Nestedness pattern in freshwater fishes of the Western Ghats: an indication of stream islands along riverscapes

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Fragmented habitats exhibit distinctive patterns of species richness and species composition. They often exhibit patterns of pronounced nestedness, wherein the species present in comparatively depauperate locations represent statistically proper subsets of those present in locations that are richer in species. The current study has been conducted on the freshwater fishes of Sharavathi River, considering 41 stream and reservoir sites with 261 sampling events to understand the nestedness pattern in fish communities. Of the 64 fish species collected, 39 are from the reservoir and 33 from the stream islands. For the species of the stream islands, including the reservoir fishes in the stream, the nestedness index, *T* was 8.27°C, while species exclusive to stream islands had *T* = 10.5°C. In contrast, in species that are common to both stream islands and the reservoir, *T* was 0.37°C. Relatively higher *T* in the exclusive stream species composition implies that they are highly depauperated due to fragmentation in the streams and its negative influence on the stream fish communities.

Keywords: Community structure, freshwater fish, habitat fragmentation, island biogeography, nestedness pattern, riverscape, stream island, Western Ghats.

HUMAN activities have changed about one-third to one-half of the earth's land surface and are leading to substantial and growing modification of the earth's biological resources. Worldwide, 34 areas have been identified as biodiversity hotspots that have exceptional concentrations of endemic species and are experiencing exceptional loss of habitat[1,2]. It is estimated that in 1995 more than 1.1 billion people, nearly 20% of the world's population, were living within these hotspots that cover about 12% of the earth's terrestrial surface, with a population growth rate of 1.8% yr^{-1}, which is substantially higher than that of the world as a whole (1.3% yr^{-1}) as well as above that of the developing countries (1.6% yr^{-1})[3]. Humans derive many utilitarian benefits from ecosystem services and goods, and the resulting impact on the global biosphere now controls many major facets of ecosystem functions[4,5], especially in the tropical regions. The most important impact is the massive degradation of habitat and extinction of species, taking place on a catastrophically short time-scale[6], resulting in the modification of both the identities and numbers of species in ecosystems[7]. The decline of many biological populations worldwide is attributed to habitat fragmentation of the terrestrial and aquatic ecosystems[8].

In aquatic systems, fragmentation can have deleterious effects on ecosystem integrity. A continuous (non-fragmented) riverine ecosystem is dominated by flow seasonality imposed by monsoonal rains[9], with floods and droughts as important features of these rivers. The aquatic environments are known for their dynamic nature, especially stream landscapes, which are highly variable in space and time. Dynesius and Nilsson[10] determined that 77% of the total discharge of the 139 largest river systems in the northern third of the world is affected by river fragmentation caused by dams, reservoirs, inter-catchment diversions, and irrigation. Thus construction of dams has resulted in the disruption of natural dispersal pathways and subsequent changes in the structure and function of aquatic and wetland communities[11], and is regarded as the biggest conservation threat to aquatic communities in many river basins throughout the world[12] due to the biased extinctions of rare species[7]. Thus understanding how populations persist in fragmented environments is a central problem in basic and applied ecology.

Among fishes inhabiting running waters, three modes of adaptation (life history, behavioural and morphological) exist for surviving floods and droughts[13]. Many species have clear adaptation to life in rapidly flowing streams, few other typical of upstream regions, large and predators are exclusive to the deep pools. Overall life-history stages of the stream fishes must be adapted to changes that occur at different spatial and temporal scales. Morphological, physiological and behavioural characteristics accompanied by climatic factors result in migration of fish species that is reflected by local extinction during unfavourable conditions and recolonization during favourable conditions[14].

Fragmented habitats, both terrestrial and aquatic, tend to exhibit distinctive patterns of species richness and species composition. As fragmentation of natural, continuous habitats continues, the areas of the fragments become

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smaller, and distances between them increase. The taxa occurring in fragments become isolated, as the surrounding habitat is often unsuitable, hampering successful immigration[15]. In such conditions, species distribution patterns within these fragmented habitats have often exhibited patterns of pronounced nestedness[16], which are common among many communities[17].

A nested biota is one in which the species present in comparatively depauperate locations represent statistically proper subsets of those present in locations that are richer in species. An area of suitable habitats, initially inhabited by a common ancestral biota, is fragmented into an archipelago of islands. On each island of the archipelago, there will be one species which is nearest its minimum sustainable population size, and thus at greatest risk of local extinction. As the area continues to shrink, populations of the archipelago's constituent species will tend to become extinct in the order of their specific extinction risks[18]. This orderly extinction pattern is the key factor in the nestedness pattern. The nestedness phenomenon has been recognized for quite some time, but only recently have statistical tests been developed for the analysis of orderliness in species assemblages[19]. Patterns of community structure in many naturally and anthropogenically fragmented environments can be analysed[20]. The best way to quantify nestedness is to use the Atmar and Patterson method, which utilizes a combination of a thermodynamic measure of order and a Monte-Carlo simulation[21]. The nestedness pattern has been revealed for several archipelagos and communities associated with them, e.g. plants, mussels, butterflies, caddisflies, orthopterans, fish parasites, fish, amphibians, reptiles, birds and mammals[15,17,19–21].

Fish assemblages in tropical rivers are characterized by high taxonomic diversity[22]. Recent compilation of freshwater and secondary freshwater fishes of the Western Ghats shows that there are 318 species, of which 27 are critically endangered and 55 endangered, while 128 are data-deficient species. Of the 27 critically endangered species, 24 are endemic to the region. Similarly, of the 55 endangered species, 37 are endemic. Yet, 49 endemic species are data-deficient[23]. Analysis of fish species composition, distribution and ecological status with reference to the terrestrial ecosystem in the catchment, revealed the preference of the endemic fish fauna to perennial streams with their catchments having evergreen to semi-evergreen forests, which also have higher levels of plant endemism[24]. Many of the species in the Western Ghats are characterized by their localized distribution (to a river basin or part of a river basin) and specific adaptation to lotic environments. Although damming the rivers at small scales is being practised widely in the region for centuries, with large-scale planning, massive projects have been initiated and implemented over the past century. The necessity to understand the implications of aquatic habitat fragmentation and its influence on the fish species composition and structure resulting due to such massive transformation has led the present study. This is the first attempt to provide the nestedness pattern in the fish community in the Western Ghats, something that is unique for fish survey. As most of the rivers of the Western Ghats are now altered, understanding the implications is vital for the effective management and restoration of running water ecosystems of the region.

Materials and methods

Study area

Sharavathi river (catchment area of 2784 km^2), one of the west-flowing rivers of Central Western Ghats, traverses over a distance of 132 km before joining the Arabian Sea (Figure 1). The region spans between 74°50′54″–75°30′63″E and 13°77′08″–14°7′27″N. It receives high annual rainfall (1715–5598 mm) that occurs mainly during June to October. The river has been exploited to generate hydroelectric power, which resulted in the construction of two major dams across it. The Linganamakki dam (74°50′54″E, 14°14′24″N, 512 m amsl), constructed in 1964 has a water-spread area of 326.34 km^2.

Eight major tributaries with numerous stream networks of this river are considered as sub-basins. These sub-basins with undulating terrains have tropical evergreen, semi-evergreen and moist deciduous forests in their catchments[24]. Formation of lacustrine ecosystem in the form of the Linganamakki reservoir has isolated these eight sub-basins into discrete flowing reaches, disrupted the flow connectivity and converted them into stream islands. We used the terms 'stream island' and 'sub-basin' interchangeably, according to the context.

Sampling

Fish sampling was carried out in 41 selected stream and reservoir sites with 261 samplings from January 2002 to August 2004. Collections were made using gill nets, cast nets, dragnets and hooks and lines of varying sizes[24]. Within each site all microhabitats like riffle zone, pools, cascade, falls, embayment, run and plunge were considered for sampling. Based on the standard literature available, the collected specimen were identified[24]. Species richness of a stream island is the sum total of the individual sampling species richness that falls within the catchment of a sub-basin. Similarly, species richness from the sampling sites of the reservoir was pooled and used as a reference list.

Data analysis

Presence–absence (1 = present, 0 = absent) matrices were assembled representing stream islands as rows in order of decreasing species richness and species as columns in

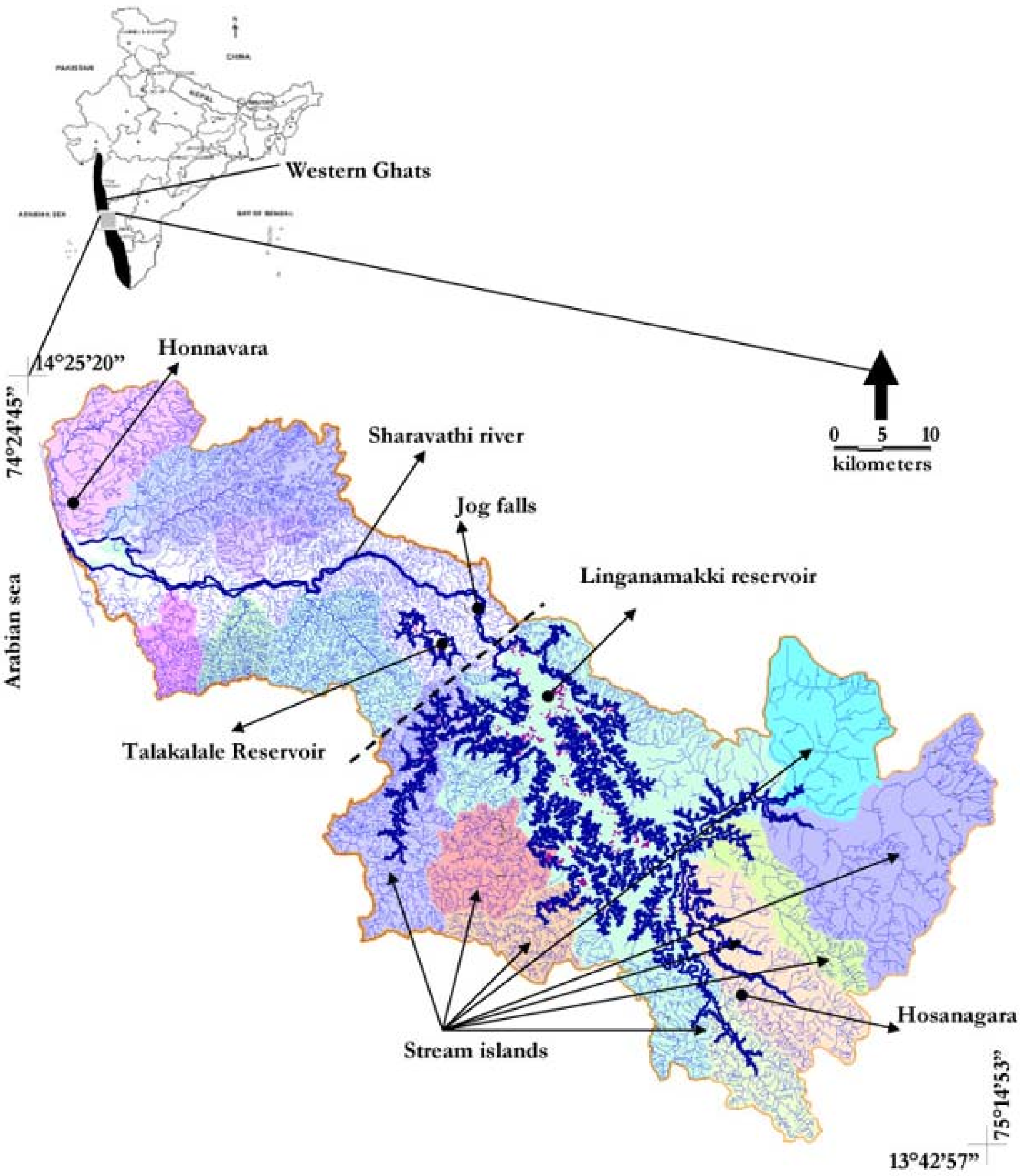

Figure 1. Sharavathi river basin drainage network. South of dashed line constitutes study area.

order of decreasing ubiquity. Nestedness analyses for different groups of species were carried out in stream islands, viz. (i) all species from the stream islands, (ii) species common to stream islands and reservoirs (derived from reference list) and (iii) species that are exclusive to stream islands.

The basis for this classification was purely on the species occurrence during sampling. Nestedness of species assemblages was determined using nested temperature calculator[25]. Nested patterns can be related to thermodynamics[26] with an index T on scale of 0–100°C, with 0°C representing complete nestedness and 100°C representing complete randomness[25]. Indication of unmarked heterogeneity in the original dataset is given by the mixed presence and absence of species or sites along the boundary line. The stability of individual populations was determined by calculating the state occupancy of the individual species[18]. Monte-Carlo randomizations of the data matrix

Table 1. Stream island-wise data on fish attributes and corresponding land-use values

		Eastern stream islands			Southern stream islands		Western stream islands		
Data type	Parameter	Nandi Holé	Haridravathi	Mavina Holé	Sharavathi	Hilkunji	Huruli Holé	Nagodi	Yenne Holé
Fish	Species richness	22	25	22	28	25	32	41	49
	Western Ghats endemics (%)	8.3	14.3	9.1	22.2	20.0	40	23.5	35.5
	Endangered (%)	0.0	7.1	9.1	5.5	13.3	12.0	11.8	9.7
	Vulnerable (%)	16.7	21.4	9.1	16.7	6.7	24.0	17.6	0.0
	Lower risk (%)	58.3	57.1	63.6	61.1	66.7	44.0	52.9	38.7
	Data deficient (%)	16.7	14.3	18.2	11.1	13.3	12.0	17.7	22.6
Land-use	Semi-evergreen (%)	3.31	2.3	4.4	19.2	43.3	32.8	52.1	37.9
	Moist-deciduous (%)	38.1	28.2	41.6	22.9	22.5	27.9	16.6	19.8
	Plantation (%)	5.5	5.6	7.9	14.7	11.6	10.7	13.7	15.9
	Water (%)	0.01	0.1	0.03	0.0	0.0	0.9	0.0	0.1
	Agricultural (%)	11.3	18.2	9.8	10.3	4.2	1.9	1.1	1.4
	Non-vegetated (%)	11.1	13.9	11.6	12.5	5.6	7.6	7.5	10.1
	Open field (%)	30.6	31.9	24.7	20.4	12.9	18.2	9.1	14.9

Note: Non-vegetated: Habitation, roads, rocky area; Open field: uncultivated agricultural land, barren land, dry river bed.

(500 runs) were used to compare with the observed matrix. If the obtained value was lower than that of the randomly generated assemblage, the assemblage can be declared as nested[27].

Results and discussions

The present investigation reports 64 fish species from the study area. Among these, 39 species are found in reservoir sampling sites (lacustrine region) and 33 in the stream islands. Stream island-wise data on species richness, endemism, IUCN (World Conservation Union) status, existing land-use pattern and fragmentation details are given in Table 1. Species richness, endemism and extent of threatened species are relatively high in the western stream islands than the southern and eastern stream islands. Similar pattern follows in case of forest cover, wherein extent of semi-evergreen to evergreen forests is relatively more in the western stream islands than the southern and eastern stream islands.

Nestedness pattern

The species assemblages in eight stream islands were nested significantly as indicated by the *T* value (Tables 2–5). Nestedness index considering all the species from the stream islands was 8.27°C, the probability of which is similar to a randomly generated nesting pattern is almost zero ($P < 6.15 \times 10^{-10}$). The species such as *Schistura denisonii denisonii*, *Oreichthys cosuatis* and *Schistura semiarmatus* with both unexpected presence and unexpected absence along with stream island Nandi Holé are responsible for idiosyncrasy. Presence of *Amblypharyngodon melettina* in the Hilkunji stream island and *Barilius gatensis* in the Haridravathi stream island represents unexpected presence (Table 2). These are the species with high risk of local extinction from those stream islands. Similarly, the ideal candidates for reintroduction are *O. cosuatis* to Huruli, Sharavathi and Haridravathi stream islands, *S. semiarmatus* to Huruli stream island and *Schistura* sp. to Yenne Holé stream island, where their probability of survival is high.

Aplocheilus lineatus, *Barilius bendelisis*, *Brachydanio rerio*, *Chanda nama*, *Cirhina fulungee*, *Danio aequipinnatus*, *Garra gotyla stenorhynchus*, *Lepidocephalus thermalis*, *Mystus cavacius*, *Mystus malabaricus*, *Parambassis ranga*, *Puntius sophore*, *P. ticto*, *Rasbora daniconius*, *Glossogobius giuris*, *Ompok bimaculatus*, *P. chola*, *Gonoproktopterus kolus*, *Acanthocobitis botia*, and *P. filamentosus* are the most ubiquitous species. Whereas species like *A. mellettina*, *Barilius canarensis*, *Clarias dussumieri dussumieri*, *Glyptothorax lonah*, *Pseudophromenus cupanus*, *Puntius arulius*, *Schistura sharavathiensis*, and *Schistura* sp.1 are the most marginal species.

T for species that are common to stream islands and reservoirs was 0.37°C. This is almost completely nested without many idiosyncratic species (Table 3). Reservoirs and streams provide hospitable habitats, resulting in structured immigration and emigration of these fish species.

For species that are exclusive to stream islands, *T* was 10.5°C, with more number of idiosyncrasy in species as well as in stream islands (Table 4). Species such as *O. cosuatis*, *B. gatensis*, *A. melettina*, *S. denisoni denisoni*, *Nemacheilus anguilla*, *Salmostoma boopis*, etc. are responsible for idiosyncrasy in the system.

Table 5 provides *T* and Monte Carlo run results for various species groups. Most of the hospitable species have wider distribution in general and are less susceptible to fragmentation, while marginal species with narrower distribution are more susceptible to fragmentation. The processes for such nestedness are selective immigration,

Table 2. Nestedness pattern of all the species found in the stream islands

Species	YNH	NGH	HRH	SVH	HDH	HKH	MVH	NDH
Aplocheilus lineatus	1	1	1	1	1	1	1	1
Barilius bendelisis	1	1	1	1	1	1	1	1
Brachydanio rerio	1	1	1	1	1	1	1	1
Chanda nama	1	1	1	1	1	1	1	1
Cirhina fulungee	1	1	1	1	1	1	1	1
Danio aequipinnatus	1	1	1	1	1	1	1	1
Garra gotyla stenorhynchus	1	1	1	1	1	1	1	1
Lepidocephalus thermalis	1	1	1	1	1	1	1	1
Mystus cavacius	1	1	1	1	1	1	1	1
Mystus malabaricus	1	1	1	1	1	1	1	1
Parambassis ranga	1	1	1	1	1	1	1	1
Puntius sophore	1	1	1	1	1	1	1	1
Puntius ticto	1	1	1	1	1	1	1	1
Rasbora daniconius	1	1	1	1	1	1	1	1
Glossogobius giuris	1	1	1	1	1	1	1	1
Ompok bimaculatus	1	1	1	1	1	1	1	1
Puntius chola	1	1	1	1	1	1	1	1
Gonoproktopterus kolus	1	1	1	1	1	1	1	1
Acanthocobitis botia	1	1	1	1	1	1	1	1
Puntius filamentosus	1	1	1	1	1	1	1	1
Mastacembelus armatus	1	1	1	1	1	1	1	0
Puntius sahyadriensis	1	1	1	1	1	1	1	0
Salmostoma boopis	1	1	1	1	1	1	0	0
Schistura denisonii denisonii	1	1	1	1	1	0	0	1
Nemacheilus anguilla	1	1	1	1	0	0	0	0
Osteocheilichthys nashii	1	1	1	1	0	0	0	0
Oreichthys cosuatis	1	0	0	0	1	1	0	1
Barilius bakeri	1	1	1	0	0	0	0	0
Channa marulius	1	1	1	0	0	0	0	0
Ompok pabo	1	1	1	0	0	0	0	0
Schistura semiarmatus	1	1	0	1	0	0	0	0
Puntius fasciatus	1	1	1	0	0	0	0	0
Schistura nagodiensis	1	1	1	0	0	0	0	0
Tor khudree	1	1	1	0	0	0	0	0
Batasio sharavatiensis	1	1	0	0	0	0	0	0
Clarias batrachus	1	1	0	0	0	0	0	0
Labeo kontius	1	1	0	0	0	0	0	0
Pseudeutropius atherinoides	1	1	0	0	0	0	0	0
Tor mussullah	1	1	0	0	0	0	0	0
Channa orientalis	1	1	0	0	0	0	0	0
Wallago attu	1	1	0	0	0	0	0	0
Barilius gatensis	1	0	0	1	0	0	0	0
Amblypharyngodon mellettina	1	0	0	0	0	1	0	0
Barilius canarensis	1	0	0	0	0	0	0	0
Clarias dussumieri dussumieri	1	0	0	0	0	0	0	0
Glyptothorax lonah	1	0	0	0	0	0	0	0
Pseudophromenus cupanus	1	0	0	0	0	0	0	0
Puntius arulius	1	0	0	0	0	0	0	0
Schistura sharavathiensis	1	0	0	0	0	0	0	0
Schistura sp.1	0	1	0	0	0	0	0	0

YNH, Yenne Holé; NGH, Nagodi Holé; HRH, Huruli Holé; SVH, Sharavathi Holé; HDH, Haridravathi Holé; HKH, Hilkunji Holé; MVH, Mavina Holé, and NDH, Nandi Holé.

selective extinction, selective levels of stress tolerance, nested habitats and passive sampling[28]. Superior dispersers generally exhibit a greater degree of nestedness than poor dispersers, and the weakest nested patterns may be expected among species with naturally poor dispersal abilities[15]. This is evident in the present analyses, wherein the species common to both reservoir and stream island show greater degree of nestedness compared to those of

Table 3. Nestedness pattern of the species common to both stream islands and reservoirs

Species	YNH	NGH	HRH	SVH	HKH	HDH	MVH	NDH
Barilius bendelisis	1	1	1	1	1	1	1	1
Brachydanio rerio	1	1	1	1	1	1	1	1
Chanda nama	1	1	1	1	1	1	1	1
Cirrhinus fulungee	1	1	1	1	1	1	1	1
Garra gotyla stenorhynchus	1	1	1	1	1	1	1	1
Mystus cavesius	1	1	1	1	1	1	1	1
Mystus malabaricus	1	1	1	1	1	1	1	1
Parambassis ranga	1	1	1	1	1	1	1	1
Glossogobius giuris	1	1	1	1	1	1	1	1
Ompok bimaculatus	1	1	1	1	1	1	1	1
Puntius chola	1	1	1	1	1	1	1	1
Gonoproktopterus kolus	1	1	1	1	1	1	1	1
Mastacembelus armatus	1	1	1	1	1	1	1	0
Puntius filamentosus	1	1	1	1	1	1	1	0
Salmostoma boopis	1	1	1	1	1	1	0	0
Osteocheilichthys nashii	1	1	1	1	0	0	0	0
Channa marulius	1	1	1	0	0	0	0	0
Ompok pabo?	1	1	1	0	0	0	0	0
Tor khudree	1	1	1	0	0	0	0	0
Batasio sharavatiensis	1	1	0	0	0	0	0	0
Clarias batrachus	1	1	0	0	0	0	0	0
Labeo kontius	1	1	0	0	0	0	0	0
Pseudeutropius atherinoides	1	1	0	0	0	0	0	0
Tor mussullah	1	1	0	0	0	0	0	0
Wallago attu	1	1	0	0	0	0	0	0
Clarias dussumieri dussumieri	1	0	0	0	0	0	0	0
Glyptothorax lonah	1	0	0	0	0	0	0	0
Puntius arulius	1	0	0	0	0	0	0	0

Table 4. Nestedness pattern of exclusively stream-dwelling species in the stream islands

Species	YNH	NGH	SVH	HDH	HRH	HKH	MVH	NDH
Aplocheilus lineatus	1	1	1	1	1	1	1	1
Brachydanio rerio	1	1	1	1	1	1	1	1
Chanda nama	1	1	1	1	1	1	1	1
Danio aequipinnatus	1	1	1	1	1	1	1	1
Garra gotyla stenorhynchus	1	1	1	1	1	1	1	1
Lepidocephalus thermalis	1	1	1	1	1	1	1	1
Parambassis ranga	1	1	1	1	1	1	1	1
Puntius sophore	1	1	1	1	1	1	1	1
Puntius ticto	1	1	1	1	1	1	1	1
Rasbora daniconius	1	1	1	1	1	1	1	1
Glossogobius giuris	1	1	1	1	1	1	1	1
Acanthocobitis botia	1	1	1	1	1	1	1	1
Puntius chola	1	1	1	1	1	1	1	0
Puntius filamentosus	1	1	1	1	1	1	1	0
Salmostoma boopis	1	1	1	1	1	1	0	0
Puntius sahyadriensis	1	1	1	1	1	0	1	0
Schistura denisonii denisonii	1	1	1	1	0	0	0	1
Nemacheilus anguilla	1	1	1	0	1	1	0	0
Osteocheilichthys nashii	1	1	1	0	1	0	0	0
Barilius bakeri	1	1	0	0	1	0	0	0
Puntius fasciatus	1	1	0	0	1	0	0	0
Schistura nagodiensis	1	1	0	0	1	0	0	0
Schistura semiarmatus	1	1	1	0	0	0	0	0
Channa orientalis	1	1	0	0	0	0	0	0
Oreichthys cosuatis	1	0	0	1	0	1	0	1
Amblypharyngodon mellettina	1	0	0	0	0	1	0	0
Barilius canarensis	1	0	0	0	0	0	0	0
Pseudophromenus cupanus	1	0	0	0	0	0	0	0
Puntius arulius	1	0	0	0	0	0	0	0
Schistura sharavathiensis	1	0	0	0	0	0	0	0
Schistura sp.1	0	1	0	0	0	0	0	0
Barilius gatensis	0	0	1	0	0	0	0	0

Table 5. Nestedness parameters for three species groups

Case	Matrix results		System temperature (°C)	
	T (°C)	Fill (%)	Average ± SD	Statistical significance (P)
All species in stream islands	8.27	36.6	50.3 ± 6.91	6.15×10^{-10}
Species common to stream islands and reservoirs	0.37	41.1	46.6 ± 8.35	1.1×10^{-8}
Species exclusive to streams	10.5	44.0	48.8 ± 7.39	1.39×10^{-7}

stream islands alone (Table 5). The fish species common to both reservoirs and stream islands showed almost packed matrix with very low *T*. This leads to the inference that the anthropogenic activities in the catchment area of Sharavathi river over the last century in the form of construction of dams have resulted in homogenization of pool-loving fish fauna. Large reservoir area provided them an ideal habitat to flourish and to migrate from one stream island to another in accordance with the changing habitat conditions favoured by changes in climate. Whereas the species restricted to stream islands are responsible for the overall increase in *T*, for the very reason that more randomness, many idiosyncratic species and sites with unexpected absence and presence occur here. This indicates that the construction of the dam might have led to the randomization of fish fauna in the lotic systems (stream-island fishes) due to submergence of lotic habitats, in addition to complete isolation of stream islands.

Analysis of the land-use data revealed that the study area is experiencing rapid changes over the last 50 years[29]. Submersion of about 326.34 km^2 area by the dam and the corresponding impacts in the form of human migrations and immigrations resulted in unequal distribution of human population over the study area. Human habitations in the stream islands of the western and southern part are less compared to the eastern stream islands due to remoteness and isolation. Consequently, large forests areas were cleared and converted to agriculture and monoculture plantations in the eastern stream islands, resulting in higher sedimentation and conversion of perennial streams into ephimeral and seasonal ones, which had further implications on the microhabitat characteristics of the streams[29]. Specific levels of stress tolerance among the species resulted in selective extinction, while species capable of migrating over a long distance and withstand lacustrine ecosystem migrated to other regions. It is apparent from the present study that selective extinction, selective migrations and selective levels of stress tolerance of the fish species determine the nestedness in a fragmented riverscape.

Conclusions

Major streams and tributaries of a riverscape become isolated stream islands due to a reservoir that choked the stream network and continuity due to habitat fragmentation as a consequence of anthropogenic activities. Fish assemblages in these isolated streams often exhibit strong nestedness pattern driven by selective extinction, levels of stress tolerance and immigration in species. The present study indicates the randomization of fish fauna in the lotic systems (stream-island fishes) and at the same time homogenization of species in the lacustrine habitats due to construction of dams.

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MEETINGS/SYMPOSIA/SEMINARS

International Congress of Global Warming on Biodiversity of Insects: Management and Conservation (GWBIMC, 2009)

Date: 9–12 February 2009
Place: Coimbatore, India

Themes: Impact of global warming on insect migration and behaviour; Impact of global warming on biodiversity/management of agricultural insects; Impact of global warming on conservation/management of forestry insects; Impact of global warming on management of medical and veterinary insects; Impact of global warming on mosquito and its transmitted diseases; Global warming on biotechnological advancement in insects; Global information system (GIS) and remote sensing (RS) on insects.

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3rd National Conference on Recent Trends in Instrumentation Applications (RETINA '09)

Date: 19–20 March 2009
Place: Kovilpatti

Topics include: Process measurement and instrumentation; Biomedical engineering; Industrial automation; Instrumentation RAG–BAG.

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