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## Impact of Physical, Chemical and Climatic Parameters on the Diversity of Rare-Endemic Fish Species in Small Streams of Palani Hills, Western Ghats, South India



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### ABSTRACT

The present study deals with ichthyofaunal diversity in small streams of Palani Hills, Western Ghats, South India. Different species of fishes were recorded during the investigation. A total of 9 fish species including very rare, endemic species of fishes were recorded during study from fifteen different sampling sites of Palani Hills, Western Ghats. Stream Width, Water depth, Current Velocity, Canopy cover, Boulder, Pebbles, Sand of the small streams were also recorded along with the physical parameters (Latitude, Longitude, Elevation, Atmosphere Temperature, Water Temperature) and chemical parameters (pH, Conductivity, Total Dissolved Solids, Salinity, Dissolved O<sub>2</sub>).

## INTRODUCTION

Western Ghats, India is a renowned UNESCO World Heritage Site and is one of the “hotspots” of biological diversity, popularly known as “Great Escarpment of India” (1). The range of the Western Ghats runs from north to south along the western edge of the Deccan Plateau, and separates the plateau from a narrow coastal plain, called Konkan, along the Arabian Sea. Western Ghats is well known for the rich freshwater fish fauna with a high level of endemism. However, a major part of the faunal diversity of Western Ghats is threatened by human intervention and invasive species (2). Hence, knowledge of the diversity and distribution of the fish fauna is essential for designing and implementing conservation strategies. In the present study, small hill streams located within the Latitudinal range of 10.10 N – 10.44 N, Longitudinal range of 77.23 E to 77.68 E within the altitudinal range of 250 m – 2050 m Mean Sea Level (MSL) that flows southeast and southwest directions covering about 90.5 sq km area from origin were studied.

Small hill streams generally have rough, rocky, boulder and pebbled substratum which affects the occurrence, distribution and productivity of fish fauna. All the freshwater resources of the Western Ghats region comprehends a very rich and colourful ichthyo-fauna, different species of fishes have been abundantly habited in different streams in the study area. It has been now well established that fish diversity is determined by the geographical location, ecological conditions, and physico-chemical nature of the aquatic habitat. Fish distribution and abundance from different parts of Western Ghats have been evaluated by different authors. Detail account of freshwater fishes has been provided by Day (3, 4). Further, investigations on the freshwater fish fauna of Western Ghats were initiated by Hora (5) and Hora and Law (6). Silas (7) listed 25 fish species from the Anamalai Hills and 10 species from the Nelliampathi Hills. Arunachalam and Manimekalan (8) reported economically important and cultivable fishes of the Nilgiri biosphere reserve later he described the assemblage structure of stream fishes in the Western Ghats (9). Meanwhile, Manimekalan and Das (10) described a new species, *Glyptothorax davissinghi* (Pisces: Sisoridae), a new catfish from Nilambur, Nilgiri Biosphere. Manimekalan and Singh (11) recorded *Schismatorhynchus* (Nukta) *nukta* (Sykes) (Pisces: Cyprinidae) from Moyar River. Later, Arunachalam *et al.* (12) reported the occurrence of *Neolissochilus wynaadensis*, from Karnataka. Earlier, Biju *et al.* (13) recorded *Puntius filamentosus* and *Puntius melanampyx* (Day) in Orukomban and Thelikal respectively. Manimekalan and Arunachalam (2002) rediscovered the critically endangered

air-breathing catfish *Clarias dayi* Hora (Pisces: Claridae) in Mudumalai Wildlife Sanctuary. Johnson and Arunachalam (15) reported the diversity, distribution and assemblage structure of fishes in streams of southern Western Ghats. Knight *et al.* (16) described a new species of barb *Puntius nigripinnis* (Teleostei: Cyprinidae) from southern Western Ghats. Rema Devi and Menon (17) described *Horababiosa palaniensis*, a new Cyprinid fish from Palani Hills, Western Ghats. Recently, Arunkumar *et al.* (18) reported nearly 37 species in the Cauvery River System. Meanwhile, Mogalekar and Jawahar (19) have described in detail the freshwater ornamental fish diversity of Tamil Nadu.

With the growing international trade of ornamental fishes, some of the fishes like *Puntius denisonii*, *Tetraodon travancoricus*, *Horababgrus nigricollaris* and several species of the genus *Puntius*, *Danio*, *Garra*, *Loaches*, *Bagrids* and *Cichlids* are in great demand in domestic as well as international market as aquarium fish. These fishes are being collected from natural habitats and exported resulting into drastic decline in their natural population. Several studies have indicated that breeding of *Nemacheilus* species *Puntius denisonii* is warranted as over-exploitation of wild stock of these fishes could be the main reason for their diminution in the wild. However, the primary constraint with the endemic ornamental fish species is the loss of natural bright colour under captivity. Therefore, few of the endemic ornamental species have been identified for captive breeding and aquaculture *Puntius denisonii* and *Danio malabaricus*, along with other species like *P. fasciatus*, *P. melanostigma*, *P. filamentosus*, *P. arulius*, *Tetraodon travancoricus*, *Chela dadyburjori*, *Horababgrus brachysoma*, *H. nigricollaris* and *Nemacheilus* as over-exploitation of wild stock of these highly-priced fishes can lead to their extinction.

## MATERIALS AND METHODS

**Study area:** The Southern Western Ghats lie between 8° - 12°N & 76° - 78°E. The region covers about 500 km of mountain valleys in Tamil Nadu and Kerala. The important eco-regions includes Agasthyamalai, Anamalai, Cardamom Hills and Nilgiris Hills. This hill chain is interrupted in the North by 30 km wide Palghat Gap at around 110° N, and south of this gap lies Anamalai Range of Hills with highest peak at Anaimudi 2695 mMSL. This area receives precipitation from both South-West (Jun-Sep) and North-East (Oct-Nov) monsoons and the Average Annual Precipitation (AAP) exceeds 2,800 mm.

In the present study, fifteen streams were surveyed in Palani hills of Western Ghats: 1. Moolayar stream 2. Kurusedi stream 3. Silver cascade stream 4. Pillar-rock stream 5. Kumbakkarai stream 6. Adukkam stream 7. Samakkadu stream 8. Kozhikottu stream 9. Rat tail falls 10. Guntar stream 11. Fairy falls 12. Bear shoal falls 13. Thalakuthu falls 14. Pachalur stream 15. Poolathur stream.

### **Sampling**

Fish sampling was done in 100 m reach of all sampling sites. 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 method of Arunachalam (9). After collection, the sampled specimens were examined, counted and few samples were preserved in 10% formalin for further laboratory analysis. Species identification and confirmation were carried out using standard fish taxonomy books (20). Stream physicochemical parameters were measured at the time of each collection: stream depth, width, velocity, water temperature, pH, conductivity, dissolved oxygen, total dissolved solids and salinity. The values of temperature, pH, conductivity, total dissolved solids and salinity were taken using a portable water analysis tester (PCS Testr 35, Eu-Tech Instruments, India). Meter tape and steel ruler were used to measure stream width and depth, respectively, while a cork and a timer watch were used to measure stream velocity; the time taken for a cork to move one meter in distance. For each study site, the latitude and longitudinal coordinates were taken once and recorded using a hand held Global Positioning System (GPS) instrument (Garmin International Inc., Olathe, SK).

### **Collection of fishes**

Fish sampling was performed in 100m reach of all study streams. In each of the streams selected for the study, sampling was made in different habitats such as pools, riffles, runs and cascades using monofilament gill nets of different mesh sizes (10-34 mm), drag, scoop and cast nets. Fish sampling followed the method of Arunachalam (9). Fishes were examined, counted and released. A few specimens (5-10) of unidentified species were preserved in buffered formalin (10%) and transported to laboratory for analysis. Species identification and confirmation were carried out using standard fish taxonomy books (20, 21). Fishes if collected were preserved in 10% formalin. The snout of the collected fish was kept downward and the caudal region upward in the jar to avoid damage of soft parts of the fish.

Fish species reported and described from the Western Ghats region up to Sep 2013 were used for collecting the information (2 - 4, 22). Each species was checked for synonyms and duplicate names were deleted. The old scientific name was replaced with latest name (23). Threatened status of the fishes is given as per IUCN Red List Species.

### Data 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 indices was carried out according to APHA method (24) as described by Dinakaran and Anbalagan (25). 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  $H' = -\sum pi \cdot \ln pi$ . 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.

### RESULTS AND DISCUSSION

The fish fauna were surveyed from the streams and rivers of the southern Western Ghats during Jan 2016 to Dec 2018. The collection sites were selected based on the earlier faunal distribution in literature. Western Ghats is a mountain range that runs almost parallel to the western coast of the Indian peninsula well known for its splendid biodiversity both in terms of richness and endemism. The physical and climatic records of the selected study sites (Adukkam, Bear Shola falls, Fairy falls, Guntar, Kozikottu, Kumbakarai, Kurusedi, Moolayar, Pachalur, Pillar Rock, Poolathur, Rattail falls, Samakadu, Silver cascade and Thalakkuttu falls) is given in Table 1.

The chemical parameters recorded from the study sites are provided in Table 2. A maximum water temperature (24.0 °C) was recorded at Poolathur and a minimum water temperature (13.4 °C) was noted at Guntar. Characteristic features of small streams such as stream width, water depth, current velocity and the percentage canopy cover, bedrock, boulder, pebbles, and sand in the study sites are provided in Table 3.

*Puntius denisonii* (Day, 1865), *Puntius dorsalis* (Jerdon, 1849), *Puntius sophore* (Hamilton, 1822), *Pethia ticto* (Hamilton, 1822), *Devario malabaricus* (Jerdon, 1849), *Nemacheilus*

*guentheri* (Day, 1867) and *Nemacheilus keralensis* (Rita, Banarescu and Nalbant, 1978) are the species of fishes recorded from the selected sites (Table 4a-c). Of the fishes recorded from sites species such as *Puntius denisonii*, *Puntius dorsalis*, *Devario malabaricus*, *Nemacheilus guentheri* and *Nemacheilus keralensis* were found to be endemic to the Western Ghats. However, these fishes were found to be the dominant species in the locations considered. Statistical analysis and diversity indices of fishes collected from small streams are given in Table 5.

In large scale studies performed in other areas, geomorphological variables such as climate and altitude have been considered as the major factors responsible for macro-invertebrate distribution (25). Results indicate that large scale variables were responsible for determining the diversity of fish communities. Multivariate analysis suggests that physical and chemical variables significantly influence the distribution and abundance of fishes in streams of southern Western Ghats. Apart from these variables, elevation was an important factor.

## CONCLUSION

In the present study, from the fish fauna that were collected from various sites in the Western Ghats, the order Cypriniformes was the most dominant, compared to other orders. The results indicated that the fish species from the southern Western Ghats are significantly influence by the physical, chemical and climatic variables. Further, present findings support the Colinvaux theory, which diversity changes with regards to elevation. Many threats to the existence of fish fauna from the small stream of Western Ghats, like tourism and export of ornamental fishes have been reported. Hence, urgent attention is necessary to create awareness among local communities of the importance of the stream habitat and its unique fish diversity, for the conservation of these fabulous resources for future generations.

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**Table No. 1: Physical/ Climatic parameters of the study sites**

Collection Site	Physical/ Climatic Parameters				
	Latitude (N)	Longitude (E)	Elevation (m)	Atmosphere Temp (°C)	Water Temp (°C)
Guntar	10.10927	77.318	1990	17.2	13.4
Bear Shola falls	10.13182	77.239	1980	17.2	14.8
Pillar Rock	10.21018	77.466	1534	17.3	15.2
Kurusedi	10.27633	77.559	1213	22.7	16.5
Fairy falls	10.13524	77.281	2050	19.7	16.7
Silver cascade	10.24537	77.516	1256	23.5	18.4
Moolayar	10.26903	77.611	1186	22.1	19.7
Thalakuttu falls	10.44181	77.686	250	22.3	20.1
Adukkam	10.23687	77.553	1406	22.4	20.1
Samakadu	10.24044	77.564	1538	27.3	20.6
Pachalur	10.39085	77.667	296	23.4	21.5
Rat tail falls	10.13143	77.373	290	28.0	22.2
Kozikottu	10.23731	77.546	1182	24.6	23.1
Kumbakarai	10.18130	77.531	400	26.7	23.2
Poolathur	10.16152	77.321	900	26.0	24.0

**Table No. 2: Chemical parameters of the study sites**

Collection Site	Chemical Parameters				
	pH	Conductivity (µsec)	Total Dissolved Solids (ppm)	Salinity (ppm)	Dis. O2 (mgL <sup>-1</sup> )
Adukkam	6.8	29.2	20.6	13.5	13.4
Bear Shola falls	7.4	97.4	85.2	51.2	8.6
Fairy falls	7.5	112.3	78.3	56.1	8.2
Guntar	6.8	74.6	55.4	63.3	13.2
Kozikottu	7.3	62.2	44.1	35.4	13.7
Kumbakarai	6.0	21.2	90.2	61.9	7.9
Kurusedi	6.2	44.5	17.4	28.9	5.4
Moolayar	6	88.5	63.1	43.9	6.9
Pachalur	6.7	121.3	94.2	63.2	10.1
Pillar Rock	6.5	29.5	20.9	17.6	6.4
Poolathur	6.9	55.2	48.4	42.1	8.1
Rat tail falls	7.3	82.3	67.2	48.9	7.4
Samakadu	7.1	18.8	13.5	15.6	7.1
Silver cascade	6.1	26.3	18.4	12.1	6.2
Thalakuttu falls	6.8	432.1	123.4	74.3	9.2



**Table No. 3: Characteristic features of small streams in the study sites in Western Ghats**

Collection Site	Stream Width (M)	Water depth (cm)	Current Velocity (sec/m)	Canopy cover (%)	Bedrock (%)	Boulder (%)	Pebbles (%)	Sand (%)
Adukkam	0.5	3.5	4.1	0	100	0	0	0
Bear Shola falls	2	20	0.03	60	0	30	30	40
Fairy falls	2	15	0.06	40	70	20	10	0
Guntar	5	11	0.03	60	60	20	20	10
Kozikottu	2	15	3	50	60	20	10	10
Kumbakarai	8	7	10.6	80	50	30	20	0
Kurusedi	1	5	51	80	60	20	20	0
Moolayar	5	5	12.65	50	100	0	0	0
Pachalur	4.3	20	0.009	80	20	40	40	0
Pillar Rock	1	5	2	50	0	40	50	10
Poolathur	1	10	0.08	90	40	30	20	10
Rat tail falls	9	24	0.04	60	0	60	30	10
Samakadu	2	3	3	0	80	20	0	0
Silver cascade	3	10	0.03	80	0	40	40	20
Thalakuttu falls	5.5	40	0.08	50	100	0	0	0

**Table No. 4a: Fishes recorded in the study sites**

Binomial	Common Name	Vernacular	Nature of the water body
<i>Puntius denisonii</i> (Day, 1865)	Denison barb	Kendai	Freshwater
<i>Puntius dorsalis</i> (Jerdon, 1849)	Long-snouted barb	Kendai	Freshwater
<i>Puntius sophore</i> (Hamilton, 1822)	Pool barb	Undakanni	Freshwater
<i>Pethia ticto</i> (Hamilton, 1822)	Ticto barb	Kadumkali	Freshwater
<i>Devario malabaricus</i> (Jerdon, 1849)	Malabar Danio	Keyal Meen	Freshwater
<i>Nemacheilus guentheri</i> (Day, 1867)	Koima	Koima	Freshwater
<i>Nemacheilus keralensis</i> (Rita, Banarescu and Nalbant, 1978)	Koima	Koima	Freshwater

**Table No. 4b: Systematics of the Fishes recorded in the study sites**

Animalia	Chordata	Actinopterygii	Cypriniformes	Cyprinidae	Puntius	<i>Puntius denisonii</i> (Day, 1865)
Animalia	Chordata	Actinopterygii	Cypriniformes	Cyprinidae	Puntius	<i>Puntius dorsalis</i> (Jerdon, 1849)
Animalia	Chordata	Actinopterygii	Cypriniformes	Cyprinidae	Puntius	<i>Puntius sophore</i> (Hamilton, 1822)
Animalia	Chordata	Actinopterygii	Cypriniformes	Cyprinidae	Pethia	<i>Pethia ticto</i> (Hamilton, 1822)
Animalia	Chordata	Actinopterygii	Cypriniformes	Cyprinidae	Devario	<i>Devario malabaricus</i> (Jerdon, 1849)
Animalia	Chordata	Actinopterygii	Cypriniformes	Nemacheilidae	Nemacheilus	<i>Nemacheilus guentheri</i> (Day, 1867)
Animalia	Chordata	Actinopterygii	Cypriniformes	Nemacheilidae	Nemacheilus	<i>Nemacheilus keralensis</i> (Rita, Banarescu and Nalbant, 1978)

**Table No. 4c: Endemism, localization, abundance and IUCN status of the fishes recorded in the study sites**

<i>Puntius sophore</i>	Non-endemic	Common	Abundant	LC	India, Pakistan, Nepal, Bangladesh, Burma, China
<i>Pethia ticto</i>	Non-endemic	Common	Abundant	LC	India, Nepal, Pakistan, Srilanka, Bangladesh, Burma
<i>Puntius denisonii</i>	Endemic	ENWG	Very rare	EN	Mundakayam, Travancore, Aralam, Kannur, Nilgiris
<i>Puntius dorsalis</i>	Non-endemic	ENWG	Very rare	EN	Tamilnadu, Kerala, Karnataka, Andhra, Orissa, Srilanka
<i>Devario malabaricus</i>	Endemic	ENWG	Threatened	LC	Western Ghats, Tamilnadu, Kerala, Karnataka,
<i>Nemacheilus guentheri</i>	Endemic	ENWG	Very rare	VU	Western Ghats, Tamilnadu, Kerala, Karnataka,
<i>Nemacheilus keralensis</i>	Endemic	ENWG	Very rare	VU	Western Ghats, Tamilnadu, Kerala, Karnataka,

**Table No. 5: Statistical analysis and diversity indices of fishes collected from small streams in Western Ghats**

	<i>P. denisonii</i>	<i>P. dorsalis</i>	<i>P. sophore</i>	<i>P. ticto</i>	<i>D. malabaricus</i>	<i>N. guentheri</i>	<i>N. keralensis</i>
N	14	14	14	14	14	14	14
Min	0	0	0	0	0	0	0
Max	5	5	9	1	6	8	8
Sum	22	11	13	3	25	45	10
Mean	1.5714	0.7857143	0.9286	0.2142857	1.785714	3.21429	0.7143
Std. error	0.4654	0.4084085	0.633	0.1138039	0.546503	0.81321	0.5687
Variance	3.033	2.335165	5.6099	0.1813187	4.181319	9.25824	4.5275
Stand. dev	1.7415	1.528125	2.3685	0.4258153	2.044827	3.04274	2.1278
Median	1	0	0	0	1	2	0
25 prcntil	0	0	0	0	0.75	0.75	0
75 prcntil	3.25	1.25	1	0.25	2.5	6.25	0.25
Skewness	0.88	2.078672	3.5029	1.565624	1.47033	0.52721	3.5659
Kurtosis	-0.6099	3.911826	12.689	0.5013774	0.975292	-1.38242	12.998
Geom. mean	0	0	0	0	0	0	0
Coeff. var	110.83	194.4886	255.07	198.7138	114.5103	94.6629	297.89
Taxa_S	9	4	5	3	11	11	3
Individuals	22	11	13	3	25	45	10
Dominance_D	0.1529	0.3223	0.503	0.3333	0.1584	0.1309	0.66
Simpson_1-D	0.8471	0.6777	0.497	0.6667	0.8416	0.8691	0.34
Shannon_H	2.008	1.241	1.044	1.099	2.082	2.162	0.639
Evenness_e^ H/S	0.8279	0.8645	0.568	1	0.7288	0.7899	0.6315
Brillouin	1.584	0.93	0.75	0.5973	1.639	1.855	0.45
Menhinick	1.919	1.206	1.387	1.732	2.2	1.64	0.9487
Margalef	2.588	1.251	1.559	1.82	3.107	2.627	0.8686
Equitability_J	0.914	0.895	0.6485	1	0.8681	0.9016	0.5817
Fisher_alpha	5.685	2.261	2.975	0	7.504	4.642	1.453
Berger-Parker	0.2273	0.4545	0.6923	0.3333	0.24	0.1778	0.8
Chao-1	12	4	11	6	21.5	12	4