Fish diversity studies of two rivers of the northeastern Godavari basin, India

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Abstract: Fish diversity was explored in two rivers of the northeastern Godavari basin: the Adan, tributary of the Painganga, and the Kathani, tributary of the Wainganga. Both rivers are part of the same basin but present different ecological, climatic and anthropogenic settings. Six sites were sampled in each river system over three years using gill nets, cast nets and locally available nets; the 'catch per unit effort' criterion was used for sampling. Forty-seven species of fish were identified. Species richness (Jackknife 1 and rarefaction) and diversity measures (Shannon and Simpson) were calculated and their values clearly show that the Kathani is a more diverse ecosystem in terms of fish diversity than the Adan. This difference is mainly due to anthropogenic influences upon the Adan.

Keywords: Adan River, diversity indices, fish diversity, Godavari basin, Kathani River, species richness.

Introduction

Several ways of measuring the species diversity of biological communities have been described (MacArthur 1965; Whittaker 1970; Pielou 1975; Chao 1984; Magurran 1988, 2004, 2005; Krebs 1989; Chao & Shen 2003), and this diversity is considered by ecologists to be an indicator of community well-being (Magurran 1988). India has considerable ichthyofaunal diversity. Day (1875) described 1,418 species of fish under 342 genera, and a century later Jayaram (1981) listed 742 freshwater species under 233 genera, 64 families and 16 orders from the Indian region. Talwar & Jhingran (1991) estimated 930 species of fresh water fish belonging to 326 genera and 99 families. On a global scale, Indian fish populations represent 11% of species, 24% of genera and 57% of families (NBSAP India 2005). In the central Indian River systems (viz. Narmada, Godavari, Tapti and Krishna) Heda (2009) described 150 species belonging to 26 families. In spite of this rich diversity, literature concerning numerical studies of fish diversity is scarce. Bhat (2003) studied the diversity and ecology of four rivers in the Uttara Kannada District of Karnataka. Kar et al. (2006) studied diversity and the effect of environmental variables on fish of Sone Lake in Assam. The Godavari River, especially its northeastern part, is largely unexplored with regards to species inventory. In this study, an attempt was made to assess and compare the fish diversity of two rivers of the northeastern Godavari basin.

Study area: (Fig. 1)

The Godavari is the second largest river in India after the Ganga, and is often referred as the *Vriddh* (Old) Ganga or the *Dakshin* (South) Ganga. It rises near Nasik (*Trunbakeshwar*) in Maharashtra at an elevation of 1,067m and flows for 1,465km before emptying into the Bay of Bengal.

The first study river, the Kathani, is a tributary of the Wainganga and lies at 20°15'.531"N & 80°31'.196"E - 20°12'.658"N & 79°59'.620"E. It is an annual river originating in the *Dhanora – Murumgaon* hills at an altitude of 426.72m, and it flows west for 70km before emptying into the Wainganga north of Gadchiroli (20°10'21"N & 79°57'49"E'). It is a mountain torrent river flowing through dry deciduous forest and runs dry in the summer, although water remains in some pools. The overall substratum type of the river is sandy with occasional rocks. The canopy is rich, with the dominant vegetation being bamboo (*Dendrocalamus strictus*), Ajan (*Terminalia* sp.) etc. The river flows through a sparsely inhabited area and no dams or significant industrial pollution were noted.

The second study river, the Adan, is a principal tributary of the Painganga and lies at 20°12'19.00"N-77°10'01"E & 19°54'87.6"N-78°12'61.4"E. The length of this river is 209.21km. It rises in the Washim District of Maharashtra and meanders north, east and south and meets the Painganga River. The river Arunavati unites with the Adan

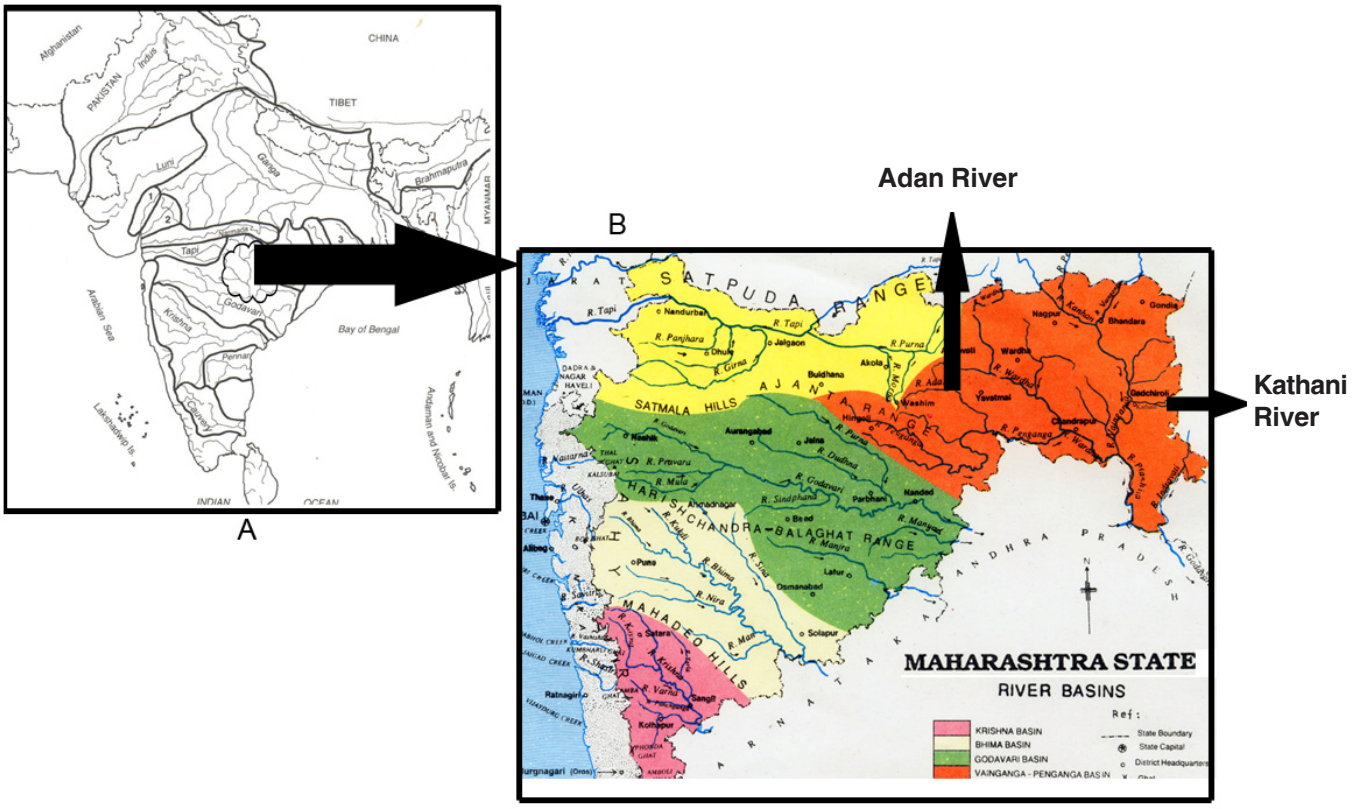

Figure 1. A - major drainages in India; B - study area

13km before it joins the Painganga. The valley of Adan is 10km to 22km wide. The river ceases to flow in summer, though some pools remain in the latter part of its course.

Two dams have been built on the Adan; one at the origin near Sonala village and the other near Karanja (Lad) city. The river flows through scrubland, degraded dry deciduous forest and areas with extensive agriculture (Table 1).

Table 1. Details of sampling sites

River	Sampling point	Geographical coordinates	Altitude (m)
Adan	Shivni bridge	20°23'48.24"N & 77°22'28.01"E	416.00
	Injori bridge	20°24'22.22"N & 77°30'10.33"E	378.00
	Sangvi	20°24'40.96"N & 77°36'27.82"E	372.00
	Mankopra	20°23'39.11"N & 77°40'00.46"E	350.00
	Bori Arab	20°20'59.89"N & 77°51'36.10"E	314.00
	Sangam - 2	19°54'80.83"N & 78°12'36.40"E	245.00
Kathani	Chavela	20°15'90.12"N & 80°22'20.07"E	246.89
	Dhanora bridge	20°17'30.23"N & 80°19'26.77"E	237.74
	Wadadin	20°14'37.80"N & 80°15'59.15"E	225.55
	Dev Doh	20°13'40.67"N & 80°09'54.27"E	209.85
	Bamni village	20°13'02.66"N & 80°05'35.21"E	205.74
	Sangam - 1	20°12'39.87"N & 79°59'35.01"E	195.99

Methods

Sampling: Six sample points were chosen on each river in order to cover all areas, sample a range of habitat types (e.g. pools, rapids, falls) and assess the impact of human interventions (e.g. some sites were adjacent to villages, and on the Adan sites above and below the dam were sampled). Samples were collected seasonally from January 2003 to September 2005. For sampling cast nets, gill nets baited hooks and locally available nets were used. The same mesh size was used for all net samplings. Collected samples were preserved in 5% formalin solution in plastic bottles. Different bottles were maintained for different sampling sites and events. Preserved fish were identified in the laboratory via identification keys given by Day (1875), Talwar and Jhingran (1991), Jayaram (1999) and Daniels (2001). At each sampling point a 100m long stretch was chosen which was sampled seasonally through 'random sampling' (Krebs, 1989, Magurran, 1988, 2004). Cast netting was done without overlapping the previous casting.

Data analysis: It is not always possible to ensure that all sample sizes are equal, and the number of species invariably increases with sample size and sampling efforts. To cope with this problem I used the rarefaction technique of Sanders to calculate the number of species expected in each sample if all samples were of a standard size (Magurran 1988; Bruce et al. 1998; Bhat 2002, 2003, 2004). The Jackknife-1 measure was used to calculate species richness based on the observed frequency of rare or unique species in the community. One problem associated with diversity measurement is determining what sample size to adopt. A practical approach to this problem is to use the concept of the species accumulation curve (Butler & Chazdon 1998), which gives an idea about the extent of sampling efficiency and rate of increase in the number of species per the effort (Christen & Nakamura 2000; Dahanukar et al. 2004; John et al. 2004; Mao et al. 2005). Two diversity measures were used to calculate the alpha diversity (i.e. within site or within sample diversity), the Shannon diversity index (H') and Simpson's index (Krebs 1989). EstimateS (Colwell 1997) and Biodiversity Pro (McAleece et al. 2006) software was used for calculations of richness estimates, diversity indices

Table 2. Species found at each sampling site

		River Kathani						River Adan					
		Chavela	Dhanora bridge	Wadadin	Dev Doh	Bamni Village	Sangam 1	Shivni bridge	Injori bridge	Sangvi	Mankopra	Bori Arab	Sangam 2
	Species	Number of individuals											
1	*Acanthocobitis moreh*	9	6	5	0	9	9	6	31	4	0	0	6
2	*Amblypharyngodon mola*	0	0	0	1	0	0	0	73	0	0	0	0
3	*Anguilla bengalensis bengalensis*	0	0	0	8	1	0	0	1	0	0	0	2
4	*Barilius bendelisis*	0	24	41	16	14	0	4	3	15	0	0	0
5	*Barilius* sp.1	0	0	0	0	0	0	3	31	4	0	0	0
6	*Barilius* sp.2	0	2	0	0	0	0	0	0	0	0	0	0
7	*Chanda nama*	3	0	0	0	0	17	1	6	1	0	0	4
8	*Channa orientalis*	0	0	5	0	0	0	0	0	0	0	0	0
9	*Channa punctatus*	0	0	5	2	4	0	0	40	0	0	0	73
10	*Channa striatus*	0	0	0	9	0	0	0	0	0	0	0	0
11	*Cirrhinus fulungee*	0	0	0	0	0	0	0	1	0	0	0	0
12	*Danio aequipinnatus*	0	0	10	9	0	0	1	0	4	0	0	0
13	*Danio* sp.	0	0	29	203	22	0	0	0	0	0	0	0
14	*Garra mullya*	41	6	14	8	0	22	0	0	3	2	1	412
15	*Glossogobius giuris*	2	7	1	6	0	6	3	18	0	2	0	4
16	*Gonoproktopterus kolus*	0	0	0	0	0	0	0	0	1	0	0	0
17	*Labeo rohita*	0	0	0	0	0	0	1	6	0	0	0	0
18	*Lepidocephalus thermalis*	0	0	14	32	6	0	0	28	0	0	4	9
19	*Macrognathus aral*	0	0	0	0	0	0	0	0	0	0	0	3
20	*Mastacembelus armatus*	0	0	0	0	4	0	0	0	0	0	0	65
21	*Mystus bleekeri*	3	0	2	0	4	0	4	0	0	0	0	2
22	*Mystus cavasius*	15	5	28	37	0	0	4	4	2	7	1	8
23	*Mystus* sp.	0	0	0	0	0	0	0	0	0	0	0	8
24	*Nemacheilus* sp.	0	0	0	0	0	0	0	0	1	0	0	0
25	*Notopterus notopterus*	0	0	1	0	0	0	1	1	0	5	0	0
26	*Ompok bimaculatus*	1	0	0	0	0	0	0	0	1	0	0	0
27	*Oreochromis mossambica*	0	0	0	5	0	0	0	0	0	0	0	0
28	*Oreonectes evezardi*	14	0	0	0	0	0	0	0	0	0	0	0
29	*Osteobrama cotio peninsularis*	0	0	0	0	0	0	2	8	1	0	0	2
30	*Osteobrama vigorsii*	0	0	0	0	0	0	2	7	0	0	0	0
31	*Parambassis ranga*	0	0	0	0	0	0	5	15	0	0	0	17
32	*Puntius amphibius*	0	0	24	45	6	0	2	0	0	1	0	0
33	*Puntius sarana sarana*	0	5	21	6	0	0	0	0	0	0	1	0
34	*Puntius sophore*	0	0	29	42	2	2	179	121	62	37	39	0
35	*Puntius* sp.	0	0	1	0	0	0	0	0	0	0	0	0
36	*Puntius ticto*	30	48	67	149	53	52	197	212	124	185	84	49
37	*Rasbora daniconius*	14	0	36	6	5	0	0	0	0	0	0	0
38	*Rita* sp.	0	0	0	0	0	0	0	0	0	0	0	1
39	*Salmostoma horai*	0	0	0	0	0	0	16	9	2	6	4	0
40	*Salmostoma novacula*	0	0	0	0	0	0	1	0	0	0	0	0
41	*Schistura denisoni denisoni*	0	0	19	0	0	0	0	0	0	0	0	1
42	*Thynnichthys sandkhol*	0	0	0	11	0	0	13	6	9	5	14	0
43	*Tor khudree*	0	0	0	0	0	0	0	0	0	0	0	2
44	*Tor mussulah*	0	0	7	59	7	9	0	0	0	0	0	0
45	*Tor tor*	0	0	0	0	0	0	2	7	0	0	0	0
46	*Wallago attu*	4	0	0	0	0	0	0	1	12	0	0	0
47	*Xenentodon cancila*	0	2	0	0	0	0	1	3	1	0	2	0

and similarity measures.

Results

3894 individuals were collected from both rivers (1508 from the Kathani and 2386 from the Adan). A total of 47 species were identified (32 Kathani, 38 Adan). Cypriniformes were the dominant group in both rivers (15 species), with dominant species from both rivers being *Puntius ticto*. The singletons (with only one individual) at Kathani are *Amblypharyngodon mola*, *Puntius sps.*, *Notopterus notopterus* and *Ompok bimaculatus*. The singletons from Adan are *Nemacheilus* sp., *Rita* sp., *Gonoproktopterus kolus*, *Labeo fulungee*, *Schistura denisoni denisoni*, *Ompok bimaculatus*, *Tor* sp., *Puntius sarana sarana*, *Salmostoma novacula* and *Tor khudree*. *Puntius ticto* is widely distributed and reported from all 12 sampling points, while 15 species were reported from only one sampling point. Cyprinidae is the most species rich family in both the rivers with 28 species, whereas 10 families were represented by only one species (Fig 2) (Table 2).

Species richness:

Species richness of both rivers combined: Jackknife 1 measure of species richness showed 56 species, which can be considered an upper bound for the species richness of both rivers combined. Species richness calculated by rarefaction gives 47 species, which is considered the lower bound. Thus I conclude that combining both rivers, number of species ranges from 47 to 56.

Species richness measures calculated for 1508 individuals for river Kathani and 2,386 individuals for Adan. Kathani shows 38 species (Jackknife 1 with SD 2.19) while Adan show 40 (Jackknife 1 with SD 3.32) species. The rarefaction of the two rivers show Adan 34 species and Kathani 32 species at 1501 individuals.

Mann-Whitney U test (Brower et al. 1990) was performed

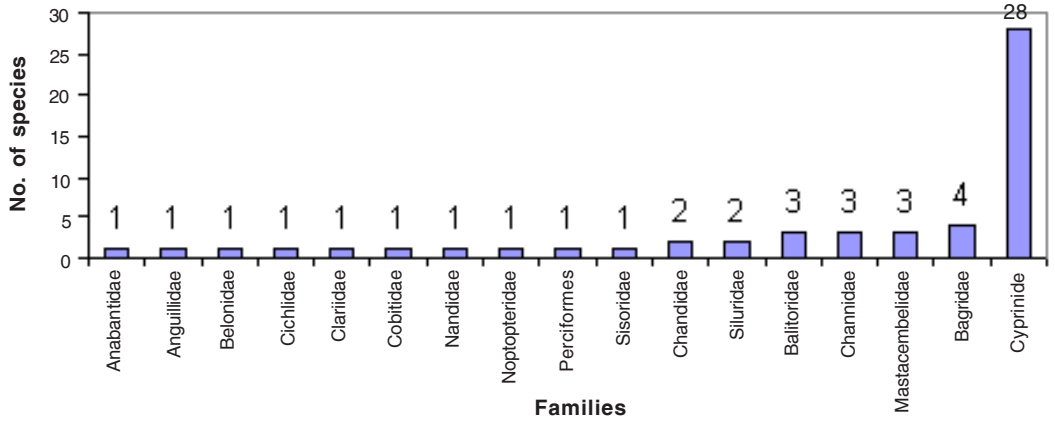

Figure 2. Number of fish species in different families (Both rivers combined)

Table 3. Values of species richness, diversity indices for Adan and Kathani

	Attributes	Adan	Kathani
1	Samples	111	143
2	Individuals (computed)	2386	1508
3	Species richness: Jack 1 Mean	47.91	36.97
4	Jack 1 SD (analytical)	3.32	2.19
5	Rarefied species richness at 1501 individuals	34.13	31.98
6	Shannon mean	2.1	2.58
7	Shannon SD (runs)	0.19	0.13
8	Simpson mean	4.8	8.34
9	Simpson SD (runs)	0.99	1.13

to find out differences in the species richness values. The null hypothesis (H_0) put was 'there is no significant difference between the species richness values of both rivers'. Null hypothesis was rejected as significant difference was detected in both rivers species richness for Jackknife 1 (U = 3413.5, P < 0.0001, CI = 6.77-9.38). However, the rarefied species richness shows no significant difference between the values at similar number of individuals (U = 12685, P = 0.0905, CI = -1.56-0.12). That means at similar number of the individuals both rivers do not show significant differences in the species richness values.

Species diversity

The Shannon index for the Kathani was 2.58, and for the Adan 2.1 (calculated using natural log). The Mann-Whitney U test showed a highly significant difference between rivers (U = 111, P < 0.0001), with the Kathani being more diverse than the Adan. The mean value of the Simpson diversity index for the Adan is 4.8, for the Kathani 8.34 (U = 24, P < 0.0001 with CI = 2.98-3.23) which again confirms that both rivers are differs in their diversity values (Table 3).

Discussion

Although both rivers are the part of same larger basin, significant differences in diversity values were observed. The Kathani is a small river in comparison to the Adan but shows higher diversity. The difference in the value of the diversity indices and species richness values can be explained by considering anthropogenic factors that include pollution (much less in the Kathani) and damming (the Adan has 2 dams). This study supports earlier studies performed by Dean et al. (1998) on the effect of human induced influences on the diversity of the fish in three small streams in southern Ontario and studies by Habit et al. (2006). Dale et al. (1999) found that an overall decrease in fish abundance occurs with increase in the length of non-forested riparian zones (a situation that can be observed in the Adan) while several studies have demonstrated that dams lower fish species diversity (Michio et al. 2007; Morita & Yamamoto 2002) (Table 4).

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Table 4. Comparison of land use pattern and anthropogenic factors for Adan and Kathani rivers.

Attributes	River Adan		River Kathani
	Washim District	Yeotmal District	Gadchiroli District
Forest cover of District from which river flows	6.46%	18.77%	69.78%
Forest area of Districts from which river flows	8.72%	27.35%	90.96%
Population Density of District from which river flows (2002):km^{-1}	300	181	67
Pollution	Moderate		Negligible
Use of pesticides in the adjacent farms	Substantial		Negligible

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