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Cover: Leaves and fruits of *Terminalia arjuna* in water colour artwork on cold pressed water colour paper by Bhama Sridharan.



## Diversity and distribution of birds in the Bharathapuzha River Basin, Kerala, India

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**Abstract:** Bharathapuzha River is the second largest, west-flowing river in Kerala, Western Ghats. This river is exposed to high levels of anthropogenic and natural pressures. This study attempts to understand the diversity and distribution of birds in this river basin. The observations were made from October 2017 to July 2019 in 70\*1 km<sup>2</sup> grids distributed in three strata (i.e., upper, middle, and lower reaches). A total of 262 bird species were recorded from the river basin. The diversity and richness of birds were found high in the upper reaches of the river and the species abundance was found more in the lower reaches. Due to the high turnover of migratory species, the rank abundance model for upper and lower reaches showed a high degree of dominance while middle reaches showed a relatively even distribution of abundances. Deforestation, sand mining, and water pollution were found to be the major threats in the river basin. Hence the results show the importance of the protection and rejuvenation of the ecosystems associated with the river for the conservation of avian diversity in the region.

**Keywords:** Bird community, ecological indicators, ecological zones, migrant birds, Nila river, rank abundance models, resident birds, riverine biodiversity, riverine birds, Western Ghats.

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**Author contributions:** ARPN—study design, field surveys, data analysis and preparation of manuscript, PP—study design, review, preparation of manuscript, ADV—data analysis, preparation of manuscript.

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## INTRODUCTION

Rivers are considered an important ecological entity that supports rich biodiversity. The water flow, geography, interaction between the terrestrial and aquatic ecosystems, and the dynamic nature make the rivers one of Earth's most complex biophysical systems (Naiman et al. 1993). Though the rivers harbour rich biodiversity, they are also prone to many natural and anthropogenic challenges. Therefore, understanding the biological communities of the river system is essential for its management and conservation prioritization. The diverse habitats on the river corridors support many birds (Stevens et al. 1977; Stauffer & Best 1980; Knopf 1985). Since birds are considered as ecological indicators, habitat quality can be assessed through long-term avifauna monitoring. Understanding the bird communities and habitat association of different species (including migratory species) in different seasons is important for planning conservation strategies (Rice et al. 1980; Naiman et al. 1993; Gergel et al. 2002).

Kerala is one of the important places for avian research. The high level of habitat heterogeneity and its mosaic nature supports a wide range of birds (Neelakantan 1969, 1970, 1981, 1982; Neelakantan & Sureshkumar 1980; Neelakantan et al. 1980; Ali & Ripley 1983; Pramod 1995). The wetlands in Kerala enhance avian diversity by hosting migratory birds, hence many of the larger wetlands in Kerala were announced as Ramsar sites (Jayson 2002; Nameer 2005)

Bharathapuzha River (10.416–11.25 N and 75.833–76.916 E) in Kerala is known for its cultural and ecological significance. This river is considered as the cradle of civilization in Kerala. The major portion of the Bharathapuzha River flows through a human-dominated and agricultural landscape. The diverse habitat in the fluvial channel of the river supports great bird diversity. Many researchers have attempted to document the bird diversity in the river basin (Namassivayam & Venugopal 1989; Namassivayam et al. 1989; Kurup 1991; Uthaman & Namassivayam 1991; Neelakantan et al. 1993; Pramod 1995; Kurup 1996; Bijukumar 2006; Arif et al. 2010). However, the information available about the bird diversity of this river basin is sporadic.

In this investigation, we considered the river basin as a single ecological entity. We employed a ridge-to-reef approach to document the bird diversity from headwaters, main tributaries, mainstream and estuary. This study aims to establish baseline information about the avifauna of the Bharathapuzha River Basin and as a potential survey design for other river basins.

## MATERIALS AND METHOD

### Study area

The river Bharathapuzha originates from the southern part of the Palakkad Gap, in the Anamalai hills in the state of Tamil Nadu. It flows through the Palakkad gap covering Pollachi in Tamil Nadu; Palakkad, Thrissur, and Malappuram districts in Kerala and debouches into the Arabian Sea at Ponnani on the Malabar coast. The total length of the river is 250 km, of which 209 km flows through Kerala and 41 km through Tamil Nadu (Figure 1). The total extent of the river drainage basin is 6,186 km<sup>2</sup> between an elevation gradient of 2,461–0 m with an annual discharge of 3.94 km<sup>3</sup> water. The study divided the river drainage basin into three different ecological zones based on the stream orders as per Strahler (1957). Streams of order one to three were denoted as upper reaches (Image 1), order four to five as middle reaches (Image 2) and sixth-order streams were denoted as lower reaches (Image 3) (Abel et al. 2008).

The major tributaries of the river are Chitrapuzha, Gayathripuzha, Kunthipuzha, and Kalpathipuzha. All these tributaries originate from the northern and southern tips of the Palakkad Gap, which are the permanent and important water sources for the river. There are 11 dams constructed on this river for drinking water supply and irrigation to serve millions of people in the region.

### Study design

The hydrology layer for the river basin was extracted using ASTER GDEM V2 and stream orders were established using the Strahler (1957) method. Field surveys were conducted along 453 km stretches at these ecological zones (Figure 1). These stretches were divided into 70 grid cells of 1 X 1 km. These selected locations were sampled from October 2017 to July 2019 in three replications which include two migratory (November–March) and one non-migratory season (April–October). In each cell bird observations were made for a 15 min period using point count with the fixed-width method (Reynolds et al. 1980). A total of 840 point counts were conducted in the sampling area. Over-flying birds, bird detections >50 m, and uncertain bird identifications were truncated from the data to improve the robustness of the study. Direct and indirect signs of birds were observed at 0600–1100 h and 1530–1900 h in each location. Direct observations were made using binoculars and spotting scopes. Bird identification was done using field guides (Ali & Ripley 1983; Ali 1999; Grimmett et al. 1999; Kazmierczak 2000) and photographs. The bird checklist was prepared using Praveen et al. (2020).

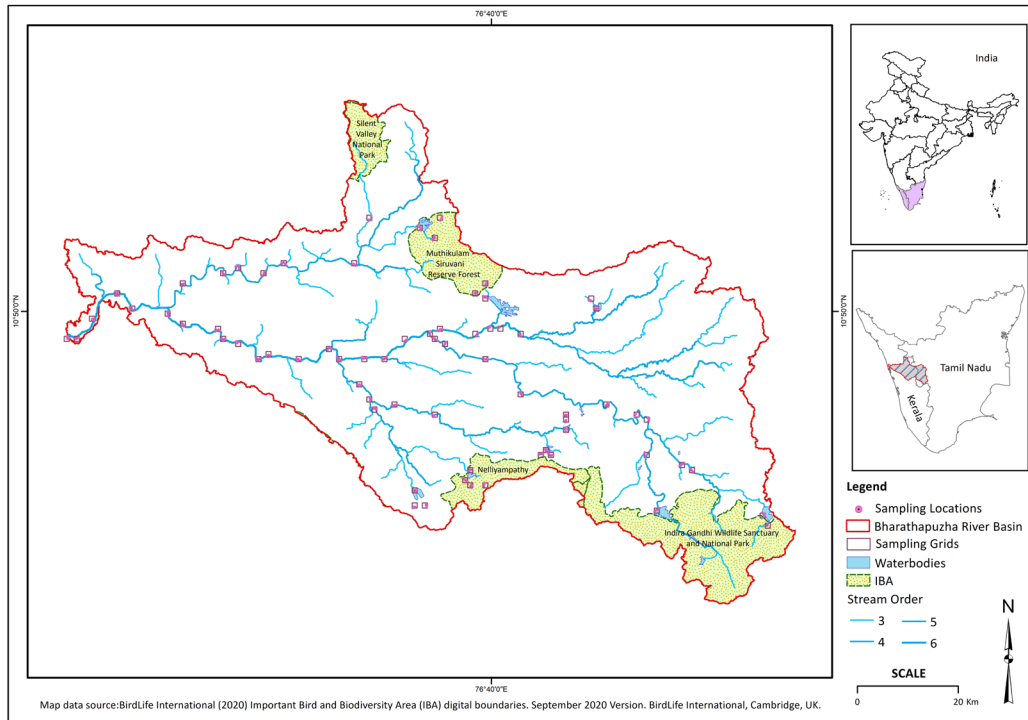


Figure 1. Location map of Bharathapuzha River Basin showing streams and sampling locations.



Image 1. Habitat in the upper reaches of Bharathapuzha River Basin. © P.N. Anoop Raj.



Image 2. Habitat in the middle reaches of Bharathapuzha River Basin. © P.N. Anoop Raj.

Opportunistic bird observations, i.e., the birds observed in the study areas after the predesigned observation period were recorded as ad libitum. The time of observation, date and number of individuals sighted, and habitat were noted.

**Data analysis:** Bird abundance data was arranged in the species vs sites contingency table. Absolute species richness for each region was tabulated. To check sampling adequacy, species richness was also estimated using Chao 1™ index. To compare diversity, dominance and evenness Shannon-Weiner (H') and Simpson index were estimated

(Magurran 1988). Relative abundance for all species was calculated in each ecological zone (Sutherland et al. 2004) using the formula.

$$RA_i = \left( \frac{N_i}{P} \right) \times 100$$

Where RA = relative abundance of species i, Ni = Abundance of species i in ecological zone, P = Population of all species in river basin.

Relative abundance was calculated with the whole population of birds in the river basin to make it comparable





Image 3. Habitat in the lower reaches of Bharathapuzha River Basin. © P.N. Anoop Raj.

between ecological zones. The relative frequency of occurrence (RF) of birds in grids was used to understand the commonality/rarity of birds in each ecological zone. Hence the birds with RF more than 50% are considered as common, 20% to 50% as less common and >20% as rare.

To understand the migratory species of birds, bird species observed were classified into three categories such as resident, local migrant or long-distance migrant (SolB 2023). To assess species distribution patterns, rank abundance distribution patterns were examined. All statistical analyses were performed using R statistical language V4.3.0 with R Studio IDE for R V2023.03.01. Diversity indices and rank abundance distributions were estimated using 'vegan': Community Ecology Package 2.6-4 (Oksanen et al. 2013).

## RESULTS

### Diversity

The bird observations were conducted from October 2017 to July 2019. A total of 262 species of birds were recorded belonging to 20 orders and 71 families (Table 1). Out of 262 bird species recorded in the study area 235 species of birds were recorded while employing the bird survey method; 27 bird species were observed in the opportunistic observations. Ecological zone-wise sampling efforts, bird species observed and the number of individual birds sighted are shown in Table 2. A total of 36,811 individuals were recorded from the river basin in migratory ( $n = 27,242$ ) and non-migratory ( $n = 9,569$ ) seasons during the survey. Passeriformes were the most dominant group in the river basin (42%) followed by Charadriiformes (13%), Falconiformes (8%),

and Ciconiformes (6%). Passerine birds were the most dominant group ( $N = 146$ ) followed by waders ( $N = 33$ ), raptors ( $N = 20$ ), and shorebirds ( $N = 19$ ). Absolute species richness and estimated species richness using Chao-1 was similar (Table 3) indicating sampling was adequate. While the Shannon-Weiner index ( $H'$ ) shows higher species diversity in upper reaches (Table 3) than in middle and lower reaches. However, Simpsons' index for evenness and dominance was found to be similar across all ecological zones.

### Bird species occurrence in different ecological zones

Rare birds were more compared to common and less common birds in all ecological zones. The upper reaches of the river basin reported 45 species of resident, two species of local migrants and four species of long-distance migrant birds as common, while 91 residents, 10 local migrants and eight long-distance migrants were rare. In the middle reaches, 43 residents, two species of local migrants and one species of long-distance migrant birds were common. 58 residents, six local migrants and three long-distance migrants were rare. In lower reaches, 48 residents, two local migrants and five migrant species were common and 48 residents, two local migrants and 10 migrant species were rare (Table 4).

Zipf-Mandlebrot distribution was found to be the best-fit model for upper reaches (deviance = 401.60) and lower reaches (deviance = 465.40). However, bird species in the middle reaches followed a log-normal abundance distribution (deviance = 615.83) (Table 5). Lower reaches had a steeper distribution than upper reaches and middle reaches indicating a high species turnover rate. While upper and lower reaches show shallow slopes, Middle reaches have more even abundances with species ranked with log-normal distribution.

## DISCUSSION

Being a human-dominated landscape, some synanthropic birds such as the Common Myna *Acridotheres tristis*, House Crow *Corvus splendens*, and Black Drongo *Dicrurus macrocercus*, were dominant in the three ecological zones of the river basin region. However, Purple-rumped Sunbird *Leptocoma zeylonica*, Red-vented Bulbul *Pycnonotus cafer*, Common Tailorbird *Orthotomus sutorius*, Asian Palm Swift *Cypsiurus balasiensis*, Yellow-billed Babbler *Turdoides affinis*, and White-cheeked Barbet *Psilopogon viridis* were the other common resident birds in the river basin. The wetland associated birds such as Cattle Egret *Bubulcus ibis*, Little Cormorant

*Microcarbo niger*, Indian Pond Heron *Ardeola grayii*, and White-throated Kingfisher *Halcyon smyrnensis* were also found commonly in the river basin. Most of these birds are generalist feeders and adapt themselves to survive in any condition. Black-bellied Tern *Sterna acuticauda*, Dark-fronted Babbler *Rhopocichla atriceps*, Asian Emerald Dove *Chalcophaps indica*, Indian Spotted Eagle *Clanga hastata*, Cinnamon Bittern *Ixobrychus cinnamomeus*, Striated Heron *Butorides striata*, Yellow Bittern *Ixobrychus sinensis*, Spot-billed Pelican *Pelecanus philippensis*, and Pheasant-tailed Jacana *Hydrophasianus chirurgus* found as rare resident birds in the river basin in which a few of these birds were specific to ecological zones.

Greenish Warbler *Phylloscopus trochiloides*, Grey Wagtail *Motacilla cinerea*, and Barn Swallow *Hirundo rustica* were found to be the common local migrant birds in the river basin. Chestnut-tailed Starling *Sturnia malabarica*, Bar-headed Goose *Anser indicus*, and Gull-billed Tern *Gelochelidon nilotica* were the rare local migrant birds.

Blyth's Reed Warbler *Acrocephalus dumetorum*, Common Sandpiper *Actitis hypoleucos*, and Booted Eagle *Hieraetus pennatus* were the common long-distance migrants. Booted Warbler *Iduna caligata*, Eurasian Curlew *Numenius arquata*, Whimbrel *Numenius phaeopus*, and Amur Falcon *Falco amurensis* were the rare long-distance migrants.

Malayan Night-heron *Gorsachius melanolophus*, Chestnut-winged Cuckoo *Clamator coromandus*, Black-bellied Tern *Sterna acuticauda*, and Indian Spotted Eagle *Clanga hastata* were some of the important sightings during the study period. The maximum flock size is seen in Little Cormorants with <300 individuals in a single location at Walayar dam. Gull species such as Black-headed Gull *Chroicocephalus ridibundus* and Pallas's Gull *Ichthyaetus ichthyaetus* congregated highly in the estuarine region. Totally, 2,200 individual birds were encountered in a single grid at Ponnani.

The study identified 60 species that are specific to the upper reaches, four to middle reaches and 16 to the lower reaches. 119 birds were common to all regions (Figure 2). Out of these, 17 birds were endemic to Western Ghats including one 'Endangered', seven 'Near Threatened', and four 'Vulnerable' birds as per the IUCN Red List of Threatened Species. This indicates that productive and heterogeneous habitats of the Bharathapuzha River Basin support birds from different niches and foraging guilds from forest to wetland-dependent birds as well as synanthropic species.

Upper reaches show higher species richness than middle and lower reaches because of the presence of

primary forests, human habitations, and dams. Hence this region supports different foraging and feeding guilds (Ali & Ripley 1983; Wiens 1989). Also, the presence of dams in the upper reaches and the presence of estuary and check dams in the lower reaches enables to host a large number of migratory birds such as Little-ringed Plover *Charadrius dubius*, Marsh Sandpiper *Tringa stagnatilis* and Barn Swallows *Hirundo rustica*. However, due to the lesser availability of the wintering grounds in the middle reaches, fewer migratory birds were observed.

Ziph-Mandlebrot distribution of rank abundances in upper reaches and lower reaches has steep concave slope indicating that few species occur in high abundances (Figure 3). Species with high abundance ranks in these regions are migratory species like Black-headed Gull *Chroicocephalus ridibundus* and Pallas's Gull *Ichthyaetus ichthyaetus* with flock sizes of <5,000 individuals which dwarf the abundances of resident species. However, in the middle reaches, flock sizes of migratory birds are smaller which shows a more even distribution of rank abundances.

#### Status of migratory birds in the Bharathapuzha River

Purathur in the Bharathapuzha River basin was identified as one of the major stop-over sites for many migratory birds (Kurup 1991; Kumar 2001). Large flocks of Black-headed Gull, Pallas's Gull, & Brown-headed Gull (<5,000), Whiskered Tern (<100), and resident egrets such as Cattle Egret and Little Egret (<100) were recorded from the Purathur region during the study period. Smaller migratory bird flocks of Little-ringed Plover and Common Sandpipers were reported from the dams and several other parts of the main course. Solitary and passage migrant birds such as the Amur Falcon were reported from the headwater region. There were consecutive sightings of these passage migrants in the river basin from 2017 (Malampuzha Dam), 2018 (Thirunavaya), and 2019 (Malampuzha Dam). This indicates the importance of the river Bharathapuzha and associated habitats for the conservation of migratory and resident birds.

#### Major Threats

During the study period, natural vegetation near the sampling locations in upper reaches was cleared for expansion of agriculture especially for cash crops like rubber, teak, coffee and coconut. Such deforestation activities for the construction of dams, human settlements and infrastructure development were also reported in various studies (Nossiter 1982; Eapen 1999; Kumar 2005; John et al. 2019).

Bharathapuzha River is one of the most affected river systems due to the predominant sand mining. Legal and

**Table 1. Relative abundances and relative frequency of occurrence of bird species in different ecological zones in Bharathapuzha River Basin.**

	Species	Upper reaches	Middle reaches	Lower reaches
<b>I</b>	<b>Anseriformes: Anatidae</b>			
1	Bar-headed Goose <i>Anser indicus</i> † <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
2	Common Teal <i>Anas crecca</i> † <sub>LC</sub>			*
3	Cotton Teal <i>Nettapus coromandelianus</i> <sub>LC</sub>			*
4	Indian Spot-billed Duck <i>Anas poecilorhyncha</i> <sub>LC</sub>	0.24 (16) <sup>⊕</sup>	0.01 (4) <sup>⊕</sup>	0.01 (17) <sup>⊕</sup>
5	Lesser Whistling Duck <i>Dendrocygna javanica</i> <sub>LC</sub>	0.33 (20) <sup>⊕</sup>	0.01 (4) <sup>⊕</sup>	0.39 (28) <sup>⊗</sup>
<b>II</b>	<b>Galliformes: Phasianidae</b>			
6	Indian Peafowl <i>Pavo cristatus</i> <sub>LC</sub>	0.22 (72) <sup>●</sup>	0.21 (70) <sup>●</sup>	0.08 (50) <sup>●</sup>
7	Red Spurrow <i>Galloperdix spadicea</i> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.02 (11) <sup>⊕</sup>	0.00 (6) <sup>⊕</sup>
8	Jungle Bush Quail <i>Perdica asiatica</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
9	Grey Francolin <i>Francolinus pondicerianus</i> <sub>LC</sub>	0.02 (20) <sup>⊕</sup>	0.00 (0)	0.00 (0)
10	Grey Junglefowl <i>Gallus sonneratii</i> <sub>LC</sub>	0.03 (24) <sup>⊗</sup>	0.00 (0)	0.00 (0)
<b>III</b>	<b>Podicipediformes: Podicipedidae</b>			
11	Little Grebe <i>Tachybaptus ruficollis</i> <sub>LC</sub>	0.01 (12) <sup>⊕</sup>	0.00 (0)	0.01 (6) <sup>⊕</sup>
<b>IV</b>	<b>Columbiformes: Columbidae</b>			
12	Rock Pigeon <i>Columba livia</i> <sub>LC</sub>	0.12 (44) <sup>⊗</sup>	0.94 (93) <sup>●</sup>	0.94 (89) <sup>●</sup>
13	Nilgiri Wood Pigeon <i>Columba elphinstonii</i> <sub>VU</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
14	Spotted Dove <i>Streptopelia chinensis</i> <sub>LC</sub>	0.39 (96) <sup>●</sup>	0.50 (78) <sup>●</sup>	0.21 (72) <sup>●</sup>
15	Laughing Dove <i>Streptopelia senegalensis</i> <sub>LC</sub>	0.02 (16) <sup>⊕</sup>	0.01 (4) <sup>⊕</sup>	0.01 (6) <sup>⊕</sup>
16	Asian Emerald Dove <i>Chalcophaps indica</i> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.00 (4) <sup>⊕</sup>	0.00 (0)
17	Grey-fronted Green Pigeon <i>Treron affinis</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
18	Yellow-footed Green Pigeon <i>Treron phoenicopterus</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (4) <sup>⊕</sup>	0.04 (11) <sup>⊕</sup>
19	Green Imperial Pigeon <i>Ducula aenea</i> <sub>LC</sub>	0.02 (16) <sup>⊕</sup>	0.03 (15) <sup>⊕</sup>	0.00 (6) <sup>⊕</sup>
<b>V</b>	<b>Cuculiformes: Cuculidae</b>			
20	Greater Coucal <i>Centropus sinensis</i> <sub>LC</sub>	0.07 (52) <sup>●</sup>	0.08 (63) <sup>●</sup>	0.07 (61) <sup>●</sup>
21	Blue-faced Malkoha <i>Phaenicophaeus viridirostris</i> <sub>LC</sub>	0.01 (20) <sup>⊕</sup>	0.00 (0)	0.00 (0)
22	Chestnut-winged Cuckoo <i>Clamator coromandus</i> † <sub>LC</sub>	*		
23	Pied Cuckoo <i>Clamator jacobinus</i> <sub>LC</sub>	0.00 (0)	0.01 (7) <sup>⊕</sup>	>0.01 (6) <sup>⊕</sup>
24	Asian Koel <i>Eudynamis scolopacea</i> <sub>LC</sub>	0.15 (76) <sup>●</sup>	0.14 (81) <sup>●</sup>	0.07 (61) <sup>●</sup>
25	Banded Bay Cuckoo <i>Cacomantis sonneratii</i> <sub>LC</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
26	Grey-bellied Cuckoo <i>Cacomantis passerinus</i> <sub>LC</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	>0.01 (6) <sup>⊕</sup>
27	Fork-tailed Drongo Cuckoo <i>Surniculus dicruroides</i> <sub>LC</sub>	>0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
28	Common Hawk Cuckoo <i>Hierococyx varius</i> <sub>LC</sub>	0.02 (28) <sup>⊗</sup>	0.01 (19) <sup>⊕</sup>	0.02 (39) <sup>⊗</sup>
29	Indian Cuckoo <i>Cuculus micropterus</i> † <sub>LC</sub>	0.03 (24) <sup>⊗</sup>	0.01 (15) <sup>⊕</sup>	0.01 (17) <sup>⊕</sup>
<b>VI</b>	<b>Caprimulgiformes: Caprimulgidae</b>			
30	Jerdon's Nightjar <i>Caprimulgus atripennis</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
31	Indian Nightjar <i>Caprimulgus asiaticus</i> <sub>LC</sub>	0.00 (0)	>0.01 (4) <sup>⊕</sup>	0.00 (0)
32	Savanna Nightjar <i>Caprimulgus affinis</i> <sub>LC</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
	<b>Caprimulgiformes: Apodidae</b>			
33	Indian Swiftlet <i>Aerodramus unicolor</i> <sub>LC</sub>	0.10 (20) <sup>⊕</sup>	0.25 (44) <sup>⊗</sup>	0.34 (33) <sup>⊗</sup>
34	Alpine Swift <i>Tachymarptis melba</i> <sub>LC</sub>	>0.01 (4) <sup>⊕</sup>	0.00 (0)	0.01 (11) <sup>⊕</sup>
35	Indian House Swift <i>Apus affinis</i> <sub>LC</sub>	0.12 (16) <sup>⊕</sup>	0.23 (11) <sup>⊕</sup>	0.08 (28) <sup>⊗</sup>
36	Asian Palm Swift <i>Cypsiurus balasensis</i> <sub>LC</sub>	1.66 (76) <sup>●</sup>	3.23 (96) <sup>●</sup>	2.39 (78) <sup>●</sup>
	<b>Caprimulgiformes: Hemiprocnidae</b>			
37	Crested Treeswift <i>Hemiproctus coronata</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
<b>VII</b>	<b>Gruiformes: Rallidae</b>			
38	Common Coot <i>Fulica atra</i> <sub>LC</sub>	0.05 (4) <sup>⊕</sup>	0.00 (4) <sup>⊕</sup>	0.00 (0)



	Species	Upper reaches	Middle reaches	Lower reaches
39	Grey-headed Swamphen <i>Porphyrio poliocephalus</i> <sub>LC</sub>	0.00 (0)	0.02 (15) <sup>⊕</sup>	0.34 (17) <sup>⊕</sup>
40	White-breasted Waterhen <i>Amaurornis phoenicurus</i> <sub>LC</sub>	0.05 (32) <sup>⊗</sup>	0.20 (78) <sup>●</sup>	0.04 (50) <sup>●</sup>
<b>VIII</b>	<b>Charadriiformes: Recurvirostridae</b>			
41	Black-winged Stilt <i>Himantopus himantopus</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.01 (6) <sup>⊕</sup>
	<b>Charadriiformes: Charadriidae</b>			
42	Pacific Golden Plover <i>Pluvialis fulva</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.02 (11) <sup>⊕</sup>
43	Red-wattled Lapwing <i>Vanellus indicus</i> <sub>LC</sub>	0.26 (56) <sup>●</sup>	0.27 (63) <sup>●</sup>	0.43 (83) <sup>●</sup>
44	Kentish Plover <i>Charadrius alexandrinus</i> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.04 (6) <sup>⊕</sup>
45	Common Ringed Plover <i>Charadrius hiaticula</i> <sup>†</sup> <sub>LC</sub>			*
46	Little Ringed Plover <i>Charadrius dubius</i> <sub>LC</sub>	0.33 (32) <sup>⊗</sup>	>0.01 (4) <sup>⊕</sup>	0.10 (44) <sup>⊗</sup>
	<b>Charadriiformes: Rostratulidae</b>			
47	Greater Painted-snipe <i>Rostratula benghalensis</i> <sub>LC</sub>	>0.01 (4) <sup>⊕</sup>	0.00 (0)	0.01 (17) <sup>⊕</sup>
	<b>Charadriiformes: Jacanidae</b>			
48	Pheasant-tailed Jacana <i>Hydrophasianus chirurgus</i> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.01 (6) <sup>⊕</sup>
49	Bronze-winged Jacana <i>Metopidius indicus</i> <sub>LC</sub>	0.00 (0)	0.15 (44) <sup>⊗</sup>	0.10 (33) <sup>⊗</sup>
	<b>Charadriiformes: Scolopacidae</b>			
50	Whimbrel <i>Numenius phaeopus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.01 (6) <sup>⊕</sup>
51	Eurasian Curlew <i>Numenius arquata</i> <sup>†</sup> <sub>NT</sub>	0.00 (0)	0.00 (0)	0.01 (6) <sup>⊕</sup>
52	Ruddy Turnstone <i>Arenaria interpres</i> <sup>†</sup> <sub>LC</sub>			*
53	Curlew Sandpiper <i>Calidris ferruginea</i> <sup>†</sup> <sub>NT</sub>			*
54	Temminck's Stint <i>Calidris temminckii</i> <sup>†</sup> <sub>LC</sub>			*
55	Little Stint <i>Calidris minuta</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.04 (11) <sup>⊕</sup>
56	Common Snipe <i>Gallinago gallinago</i> <sup>†</sup> <sub>LC</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
57	Terek Sandpiper <i>Xenus cinereus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.01 (6) <sup>⊕</sup>
58	Common Sandpiper <i>Actitis hypoleucos</i> <sup>†</sup> <sub>LC</sub>	0.28 (48) <sup>⊗</sup>	0.11 (44) <sup>⊗</sup>	0.37 (94) <sup>●</sup>
59	Green Sandpiper <i>Tringa ochropus</i> <sup>†</sup> <sub>LC</sub>	0.04 (20) <sup>⊕</sup>	0.05 (33) <sup>⊗</sup>	0.13 (67) <sup>●</sup>
60	Common Greenshank <i>Tringa nebularia</i> <sup>†</sup> <sub>LC</sub>	0.02 (8) <sup>⊕</sup>	>0.01 (4) <sup>⊕</sup>	0.04 (11) <sup>⊕</sup>
61	Marsh Sandpiper <i>Tringa stagnatilis</i> <sup>†</sup> <sub>LC</sub>	0.09 (20) <sup>⊕</sup>	0.01 (4) <sup>⊕</sup>	0.19 (67) <sup>●</sup>
62	Wood Sandpiper <i>Tringa glareola</i> <sup>†</sup> <sub>LC</sub>	0.08 (12) <sup>⊕</sup>	0.00 (4) <sup>⊕</sup>	0.08 (33) <sup>⊗</sup>
63	Common Redshank <i>Tringa totanus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.01 (4) <sup>⊕</sup>	0.03 (11) <sup>⊕</sup>
	<b>Charadriiformes: Glareolidae</b>			
64	Small Pratincole <i>Glareola lactea</i> <sub>LC</sub>	0.03 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
	<b>Charadriiformes: Laridae</b>			
65	Black-headed Gull <i>Chroicocephalus ridibundus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	1.39 (28) <sup>⊗</sup>
66	Brown-headed Gull <i>Chroicocephalus brunnicephalus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	1.62 (33) <sup>⊗</sup>
67	Pallas's Gull <i>Ichthyaetus ichthyaetus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	1.31 (22) <sup>⊗</sup>
68	Lesser Black-backed Gull <i>Larus fuscus</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.52 (17) <sup>⊕</sup>
69	Little Tern <i>Sternula albifrons</i> <sub>LC</sub>	0.02 (4) <sup>⊕</sup>	0.05 (15) <sup>⊕</sup>	0.00 (0)
70	Gull-billed Tern <i>Gelochelidon nilotica</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.05 (6) <sup>⊕</sup>
71	Caspian Tern <i>Hydroprogne caspia</i> <sub>LC</sub>			*
72	Whiskered Tern <i>Chlidonias hybrida</i> <sub>LC</sub>	0.26 (20) <sup>⊕</sup>	0.05 (19) <sup>⊕</sup>	0.39 (44) <sup>⊗</sup>
73	Black-bellied Tern <i>Sterna acuticauda</i> <sub>EN</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
74	River Tern <i>Sterna aurantia</i> <sub>NT</sub>	0.15 (28) <sup>⊗</sup>	0.07 (30) <sup>⊗</sup>	0.25 (61) <sup>●</sup>
<b>IX</b>	<b>Ciconiiformes: Ciconiidae</b>			
75	Asian Openbill <i>Anastomus oscitans</i> <sub>LC</sub>	0.40 (52) <sup>●</sup>	0.24 (63) <sup>●</sup>	0.81 (94) <sup>●</sup>
76	Woolly-necked Stork <i>Ciconia episcopus</i> <sub>VU</sub>	0.20 (20) <sup>⊕</sup>	0.05 (15) <sup>⊕</sup>	0.17 (50) <sup>●</sup>
77	Painted Stork <i>Mycteria leucocephala</i> <sub>NT</sub>	0.11 (8) <sup>⊕</sup>	0.00 (0)	0.00 (0)
<b>X</b>	<b>Suliformes: Anhingidae</b>			

	Species	Upper reaches	Middle reaches	Lower reaches
78	Oriental Darter ( <i>Anhinga melanogaster</i> ) <sub>NT</sub>	0.04 (16) <sup>⊕</sup>	0.05 (41) <sup>⊗</sup>	0.08 (56) <sup>●</sup>
	<b>Suliformes: Phalacrocoracidae</b>			
79	Little Cormorant <i>Microcarbo niger</i> <sub>LC</sub>	1.82 (52) <sup>●</sup>	0.88 (93) <sup>●</sup>	2.66 (100) <sup>●</sup>
80	Great Cormorant <i>Phalacrocorax carbo</i> <sub>LC</sub>	0.04 (8) <sup>⊕</sup>	0.00 (0)	0.01 (17) <sup>⊕</sup>
81	Indian Cormorant <i>Phalacrocorax fuscicollis</i> <sub>LC</sub>	0.06 (28) <sup>⊗</sup>	0.02 (19) <sup>⊕</sup>	0.03 (28) <sup>⊗</sup>
<b>XI</b>	<b>Pelecaniformes: Pelecanidae</b>			
82	Spot-billed Pelican <i>Pelecanus philippensis</i> <sub>NT</sub>	>0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
	<b>Pelecaniformes: Ardeidae</b>			
83	Yellow Bittern <i>Ixobrychus sinensis</i> <sub>LC</sub>	>0.01 (4) <sup>⊕</sup>	>0.01 (4) <sup>⊕</sup>	0.01 (6) <sup>⊕</sup>
84	Cinnamon Bittern <i>Ixobrychus cinnamomeus</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
85	Black Bittern <i>Ixobrychus flavicollis</i> <sub>LC</sub>	*		
86	Grey Heron <i>Ardea cinerea</i> <sub>LC</sub>	0.05 (24) <sup>⊗</sup>	0.02 (30) <sup>⊗</sup>	0.08 (78) <sup>●</sup>
87	Purple Heron <i>Ardea purpurea</i> <sub>LC</sub>	0.04 (20) <sup>⊕</sup>	0.07 (56) <sup>●</sup>	0.10 (67) <sup>●</sup>
88	Great Egret <i>Ardea alba</i> <sub>LC</sub>	0.03 (20) <sup>⊕</sup>	0.03 (19) <sup>⊕</sup>	0.17 (61) <sup>●</sup>
89	Intermediate Egret <i>Ardea intermedia</i> <sub>LC</sub>	0.09 (36) <sup>⊗</sup>	0.11 (59) <sup>●</sup>	0.52 (94) <sup>●</sup>
90	Little Egret <i>Egretta garzetta</i> <sub>LC</sub>	0.35 (60) <sup>●</sup>	0.43 (85) <sup>●</sup>	1.12 (100) <sup>●</sup>
91	Western Reef Egret <i>Egretta gularis</i> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.05 (17) <sup>⊕</sup>
92	Cattle Egret <i>Bubulcus ibis</i> <sub>LC</sub>	1.10 (84) <sup>●</sup>	0.93 (100) <sup>●</sup>	1.99 (100) <sup>●</sup>
93	Indian Pond Heron <i>Ardeola grayii</i> <sub>LC</sub>	0.42 (88) <sup>●</sup>	0.76 (100) <sup>●</sup>	0.67 (100) <sup>●</sup>
94	Striated Heron <i>Butorides striata</i> <sub>LC</sub>	>0.01 (4) <sup>⊕</sup>	0.01 (4) <sup>⊕</sup>	0.00 (0)
95	Black-crowned Night Heron <i>Nycticorax nycticorax</i> <sub>LC</sub>	0.01 (12) <sup>⊕</sup>	0.02 (15) <sup>⊕</sup>	0.04 (28) <sup>⊗</sup>
96	Malayan Night Heron <i>Gorsachius melanolophus</i> <sub>LC</sub>	*		
	<b>Pelecaniformes: Threskiornithidae</b>			
97	Glossy Ibis <i>Plegadis falcinellus</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.04 (6) <sup>⊕</sup>
98	Black-headed Ibis <i>Threskiornis melanocephalus</i> <sub>NT</sub>	0.52 (44) <sup>⊗</sup>	0.04 (22) <sup>⊗</sup>	0.36 (56) <sup>●</sup>
<b>XII</b>	<b>Accipitriformes: Pandionidae</b>			
99	Osprey <i>Pandion haliaetus</i> <sup>†</sup> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.00 (0)	0.00 (0)
	<b>Accipitriformes: Accipitridae</b>			
100	Black-winged Kite <i>Elanus caeruleus</i> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.00 (0)	0.01 (11) <sup>⊕</sup>
101	Oriental Honey Buzzard <i>Pernis ptilorhynchus</i> <sub>LC</sub>	0.03 (36) <sup>⊗</sup>	0.02 (19) <sup>⊕</sup>	0.01 (17) <sup>⊕</sup>
102	Crested Serpent Eagle <i>Spilornis cheela</i> <sub>LC</sub>	0.09 (56) <sup>●</sup>	0.08 (59) <sup>●</sup>	0.06 (61) <sup>●</sup>
103	Changeable Hawk Eagle <i>Nisaetus cirrhatus</i> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.00 (0)	0.00 (0)
104	Legge's Hawk Eagle <i>Nisaetus kelaarti</i> <sub>NE</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
105	Black Eagle <i>Ictinaetus malaiensis</i> <sub>LC</sub>	0.02 (16) <sup>⊕</sup>	0.00 (4) <sup>⊕</sup>	0.01 (11) <sup>⊕</sup>
106	Indian Spotted Eagle <i>Clanga hastata</i> <sub>VU</sub>	0.00 (0)	0.00 (0)	0.00 (6) <sup>⊕</sup>
107	Booted Eagle <i>Hieraetus pennatus</i> <sup>†</sup> <sub>LC</sub>	0.01 (16) <sup>⊕</sup>	0.02 (22) <sup>⊗</sup>	0.06 (61) <sup>●</sup>
108	White-eyed Buzzard <i>Butastur teesa</i> <sub>LC</sub>	0.00 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
109	Western Marsh Harrier <i>Circus aeruginosus</i> <sup>†</sup> <sub>LC</sub>			*
110	Crested Goshawk <i>Accipiter trivirgatus</i> <sub>LC</sub>	*		
111	Shikra <i>Accipiter badius</i> <sub>LC</sub>	0.05 (56) <sup>●</sup>	0.02 (19) <sup>⊕</sup>	0.02 (39) <sup>⊗</sup>
112	Black Kite <i>Milvus migrans</i> <sub>LC</sub>	0.12 (36) <sup>⊗</sup>	0.15 (52) <sup>●</sup>	1.15 (83) <sup>●</sup>
113	Brahminy Kite <i>Haliastur indus</i> <sub>LC</sub>	0.35 (80) <sup>●</sup>	0.59 (96) <sup>●</sup>	1.73 (100) <sup>●</sup>
114	Grey-headed Fish Eagle <i>Haliaeetus ichthyaetus</i> <sub>NT</sub>	*		
<b>XIII</b>	<b>Strigiformes: Tytonidae</b>			
115	Common Barn Owl <i>Tyto alba</i> <sub>LC</sub>		*	*
	<b>Strigiformes: Strigidae</b>			
116	Oriental Scops Owl <i>Otus sunia</i> <sub>LC</sub>	0.01 (4) <sup>⊕</sup>	0.00 (0)	0.00 (0)
117	Brown Fish Owl <i>Ketupa zeylonensis</i> <sub>LC</sub>	0.01 (8) <sup>⊕</sup>	0.00 (0)	0.00 (0)



	Species	Upper reaches	Middle reaches	Lower reaches
118	Jungle Owlet <i>Glaucidium radiatum</i> <sub>LC</sub>	0.01 (12) <sup>⊗</sup>	0.00 (0)	0.00 (0)
119	Spotted Owlet <i>Athene brama</i> <sub>LC</sub>	0.04 (24) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>
120	Mottled Wood Owl <i>Strix ocellata</i> <sub>LC</sub>	0.00 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
<b>XIV</b>	<b>Trogoniformes: Trogonidae</b>			
121	Malabar Trogon <i>Harpactes fasciatus</i> <sub>LC</sub>	0.02 (16) <sup>⊗</sup>	0.00 (0)	0.00 (0)
<b>XV</b>	<b>Bucerotiformes: Upupidae</b>			
122	Common Hoopoe <i>Upupa epops</i> <sub>LC</sub>	>0.01 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
	<b>Bucerotiformes: Bucerotidae</b>			
123	Great Hornbill <i>Buceros bicornis</i> <sub>VU</sub>	0.01 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
124	Malabar Grey Hornbill <i>Ocyrceros griseus</i> <sub>LC</sub>	0.04 (28) <sup>⊗</sup>	0.02 (11) <sup>⊗</sup>	0.01 (17) <sup>⊗</sup>
<b>XVI</b>	<b>Coraciiformes: Alcedinidae</b>			
125	Common Kingfisher <i>Alcedo atthis</i> <sub>LC</sub>	0.09 (68) ●	0.14 (81) ●	0.08 (72) ●
126	Stork-billed Kingfisher <i>Pelargopsis capensis</i> <sub>LC</sub>	0.02 (24) <sup>⊗</sup>	0.07 (59) ●	0.03 (39) <sup>⊗</sup>
127	White-throated Kingfisher <i>Halcyon smyrnensis</i> <sub>LC</sub>	0.35 (92) ●	0.57 (100) ●	0.32 (100) ●
128	Pied Kingfisher <i>Ceryle rudis</i> <sub>LC</sub>	0.04 (20) <sup>⊗</sup>	0.11 (52) ●	0.11 (72) ●
	<b>Coraciiformes: Meropidae</b>			
129	Blue-bearded Bee-eater <i>Nyctornis athertoni</i> <sub>LC</sub>	0.01 (12) <sup>⊗</sup>	0.00 (0)	0.00 (0)
130	Green Bee-eater <i>Merops orientalis</i> <sub>LC</sub>	0.48 (64) ●	0.56 (85) ●	0.67 (94) ●
131	Blue-tailed Bee-eater <i>Merops philippinus</i> <sub>LC</sub>	0.01 (16) <sup>⊗</sup>	0.10 (33) <sup>⊗</sup>	0.10 (50) <sup>⊗</sup>
132	Chestnut-headed Bee-eater <i>Merops leschenaulti</i> <sub>LC</sub>	0.11 (28) <sup>⊗</sup>	0.15 (44) <sup>⊗</sup>	0.30 (72) ●
	<b>Coraciiformes: Coraciidae</b>			
133	Indian Roller <i>Coracias benghalensis</i> <sub>LC</sub>	0.03 (36) <sup>⊗</sup>	0.05 (33) <sup>⊗</sup>	0.00 (0)
134	Dollarbird <i>Eurystomus orientalis</i> <sub>LC</sub>	0.00 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
<b>XVII</b>	<b>Piciformes: Megalaimidae</b>			
135	Malabar Barbet <i>Psilopogon malabaricus</i> <sub>LC</sub>	*		
136	Coppersmith Barbet <i>Psilopogon haemacephalus</i> <sub>LC</sub>	0.12 (52) ●	0.03 (30) <sup>⊗</sup>	0.02 (17) <sup>⊗</sup>
137	Brown-headed Barbet <i>Psilopogon zeylanicus</i> <sub>LC</sub>	*		
138	White-cheeked Barbet <i>Psilopogon viridis</i> <sub>LC</sub>	0.45 (100) ●	0.34 (96) ●	0.16 (83) ●
	<b>Piciformes: Picidae</b>			
139	Heart-spotted Woodpecker <i>Hemicircus canente</i> <sub>LC</sub>	0.01 (8) <sup>⊗</sup>	0.01 (7) <sup>⊗</sup>	0.00 (0)
140	Brown-capped Pygmy Woodpecker <i>Yungipicus nanus</i> <sub>LC</sub>	0.03 (32) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.00 (0)
141	Rufous Woodpecker <i>Micropternus brachyurus</i> <sub>LC</sub>	0.01 (12) <sup>⊗</sup>	0.00 (0)	0.00 (0)
142	Black-rumped Flameback <i>Dinopium benghalense</i> <sub>LC</sub>	0.07 (52) ●	0.03 (22) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>
143	Lesser Yellownappe <i>Picus chlorolophus</i> <sub>LC</sub>	0.03 (28) <sup>⊗</sup>	0.00 (4) <sup>⊗</sup>	0.00 (0)
144	Streak-throated Woodpecker <i>Picus xanthopygaeus</i> <sub>LC</sub>	0.01 (8) <sup>⊗</sup>	0.00 (0)	0.00 (0)
<b>XVIII</b>	<b>Falconiformes: Falconidae</b>			
145	Common Kestrel <i>Falco tinnunculus</i> <sub>LC</sub>	>0.01 (4) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.01 (6) <sup>⊗</sup>
146	Amur Falcon <i>Falco amurensis</i> <sup>†</sup> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.01 (6) <sup>⊗</sup>
147	Peregrine Falcon <i>Falco peregrinus</i> <sub>LC</sub>	*		
<b>XIX</b>	<b>Psittaciformes: Psittaculidae</b>			
148	Rose-ringed Parakeet <i>Psittacula krameri</i> <sub>LC</sub>	0.33 (84) ●	0.48 (93) ●	0.11 (78) ●
149	Plum-headed Parakeet <i>Psittacula cyanocephala</i> <sub>LC</sub>	0.05 (20) <sup>⊗</sup>	0.05 (11) <sup>⊗</sup>	0.02 (11) <sup>⊗</sup>
150	Malabar Parakeet <i>Psittacula columboides</i> <sub>LC</sub>	0.18 (56) ●	0.07 (19) <sup>⊗</sup>	0.00 (0)
151	Vernal Hanging Parrot <i>Loriculus vernalis</i> <sub>LC</sub>	0.14 (48) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>	0.02 (22) <sup>⊗</sup>
<b>XX</b>	<b>Passeriformes: Pittidae</b>			
152	Indian Pitta <i>Pitta brachyura</i> <sup>‡</sup> <sub>LC</sub>	0.01 (20) <sup>⊗</sup>	0.01 (7) <sup>⊗</sup>	0.00 (0)
	<b>Passeriformes: Campephagidae</b>			
153	Orange Minivet <i>Pericrocotus flammeus</i> <sub>LC</sub>	0.21 (44) <sup>⊗</sup>	0.02 (7) <sup>⊗</sup>	0.01 (6) <sup>⊗</sup>

	Species	Upper reaches	Middle reaches	Lower reaches
154	Large Cuckooshrike <i>Coracina macei</i> <sub>LC</sub>	0.04 (28) <sup>⊗</sup>	0.01 (15) <sup>⊗</sup>	0.01 (6) <sup>⊗</sup>
155	Black-headed Cuckooshrike <i>Lalage melanoptera</i> <sub>LC</sub>	0.02 (20) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.02 (28) <sup>⊗</sup>
	<b>Passeriformes: Oriolidae</b>			
156	Indian Golden Oriole <i>Oriolus kundoo</i> † <sub>LC</sub>	0.04 (24) <sup>⊗</sup>	0.04 (22) <sup>⊗</sup>	0.06 (44) <sup>⊗</sup>
157	Black-naped Oriole <i>Oriolus chinensis</i> † <sub>LC</sub>	0.02 (20) <sup>⊗</sup>	0.01 (15) <sup>⊗</sup>	0.02 (28) <sup>⊗</sup>
158	Black-hooded Oriole <i>Oriolus xanthornus</i> <sub>LC</sub>	0.27 (88) ●	0.18 (74) ●	0.12 (67) ●
	<b>Passeriformes: Artamidae</b>			
159	Ashy Woodswallow <i>Artamus fuscus</i> <sub>LC</sub>	0.12 (44) <sup>⊗</sup>	0.23 (37) <sup>⊗</sup>	0.17 (72) ●
	<b>Passeriformes: Vangidae</b>			
160	Malabar Woodshrike <i>Tephrodornis sylvicola</i> <sub>LC</sub>	0.02 (16) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>
161	Common Woodshrike <i>Tephrodornis pondicerianus</i> <sub>LC</sub>	*	*	
	<b>Passeriformes: Aegithinidae</b>			
162	Common Iora <i>Aegithina tiphia</i> <sub>LC</sub>	0.19 (68) ●	0.09 (70) ●	0.08 (67) ●
	<b>Passeriformes: Dicruridae</b>			
163	Black Drongo <i>Dicrurus macrocercus</i> <sub>LC</sub>	0.51 (96) ●	0.50 (100) ●	0.43 (94) ●
164	Ashy Drongo <i>Dicrurus leucophaeus</i> † <sub>LC</sub>	0.02 (20) <sup>⊗</sup>	0.00 (0)	>0.01 (6) <sup>⊗</sup>
165	Bronzed Drongo <i>Dicrurus aeneus</i> <sub>LC</sub>	>0.01 (4) <sup>⊗</sup>	0.00 (0)	0.01 (11) <sup>⊗</sup>
166	Greater Racket-tailed Drongo <i>Dicrurus paradiseus</i> <sub>LC</sub>	0.27 (64) ●	0.08 (37) <sup>⊗</sup>	0.10 (44) <sup>⊗</sup>
	<b>Passeriformes: Monarchidae</b>			
167	Black-naped Monarch <i>Hypothymis azurea</i> <sub>LC</sub>	0.04 (28) <sup>⊗</sup>	0.01 (4) <sup>⊗</sup>	0.00 (0)
168	Indian Paradise-flycatcher <i>Terpsiphone paradisi</i> † <sub>LC</sub>	0.07 (48) <sup>⊗</sup>	0.02 (19) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>
	<b>Passeriformes: Laniidae</b>			
169	Brown Shrike <i>Lanius cristatus</i> † <sub>LC</sub>	0.03 (20) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.03 (22) <sup>⊗</sup>
170	Bay-backed Shrike <i>Lanius vittatus</i> <sub>LC</sub>	>0.01 (4) <sup>⊗</sup>	0.00 (0)	>0.01 (6) <sup>⊗</sup>
171	Long-tailed Shrike <i>Lanius schach</i> <sub>LC</sub>	0.01 (8) <sup>⊗</sup>	0.02 (30) <sup>⊗</sup>	>0.01 (6) <sup>⊗</sup>
	<b>Passeriformes: Corvidae</b>			
172	Rufous Treepie <i>Dendrocitta vagabunda</i> <sub>LC</sub>	0.30 (84) ●	0.30 (85) ●	0.14 (89) ●
173	White-bellied Treepie <i>Dendrocitta leucogastra</i> <sub>LC</sub>	0.02 (12) <sup>⊗</sup>	0.00 (0)	0.00 (0)
174	House Crow <i>Corvus splendens</i> <sub>LC</sub>	1.34 (100) ●	2.77 (100) ●	4.46 (100) ●
175	Large-billed Crow <i>Corvus macrorhynchos</i> <sub>LC</sub>	0.57 (84) ●	0.67 (85) ●	0.57 (78) ●
	<b>Passeriformes: Stenostiridae</b>			
176	Grey-headed Canary-flycatcher <i>Culicicapa ceylonensis</i> † <sub>LC</sub>	*		
	<b>Passeriformes: Paridae</b>			
177	Cinereous Tit <i>Parus cinereus</i> <sub>LC</sub>	0.03 (8) <sup>⊗</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Alaudidae</b>			
178	Jerdon's Bushlark <i>Mirafra affinis</i> <sub>LC</sub>	0.07 (24) <sup>⊗</sup>	0.01 (7) <sup>⊗</sup>	0.01 (11) <sup>⊗</sup>
179	Oriental Skylark <i>Alauda gulgula</i> <sub>LC</sub>	*		
180	Malabar Lark <i>Galerida malabarica</i> <sub>LC</sub>		*	*
	<b>Passeriformes: Cisticolidae</b>			
181	Common Tailorbird <i>Orthotomus sutorius</i> <sub>LC</sub>	0.39 (96) ●	0.61 (100) ●	0.31 (94) ●
182	Jungle Prinia <i>Prinia sylvatica</i> <sub>LC</sub>	0.03 (16) <sup>⊗</sup>	0.00 (0)	>0.01 (6) <sup>⊗</sup>
183	Ashy Prinia <i>Prinia socialis</i> <sub>LC</sub>	0.01 (12) <sup>⊗</sup>	0.08 (48) <sup>⊗</sup>	0.12 (67) ●
184	Plain Prinia <i>Prinia inornata</i> <sub>LC</sub>	0.07 (40) <sup>⊗</sup>	0.21 (70) ●	0.14 (72) ●
185	Zitting Cisticola <i>Cisticola juncidis</i> <sub>LC</sub>	0.01 (4) <sup>⊗</sup>	>0.01 (4) <sup>⊗</sup>	0.02 (28) <sup>⊗</sup>
	<b>Passeriformes: Acrocephalidae</b>			
186	Thick-billed Warbler <i>Arundinax aedon</i> † <sub>LC</sub>	0.01 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
187	Booted Warbler <i>Iduna caligata</i> † <sub>LC</sub>	>0.01 (4) <sup>⊗</sup>	0.00 (0)	0.00 (0)
188	Blyth's Reed Warbler <i>Acrocephalus dumetorum</i> † <sub>LC</sub>	0.45 (96) ●	0.48 (93) ●	0.34 (89) ●



	Species	Upper reaches	Middle reaches	Lower reaches
189	Clamorous Reed Warbler <i>Acrocephalus stentoreus</i> <sub>LC</sub>	0.05 (32) <sup>§</sup>	0.01 (11) <sup>®</sup>	0.01 (11) <sup>®</sup>
	<b>Passeriformes: Hirundinidae</b>			
190	Barn Swallow <i>Hirundo rustica</i> <sup>‡</sup> <sub>LC</sub>	0.44 (48) <sup>§</sup>	0.51 (63) ●	0.81 (67) ●
191	Wire-tailed Swallow <i>Hirundo smithii</i> <sub>LC</sub>	0.00 (0)	0.00 (0)	0.11 (17) <sup>®</sup>
192	Red-rumped Swallow <i>Cecropis daurica</i> <sub>LC</sub>	0.30 (28) <sup>§</sup>	0.48 (52) ●	1.11 (72) ●
193	Streak-throated Swallow <i>Petrochelidon fluvicola</i> <sub>LC</sub>	0.00 (0)	0.02 (4) <sup>®</sup>	0.00 (0)
	<b>Passeriformes: Pycnonotidae</b>			
194	Flame-throated Bulbul <i>Rubigula gularis</i> <sub>LC</sub>	0.14 (24) <sup>§</sup>	0.00 (0)	0.00 (0)
195	Red-vented Bulbul <i>Pycnonotus cafer</i> <sub>LC</sub>	1.00 (100) ●	0.86 (96) ●	0.57 (100) ●
196	Red-whiskered Bulbul <i>Pycnonotus jocosus</i> <sub>LC</sub>	0.63 (88) ●	0.62 (89) ●	0.46 (89) ●
197	White-browed Bulbul <i>Pycnonotus luteolus</i> <sub>LC</sub>	0.15 (52) ●	0.03 (19) <sup>®</sup>	0.06 (28) <sup>§</sup>
198	Yellow-browed Bulbul <i>Acritillas indica</i> <sub>LC</sub>	0.21 (64) ●	>0.01 (4) <sup>®</sup>	0.01 (11) <sup>®</sup>
	<b>Passeriformes: Phylloscopidae</b>			
199	Green Leaf Warbler <i>Phylloscopus nitidus</i> <sup>†</sup> <sub>LC</sub>	0.05 (44) <sup>§</sup>	0.02 (15) <sup>®</sup>	0.02 (22) <sup>§</sup>
200	Greenish Leaf Warbler <i>Phylloscopus trochiloides</i> <sup>‡</sup> <sub>LC</sub>	0.42 (84) ●	0.14 (67) ●	0.10 (72) ●
201	Large-billed Leaf Warbler <i>Phylloscopus magnirostris</i> <sup>‡</sup> <sub>LC</sub>	0.01 (4) <sup>®</sup>	>0.01 (4) <sup>®</sup>	0.00 (0)
	<b>Passeriformes: Zosteropidae</b>			
202	Indian White-eye <i>Zosterops palpebrosus</i> <sub>LC</sub>	0.17 (20) <sup>®</sup>	0.00 (0)	>0.01 (6) <sup>®</sup>
	<b>Passeriformes: Timaliidae</b>			
203	Tawny-bellied Babbler <i>Dumetia hyperythra</i> <sub>LC</sub>	0.04 (16) <sup>®</sup>	0.00 (0)	0.00 (0)
204	Dark-fronted Babbler <i>Rhopocichla atriceps</i> <sub>LC</sub>	0.03 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
205	Indian Scimitar Babbler <i>Pomatorhinus horsfieldii</i> <sub>LC</sub>	0.04 (20) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Pellorneidae</b>			
206	Puff-throated Babbler <i>Pellorneum ruficeps</i> <sub>LC</sub>	0.04 (16) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Leiothrichidae</b>			
207	Jungle Babbler <i>Argya striata</i> <sub>LC</sub>	0.61 (60) ●	0.05 (11) <sup>®</sup>	0.03 (11) <sup>®</sup>
208	Yellow-billed Babbler <i>Argya affinis</i> <sub>LC</sub>	1.43 (100) ●	1.40 (93) ●	0.54 (72) ●
209	Common Babbler <i>Argya caudata</i> <sub>LC</sub>	0.02 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
210	Rufous Babbler <i>Argya subrufa</i> <sub>LC</sub>	0.09 (16) <sup>®</sup>	0.01 (4) <sup>®</sup>	0.00 (0)
211	Wayanad Laughingthrush <i>Pterorhinus delesserti</i> <sub>LC</sub>	0.07 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Sittidae</b>			
212	Velvet-fronted Nuthatch <i>Sitta frontalis</i> <sub>LC</sub>	0.07 (24) <sup>§</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Sturnidae</b>			
213	Common Hill Myna <i>Gracula religiosa</i> <sub>LC</sub>	0.33 (24) <sup>§</sup>	0.00 (0)	0.00 (0)
214	Rosy Starling <i>Pastor roseus</i> <sup>†</sup> <sub>LC</sub>	0.08 (12) <sup>®</sup>	0.02 (4) <sup>®</sup>	0.17 (17) <sup>®</sup>
215	Brahminy Starling <i>Sturnia pagodarum</i> <sub>LC</sub>	0.01 (4) <sup>®</sup>	0.04 (11) <sup>®</sup>	0.00 (0)
216	Chestnut-tailed Starling <i>Sturnia malabarica</i> <sub>LC</sub>	0.01 (8) <sup>®</sup>	0.00 (0)	0.06 (11) <sup>®</sup>
217	Malabar Starling <i>Sturnia blythii</i> <sub>NE</sub>	0.04 (12) <sup>®</sup>	0.01 (4) <sup>®</sup>	0.02 (6) <sup>®</sup>
218	Common Myna <i>Acridotheres tristis</i> <sub>LC</sub>	1.12 (100) ●	1.45 (100) ●	1.14 (100) ●
219	Jungle Myna <i>Acridotheres fuscus</i> <sub>LC</sub>	0.33 (64) ●	0.04 (15) <sup>®</sup>	0.02 (6) <sup>®</sup>
	<b>Passeriformes: Turdidae</b>			
220	Nilgiri Thrush <i>Zoothera neilgherriensis</i> <sub>NE</sub>	0.01 (8) <sup>®</sup>	0.00 (0)	0.00 (0)
221	Orange-headed Thrush <i>Geokichla citrina</i> <sub>LC</sub>	0.05 (28) <sup>§</sup>	0.01 (19) <sup>®</sup>	0.02 (28) <sup>§</sup>
	<b>Passeriformes: Muscipidae</b>			
222	Asian Brown Flycatcher <i>Muscicapa dauurica</i> <sub>LC</sub>	0.01 (8) <sup>®</sup>	0.00 (0)	0.00 (0)
223	Brown-breasted Flycatcher <i>Muscicapa muttui</i> <sup>†</sup> <sub>LC</sub>	0.10 (52) ●	0.01 (11) <sup>®</sup>	0.02 (28) <sup>§</sup>
224	Indian Robin <i>Copsychus fulicatus</i> <sub>LC</sub>	0.06 (28) <sup>§</sup>	0.02 (11) <sup>®</sup>	0.01 (11) <sup>®</sup>
225	Oriental Magpie Robin <i>Copsychus saularis</i> <sub>LC</sub>	0.26 (84) ●	0.19 (78) ●	0.07 (61) ●

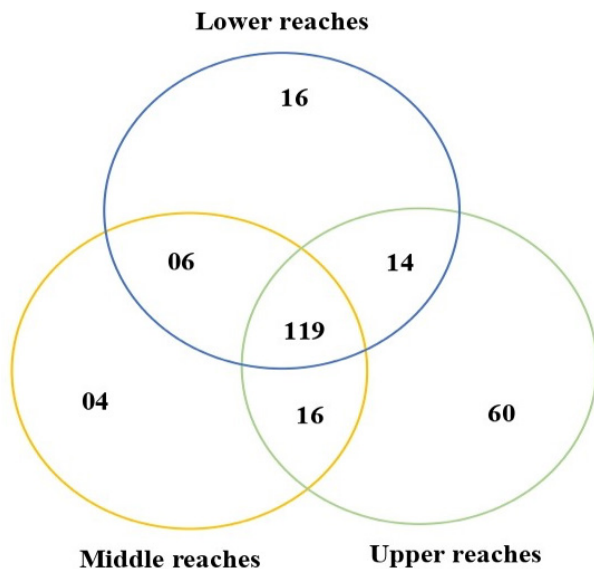
	Species	Upper reaches	Middle reaches	Lower reaches
226	White-rumped Shama <i>Copsychus malabaricus</i> <sub>LC</sub>	*		
227	White-bellied Blue Flycatcher <i>Cyornis pallidipes</i> <sub>LC</sub>	0.03 (16) <sup>®</sup>	0.00 (0)	0.00 (0)
228	Tickell's Blue Flycatcher <i>Cyornis tickelliae</i> <sub>LC</sub>	0.03 (24) <sup>®</sup>	0.00 (0)	0.00 (0)
229	Nilgiri Flycatcher <i>Eumyias albicaudatus</i> <sub>LC</sub>	*		
230	Verditer Flycatcher <i>Eumyias thalassinus</i> ‡ <sub>LC</sub>	>0.01 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
231	Malabar Whistling Thrush <i>Myophonus horsfieldii</i> <sub>LC</sub>	0.18 (44) <sup>®</sup>	0.01 (7) <sup>®</sup>	0.00 (0)
232	Black-and-orange Flycatcher <i>Ficedula nigrorufa</i> <sub>LC</sub>	*		
233	Rusty-tailed Flycatcher <i>Ficedula rufigauda</i> † <sub>LC</sub>	0.01 (12) <sup>®</sup>	0.00 (0)	0.00 (0)
234	Taiga Flycatcher <i>Ficedula albicilla</i> † <sub>LC</sub>	*		
235	Blue-capped Rock Thrush <i>Monticola cinclorhyncha</i> ‡ <sub>LC</sub>	0.02 (8) <sup>®</sup>	0.00 (0)	0.00 (0)
236	Pied Bushchat <i>Saxicola caprata</i> <sub>LC</sub>	0.11 (48) <sup>®</sup>	0.05 (30) <sup>®</sup>	0.05 (33) <sup>®</sup>
	<b>Passeriformes: Dicaeidae</b>			
237	Thick-billed Flowerpecker <i>Dicaeum agile</i> <sub>LC</sub>	0.02 (12) <sup>®</sup>	0.00 (0)	0.00 (0)
238	Pale-billed Flowerpecker <i>Dicaeum erythrorhynchos</i> <sub>LC</sub>	0.35 (92) ●	0.29 (85) ●	0.17 (83) ●
239	Nilgiri Flowerpecker <i>Dicaeum concolor</i> <sub>LC</sub>	0.01 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Nectariniidae</b>			
240	Purple-rumped Sunbird <i>Leptocoma zeylonica</i> <sub>LC</sub>	0.93 (100) ●	0.83 (100) ●	0.44 (100) ●
241	Crimson-backed Sunbird <i>Leptocoma minima</i> <sub>LC</sub>	0.08 (32) <sup>®</sup>	0.00 (0)	0.00 (0)
242	Purple Sunbird <i>Cinnyris asiaticus</i> <sub>LC</sub>	0.23 (84) ●	0.22 (74) ●	0.17 (72) ●
243	Loten's Sunbird <i>Cinnyris lotenius</i> <sub>LC</sub>	0.18 (76) ●	0.06 (41) <sup>®</sup>	0.05 (39) <sup>®</sup>
244	Little Spiderhunter <i>Arachnothera longirostra</i> <sub>LC</sub>	0.05 (20) <sup>®</sup>	>0.01 (4) <sup>®</sup>	0.00 (0)
	<b>Passeriformes: Irenidae</b>			
245	Asian Fairy-bluebird <i>Irena puella</i> <sub>LC</sub>	0.05 (16) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Chloropseidae</b>			
246	Jerdon's Leafbird <i>Chloropsis jerdoni</i> <sub>LC</sub>	0.13 (56) ●	0.05 (37) <sup>®</sup>	0.04 (39) <sup>®</sup>
247	Golden-fronted Leafbird <i>Chloropsis aurifrons</i> <sub>LC</sub>	0.04 (20) <sup>®</sup>	0.02 (19) <sup>®</sup>	0.01 (11) <sup>®</sup>
	<b>Passeriformes: Ploceidae</b>			
248	Streaked Weaver <i>Ploceus manyar</i> <sub>LC</sub>	0.00 (0)	0.01 (4) <sup>®</sup>	0.00 (0)
249	Baya Weaver <i>Ploceus philippinus</i> <sub>LC</sub>	0.00 (0)	0.23 (7) <sup>®</sup>	0.00 (0)
	<b>Passeriformes: Estrildidae</b>			
250	Red Munia <i>Amandava amandava</i> <sub>LC</sub>			*
251	Indian Silverbill <i>Euodice malabarica</i> <sub>LC</sub>	0.01 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
252	White-rumped Munia <i>Lonchura striata</i> <sub>LC</sub>	0.00 (0)	0.01 (4) <sup>®</sup>	0.01 (11) <sup>®</sup>
253	Scaly-breasted Munia <i>Lonchura punctulata</i> <sub>LC</sub>	0.06 (8) <sup>®</sup>	0.08 (19) <sup>®</sup>	0.27 (33) <sup>®</sup>
254	Tricoloured Munia <i>Lonchura malacca</i> <sub>LC</sub>	0.15 (24) <sup>®</sup>	0.24 (30) <sup>®</sup>	0.34 (39) <sup>®</sup>
	<b>Passeriformes: Passeridae</b>			
255	House Sparrow <i>Passer domesticus</i> <sub>LC</sub>	0.00 (0)	0.04 (19) <sup>®</sup>	0.01 (6) <sup>®</sup>
256	Yellow-throated Sparrow <i>Gymnoris xanthocollis</i> <sub>LC</sub>	0.01 (4) <sup>®</sup>	0.00 (0)	0.00 (0)
	<b>Passeriformes: Motacillidae</b>			
257	Forest Wagtail <i>Dendronanthus indicus</i> † <sub>LC</sub>	0.02 (16) <sup>®</sup>	0.00 (0)	0.00 (0)
258	Grey Wagtail <i>Motacilla cinerea</i> ‡ <sub>LC</sub>	0.10 (52) ●	0.04 (33) <sup>®</sup>	0.01 (17) <sup>®</sup>
259	Western Yellow Wagtail <i>Motacilla flava</i> † <sub>LC</sub>	0.04 (24) <sup>®</sup>	0.01 (7) <sup>®</sup>	0.01 (22) <sup>®</sup>
260	White-browed Wagtail <i>Motacilla maderaspatensis</i> <sub>LC</sub>	0.16 (56) ●	0.33 (78) ●	0.29 (83) ●
261	Paddyfield Pipit <i>Anthus rufulus</i> <sub>LC</sub>	0.05 (36) <sup>®</sup>	0.02 (15) <sup>®</sup>	0.01 (28) <sup>®</sup>
	<b>Passeriformes: Fringillidae</b>			
262	Common Rosefinch <i>Carpodacus erythrinus</i> ‡ <sub>LC</sub>			*

Migratory status: †—long distance migrant | ‡—local migrant | IUCN Status: LC—Least Concern | NT—Near Threatened | VU—Vulnerable | EN—Endangered | NE—Not Evaluated. \*—Opportunistic sightings. Rarity: ●—Common | <sup>®</sup>—Less common | <sup>®</sup>—Rare.



**Table 2. Ecological zone-wise sampling effort for avifauna diversity survey in Bharathapuzha River Basin.**

Ecological zone	Grids (n)	Point counts (n)	Total effort (Hours)	Species observed (n)	Individuals encountered (n)
Upper reaches	25	300	75	209	11,280
Middle reaches	27	324	81	145	10,602
Lower reaches	18	216	54	155	14,929
<b>Overall</b>	<b>70</b>	<b>840</b>	<b>210</b>	<b>235</b>	<b>36,811</b>

**Figure 2. Occurrence of various bird species in different ecological zones.**

illegal sand mining altered the river ecosystem, especially in the mainstream. The illegal sand mining and over-exploitation of sand destroyed the river ecosystem (Sreedhar & Irfan 2016). There were several sighting reports and nesting records of 'Endangered' Black-bellied Tern in the river basin (Susanthkumar 2004; Aarif et al. 2010). However, in this study, we couldn't find nesting of these birds in the river basin. Sand mining is still prevalent in the lower reaches of the Bharathapuzha River Basin. It can be detrimental to the benthic ecosystem on which many bird species are dependent. Hence sand mining may have cascading effects on the biodiversity of the entire river basin.

Due to the strong opposition by the local people, nature enthusiasts and NGOs, there have been various regulations and restrictions imposed on sand mining activities. Even though, illegal sand mining is prevalent in several locations in the river basin. Interestingly, legal sand mining in the estuary region, at Ponnani is also observed (Image 4).

**Table 3. Diversity indices calculated for various ecological zones.**

	Upper reaches	Middle reaches	Lower reaches
<b>Dominance (D)</b>	0.021	0.038	0.035
<b>Simpson (1-D)</b>	0.98	0.96	0.96
<b>Shannon (H')</b>	4.35	3.82	3.88
<b>Chao-1</b>	220.70	158.20	158.50
<b>Observed species richness</b>	209	145	155

## CONCLUSION

The study covered 48% of the total bird species recorded from Kerala (Chandran et al. 2020). The last published checklist of birds of the region by Bijukumar (2006) has reported 143 bird species from the river basin. This study updates the checklist and increases the number of bird species on the list to 262.

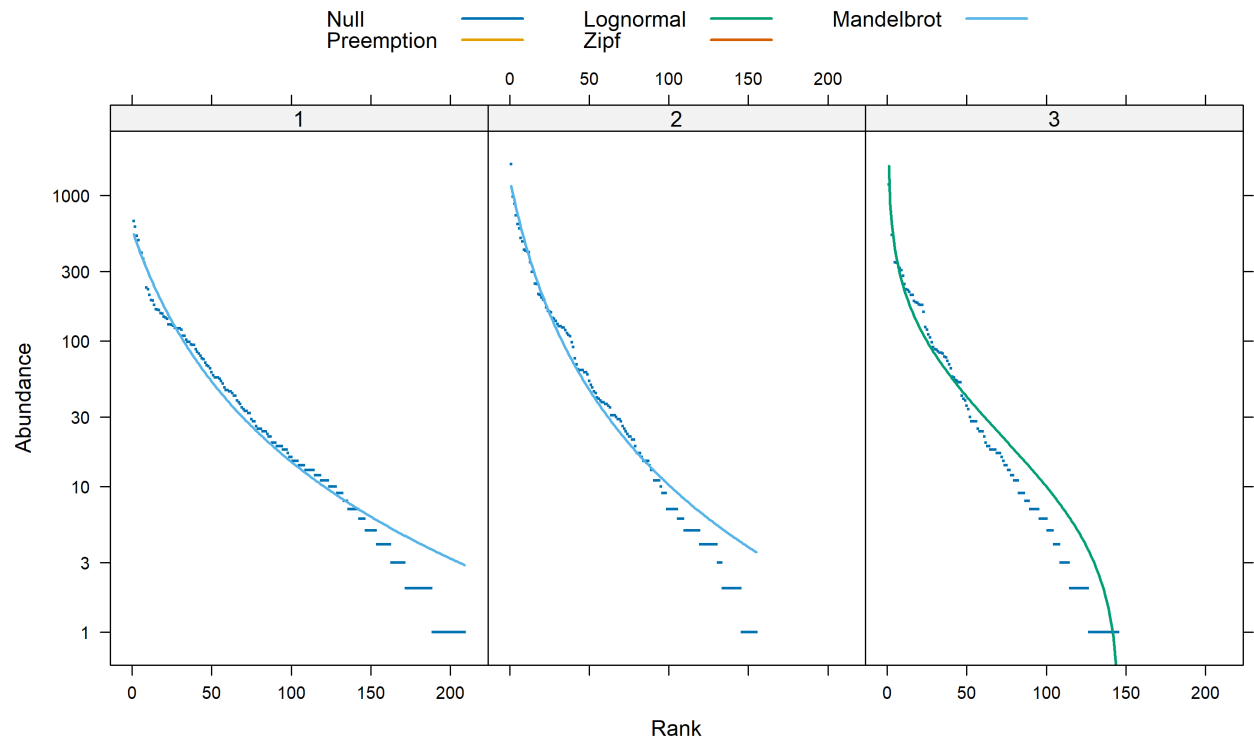
The holistic approach of the river as a single ecological entity helps to understand the changes in the avian diversity in different regions of the river over time. The headwater region of the river basin supports the resident birds. The main course and estuary regions play a pivotal role in the conservation of migratory birds. Hence protection of the forests in the upper reaches and all-natural habitats in the lower reaches are equally important for the conservation of birds. Bringing back the natural ecosystem of the river is everyone's responsibility. Hence community-mediated policy interventions are very much required to reduce sand mining and rebuild the riverine ecosystem, which ultimately protects the biodiversity.

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**Table 4. Common and rare birds reported in each ecological zone.**

Migratory status	Upper reaches			Middle reaches			Lower reaches		
	Common	Less common	Rare	Common	Less common	Rare	Common	Less common	Rare
Resident	45	39	91	43	18	58	48	25	48
Local migrant	2	5	10	2	3	6	2	5	7
Long distance migrant	4	1	8	1	3	9	5	7	10


**Figure 3. Best fit rank abundance model for birds observed in different regions of Bharathapuzha River Basin: 1—Upper reaches | 2—Lower reaches | 3—Middle reaches.**
**Table 5. Estimated RAD of bird species from distinct ecozones based on stream order in Bharathapuzha River Basin.**

		Null	Log-normal	Pre-emption	Zipf	Zipf-Mandlebrot
Upper reaches	Deviance	3698.84	622.88	1028.77	2780.50	401.60*
	AIC	4660.40	1588.44	1992.32	3746.05	1369.15
	$\Delta$ AIC	3291.25	219.29	623.17	2376.9	0
Middle reaches	Deviance	5204.45	615.83*	1280.85	2491.06	1280.85
	AIC	5876.61	1291.99	1955.01	3167.22	1959.01
	$\Delta$ AIC	4584.62	0	663.02	1875.23	667.02
Lower reaches	Deviance	7401.81	742.92	1571.21	3466.99	465.40*
	AIC	8163.55	1508.65	2334.94	4232.73	1233.14
	$\Delta$ AIC	6930.41	275.51	1101.80	2999.59	0

AIC—Akaike information criterion



**Image 4.** Sand dredging along the coast of Ponnani estuary in lower reaches of Bharathapuzha River Basin. © P.N. Anoop Raj.

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