Diversity, distribution and assemblage structure of fishes in streams of southern Western Ghats, India

J.A. Johnson [1] & M. Arunachalam [2]

[1] Wildlife Institute of India, P.Box No. 18, Chandrabani, Dehradun, Uttarakhand 248001, India
[2] Sri Paramakalyani Centre for Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi, Tamil Nadu 627412, India
Email: [1] jajohny@rediffmail.com

Abstract: Diversity, distribution and assemblage structure of fishes were studied in 10 selected streams of southern Western Ghats. The sampling was performed between April 2001 and March 2002. Sixty species of primary freshwater fishes belonging to four orders, 13 families and 27 genera were recorded from the study area. Cyprinids were the most dominant assemblage members in all study streams. Maximum number of species, number of individuals and cyprinids were recorded from Thalayanai stream. More specialized forms *Homaloptera santhamparaiensis, Glyptothorax madraspatanum, Noemacheilus guentheri, N. keralensis, N. semiarmatus* and *N. triangularis* were recorded in Panniyar stream. High diversity was observed in Achankoil stream. Evenness index of similarity was uniform in all study streams. Similarity cluster analysis showed streams from nearby basins had similar faunal assemblages. Principal Component Analysis was performed to study the similarity of fish assemblages between the study streams. The analysis described clear pattern of segregation between Thalayanai and Karaiyar (east flowing) and Kallar and Achankoil (west flowing) streams. Thirty-nine Western Ghats endemic fishes were recorded from the study area. Current distribution and threats to endemic fishes are discussed.

Keywords: Assemblage structure, endemic fishes, fish diversity, species richness, Western Ghats.

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Introduction

Freshwater habitats in rivers, streams, springs and headwaters are heterogeneous due to variations in altitude, flow rates, dissolved oxygen, physical substrate and the riparian zones that provide food, shade and cover (Armantrout 1990). As a result, freshwater habitats harbour diverse fauna, with fish serving as prime indicators of ecosystem status (Karr et al. 1986). Riverine fauna show a high degree of endemism, with most endemic fish species living in headwater streams and/or short stretches of river (Groombridge 1992; Kottelat & Whitten 1997). Thus riverine freshwater habitats are among the least studied, and likely many species still await discovery (Kottelat & Whitten 1997).

The Western Ghats biogeographic region of India is home to a highly diverse fish fauna, consisting of 288 known species belonging to 12 orders, 41 families and 109 genera (Dahanukar et al. 2004), of which 116 (53%) species are endemic to this region (Daniels 2001). Until recently few details on abundance and assemblage organization were available for streams and rivers (Silas 1951; 1953; Rajan 1963; Johnsingh & Vickram 1987; Devi 1992; Devi & Menon 1994; Devi et al. 1997; Easa & Shaji 1997; Johnson & Soranam 1999; Arunachalam & Johnson 2002; Arunachalam et al. 2002), however, recent studies have examined diversity distribution and assemblage organization. Arunachalam (2000) studied association of microhabitat variables to species diversity and habitat usage, and diversity, endemism and distribution patterns of fishes have been studied in the central (Bhat, 2003; 2004; Dahanukar et al. 2004) and Kerala regions (Raghavan et al. 2008). While reports on the fish assemblage and distribution patterns seem to cover the Western Ghats fairly well, gaps remain with regard to assemblage structure of the southern region. Thus the main objective of this study is to describe fish assemblage structure in streams of the southern Western Ghats, assess species diversity and similarity of faunal assemblage between streams and evaluate endemism and current conservation status of Western Ghats fish populations.

Materials and Methods

Study Area: The southern Western Ghats lie between 8°-12°N & 76°-78°E. The region covers about 500km of mountain valleys shared by Tamil Nadu and Kerala. The important ecoregions of this area are Agasthyamalai, Anamalai, Cardamom hills and Nilgiris. This hill chain is interrupted in the north by the 30km wide Palghat gap at around 11°N, and south of this gap lies the Anamalai range of hills with its highest peak Anaimudi at 2695m. This area receives precipitation from both southwest (June to September) and northeast (October to November) monsoons and the average annual precipitation exceeds 2,800mm. Many torrential and perennial hill streams of this

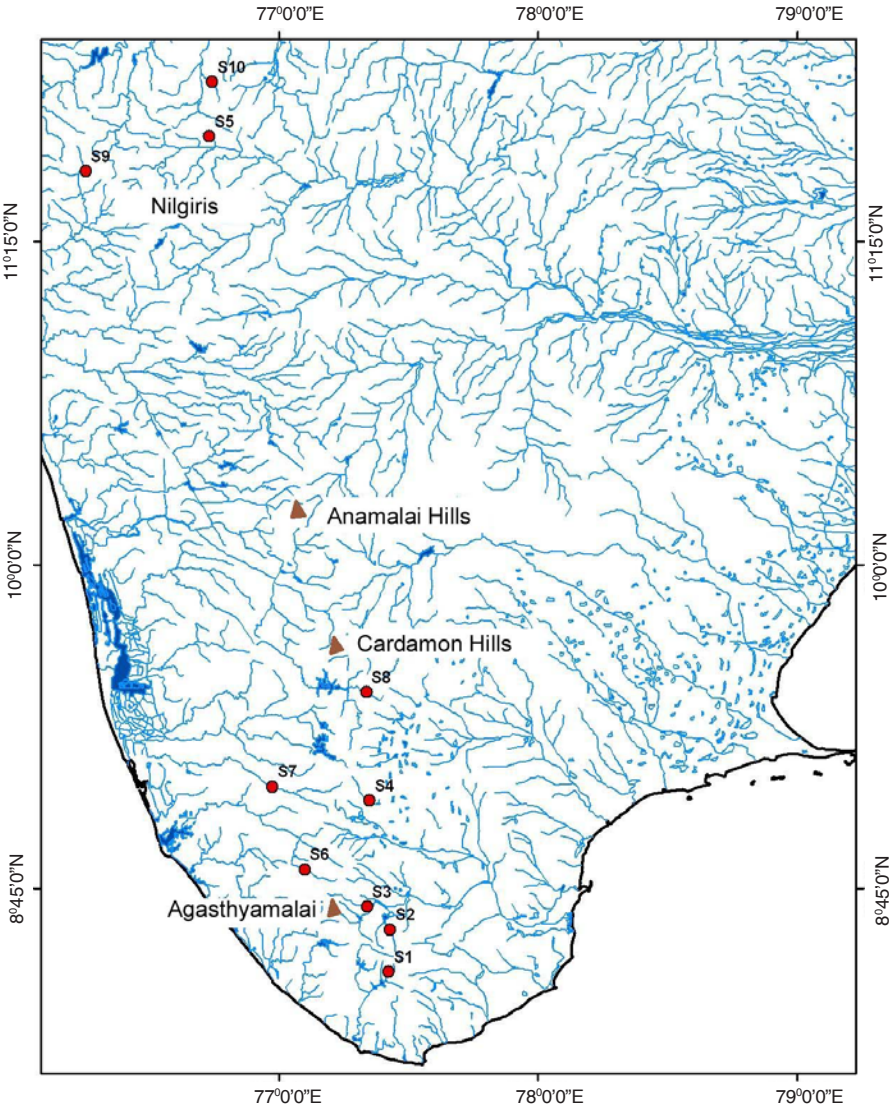

Figure 1. Map indicating sampling sites in southern Western Ghats.
S1 - Samikuchi; S2 - Thalayanai; S3 - Karaiyar; S4 - Hanumannadhi; S5 - Gogalthurai; S6 - Kallar; S7 - Achankoil; S8 - Panniyar; S9 - Thalipuzha; S10 - Bavalipuzha.

region are the main source of major west and east flowing rivers. The western portion is drained by the Vamanapuram, Pamba, Periyar, Bharathapuzha and Chaliyar. In addition to major rivers, number of quick flowing streams originate and quickly discharge into Arabian Sea. The eastern portion is drained by the Tamiraparani, Vaigai, Moyar, Bhavani and Cauvery rivers. In the present study ten streams covering major river basins in Tamil Nadu and Kerala states were selected (Fig. 1) and the sampling was carried out between April 2001 and March 2002. The study streams and their general features are given in Table 1.

Data collection: Fish sampling was performed in 100m reach of all study streams. In each stream the sampling was made in different habitats such as pools, riffles, runs and cascades using monofilament gill nets of different mesh sizes (10 to 34 mm), drag, scoop and cast nets. Fish sampling followed the method of Arunachalam (2000). After collection fishes were examined, counted and released. A few specimens (5-10) of unidentified species were preserved in buffered formalin (10%) and transported to the laboratory for analysis. Species identification and confirmation were carried out using standard fish taxonomy textbooks (Talwar & Jhingran 1991; Jayaram 1999). Data on current conservation status was obtained from reports of the Conservation Assessment and Management Plan workshop (Molur & Walker 1998) on freshwater fishes of India.

Analysis: Information about structure of assemblages was extracted by adopting different univariate indices, namely Margalef's species richness index, Shannon diversity index and Shannon evenness index. The calculation of these indices was followed by the methods of Magurran (1988) and Padhye et al. (2006). Margalef's species richness is calculated using the equation $R = (S-1)/\ln N$, where S is the number of species, N is the total number of individuals. The Shannon index of diversity is obtained by the following equation $H' = \sum pi$. In pi, where $pi = ni/N$; ni is the number of individuals of 'i'th species and $N = \sum ni$. Evenness index is calculated by $E = H'/\ln S$, where S is the number of species. The indices were used to compare the species richness, diversity and equitability across the study streams. The quantitative data of species along with the number of individuals belonging to each species were used to calculate percent similarity index using Bray-Curtis similarity index based on Padhye et al. (2006). Dendrograms were constructed to understand the similarity between the sampling sites. This was done using Bray-Curtis similarity index using non-transformed species abundance data (Anderson 2001). Further, Principal Component Analysis (PCA) was performed to study the similarity of fish assemblage between the study streams and understand which species contributed to the difference in fish assemblage between east and west flowing streams.

Results

Fish assemblage structure, species diversity and similarity:

During the study a total of 60 species of primary freshwater fishes belonging to four orders, 13 families and 27 genera were recorded from the study streams (Table 2). Number of species, total abundance, cyprinid abundance and their percentage, richness index, Shannon diversity and evenness index for study streams are given in Table 3. Maximum numbers of species and individuals were recorded in Thalayanai stream, while low number of species and individuals were recorded in Hanumannadhi stream. In the assemblage structure, cyprinids constituted the dominant group (72.6 to 92.3%) and the cyprinids *Danio*

Table 1. Summary of study sites characters in southern Western Ghats

Sites	River basin East/ West flowing	Latitude/longitude	Altitude (m)	Stream order	Stream gradient (%)	Mean width (m)	Riparian vegetation
Samikuchi (S1)	Chittar - II - West flowing	8°25'48"N & 77°25'22"E	500	3	7	45.6	50% old growth forests and rubber plantation
Thalayanai (S2)	Manimuthar - East flowing	8°35'36"N & 77°25'42"E	300	3	7	25.6	60-70% old growth forest
Karaiyar (S3)	Tamiraparani - East flowing	8°40'56"N & 77°20'24"E	300	3	7	13.8	70-80% old growth forest
Hanumannadhi (S4)	Chittar - East flowing	9°05'30"N & 77°20'59"E	200	3	2	37.4	20% areca and coconut farms
Gugalthurai (S5)	Cauveri - East flowing	11°40'28"N & 76°45'34"E	600	3	6	11.5	60% old growth forest
Kallar (S6)	Vamanapuram - West flowing	8°45'25"N & 77°15'39"E	800	3	7	22	70% old growth forest
Achankoil (S7)	Achankoil - West flowing	9°10'12"N & 76°50'28"E	600	4	4	20	70-80% old growth forest
Panniyar (S8)	Periyar - West flowing	9°45'14"N & 77°15'35"E	912	3	6	14	60-70% clove and cardamom plantations
Thalipuzha (S9)	Cauvery - East flowing	11°30'51"N & 76°15' 46"E	750	3	3	9.1	50% areca and orchard plantation
Bavalipuzha (S10)	Cauvery - East flowing	11°55'22"N & 76°45' 37"E	1350	3	4	20	60-70% old growth forest

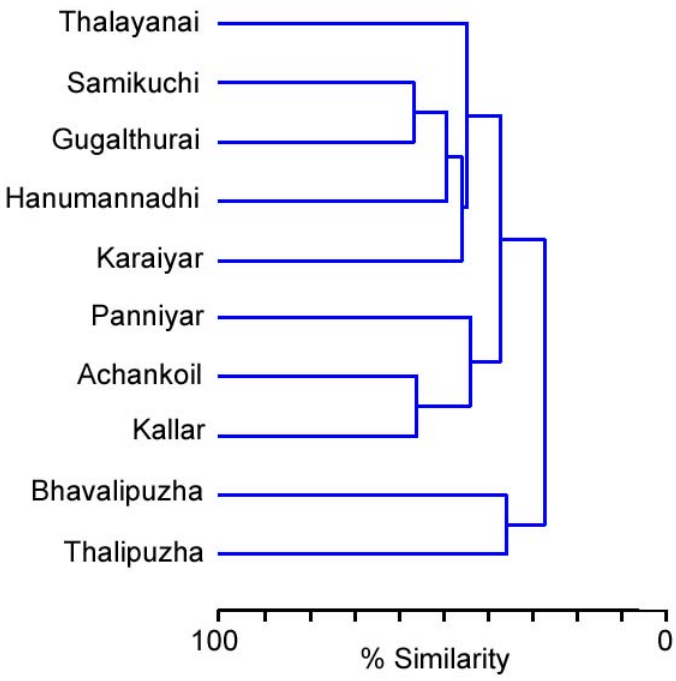

Figure 2. Dendrograms resulting from Bray-Curtis similarities of species abundance data of study streams. [S1-Samikuchi; S2-Thalayanai; S3-Karaiyar; S4-Hanumannadhi; S5-Gogalthurai; S6-Kallar; S7-Achankoil; S8-Panniyar; S9-Thalipuzha; S10-Bavalipuzha.]

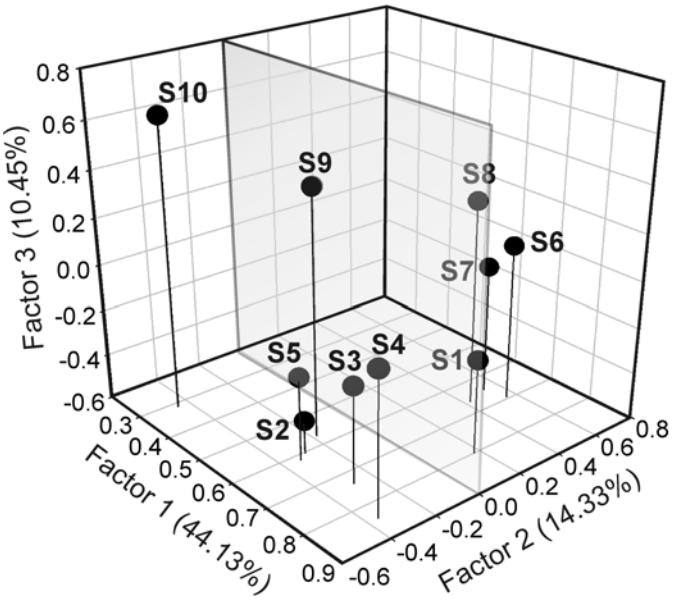

Figure 3. Principal Component Analysis (PCA) of streams based on freshwater fish species assemblage. Only first three significant factors with eigenvalue more than one are plotted. East flowing streams (S2, S3, S4, S5, S9 and S10) separate from the west flowing streams (S1, S6, S7 and S8) on the F2 axis (separated by a grey transparent plane). Numbers in parenthesis are percent variation explained by each PCA factor. Stream numbers are as per Fig. 2.

aequipinnatus, *Garra mullya* and *Rasbora daniconius* were represented in all the study streams. The maximum number of cyprinid individuals was recorded from Thalayanai stream, which represented a number of big sized barbs such as *Hypselobarbus curmuca*, *H. kolus*, *H. dubius*, *H. dobsoni*, *Tor khudree* and *Barbodes sarana*. Low cyprinid populations was observed in Bhavalipuzha, followed by Panniyar stream and these streams harboured some specilized forms like *Homaloptera santhamparaiensis*, *Glyptothorax madraspatanum*, *Noemacheilus guentheri*, *N. keralensis*, *N. semiarmatus* and *N. triangularis*. Shannon diversity index showed high value in Achankoil, Kallar and Bhavalipuzha streams. The evenness index of species distribution was uniformly similar in all study streams except Thalayanai stream, where the equitability of species was low.

Cluster analysis of species composition showed that the streams from near by basins had similar faunal assemblage when the dendrogram was drawn based on the Bray-Curtis similarity index (Fig. 2). Among the east flowing streams, Karaiyar and Thalayanai had more similarity in fish species assemblage. Similarly, in west flowing streams, Bhavalipuzha and Thalipuzha had similar fish assemblage. Principal Component Analysis showed a clear pattern of similarity between the study streams with respect to the fish assemblage (Fig. 3). PCA extracted three significant factors with factor loading above one. These three factors together explained about 70% of total variation in the data. West flowing rivers (S1, S6, S7 and S8) were separated from the east flowing rivers mainly on the F2 axis (separated by a transparent plane in Fig. 3). Out of the total 60 fish species, 29 had positive factor loading on F2 axis and were either restricted or had high abundance in the west flowing streams while 31 had negative factor loading on F2 axis and were either restricted or had low abundance to

Table 2. List of fish species recorded from the study streams of Western Ghats.

Fish species	S1*	S2	S3	S4	S5	S6	S7	S8	S9	S10
Cyprinodontiformes										
Aplocheilidae										
Genus: Aplocheilus										
Aplocheilus lineatus	-	-	-	-	-	-	18	-	11	-
Aplocheilus panchax	-	-	-	-	-	-	8	-	-	-
Cyriniformes										
Cyprinidae										
Genus: Barbodes										
Barbodes carnaticus	-	-	-	-	48	-	-	-	-	-
Barbodes sarana	-	8	-	-	12	-	-	-	-	-
Genus: Barilius										
Barilius bakeri	42	-	-	-	-	72	76	44	-	-
Barilius gatensis	-	-	-	-	24	-	-	-	54	-
Genus: Danio										
Danio aequipinnatus	42	85	68	88	44	38	34	36	42	28
Danio (Brachydanio) rerio	-	-	-	-	-	-	-	-	-	25
Genus: Garra										
Garra gotyla stenorhynchus	-	-	-	-	-	-	-	-	-	15
Garra hughi	-	-	-	-	-	15	-	-	-	-
Garra mcclellandi	-	-	-	-	-	-	-	33	-	-
Garra mullya	32	48	18	36	24	45	46	14	36	42
Genus: Horalabiosa										
Horalabiosa arunachalami	-	-	-	-	-	-	-	11	-	-
Horalabiosa joshuai	-	-	28	-	-	-	-	-	-	-
Genus: Hypselobarbus										
Hypselobarbus curmuca	-	16	-	-	-	-	-	-	-	-
Hypselobarbus dobsoni	-	68	-	-	-	-	-	-	-	-
Hypselobarbus dubius	-	18	-	-	-	-	-	-	-	-
Hypselobarbus kolus	-	14	-	-	-	-	-	-	-	-
Hypselobarbus kurali	-	-	-	-	-	26	-	-	-	-
Hypselobarbus micropogon	-	-	-	-	32	-	-	-	8	-
Genus: Osteochilichthys										
Osteochilichthys nashii	-	-	-	-	-	-	-	-	15	-
Genus: Puntius										
Puntius amphibious	-	68	-	-	-	-	55	-	-	-
Puntius arenatus	-	-	-	-	-	-	32	-	-	-
Puntius tambraparniei	-	88	22	-	-	-	-	-	-	-
Puntius bimaculatus	64	45	-	34	28	-	-	-	-	-
Puntius conchonius	-	-	-	-	-	-	-	-	16	22
Puntius denisonii	-	-	-	-	-	-	24	-	-	-
Puntius dorsalis	32	22	-	-	38	-	38	-	-	-
Puntius fasciatus	-	-	-	-	-	35	-	-	-	-
Puntius filamentosus	22	38	24	-	14	56	52	-	-	-
Puntius kannikattiensis	-	-	22	-	-	-	-	-	-	-
Puntius melanampyx	32	-	-	-	-	65	46	45	32	-
Puntius parrah	-	-	-	-	-	-	-	-	-	34
Puntius sophore	-	-	-	-	-	-	-	-	-	24
Puntius ticto	18	-	-	-	26	-	-	-	-	-
Genus: Rasbora										
Rasbora caverii	-	-	-	-	-	-	-	-	-	14
Rasbora daniconius	22	32	32	43	38	34	54	45	15	18
Genus: Salmostoma										
Salmostoma boopis	-	-	-	-	-	-	15	-	-	-
Salmostoma clupeoides	-	-	-	-	20	-	-	-	-	15
Genus: Tor										
Tor khudree	24	12	37	-	23	30	-	-	-	-
Balitoridae										
Genus: Bhavania										
Bhavania australis	12	18	17	-	-	24	22	-	-	-
Genus: Noemacheilus										
Noemacheilus denisoni	-	-	-	-	-	15	-	-	-	-
Noemacheilus guentheri	-	-	-	-	-	-	-	6	-	-
Noemacheilus keralensis	-	-	-	-	-	-	-	28	-	-
Noemacheilus semiarmatus	-	-	-	-	-	-	-	15	13	16
Noemacheilus triangularis	12	15	10	24	18	28	-	25	-	-
Genus: Homaloptera										
Homaloptera santhamparaiensis	-	-	-	-	-	-	-	7	-	-
Genus: Botia										
Botia striata	-	-	-	-	-	5	-	-	-	-
Gobitidae										
Genus: Lepidocephalus										
Lepidocephalus thermalis	-	-	-	14	18	15	-	-	-	-
Siluriformes										
Bagridae										
Genus: Mystus										
Mystus armatus	-	-	-	-	-	-	-	-	25	-

Fish species	S1*	S2	S3	S4	S5	S6	S7	S8	S9	S10
Genus: Batasio										
Batasio travancoria	-	-	-	-	-	-	10	-	-	-
Clariidae										
Genus: Clarias										
Clarias dussumieri	-	-	-	-	-	-	-	-	-	15
Siluridae										
Genus: Silurus										
Silurus wynaadensis	-	8	-	-	-	8	-	-	-	-
Sisoridae										
Genus: Glyptothorax										
Glyptothorax madraspatanum	-	2	-	-	-	-	-	5	-	-
Schilbeidae										
Genus: Proeutropiichthys										
Proeutropiichthys taakree taakree	-	-	-	-	-	-	4	-	-	-
Perchiformes										
Ambassidae										
Genus: Pseudambassis										
Pseudambassis baculis	-	-	-	-	-	-	-	-	-	28
Pseudambassis ranga	-	-	-	-	-	-	-	-	-	24
Channidae										
Genus: Channa										
Channa orientalis	-	-	-	-	-	10	-	-	-	-
Cichlidae										
Genus: Etroplus										
Etroplus maculates	-	-	-	-	-	-	34	-	-	-
Mastacembelidae										
Genus: Mastacembelus										
Mastacembelus armatus	-	4	-	-	-	-	-	-	-	10

*Stream numbers as per Table 1.

Table 3. Variation in species abundance, cyprinid abundance, richness index, Shannon index and evenness index

Study sites	S1*	S2	S3	S4	S5	S6	S7	S8	S9	S10
Species	12	19	10	6	15	17	17	13	11	15
Individuals	354	609	278	239	407	521	568	314	267	330
Cyprinid abundance	330	562	251	201	335	396	520	228	226	237
Cyprinids Percentage (%)	93.2	92.3	90.3	84.1	82.3	80.0	91.6	72.6	84.6	72.0
Shannon index	2.38	2.61	2.17	1.64	2.63	2.64	2.66	2.36	2.24	2.64
Margalef's index	1.87	2.81	1.60	0.91	2.33	2.56	2.52	2.09	1.80	2.41
Evenness index	0.96	0.88	0.94	0.91	0.97	0.93	0.94	0.92	0.93	0.97

*Stream numbers as per Table 1.

east flowing rivers. Out of these, fishes like *Puntius conchonius*, *Danio (Brachydanio) rerio*, *Garra gotyla stenorhynchus*, *Mystus armatus* and *Pseudambassis ranga*, which were restricted to the east flowing streams and *Puntius denisonii* and *Etroplus maculates*, which were restricted while west flowing streams showed similar pattern to the one documented by Easa & Shaji (1997). Other fish species which were restricted to east flowing streams were *Barbodes carnaticus*, *Horalabiosa joshuai*, *Hypselobarbus curmuca*, *H. dobsoni*, *H. dubius*, *H. kolus*, *H. micropogon*, *Puntius kannikattiensis*, *P. parrah*, *Rasbora caverii* and *Salmostoma clupeoides* and those restricted to the west flowing streams were *Hypselobarbus kurali*, *Puntius fasciatus*, *Puntius arenatus*, *Homaloptera santhamparaiensis*, *Noemacheilus keralensis* and *Batasio travancoria*.

Endemism and current conservation status:

Out of 60 species, 39 species are endemic to Western Ghats of Peninsular India (Table 4). Among the endemic species nine are strictly endemic to west flowing systems of southern Western Ghats (*Barilius bakeri*, *Batasio travancoria*, *Gara hughi*, *Horalabiosa arunachalami*, *Homaloptera santhamparaiensis*, *Hypselobarbus kurali*, *Puntius denisonii*, *Noemacheilus guentheri* and *N. keralensis*) and five are endemic to east flowing system of southern Western Ghats (*Garra gotyla stenorhynchus*, *Horalabiosa joshuai*, *Hypselobarbus dubius*, *Puntius tambraparniei* and *Puntius kannikattiensis*). Out of 39 endemic species, 25 (64%) are in threatened categories (Table 4), of which three species, *Puntius tambraparniei*, *Puntius narayani* and *Silurus wynaadensis* are Critically Endangered; 14 species (*Garra gotyla stenorhynchus*, *Bhavania australis*, *Garra hughi*, *Puntius denisonii*, *P. dorsalis*, *P. fasciatus*, *P. parrah*, *Hypselobarbus curmuca*, *H. kolus*, *H. kurali*, *H. dubius*, *H. micropogon*, *Noemacheilus keralensis* and *Botia striata*) are Endangered; eight species (*Barbodes carnaticus*, *Barilius bakeri*, *Batasio travancoria*, *Clarias dussumieri*, *Glyptothorax madraspatanum*, *Proeutropiichthys taakree taakree*, *Tor khudree* and *Noemacheilus semiarmatus*) are in Vulnerable categories (Molur & Walker 1998).

Discussion

The Western Ghats streams exhibit high variability in fish assemblages and the assemblage composition is determined by specific ecological conditions. Notable highest diversity of

Table 4. Conservation status of endemic fish recorded from the study streams

SNo	Western Ghats endemic species	Status*	Endemic to	
			West flowing system	East flowing system
1.	*Barbodes carnaticus*	VU		
2.	*Barilius bakeri*	VU	+	
3.	*Barilius gatensis*	NE		
4	*Garra gotyla stenorhynchus*	EN		+
5.	*Garra hughi*	EN	+	
6.	*Garra mcclellandi*	NE		
7.	*Horalabiosa arunachalami*	NE	+	
8.	*Horalabiosa joshuai*	NE		+
9.	*Hypselobarbus curmuca*	EN		
10.	*Hypselobarbus dobsoni*	NE		
11.	*Hypselobarbus dubius*	EN		+
12.	*Hypselobarbus kolus*	EN		
13.	*Hypselobarbus kurali*	EN	+	
14.	*Hypselobarbus micropogon*	EN		
15.	*Osteochilichthys nashii*	NE		
16.	*Puntius tambraparniei*	CR		+
17.	*Puntius bimaculatus*	NE		
18.	*Puntius denisonii*	EN	+	
19.	*Puntius dorsalis*	EN		
20.	*Puntius fasciatus*	EN		
21.	*Puntius kannikattiensis*	NE		+
22.	*Puntius melanampyx*	NE		
23.	*Puntius parrah*	EN		
24.	*Rasbora caverii*	NE		
25.	*Salmostoma boopis*	NE		
26.	*Tor khudree*	VU		
27.	*Bhavania australis*	EN		
28.	*Noemacheilus denisoni*	NE		
29.	*Noemacheilus guentheri*	LRlc	+	
30.	*Noemacheilus keralensis*	EN	+	
31.	*Noemacheilus semiarmatus*	VU		
32.	*Noemacheilus triangularis*	LRlc		
33.	*Homaloptera santhamparaiensis*	NE	+	
34.	*Botia striata*	EN		
35.	*Batasio travancoria*	VU	+	
36.	*Clarias dussumieri*	VU		
37.	*Silurus wynaadensis*	CR		
38.	*Glyptothorax madraspatanum*	VU		
39.	*Proeutropiichthys taakree taakree*	VU		

* - Based on Molur & Walker (1998); CR - Critically Endangered; EN - Endangered; VU - Vulnerable; LRlc - Lower Risk-least concern; NE - Not Evaluated.

species richness and endemic forms are encountered in Thalayanai, Kallar and Achankoil streams of southern Western Ghats. Ali & Ripley (1983) hypothesized that the southernmost division of the Western Ghats (south of Palghat Gap 8°- 9°N) seems to be a natural pass which has played a significant role in isolating a variety of organisms on either side for a long period of time. This proposition is supported by diversity patterns in birds (Ali & Ripley 1983), amphibians (Daniels 1992; Bhatta 1997) and flora (Nayar 1996). Moreover, the high hill ranges (Malabar, Travancore hills of Kerala and Nilgiris, Anamalai, Palani and Tirunelveli hills of Tamil Nadu) are largely restricted to south of 11°N. Thus it is evident that environmental conditions such as widespread rainfall (both south-west and north-east monsoons) and cooler climate have played important roles in diversity patterns and endemism in the southern Western Ghats (Daniels 1992; Dahanukar et al. 2004). The diversity of fish species observed in the present study is in line with findings for other flora and fauna.

The species richness of river fauna may be dependent on the accessibility of streams (Horwitz 1978). The high species richness streams of Thalayanai and Achankoil are located in well protected areas and less accessible to people. In addition to the stream accessibility, diversity and distribution patterns of freshwater fishes are associated with different sets of environmental gradients that have been well studied in streams of the Western Ghats (Johnson 1999; Arunachalam 2000; Bhat 2003, 2004). In the present study streams from west flowing systems encountered more endemic forms. These endemic fishes are usually well specialized, and their movements along the river may be very limited. For example, the species *Puntius denisonii* is endemic to Achankoil river, found only in rapids of the upstream region. Moreover, the west flowing streams originate from high hills and have short stretches with series of rapids and pools, and the fauna of rapids are known to have a very high rate of endemism (Easa & Shaji 1997; Kottelat & Whitten 1997).

In the present findings, cyprinids dominate the assemblage structure as they occupy all possible habitats in Western Ghats streams due to their high adaptive variability. Four of the recorded species, *Danio aequipinnatus*, *Garra mullya*, *Puntius filamentosus* and *P. conchonius* have widespread distribution in India (Talwar & Jhingran 1991; Jayaram 1999) and they are common and abundant species in Western Ghats streams. Such extensive distribution and their common high abundance suggest that most of these species are capable of tolerating a wide range of environmental conditions. Ajithkumar (1997) pointed out that the distribution of hill stream loaches, *Bhavania australis*, *Noemacheilus denisoni*, *N. guentheri*, *N. semiarmatus and N. triangularis* are restricted to Mysore, Nilgiris and in the central part of Western Ghats. In this study these species are recorded from various streams in the southern Western Ghats (Table 2), showing that they have well established distribution. Moreover, the endangered big sized barbs *Hypselobarbus curmuca* (known from Krishna, Godavari and Cauvery basin); *H. dobsoni* (known only from Krishna river basin); *H. dubius* (small population in Cauvery at Nilgiris); *H. kolus* (small numbers in Godavari, Krishna and Cauvery) have very restricted distribution and small fragment of population exist in the Western Ghats rivers (Talwar & Jhingran 1991; Menon 1992; Molur & Walker 1998; Jayaram 1999). Viable populations of these endangered species are found in the Thalayanai stream, new from the present study. These restricted and patchy distributions of species have led to small and vulnerable populations.

The present work shows remarkable species diversity and endemism in the southern part of the Western Ghats, and the recent description of three new species (*Horalabiosa arunachalami*, *Homaloptera santhamparaiensis* and *Puntius kannikattiensis*) from the study area indicate that our understanding of the diversity of fish in this area is still far from being complete. Moreover, the study also revealed that many species in the study area are being threatened by various human activities. The major activities are habitat modification, sand mining, removal of riparian vegetation, agriculture activities and destructive fishing. Habitat modifications are very common in southern Western Ghats streams where the channels are locally modified for various purposes like extraction of water for drinking, agriculture etc. As a result there is low surface flow water available in the downstream area and which creates threats to many localized species. In addition, increased sedimentation due to removal of riparian vegetation and entry of agricultural runoff causes severe threats to Western Ghats fish diversity. These lead to silt deposition along the stream bed, converting the heterogeneous

stony substrate into homogenous sandy substrates and ultimately results in loss of spawning habitat for many fish species. Another major threat to freshwater fish is sand mining along the stream channel which leads to formation of more deeper pools and loss of run and riffle habitats. Moreover, along with sand the microbial and other invertebrate communities in the stream bottom also get lost, as a result the resource availability for stream fishes would affect. In addition to that, destructive fishing methods like liming, mixing latex of euphorbia, poisoning in stream pool also bring drastic effects on fish diversity. Special attention is to be given for conservation of these threatened species, especially the highly threatened large barbs of the Western Ghats, through captive breeding and ranching. Furthermore, habitat requirements of many of the threatened and endemic species are poorly understood and more detailed studies are warranted.

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Author Details: Dr. J.A. Johnson, a freshwater fish ecologist, completed his PhD from Sri Paramakalyani Centre for Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi Tamil Nadu. He has a vast knowledge on taxonomy and ecology of freshwater fishes of India. Presently he is working as a Scientist in the Wildlife Institute of India, Dehradun.

Dr. M. Arunachalam is a Professor and Head at Sri Paramakalyani Centre for Environmental Sciences, Manonmaniam Sundaranar University, Alwarkurichi Tamil Nadu. He is a leading ichthyologist working on taxonomy and ecology of hill stream fishes of Western Ghats and conservation and management of wetlands.

Author Contribution: The study: JAJ works on taxonomy, ecology and conservation of freshwater fishes of India. MA - Supervision of taxonomy and ecology of freshwatter fishes of Western Ghats. Current paper: JAJ - involved in field sampling, data analysis and prepared the manuscript. MA - assisted in field sampling and technical guidance in data analysis.