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INSIGHT TO THE SPATIAL DISTRIBUTION OF AMPHIBIANS AT MAJOR WETLANDS AND ASSOCIATED ECOSYSTEMS OF WESTERN GHATS FROM MAHARASHTRA, INDIA

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Abstract

Present study was emphasized to reveal the comparative status of amphibian diversity at five major wetlands and their adjoining ecosystems from Ajara tahsil of Kolhapur district, Maharashtra, India. Diversity of amphibians was analyzed by using standard methods as prescribed by standard literature. In deep, diversity attributes like Whittekar's B - diversity, diversity indices such as Shannon (H), Simpson (1-D), Dominance (D) and Shannon's evenness indices; Individual rarefication curve and Renyi's Diversity Profile were estimated so as to compare diversity status among studied wetlands. The results of present investigation divulged that total 22 species of amphibians belonging to 17 genera and 7 families were recorded. On the basis of this Gavase and Dhanagarmola wetlands were found rich in the diversity. However, Statistical analysis revealed that Gavase and Dhanagamola wetlands have similar ecological conditions, hence, amphibian diversity status was noted similar to each other. On the other hand, due to high anthropological activities, Yarandol and Ningidage wetlands exhibited poor amphibian diversity. Comparatively, Khanapur wetland has an average diversity status.

Keywords*: Amphibian diversity; Wetlands; Whittakar's B-diversity; Diversity indices; Individual rarefiction curve; Reyni's profile*

Introduction

Wetlands provide feeding, breeding and nesting ground to the many of the organisms especially, fishes, amphibians, reptiles and birds. Amphibians are sensitive animals especially towards the change in ecological conditions. Although, amphibians are not totally dependent on water bodies (terrestrial and burrowing, arboreal, semi-aquatic and aquatic), during development, one of its life stages requires aquatic environment viz. tadpole stage. Many of the workers have attempted to report the diversity of amphibians from various regions but no concrete work was done with reference to wetlands. However, Padhye and Gate [1] put forward an overview of amphibian fauna of Maharashtra state in which 43 species of amphibians out of 224 species from India were distributed among six families viz, Icthyophiidae, Caecilidae, Bufonidae, Microhylidae, Ranidae and Rhacophoridae. Out of which seven genera are endemic to Western Ghats and three are represented in Maharashtra state. Trevor [2] studied changes in dewpond numbers and amphibian diversity over 20 years on Chalk down land in Sussex, England. Vasudevan *et al.* [3] have studied structure and composition of rain forest floor with respect to amphibian communities in Kalakadai-Mundanthurai Tiger reserve. Vasudevan *et al.*

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[4] have given an emphasis on species turnover: The case of stream amphibians of rain forests in Western Ghats. Roelants *et al.* [5] have reported the global patterns of diversification in the history of modern amphibians. Naniwadekar and Vasudevan [6] have studied patterns in anurans along an elevation gradient in the Western Ghats.

Vences and Kohler [7] studied on global diversity of amphibians in freshwater. The article presented a review of species numbers, biogeographic patterns and evolutionary trends of amphibians in freshwater. Nath *et al.* [8] studied the amphibian community structure, spatial overlap and herpetic-faunal assemblage at Mannampandal, Tamil Nadu.

Materials and methods

Study Area

Ajara is one of the important tahsil of Kolhapur district, located at southern region with N 16º 12’ and E 74º 2’. Total population of the tahsil is about 1,210,430 residing in 74 villages. The total area of the tahsil is about 54,853ha. Geographically, the area is undulating throughout the tahsil except some part of its north-western region. The climate is moderate subtropical with an average annual rainfall of 2000 mm. Ajara is famous for its natural landscape, since most of the area is covered with forest and falls under corridor of Western Ghats and Konkan [9].

Gavase wetland (Fig. 1) is situated south-west to the Ajara city at N 16º 05’ 761” and E 74º 07’ 596”. The reservoir was man-made and construction of the dam was completed in the year 2003. According to government records, the total submergence area of the reservoir is 15.2 ha while the actual submergence area estimated during the study is 37.04 ha during monsoon season and 3.79ha during summer season [9].

Fig. 1. Map of Gavase: a - GPS map; b – Google map.

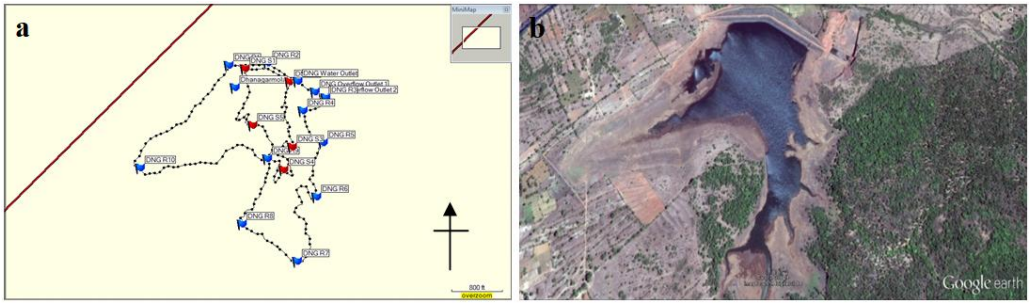

Fig. 2. Map of Dhangarmola wetland: a - GPS map; b – Google map.

Dhangarmola wetland (Fig. 2) is situated at south-west to the Ajara city with longitude and latitude of 16º 03’ 687” and 74º 05’ 647”. The dam was constructed in the year 2000. The

total submergence area of the reservoir with respect to government records is 41.09ha and actual submergence area mapped by GPS is 55.17ha. The submergence area mapped during summer season is 7.32ha [9].

The location of Yarandol freshwater body (Fig. 3) is N 16º 03' 629" and E 74º 10' 539", situated to the south of Ajara city. This reservoir was constructed in the year 1998. The total submergence area of the reservoir when constructed was 65.95ha. On the other hand, submergence area at present is 71.48ha during monsoon season. The total submergence area got reduced to 36.52ha during summer season [9].

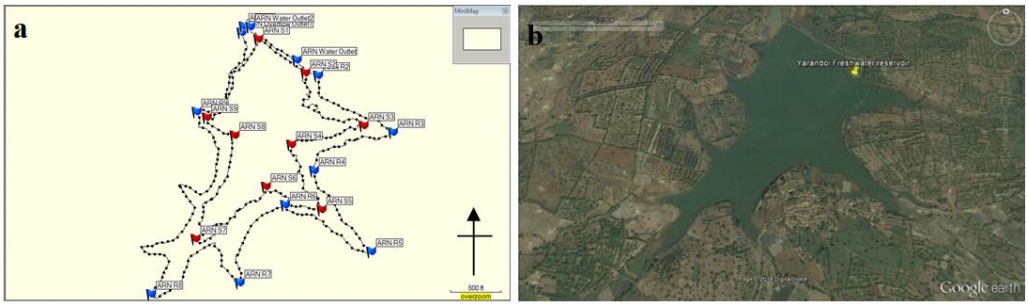

Fig. 3. Map of Yarandol wetland: a - GPS map; b – Google map.

Khanapur wetland was (Fig. 4) constructed in the year 1995 which is situated at south-west of Ajara city with the location of N 16º 05' 352" and E 74º 18' 132". Total submergence area of the reservoir according to secondary data is 16.7 ha while actual mapped submergence area is 20.71ha. The submergence area of the reservoir during summer season was 3.13ha [9].

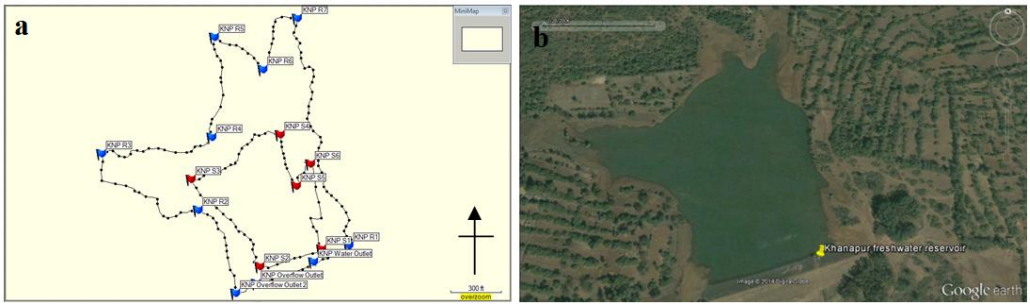

Fig. 4. Map of Khanapur wetland: a - GPS map; b – Google map.

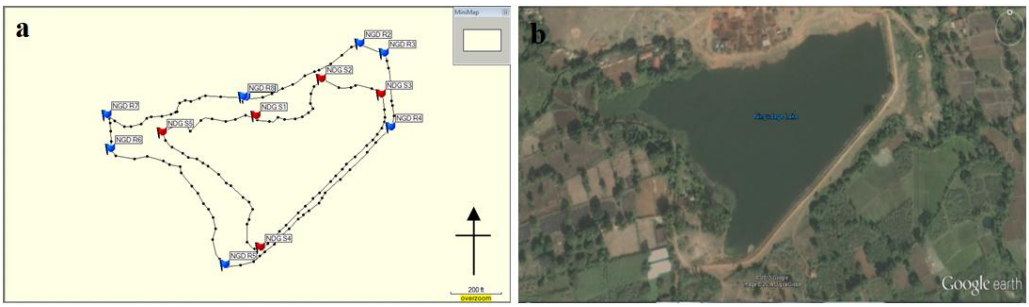

Fig. 5. Map of Ningudage wetland: a - GPS map; b – Google map.

Ningudage freshwater body is (Fig. 5) situated at north-east of the Ajara city with the location of N 16º 09' 325" and E 74º 18' 132". The reservoir was constructed in the year 1982.

The submergence area was 9 ha with reference to government records. However, GPS mapping showed that the actual submergence area is 4.28ha. The submergence area during summer season was 2.35ha [9].

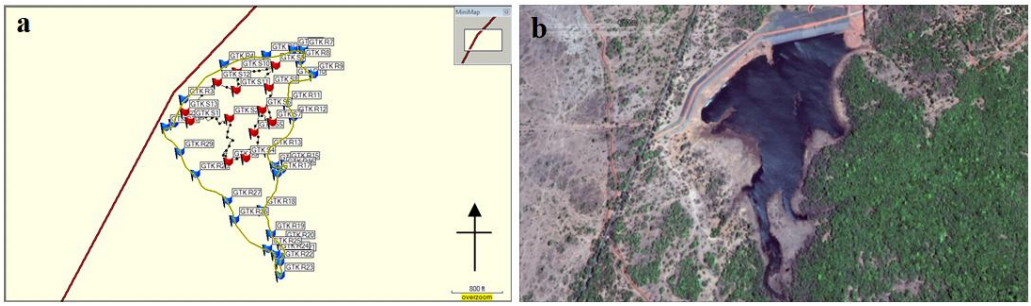

Fig. 6. Map of Ghatkarwadi wetland: a - GPS map; b – Google map.

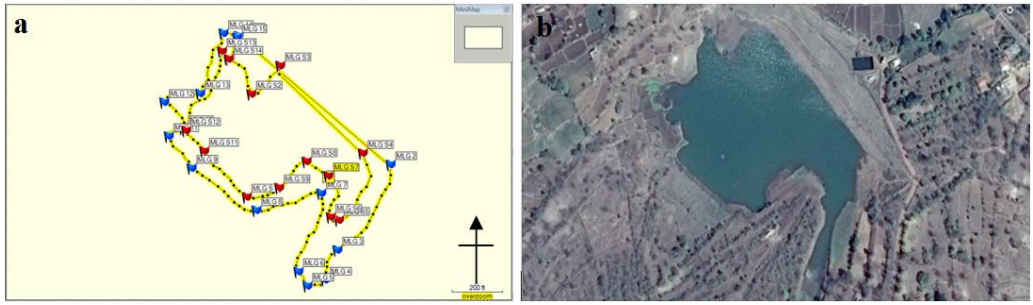

Fig. 7. Map of Maligre wetland: a - GPS map; b – Google map.

Note: Indicates boundry line of water during summer season; Indicates boundry line of water during monsoon season

Diversity Analysis

Amphibians are sensitive creatures of the universe and need more attention. The present study was carried out in the monsoons of the years 2011-12 to 2014-15. During the study period, frequent visits were made to reservoirs and their adjoining areas to collect amphibians through visual survey technique [9]. Collected specimens of amphibians were identified on the field by using standard references, viz. The book of Indian reptiles and amphibians [11] and Pictorial guide to frogs and toads of Western Ghats [12], photographed (using Canon 600 D Camera with 18-55 mm lens) whenever possible and collected specimens of amphibian were released back to collection point. Time constraint method was used to collect data for the analysis of diversity indices [13]. The Shannon index has been a popular diversity index in the ecological literature [14-16], where it is known as Shannon's diversity index, the Shannon - Wiener index, the Shannon- Weaver index and the Shannon entropy [17-20].

Time constrained method: In this technique, a predetermined duration is set for sampling the area or habitat. The presence of different species and the number of individuals observed are recorded. Visual encounter protocols are followed that is, animals are counted as they walk over the forest floor or stream bottom, hide in crevices or cling to cave walls, found by turning over surface debris or heard calling. The number of observers x total amount of time sampled is recorded. In terrestrial and aquatic situations, times may be set for 15 or 30 minutes, occasionally longer, depending on the number of observers and the amount or quality of habitat to be surveyed. For the present study, the predetermined amount of time was set to 90 minutes, as the number of observer was single. The results obtained from the survey were analyzed for diversity indices:

a. Diversity indices like Whittakar's B- diversity, Shannon's evenness index (H), Simpson (1-D), Dominance (D) indices were estimated by using PAST Version 2.17c as suggested in standard literature [21].
b. Rarefication curve and Renyi's diversity profile were estimated by BioDiversity-R version 3.0.2 as suggested in Tree diversity analysis [22].

Results and discussion

The analysis of amphibian diversity was carried out at all five wetlands and depicted in Table 1 while composition of amphibians at all reservoirs is represented in figure 8 to figure 12.

Table 1. Distribution of amphibians at study sites

S. No	Common Name		Gavase	Dhangarmola	Yarandol	Khanapur	Ningudage
1	*Xanthophryne tigerina*(Biju, Bocxlaer, Giri, Loader and Bossuyt, 2009)	Yellow Tiger Toad	+	+	-	-	-
2	*Duttaphrynus melanostictus*(Schneider, 1799)	Common Indian Toad	+	+	+	+	+
3	*Hoplobatrachus tigerinus*(Daudin, 1803)	Indian Bull Frog	+	+	+	+	+
4	*Euphlyctis cyanophlyctis*(Schneider, 1799)	Common Skittering frog	+	+	+	+	+
5	*Sphaerotheca brevipus*(Schneider, 1799)	Indian Burrowing Frog	+	+	+	+	+
6	*Fejervarya sp.1*		+	+	+	+	+
7	*Fejervarya sp.2*		+	-	-	-	-
8	*Minervarya sahyadris*(Dubois, Ohler & Biju, 2001)	Minervarya Frog	+	+	-	+	-
9	*Microhyla ornata*(Dumeril & Bibron, 1841)	Ornate Narrow-mouthed Frog	+	+	+	+	+
10	*Uperondon globulosus*(Gunther, 1864)	Indian Baloon Frog	-	-	-	-	+
11	*Microhyla rubra*(Jordan, 1854)	Red narrow-mouthed Frog	+	+	-	-	-
12	*Clinotarsus curtipes*(Jordan, 1854)	Bicoloured Frog	+	+	-	+	-
13	*Hylarana temporalis*(Gunther, 1864)	Bronze Frog	+	+	+	+	-
14	*Hylarana malabarica*(Tschudi, 1838)	Fungoid Frog	+	+	-	+	-
15	*Indirana beddomii*(Gunther, 1875)	Beddome's Frog	+	+	+	+	-
16	*Limnonectus limnocharis*	Indian Cricket Frog	+	+	+	+	+
17	*Nyctibatrachus spp.*		+	+	-	-	-
18	*Polypedates maculatus*(Gray, 1830)	Common Tree Frog	+	+	-	+	-
19	*Pseudophilautus amboli*(Biju & Bossuet, 2009)	Amboli Bush Frog	+	+	+	+	+
20	*Roarchestes bombayensis*(Annandale, 1919)	Konkan Bush Frog	+	+	-	-	-
21	*Ichthyophis beddomei*(Peters, 1879)		+	+	+	+	-
22	*Ichthyophis bombayensis*(Taylor, 1960)		+	+	-	+	-

Note: +: Present, -: Absent

The present investigation was an attempt to analyze diversity status of amphibians, it has revealed that Gavase freshwater body, and composition of the same is shown in figure 8. The diversity of amphibians at this reservoir is rich, exhibiting 21 species belonging to 7 families. Since the Dicroglossidae was dominant family with 28.57% among all, which followed by Ranidae (23.81%). The seven families recorded at the Gavase water body are Bufonidae, Dicroglossidae, Microhylidae, Ranidae, Nyctibatrachidae, Rhacophoridae and Ichythyophiidae. The total number of genera investigated at this site was 17.

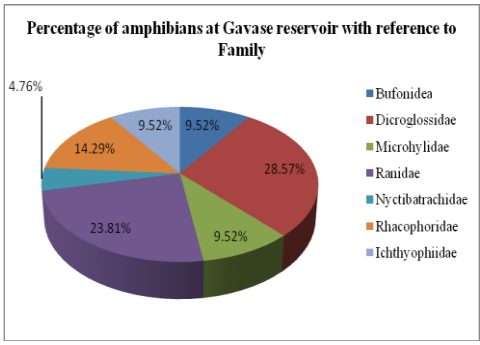

Fig. 8. Percentage composition of amphibians at Gavase water body with reference to family

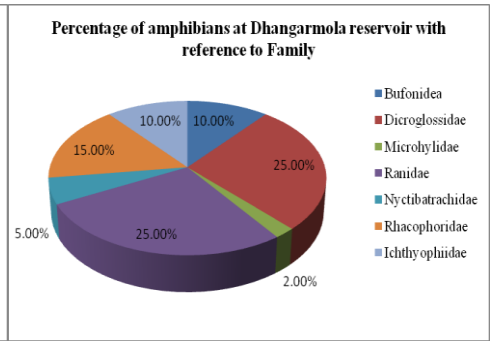

Fig. 9. Percentage composition of amphibians at Dhangarmola water body with reference to family

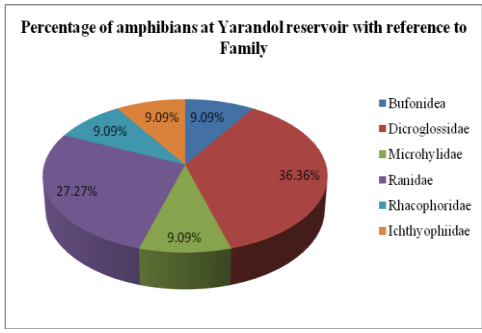

Fig. 10. Percentage composition of amphibians at Yarandol water body with reference to family

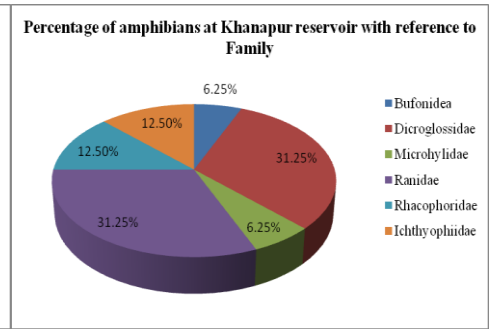

Fig. 11. Percentage composition of amphibians at Khanapur water body with reference to family

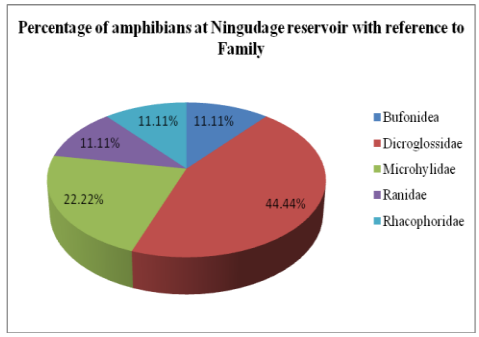

Fig. 12. Percentage composition of amphibians at Ningudage water body with reference to family

However, various taxons were recorded with diversified microhabitats and categorized based on their habitats, as terrestrial and burrowing, arboreal, semi-aquatic and aquatic. During the study period, amphibians were mostly recorded in the months of rainy season while some records also have been made immediately after monsoon and post monsoon season. Out of the genera, three were terrestrial and burrowing (*Xanthophryne*, *Duttaphrynus* and *Sphaerotheca*). These individuals were recorded from the adjoining region of the study site, beneath the crevices of rocks, undercover of leaves, on the open ground etc. Genera *Polypedates*, *Pseudophilautus* and *Roarchestes* were arboreal in habitat and observed on and beneath the

leaves, barks and branches of plants etc. These three species were especially recorded on the shrubby plants around the study site. Two of the amphibian taxa were found aquatic viz. *Euphlyctis* and *Nyctibatrachus* while remaining taxa were semi-aquatic. Semi-aquatic taxa were reported from the reservoir as well as surrounding area while aquatic species were recorded from reservoir water. Especially, species of *Nyctibatrachus* were observed under the stream water entering the reservoir. During study period, egg clutches were also observed attached to stem of large trees, which might belong to *Nyctibatrachus.*

The study of amphibians at Dhangarmola freshwater body exhibited 20 species belonging to 17 genera and 7 families and the composition of this amphibian diversity is as shown in figure 9. The study has also revealed that Dicroglossidae and Ranidae were dominant families occupying similar percentage of composition (25.00%) followed by Rhacophoridae (15.00%). The seven families recorded at this reservoir are *Bufonidae* (10%), *Dicroglossidae* (25%), *Microhylidae* (10%), *Ranidae* (25%), *Nyctibatrachidae* (5%), *Rhacophoridae* (15%) and *Ichythyophiidae* (10%). The total number of genera investigated at this site was 17. However, various taxons were recorded with diversified micro-habitats and categorized as terrestrial and burrowing, arboreal, semiaquatic and aquatic on the basis of their habitats. Most of the amphibians were cited in the months of rainy season while some of them were cited immediately after monsoon and in the post monsoon season. Out of all genera, three are (*Xanthophryne, Duttaphrynus* and *Sphaerotheca*) terrestrial and burrowing in habitat. These individuals were recorded from the adjoining region of the study site, beneath the crevices of rocks, undercover of leaves, on the open ground etc. Genera *Polypedates, Pseudophilautus* and *Roarchestes* were arboreal in habitat and observed on and beneath the leaves, barks and branches of plants etc. These three species were especially recorded on the shrubby plants surrounding the reservoir. Two of the amphibian taxa found were aquatic viz. *Euphlyctis*and *Nyctibatrachus*while remaining taxa were semi-aquatic. Semi-aquatic taxa were reported from the reservoir as well as surrounding area while aquatic species were recorded from reservoir water. Especially, species of *Nyctibatrachus* were observed under the stream water entering the reservoir. During study period, foamy egg clutches were also observed attached to branches of large trees hanging on the reservoir water, which belong to *Rhacophorus malabaricus* but no direct record was made.

Composition of amphibian diversity at Yarandol wetland is represented in figure 10. The investigation showed totally 11 species of amphibians at this wetland, belonging to 6 families and 11 genera. The study has also revealed that *Dicroglossidae* (36.36%), followed by *Ranidae* (27.27%) were dominant families. The site showed the percentage of other families as *Rhacophoridae* (9.09%), *Bufonidae* (9.09%), *Microhylidae* (9.09%) and *Ichythyophiidae* (9.09%). Various taxons were recorded with diversified micro-habitats and categorized as terrestrial and burrowing, arboreal, semiaquatic and aquatic on the basis of their habitats. Most of the amphibians were cited in the months of rainy season while some of them were cited immediately after monsoon and in the post monsoon season. Out of all genera, one is terrestrial and burrowing namely, *Duttaphrynus* which was commonly cited during the study period. The record of these taxa was mainly from the adjoining region of the study site, beneath the crevices of rocks, undercover of leaves, on the open ground and small pits formed at reservoir. *Hoplobatrachus, Fejervarya, Microhyla, Hylarana, Indirana and Limnonectus* are semi-aquatic and observed mostly in the reservoir water and occasionally at adjoining region. Only the species of *Euphlyctis* is aquatic anuran whivh was recorded from this study areawhile *Pseudophilautus*is only arboreal anuran found during study period. Semi-aquatic taxa were reported from the reservoir as well as surrounding area while aquatic species were recorded from reservoir water.

Khanapur wetland exhibited 16 species of amphibians among which 14 were anurans and 2 were caecilians. The composition chart is as shown in figure 11. The total species of amphibians are mainly belonging to 14 genera and 6 families viz. *Bufonidae, Dicroglossidae,*

Microhylidae, Ranidae, Rhacophoridae and *Ichythyopidae.* Between these, *Dicroglossidae* and *Ranidae* were dominant with 31.25 % of individuals each. These taxons were recorded from diversified microhabitats and categorized as terrestrial and burrowing, arboreal, semiaquatic and aquatic on the basis of their habitats. Most of the amphibians were cited in the months of rainy season while some of them were cited immediately after monsoon and in the post monsoon season. The genera like *Duttaphrynus*and *Sphaerotheca* were terrestrial and burrowing and observed at the adjoining region of this reservoir. One of the species belonging to *Euphlyctis* was aquatic, two species (*Polypedates and Pseudophilautus*) were arboreal while remaining were semi-aquatic.The arboreal species were observed from the shrubby aquatic vegetation at the adjacent places of this reservoir while semi-aquatic species were recorded from the water as well as the adjoining region. Among all, the species, *Hoplobatrachus was* commonly observed. Two species of *Ichythyophis* were also noted from this site.

Ningudage wetland displayed very less species of amphibians among all study sites. There were 9 species of amphibians composed of 5 families and 9 genera. The composition chart is depicted in figure 12. The only site where *Uperondon* species was observed, which is terrestrial and burrowing anuran, along with this *Duttaphrynus* and *Sphaerotheca* were another two anurans belonging to the same habitat. One species was aquatic in habitat (*Euphlyctis*), one species was arboreal (*Pseudophilautus*) and remaining were semi-aquatic (*Hoplobatrachus, Fejervarya, Microhyla and Limnonectus*) in habitat. The *Uperondon* species was observed only once during the study period burrowed in the soil at the dam site of the reservoir. Other terrestrial and burrowing anurans were noticed commonly at the adjoining region of the site. Only the arboreal species were observed commonly on the shrubby plants at the adjacent area of the reservoir while semi-aquatic species were found under water as well as nearby places of the water-body.

Statistical analysis of biological parameters:

Whittaker's B - Diversity

Whittaker's B - Diversity is one of the significant analytical methods for the comparison of the diversity indices among various habitats or landscapes. Whittaker's B - Diversity index tending to zero represents that sites showing similar species *richness* and abundance, on the contrary, increasing values exhibits increase in dissimilarity in species richness and abundance. The results of Whittaker's B - Diversity for amphibians are expressed in table 2.

Table 2. Whittaker's B- Diversity of amphibians among the study sites

Reservoirs	Gavase	Dhangarmola	Yarandol	Khanapur	Ningudage
Gavase	0				
Dhangarmola	0	0			
Yarandol	0.222	0.222	0		
Khanapur	0	0	0.222	0	
Ningudage	0.263	0.263	0.066	0.263	0

Whittaker's B - Diversity for amphibian diversity

Whittaker's B - Diversity for amphibians' at all five reservoirs clearly indicates the categorization of these wetlands on the basis of ecology. Whittaker's B - Diversity is equal to zero at Gavase, Dhangarmola and Khanapur wetlands. Hence, it can be predicted that the type of habitat and disturbance level at all above reservoirs are same with respect to amphibian diversity. The Whittaker's B - Diversity indicated that all these reservoirs show exact similar composition and abundance. However, Yarandol and Ningudage showed quite similar species composition and abundance. Furthermore, both these reservoirs showed dissimilarity of species composition and abundance with previous three water reservoirs.

Whittaker's B - Diversity for amphibians indicates that the selected sites for the present study can be significantly categorized on the basis of ecological status. Gavase and Dhangarmola are the wetlands having similar ecological conditions, hence showed quite similar

species composition and abundance. Khanapur water reservoir showed few degree of dissimilarity with these two reservoirs and the later two (Yarandol and Ningudage) were at the similar line for the species composition and abundance. Based on these results, the wetlands can be preliminarily and broadly categorized in three different ecological habitats. Gavase and Dhangarmola wetlands are to be rich ecological conditions as both reservoirs covered with thick forest at three sides and considerably undisturbed. Khanapur water body is also with good ecological condition but comparative disturbance was observed and the forest type is of monoculture with *Acacia auriculiformis.* However, wetlands from Yarandol and Ningudage were disturbed with continuous anthropogenic activities due to nearby villeges. Hence, species composition of Gavase and Dhangarmola were significantly similar while Khanapur also showed some degree of similarity with these two. However, Whittaker's B - Diversity for amphibians showed exact similar species composition and abundance at these three reservoirs. On the other hand, Yarandol and Ningudage showed quite similar species composition and abundance while these showed high degree of dissimilarity with above three.

Diversity indices

Diversity indices provide a summary of richness and evenness. These can be estimated by various ways to study the richness, evenness and dominance. The most popularly used diversity indices are the Shannon and Simpson diversity indices. When we consider the Shannon (H) diversity index, larger the index value more the species richness and smaller the index value, species richness is less. Simpson index is inversely proportional to Shannon index. Hence, the reciprocal of Simpson index is calculated and accordingly results have been discussed. Two of other indices are Shannon's evenness index and Dominance (D) index. These are also important indices. The Shannon's evenness index implies how the species are evenly distributed in a specified area and dominance index indicates the dominance of two or more species.

Shannon (H), Simpson (1-D), Dominance (D) and Shannon's evenness indices are interrelated with each other. As dominance index increases, the respective Shannon (H) and Simpson (1-D) indices along with evenness decreases.

Diversity indices for amphibian diversity

Amphibians are very important group of chordates. These play a vital role in food chain. Since monitoring amphibians at field for the diversity indices is quite difficult task as they live dual life on land and under water. The investigations revealed that the dominance (D) index was least at Gavase water body followed by Dhangarmola and then Khanapur water body. However, the highest dominance value was observed at Ningudage water reservoir. Yarandol wetland was at second position for its dominance index. Shannon (H) and Simpson (1-D) values were right in parallel position with each other. The diversity indices for amphibians exhibited that the Shannon (H) species richness increased with increase in Simpson (1-D) index at all wetlands. The Shannon's evenness index values were quite different from that of Shannon and Simpson indices.

The Shannon and Simpson indices are in descending order as Gavase > Dhangarmola > Khanapur > Yarandol > Ningudage. The Shannon's evenness index in sequence is Gavase (0.7664) > Yarandol (0.754) > Dhangarmola (0.7124) > Ningudage (0.6555) > Khanapur (0.6408). Even though the trend of evenness was varied and species were more evenly distributed at Ningudage water body than that of Dhangarmola water body, the richness indices indicates that the later was having better ecological conditions. The total individuals spotted at Ningudage water body as compared to Dhangarmola are quite less hence; the evenness value might be more. Hence, the present investigation suggests that the Gavase and Dhangarmola are rich in ecology as the species richness was more and Ningudage and Yarandol are poor in richness as the species richness was less.

Individual rarefication curve

This is the graphical representation which is useful when the species richness between various sites having variable number of individuals is compared because larger the number of individuals, more species are found, since there might be bias in the richness values. Thus rarefication curve bring down the larger sample size to smaller one in order to compare them on equal sample size basis. Using this graph, one can easily compare the species richness, more particularly, richness of varied sample sizes.

Rarefication curve for amphibian diversity (Fig. 13) is rectified to 60 individuals at Ningudage water body where eight taxa have been found. On the similar line, Gavase and Dhangarmola water bodies showed 10 taxa while Yarandol water body exhibited 7 taxa. It was clear that the richness of Gavase and Dhangarmola were more while Yarandol was at the least.

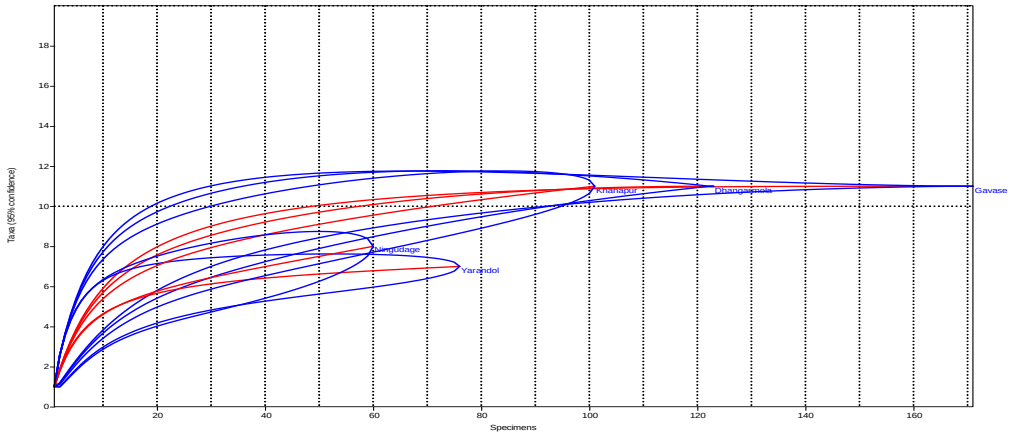

Fig. 13. Individual rarefication curve for amphibians at study sites
Note: Blue lines in figure are 95% Confidence Interval by bootstrapping

Renyi's Diversity Profile

Renyi's diversity profile is the profile where the diversity of species is compared among various sites or habitats. The X - axis represents alpha and when it is equal to zero it corresponds to species richness.

Table 3. Alpha- diversity indices for amphibian fauna at the study sites

Reservoirs/Indices	Taxa_S	Individuals	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S
Gavase	**11**	**171**	**0.1402**	**0.8598**	**2.132**	**0.7664**
Lower	9	171	0.1479	0.8051	1.854	0.5783
Upper	12	171	0.1947	0.852	2.079	0.7569
Dhangarmola	**11**	**123**	**0.1517**	**0.8483**	**2.059**	**0.7124**
Lower	9	123	0.1456	0.7958	1.798	0.5894
Upper	12	123	0.2038	0.8544	2.093	0.7773
Yarandol	**7**	**76**	**0.2161**	**0.7839**	**1.664**	**0.754**
Lower	8	76	0.1427	0.7822	1.742	0.6038
Upper	11	76	0.2178	0.8573	2.109	0.829
Khanapur	**11**	**101**	**0.1713**	**0.8287**	**1.953**	**0.6408**
Lower	8	101	0.1442	0.7944	1.798	0.6026
Upper	12	101	0.2052	0.8558	2.094	0.8012
Ningudage	**8**	**60**	**0.2278**	**0.7722**	**1.657**	**0.6555**
Lower	7	60	0.1406	0.7744	1.714	0.6158
Upper	11	60	0.2256	0.8594	2.097	0.8484

However, Shannon index is corresponded when alpha is equal to one. Furthermore, the slope of line indicates the distribution of species. Steeper is the slope line more the unevenness

in the distribution of species (lower density). Even further, when two lines intersect each other, one cannot order them as lower or higher diversity due to uneven trend of species richness and their proportion among the sites based on Renyi's diversity profile. However, when there is no intersection between two lines (sites), one can compare those sites significantly.

The Renyi's diversity for amphibians (Fig. 14) revealed that lines of Gavase, Dhangarmola and Khanapur intersect each other hence the comparison is insignificant. Since, these lines display the highest species distribution. However, lines of Yarandol and Ningudage intersect each other and the curve is steeper than first group, hence considered to be with lower species diversity.

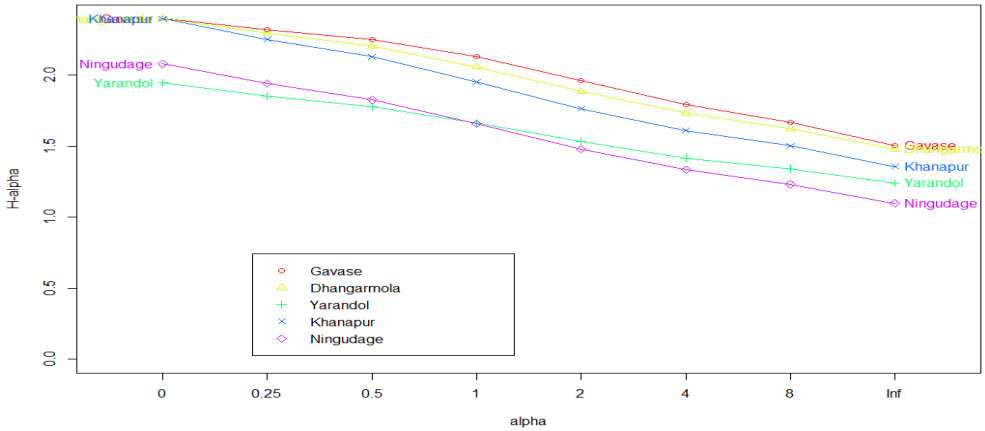

Fig. 14. Renyi's diversity profile for amphibians at study sites

Conclusion

The amphibian diversity was rich at Gavase and Dhangarmola wetlands followed by Khanapur wetland. On the other hand, Yarandol and Ningudage wetlands exhibited very less amphibians. Since the former two reservoirs are undisturbed and with minimal anthropological activities while Khanapur water body face medium level of human activities. However, the later two reservoirs face extreme anthropological activities by the means of domestic as well as agricultural influence. This can also be noted through analysis of physico-chemical characteristics. On the basis of diversity indices, rarefication curve and Renyi's profile, it can be concluded that Gavase and Dhangarmola freshwater bodies are rich in diversity profiles. These two wetlands were found to be similar in habitat. However, Yarandol and Ningudage freshwater bodies were observed poor in diversity profiles and showed similarity in habitat. Khanapur wetland was noted partial disturbance and alike with both types of habitats.

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