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Cover: *Geodorum laxiflorum* Griff.—inflorescence (Orchidaceae) © Ashish Ravindra Bhojar.



Reptilian assemblages in the wetlands of Amboli hill complex, northern Western Ghats, Maharashtra, India during the monsoon season

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Abstract: We studied the reptilian diversity in and around five man-made wetlands in Amboli hill complex of the northern Western Ghats, in the monsoon seasons from 2011 to 2015. During the study we recorded 37 reptile species: 26 snakes, 10 lizards, and one turtle. Several endemic, range-restricted and newly-described species were recorded. We recorded the Indian Black Turtle *Melanochelys trijuga*, which is under 'Near Threatened' category of IUCN Red List 2020. We observed the greatest species richness at Gavase and Dhangarmola wetlands, followed by Khanapur, Yarandol, and Ningudage.

Keywords: Anthropogenic activities, biodiversity hotspot, exotic vegetation, man-made wetlands.

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INTRODUCTION

India is home to approximately 610 species of reptiles, about 50% of which are endemic (Khandekar et al. 2021). Reptile diversity of the northern Western Ghats (WG) in Kaas (Maharashtra part) comprises 57 species (Chickane & Bhosale 2012), while the Gujarat part comprises 65 species (Patel et al. 2018), the central WG contain 71 species (Ganesh et al. 2013) and certain parts of southern WG 46 species (Chandramouli & Ganesh 2010).

Wetlands provide important habitats for fish, amphibians, reptiles, and birds. Although not all reptiles are completely dependent on water bodies, some prefer to live on the edges due to the abundance of prey. One study of European reptiles noted 17 species at Romanian shore (Florina et al. 2015). Some reptiles are permanently dependent on wetlands and some are ephemerals (Griffin & Channing 1991). In India, Vyas et al. (2012) reported 25 species of reptiles in and around the five man-made wetlands in Gujarat. As of 2012, 117 species of reptiles were recorded from Maharashtra (Dasgupta et al. 2012). Several reptile studies have been done in India, but there remains a deficiency of information regarding reptiles in wetlands. The present

project focused on the study of reptiles in and around wetlands in the northern WG.

MATERIALS AND METHODS

Study area

The present study was carried in the Ajara Tehsil, located in the southern part of Kolhapur district, Maharashtra (Figure 1). It is located on the eastern edge of the Western Ghats, where the hill ranges run north-south. The forests mainly belong to 3B/C2 – southern moist mixed deciduous forests and 2A/C2 – west coast semi-evergreen - mixed forests, as classified by Champion & Seth (1968). Recently, the state government of Maharashtra declared Ajara forest as a 'conservation reserve'. This declaration will help in conservation of both the habitat and its wildlife. The current study was carried in five man-made wetlands built under a 'watershed development program' by the government of Maharashtra with the aim of supplying water for agriculture and consumption (Table 1).

Methods

Reptiles were recorded using visual the encounter

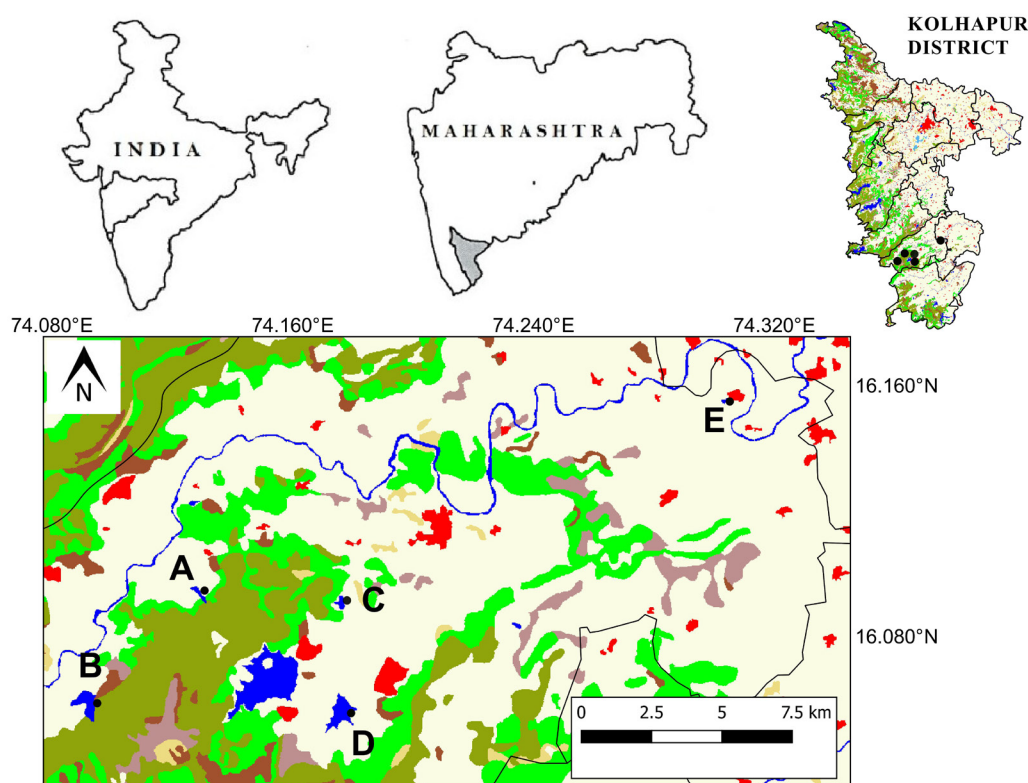


Figure 1. Study area: A—Gavase | B—Dhangarmola | C—Khanapur | D—Yarandol | E—Ningudage.

survey (Campbell & Christman 1982) and time-constrained method (Eekhout 2010). The survey was carried in the monsoon season, from 2011–2015. In this survey, we walked along the edge of the wetlands and searched for reptiles in and around the sampling locations. The survey was carried out in the morning from 0830 to 1000 h; each wetland was surveyed five times per monsoon season. Every survey was carried out for 90 minutes; all the observations were carried out by a single observer. Rarefaction curve was generated based on the number of sightings in the survey; along with it opportunistic sightings were used for preparation of checklist. Reptiles were photographed using a DSLR camera (Canon 600D); identification characters were based on consultation of standard literature (Daniel 2002; Das 2008; Whitaker & Captain 2008). For nomenclature, we followed Khandekar et al. (2021), effecting other nomenclatural updates from recent publications (Ganesh et al. 2020, 2021; Mallik et al. 2020, 2021; Deepak et al. 2021; Gowande et al. 2021). Jaccard's similarity index of species richness between wetlands was calculated using PAST software (Hammer et al. 2001).

RESULTS AND DISCUSSION

Overall 37 reptile species, belonging to 13 families (Table 2) were recorded. Colubridae was the most diverse family, comprising 16 species. Out of 37 species, 26 were snakes, 10 were lizards, and one was a turtle. The highest number of species were recorded from Gavase and Dhangarmola (36 species), followed by Khanapur (25 species), and Yarandol (22 species), while the lowest was from Ningudage (13 species). Jaccard's similarity index on presence-absence data of species shows that Gavase and Dhangarmola are more similar in their reptilian species richness (Figure 2). The alpha and beta diversity values of the sampling sites are given in Tables 3 and 4, respectively.

The results of Whittaker's B-diversity for reptiles (Table 3) showed that the species composition and abundance of reptiles are comparable at Gavase and Dhangarmola, whereas Khanapur was slightly different from the rest. However, a high degree of dissimilarity was observed between Gavase and Ningudage, which may be due to the variation in the anthropogenic disturbance levels among these reservoirs. Whittaker's B-diversity for reptiles indicates that the selected sites for the present study can be significantly categorized on the basis of ecological status.

Table 1. Description of man-made wetlands.

	Name of the Wetland (Coordinates)	Submergence area (ha)	
		Monsoon	Summer
1	Gavase (16.094°, 74.130°)	37.04	3.79
2	Dhangarmola (16.058°, 74.094°)	55.17	7.32
3	Khanapur (16.091°, 74.177°)	20.71	3.13
4	Yarandol (16.055°, 74.179°)	71.48	36.52
5	Ningudage (16.154°, 74.305°)	4.28	2.35

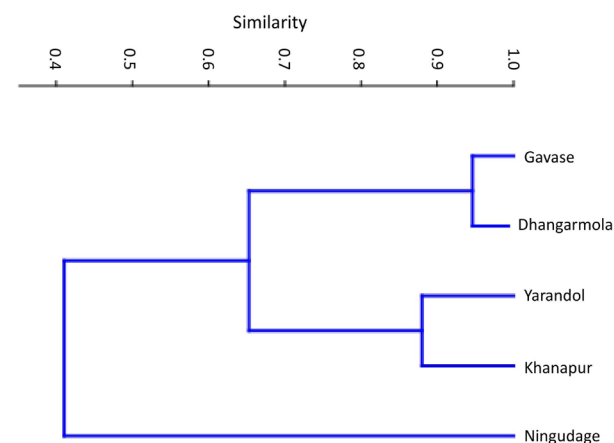


Figure 2. Jaccard's similarity index on presence-absence data of species found at five wetlands.

Diversity indices for reptiles (Table 4) at Gavase freshwater reservoir computed from 139 individuals which belong to 24 taxa resulted in values having a lower dominance index (0.084). On the other hand, Ningudage water body value, computed based on 29 individuals, which belong to 9 taxa resulted in readings with the maximum dominance value (0.291). The sampling sites here arranged in the ascending order of dominance (D) index are Gavase (0.084) < Dhangarmola (0.1) < Khanapur (0.104) < Yarandol (0.182) < Ningudage (0.291).

On the results obtained above, the species richness was observed highest at Gavase water body while lowest was noted at Ningudage water body. Furthermore, based on trends, diversity indices observed from present study indicate three different categories of reservoirs: those in Gavase & Dhangarmola in category I, Khanapur water body in category II, and Yarandol & Ningudage in category III. The results obtained for Shannon (D), Simpson (1-D), and Shannon's evenness value indicates that previous three were similar values. Additionally, the latter two showed quite similar index ratios.

The Shannon (H), Simpson (1-D), and Shannon's evenness indices for reptilian diversity at all the reservoirs in descending order are Gavase, Dhangarmola, Khanapur,

Table 2. List of reptile species recorded at the five wetlands.

	Common, scientific name	A	B	C	D	E
	Typhlopidae					
1	Beaked Worm Snake <i>Grypotyphlops acutus</i> (Duméril & Bibron, 1844)	+	+	-	-	+
	Uropeltidae					
2	Large-scaled Shieldtail <i>Uropeltis macrolepis</i> (Peters, 1862)	+	+	+	+	-
	Pythonidae					
3	Indian Rock Python <i>Python molurus</i> (Linnaeus, 1758)	+	+	-	-	-
	Erycidae					
4	Red Sand Boa <i>Eryx johnii</i> (Russell, 1801)	+	+	-	+	-
5	Common Sand Boa <i>Eryx conicus</i> (Schneider, 1801)	+	+	+	+	-
	Colubridae					
6	Oriental Rat Snake <i>Ptyas mucosa</i> (Linnaeus, 1758)	+	+	+	+	+
7	Banded Kukri Snake <i>Oligodon arnensis</i> (Shaw, 1802)	+	+	+	+	-
8	Bronzeback Tree Snake <i>Dendrelaphis tristis</i> (Daudin, 1803)	+	+	-	-	-
9	Checkered Keelback <i>Fowlea piscator</i> (Schneider, 1799)	+	+	+	+	+
10	Striped Keelback <i>Amphiesma stolatum</i> (Linnaeus, 1758)	+	+	+	+	-
11	Green Keelback <i>Rhabdophis plumbicolor</i> (Cantor, 1839)	+	+	+	+	+
12	Common Cat Snake <i>Boiga trigonata</i> (Schneider, 1802)	+	+	-	-	-
13	Forsten's Cat Snake <i>Boiga forsteni</i> (Duméril, Bibron & Duméril, 1854)	+	+	-	-	-
14	Beddome's Cat Snake <i>Boiga beddomei</i> (Wall, 1909)	+	+	-	-	-
15	Green Vine Snake <i>Ahaetulla oxyrhyncha</i> (Bell, 1825)	+	+	+	+	-
16	Brown Vine Snake <i>Ahaetulla sahyadrensis</i> (Mallik, Srikanthan, Pal, D'Souza, Shanker & Ganesh, 2020)	+	-	-	-	-
17	Common Trinket Snake <i>Coelognathus helena</i> (Daudin, 1803)	+	+	+	+	+
18	Montane Trinket Snake <i>Coelognathus helena monticularis</i> (Schulz, 1992)	+	+	+	+	-
19	Barred Wolf Snake <i>Lycodon striatus</i> (Shaw, 1802)	+	+	-	-	-
20	Travancore Wolf Snake <i>Lycodon travancoricus</i> (Beddome, 1870)	+	+	-	+	-
21	Banded Racer <i>Platyceps plini</i> (Merrem, 1820)	+	+	+	+	+
	Elapidae					
22	Common Indian Krait <i>Bungarus caeruleus</i> (Schneider, 1801)	+	+	+	+	+
23	Spectacled Cobra <i>Naja naja</i> (Linnaeus, 1758)	+	+	+	+	+
	Viperidae					
24	Russell's Viper <i>Daboia russelii</i> (Shaw & Nodder, 1797)	+	+	+	+	+
25	Bamboo Pit Viper <i>Craspedocephalus gramineus</i> (Shaw, 1802)	+	+	-	-	-
26	Malabar Pit Viper <i>Craspedocephalus malabaricus</i> (Jerdon, 1854)	+	+	+	+	-
	Agamidae					
27	Sahyadri Forest Lizard <i>Monilesaurus rouxii</i> (Duméril & Bibron, 1837)	+	+	+	+	-
28	Indian Garden Lizard <i>Calotes vultuosus</i> (Harlan, 1825)	+	+	+	+	+
	Scincidae					
29	Bronze Grass Skink <i>Eutropis cf. macularia</i> (Blyth, 1853)	+	+	+	+	-
30	Common Keeled Skink <i>Eutropis carinata</i> (Schneider, 1801)	+	+	+	+	+
31	Günther's Supple Skink <i>Riopa guentheri</i> (Peters, 1879)	+	+	+	+	-
	Lacertidae					
32	Lacertid lizard <i>Ophisops cf. beddomei</i> (Jerdon, 1870)	+	+	-	-	-
	Gekkonidae					
33	Yellow Green House Gecko <i>Hemidactylus flaviviridis</i> (Rüppell, 1835)	+	+	-	+	+

34	Spotted Rock Gecko <i>Hemidactylus maculatus</i> (Duméril & Bibron, 1836)	+	+	+	+	+
35	Deccan Ground Gecko <i>Cyrtodactylus deccanensis</i> (Günther, 1864)	+	+	-	-	-
	Varanidae					
36	Bengal Monitor Lizard <i>Varanus bengalensis</i> (Daudin, 1802)	+	+	+	+	-
	Geoemydidae					
37	Indian Black Turtle <i>Melanochelys trijuga</i> (Schweigger, 1812)	-	+	-	-	-
		36	36	22	25	13

+—Present | —Absent | A—Gavase | B—Dhangarmola | C—Yarandol | D—Khanapur | E—Ningudage.

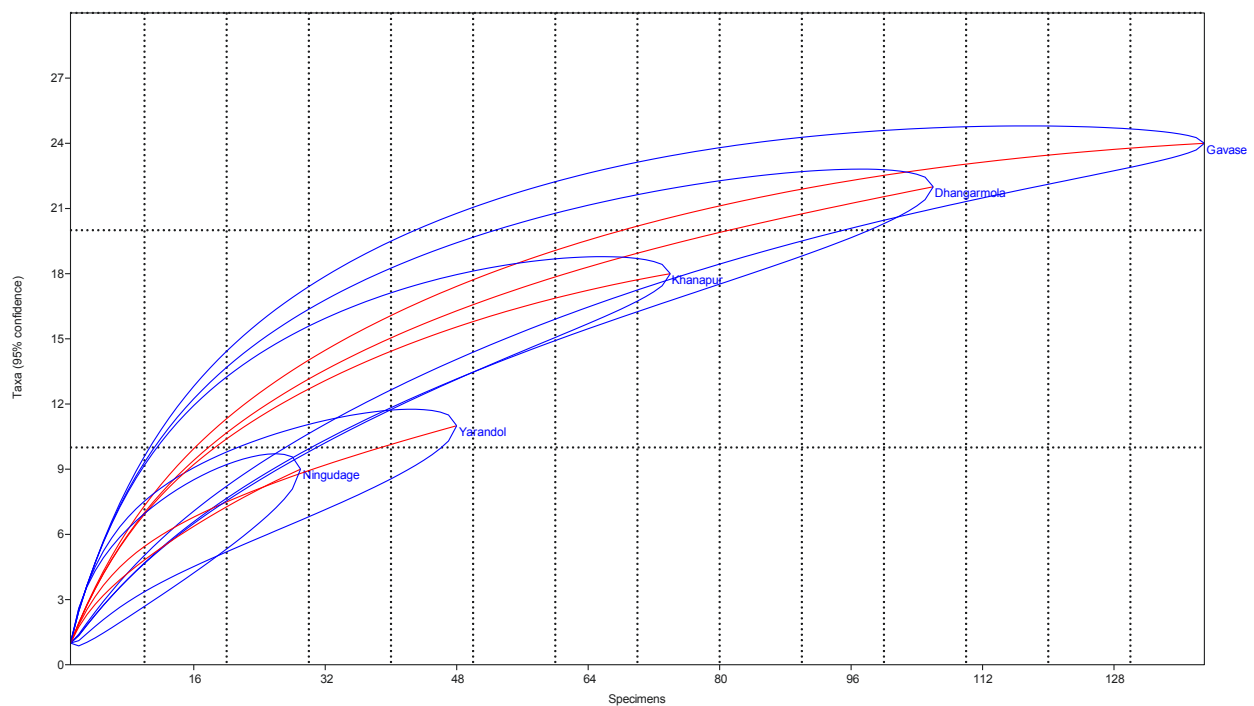


Figure 3. Rarefaction curve of species richness at wetlands. Note: Blue lines indicate 95% confidence interval estimated by bootstrapping.

Yarandol, and Ningudage. Individual rarefaction curves for all reservoirs are in Figure 3.

The study of reptilian fauna revealed that minimum individuals were observed at Ningudage water body. On that basis, a rarefaction curve was drawn that indicates that Gavase reservoir has maximum richness while Yarandol and Ningudage water bodies are at minimum richness levels. The results obtained from this method are similar to that of Shannon and Simpson indices.

Reyni's diversity profile for all reservoirs is depicted in Figure 4. The investigation of Renyi's diversity profile for reptiles indicates that the Gavase is at the top with respect to distribution of species; followed by Dhangarmola and Khanapur. Computed lines of Dhangarmola and Khanapur water bodies intersect each other and hence one cannot compare these sites. Since

the computed line of Ningudage is steeper, it indicates the uneven distribution of species in that site.

Gavase and Dhangarmola wetlands showed the highest species richness among all wetlands and have the highest species similarity. Both these wetlands are in the same hill range; located on hillslopes covered with forest from three sides and anthropogenic disturbances are low. Khanapur wetland is also located in the same hilly range, but vegetation surrounding the wetland is a monoculture plantation of *Acacia auriculiformes*, and anthropogenic activities were observed. Despite its similarity and proximity with the above two wetlands, Khanapur wetland showed reduced species compared to above-mentioned wetlands. Exotic plants reduce reptilian diversity (Martin & Murray 2011), and *Acacia auriculiformes* might have reduced richness of reptile

Table 3. Alpha-diversity indices of reptiles among the study sites.

Reservoir/ Indices	Taxa_S	Individuals	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S
Gavase	24	139	0.084	0.916	2.758	0.657
Lower	17	139	0.0899	0.8683	2.344	0.5336
Upper	23	139	0.1316	0.9096	2.652	0.6956
Dhangarmola	22	106	0.1	0.9	2.613	0.62
Lower	15	106	0.0899	0.8637	2.29	0.5541
Upper	22	106	0.1362	0.9101	2.652	0.7221
Yarandol	11	48	0.182	0.818	1.945	0.636
Lower	11	48	0.0885	0.8307	2.054	0.6263
Upper	18	48	0.1684	0.9106	2.607	0.8233
Khanapur	18	74	0.104	0.896	2.513	0.686
Lower	14	74	0.0869	0.855	2.21	0.5877
Upper	20	74	0.1446	0.9131	2.661	0.7741
Ningudage	9	29	0.291	0.709	1.627	0.565
Lower	9	29	0.0916	0.8038	1.895	0.6718
Upper	15	29	0.1962	0.9084	2.53	0.8804

Table 4. Whittaker's B- Diversity of reptiles among the study sites.

Reservoirs	Gavase	Dhangarmola	Yarandol	Khanapur	Ningudage
Gavase	0				
Dhangarmola	0.0435	0			
Yarandol	0.3714	0.3333	0		
Khanapur	0.1429	0.1	0.2414	0	
Ningudage	0.4546	0.4194	0.3	0.3333	0

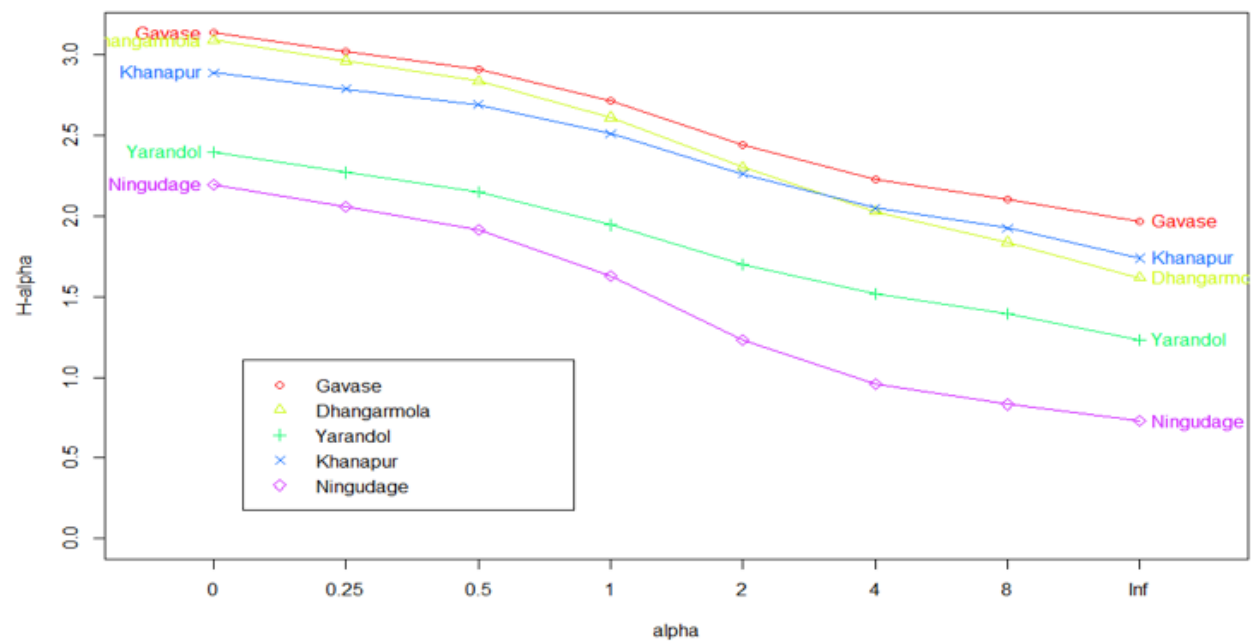


Figure 4. Renyi's diversity profile for reptiles for individual study sites.

species at the Khanapur wetlands. Yarandol and Ningudage wetlands are located away from forest area; anthropogenic activities were considerably high due to their location near the human settlement.

The study reconfirmed that different reptile taxa occupy various microhabitats. Among all the taxa, three species are burrowing snakes—*Grypotyphlops acutus*, *Eryx johnii*, and *Eryx conicus*—all these were recorded under leaf litter. Keelback snakes such as *Fowlea piscator*, *Amphiesma stolatum*, and *Rhabdophis plumbicolor* were recorded from water bodies and fringes. Six species of arboreal snakes were observed at the study site, viz: *Boiga forsteni*, *Boiga beddomei*, *Ahaetulla oxyrhyncha*, *Ahaetulla sahyadrensis*, *Craspedocephalus gramineus*, and *C. malabaricus*. *Boiga trigonata*, *Lycodon striatus*, and *Lycodon travancoricus* are terrestrial and arboreal in habit. Lizards, except *Monilesaurus rouxii* are predominantly ground-dwelling. However, *Calotes vultuosus* was frequently found on the trunks of trees. But for these arboreal agamids, all other species of lizards were found under leaf litter and beneath crevices of fallen logs on ground and crevices of rocks. This aspect was studied to prove that non-aquatic reptiles will also benefit by conserving certain ear-marked wetlands. During the survey only one turtle species *Melanochelys trijuga* was found, which is under the 'Near Threatened' category of IUCN Red List (Ahmed et al. 2020); aquatic in habit. We opine that other aquatic turtles known from this region, such as *Lissemys punctata* and *Nilssonina leithi* could not be recorded due to lack of intensive aquatic sampling in the water bodies.

The present study area in the Ajara range is just 30 airline km away from Amboli, site of several previous herpetological expeditions that reported many new lizards and snakes, including *Melanophidium khairi*, *Rhabdops aquaticus*, *Dendrelaphis giri*, *Calliophis castoe*, *Hemidactylus varadgiri* and several new species of *Cnemaspis* (Vogel & van Rooijen 2011; Smith et al. 2012; Gower et al. 2016; Giri et al. 2017; Sayyed et al. 2018; Chaitanya et al. 2019; Deepak et al. 2021). However, these species could not be recorded during the present study, likely due to the easterly position of the Ajara range compared to Amboli, which is situated well within the Western Ghats.

It is to be acknowledged that man-made constructions of wetlands, especially as a result of damming, have proven to be counter-productive for biodiversity conservation in the Western Ghats (Mohite & Samant 2012). However, scientifically-informed management interventions consisting of artificial creating or propagation of wetlands will help in

biodiversity conservation. It is thus concluded that man-made wetlands do support a sizeable amount of reptilian diversity. Awareness about the biodiversity value of wetlands among the citizens is therefore necessary for its conservation. Based on these results, we recommend intensive biodiversity studies in the far larger Hidkal Reservoir, situated 40 airline km west of Ajara Tehsil, abutting the state boundary in Karnataka.

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