, and manuscript revision. Both authors read and approved the final manuscript. All authors read and approved the final manuscript.

Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability Statement

The data used to support the findings of this study are included in this manuscript.

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