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Diversity and Conservation Status of Birds in Barandabhar Corridor Forest, Chitwan, Nepal

Jagan Nath Adhikari[1,3*], Bishnu Prasad Bhattarai[2], Tej Bahadur Thapa[2]

[*1]Birendra Multiple Campus, Tribhuvan University, Bharatpur, Chitwan, Nepal

[2]Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, Nepal

[3]Himalayan Environment & Public Health Network (HEPHN), Bharatpur, Chitwan, Nepal

[*]Corresponding author: jnnadhikari@gmail.com

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Abstract

Present study conducted to explore the diversity and conservation status of birds in the Barandabhar Corridor Forest using hotspot area search methods and birding routes. The study recorded 304 bird species belonging to 18 orders and 69 families including 59 % residential, 8 % summer visitors, 32 % winter visitors and 1 % vagrants. This bio-corridor acts as the step-off point of many winter and summer visitor birds for continental, regional and local migration. The highest species richness was belonged to order Passeriformes (38 families and 155 spp.) and the least numbers of the species from order Podicipediformes (one family and one species). The highest number of birds was recorded in the forest as compared to other habitats. But, species richness per unit of land cover area was found higher in grasslands (98 spp.) followed by wetlands (51 spp.). Results revealed that six species of birds highly abundant, 25 species abundant, 117 species very common, 103 species common, 46 species fairly common and 7 species were rare species. Among the IUCN globally threatened species, it was observed that 3 critically endangered birds (Redheaded Vulture *Sarcogyps calvus*, Long-billed Vulture *Gyps indicus*, White-rumped Vulture *Gyps bengalensis)*, 1 endangered species (Egyptian Vulture *Neophron percnopterus)*, 5 Vulnerable (Pallas's Fish Eagle *Haliaeetus leucoryphus*, Lesser Adjuntant Stork *Leptoptilos javanicus*, Woolly-necked Stork *Ciconia episcopus*, Grey-crowned Prinia *Prinia cinereocapilla*, Bristled grassbird *Chaetornis striatus*, 7 near threatened species and 288 least concerned birds. Therefore, this area is regarded as the hotspots of bird diversity especially for wetland dependent and migratory birds including globally threatened species that needs strict and immediate conservation attention.

INTRODUCTION

Nepal, the Himalayan country is rich in landscape heterogeneity that supports diverse flora and fauna, including 8.87 % of the global bird species[1]. Nepal is known as the paradise of birds. A total of 887 species has been recorded from Nepal[1,2]. Nepal is of great value for birds, particularly, a total of 35 globally threatened species, 19 near threatened species and 15 restricted-range species are recorded in Nepal[3]. Spiny Babbler *Turdoides nipalensis* is the only one endemic bird to Nepal. Nine species of birds are Nationally Protected according to NPWC Act 1973 and 111 birds are enlisted in CITES category[1]. More than 130 breeding and wintering species (15 %) of the birds are now considered as nationally threatened. As many as eight species of birds have become extinct from Nepal[3]. Earlier studies suggest that habitat loss is the major threats to birds (86 %). Other threats are hunting, illegal trade and poisoning[4].The order Passeriformes has the highest representation among the bird species (465 spp.), followed by Chradriiformes (68 spp.),

Falconiformes (59 spp.), Piciformes (33 spp.), Anserformes (33 spp.), Ciconiformes (27 spp.), Galliformes (21 spp.), Colubiformes (33 spp.) etc[5,6].The Indo-Malayan about 111 species of birds are mainly confined to the Terai of Nepal[5].Using birds to assess biodiversity conservation priorities is very useful because they are widespread, diverse, taxonomically well known. Birds can be a good indicator of impact of climate change on biodiversity[7]. Zoo-geographically, Nepal falls between two great regions the Paleartic in North and Oriental to the south with inter-digitations of fauna throughout the whole length of the country[8]. The Chitwan National Park (CNP) in the Chitwan valley harbours spectacular bird life. The Fresh water swamp of Rapti and Khageri river flood plain stands with Sal (*Shorea robusta*) and Khair (*Acacia catcheu*) trees and the profuse aquatic vegetation is the habitat for rich micro and macro living forms including many species of snails, fishes and frogs[11,35]. Such abundant food renewed each year by floodwater of Narayani and Rapti Rivers, has been attracting thousands of resident water birds every year. More than 600 species of birds have been recorded in CNP[9,35]. Barandabhar forest is only the corridor, which links two different ecosystems, CNP to the Mahabhrat Range. This small patch supports more species of bird's life and other animals. Hence, this study was designed to explore the diversity and conservation status of the birds in Barandabhar Corridor Forest (BCF).

MATERIALS AND METHODS

Study area

The Barandabhar Corridor Forest (BCF) is a functional vertical (South-North) bio-corridor that connects two different ecosystems with significant altitudinal variations, specially the lowland Chitwan National Park and the highland Mahabharat range in Nepal, located in between 27°34' to 27º40'N latitude and 84º21' to 84º28'E longitude, covering an area 96.02 km^2 (**Figure 1**).The forest is regarded as the only remaining wildlife corridor that links the lowland to mid-hill ecosystems in the central region of the country[10]. Due to high bird including biodiversity, this corridor forest and wetlands have been delineated as the Important Bird and Biodiversity Areas (NP02-IBAs) among the 32 IBAs in Nepal[32]. The East-West Highway divides the Barandabhar Corridor Forest into two executive jurisdictions. The buffer zone forest south of the East-West highway is managed under the patronage of Chitwan National Park, while the district forest office patronizes the forest north of the highway[11].The vegetation in the BCF is dominated by almost monotypic stands of *Shorea robusta* and small fragments of riverine and mixed-hardwood forests[11,12]. Majority areas of Barandabhar Forest comprise *Shorea* (Sal) forest, which extends up to the foothills of the Mahabharat range. Disturbed or degraded Sal forest occupies almost the entire length of the edge on northern section of Barandabhar Forest where *Shorea robusta* is the dominant species, along with *Terminalia tomentosa* and *Cheistocalyx operculata*[10,13]. The riverine forest of the Barandabhar occupies a very small area located mostly in Khageri and Rapti river sites. The dominant tree species of riverine forest includes *Trewia nudiflora*, *Bombax ceiba*, *Mallotus philippensis*, *Listsea monopelata*, and *Sapium insignene*. Besides, BCF is also rich in wetlands that are the pristine habitats for the wetland dependent birds. The major wetlands of this area are three rivers (Rapti, Budirapti and Khageri) and lakes (Beeshazarilake- a Ramsar site, Ratomate lake, Batulpokhari, Rhino lake, Tiger lake, Tikauli lake, Gundre-Mandre lake)[13]. The CNP including BCF has a distinctive assemblage of rare and threatened fauna that supports more than 70 mammal species, 600 bird species, 56 species of herpeto fauna, 156 species of butterflies and 120 species of fish[9].

Data collection

Birds were surveyed using two different methods, depending upon location: area searches (AS) method for areas considered as the hotspots of birds and birding routes(BR) during November 2016 to October 2017. Eleven birding routes were established and used for bird monitoring. The birding routes were determined on the basis a protocol that assumed to cover different habitat types such as wetland, forest, grassland, edge of the forest and open areas (e.g., flood plains, barren lands, degraded lands)[14,16]. In each birding routes, at an interval of 100m, a circular point was fixed (for point count) and birds were recorded with the help of binoculars. Direct observation method used to identify and record the individuals of bird species[14,15]. The area search method is highly useful to measure the breeding and landbird populations at the fixed sites[17]. In each hotspots or fixed sites (Khageri and Rapti rivers, Kumal lake, Batulpokhari lake, Beeshazari lake, Tikauli and Chepang lake, Ratomate lake, Rhino lake and Gundre-Mandre lake), we observed the birds around its peripheries at an interval of 100m with circular plots of varying radii. During the survey, the number of individuals, habitat types etc. were recorded in standard field data sheet. In AS sampling, the birds were counted early in the morning from 6 AM to 10 AM and in the evening from 4 PM to 6 PM[14,15].

Data analysis

The collected data were entered into MS-Excel and further statistical analyses were performed in S-Plus and the various indices of species diversity were determined in PASTV3.18[18]. These diversity indices include Simpson's dominance and diversity, Shannon, Evenness indices including Beta diversity of birds in different habitat types.

Local occurrence status of birds was identified according to the terms described by Bull[19]. These status were classified as- very abundant (above 500 individuals), abundant (201-500), very common (51-200), common (21-50), fairly common (5-20) and rare (below five individuals). Seasonal birds were identified according to the literatures and bird guide books[6].

RESULTS AND DISCUSSION

Species diversity

The present study recorded 304 bird species belonging in 18 orders and 69 families in Barandabhar Corridor Forest. The highest numbers of the species were belonged to order Passeriformes (38 Families and 155 spp.) and least numbers of the species were belonged to order Podicipediformes (one family and one species) (**Table 1**). The species dominance was very low (*Dominance Index =0.0086*), that indicates the higher diversity of the bird species at BCF (*Simpson Index 1-D= 0.9914, Evenness= 0.5781*). Shannon's Index of diversity also indicated that more species diversity at BCF (*H=5.169*). Order Passeriformes showed the highest diversity and low dominance (*Simpson Index 1-D=0.9851, Shannon's Index=4.572, Dominance Index = 0.0086, Evenness = 0.6239*) (**Table 2**). Order Podicipediformes was not included in analysis, because only one family (Podicipedidae) and only one species (Black-necked Grebe *Podiceps nigricollis*) was recorded from this order. Similar type of study conducted by Ali et al. at Mangala Dam, India found a total of 31,920 birds of 141 species[20].However, the assessment of the birds conducted by Khan and Ali to the same area (Mangla Dam) found the Shannon Index (*H = 3.31)* in 2013-2014 and the Simpson Index (*D= 0.94)*[21]. Giri and Chalise was found that highest diversity of birds (*H =2.6228*) in February and lowest (*H = 1.2014*) in June in the Phewa Lake[22]. Likewise, the study of Chaudhariet al. at Khata Corridor forest of Bardia district, Nepal, found Shannon's Index of Diversity (*H = 3.114*) and species evenness (*0.629*) that indicated the high species diversity of birds[23]. Earlier studies of birds in Koshi Tappu Wildlife Reserve described a total of 485 bird species including residents and migrants that represents 61 bird families of the world. The study showed that the highest number of bird species from the Muscicapidae (44 spp.) followed by Accipitridae (42 spp.), Sylviidae (40), Corvidae (31), Passeridae (31), Anatidae (28) and Scolopacidae (20)[24]. However, Koshi Tappu had a large number of wetland dependent birds compared to BCF. The study on population status and diversity of wetland birds in Rapti and Narayani rivers reported 46 species of water birds including 12 species of water fowl in 2011[33]. Seasonal study of birds help to identify the actual status of the birds, it helps to identify weather the bird is resident, summer visitor, winter visitor or Vagrant. Our results showed that 59 % species were residential, 8 % were summer visitors, 32 % were winter visitors and 1 % were the vagrants. The forage category of birds included insectivores (189 spp.), 36 carnivores, 23 frugivores, 13 herbivores, 5 nectarivores, 11 omnivores and 27 piscivorous. The seasonal changes in diversity of birds in BCF reflect its role in connectivity of lowland and highland. However, the baseline information such as the extension of bufferzone area of CNP up to the northern part of BCF and its boundaries is lacking[34].

Species accumulation curves

An ordinary count of number of species in a sample is usually a biased underestimate of the true number of species in the environment, simply because increasing the sampling effort (through counting more individuals, examining more sampling units, or sampling a larger area) inevitably increases the number of species[25]. This effect illustrated in a species accumulation curve, in which the x-axis is the number of individuals recorded and the y-axis is the number of species observed or species richness (**Figure 2**). The species accumulation curve was exponentially increased up to 5,000 individuals and then, the curve was slightly increased up to 27,660. The common species were initially encountered and the rare species encountered very slowly, hence the curve was nearly constant. The curve continues to rise as more individuals are sampled, but the slope becomes shallower because progressively more sampling is required to detect the rare species[26]. This result indicates that BCF has a large number of rare and threatened species having low population.

Habitat Associations and Bird Diversity

Present study found a total of 51 species of wetland birds that mainly recorded in the river sand lakes of different parts of BCF. Most of the area of the BCF is covered by the Sal forest, however, small patch of the grassland present inside the *Shorea* and riverine forest supports the highest number of bird species (n=98). Open area birds (n=39) mainly shared the habitats with riverine forest and Sal forest (**Table 3**).

Kafle found a total of 36 species of water birds in Rupa Lake that represents 19 % of the 193 wetland dependent birds found in Nepal[27]. Principal component analysis (PCA) of species richness in different habitats showed four distinct accumulations of species as a) *Shorea* forest, riverine forest and open areas; b) Mixed hardwood forest; c) wetlands and d) grasslands (**Figure 3**). Avian species diversity in different habitat types in and around North Nandi Forest, Kenya reported a significant difference on bird abundance across the four habitats (indigenous forest, disturbed forest, plantation forest and farmlands adjacent to North Nandi Forest reserve) ($F = 15.141$, $P \leq 0.05$),

similar to our study (*F=167.3, p<0.0000*)[28]. At beta level, sal forest and wetland followed by riverine forest and grassland were the habitat types with the highest difference or lowest degree of similarity in bird species and relative abundance, in all coefficients of similarity estimated (**Table 3**).

Conservation Status of Birds in BCF

The field data from 2016 to 2017 showed that six species were highly abundant, 25 species were abundant, 117 species were very common, 103 species were common, 46 species were fairly common and seven species were rare species of birds found in BCF (**Figure 4**).

Sharma recorded twelve nationally threatened species of birds including two critically endangered birds in the Barandabar Corridor Forest (BCF)[29]. The study of Baral and Inskipp found a total of 15 globally threatened and 13 near-threatened species in Suklaphanta Wildlife Reserve[30]. Present study found three critically endangered birds (Red-headed Vulture *Sarcogyps calvus*, Long-billed Vulture *Gyps indicus,* White-rumped Vulture *Gyps bengalensis)* one endangered species (Egyptian Vulture *Neophron percnopterus)*, fiveVulnerable (Pallas's Fish Eagle *Haliaeetus leucoryphus*, Lesser Adjuntant Stork *Leptoptilos javanicus*, Woolly-necked Stork *Ciconia episcopus*, Grey-crowned Prinia *Prinia cinereocapilla*, Bristled grassbird *Chaetornis striatus* and seven near threatened species (Grey-headed Fish Eagle *Icthyophaga ichthyaetus*, Ferruginous Duck *Aythyanyroca,* Great Hornbill *Buceros bicornis*, River Lapwing *Vanellus duvaucelii*, Alexandrine Parakeet *Psittacula eupatria*, Red-breasted Parakeet *Psittacula alexandri*, Oriental Darter *Anhinga melanogaster)* and 288 least concerned birds as IUCN category (**Figure 5**)[2,35].

The state of Nepal's birds (BCN and DNPWC) described 149 bird species (17 %) of Nepal's birds as nationally threatened that included 61 Critically Endangered species, 38 Endangered and 50 Vulnerable. These 16 additional species are considered as threatened in 2010 compared to the list of 2004[2,31].

CONCLUSION

The present study found that BCF is rich in bird diversity including 304 species belonging in 18 orders and 69 families. The heterogeneous habitats of this area are the main cause of the high diversity of birds including wetlands dependent (51 species) and migratory birds. There were 59% species were residential, 8% were summer visitors, 32% were winter visitors and 1% were vagrants. This area acts as the step-off point for many winter and summer visitor birds from higher altitudes to lower altitudes.

The highest numbers of the species were of order Passeriformes (38 Families and 155 spp.) and least numbers of the species were from order Podicipediformes (one family and one spp.). The highest number of birds was recorded in the forest as compared to others. However, species richness was found higher in grasslands followed by wetlands in terms of land cover area. The study found that there were six species highly abundant, 25 species abundant, 117 species very common, 103 species common, 46 species fairly common and seven species were rare species in terms of local level status. In contrast, among the globally threatened species, this study found three critically endangered birds (Red-headed Vulture *Sarcogyps calvus*, Long-billed Vulture *Gyps indicus,* White-rumped Vulture *Gyps bengalensis)*, one endangered species (Egyptian Vulture *Neophron percnopterus)*, 5 Vulnerable (Pallas's Fish Eagle *Haliaeetus leucoryphus*, Lesser Adjuntant Stork *Leptoptilos javanicus*, Woolly-necked Stork *Ciconia episcopus*, Grey-crowned Prinia *Prinia cinereocapilla*, Bristled grassbird *Chaetornis striatus* and 7 near threatened species and 288 least concerned species of birds.

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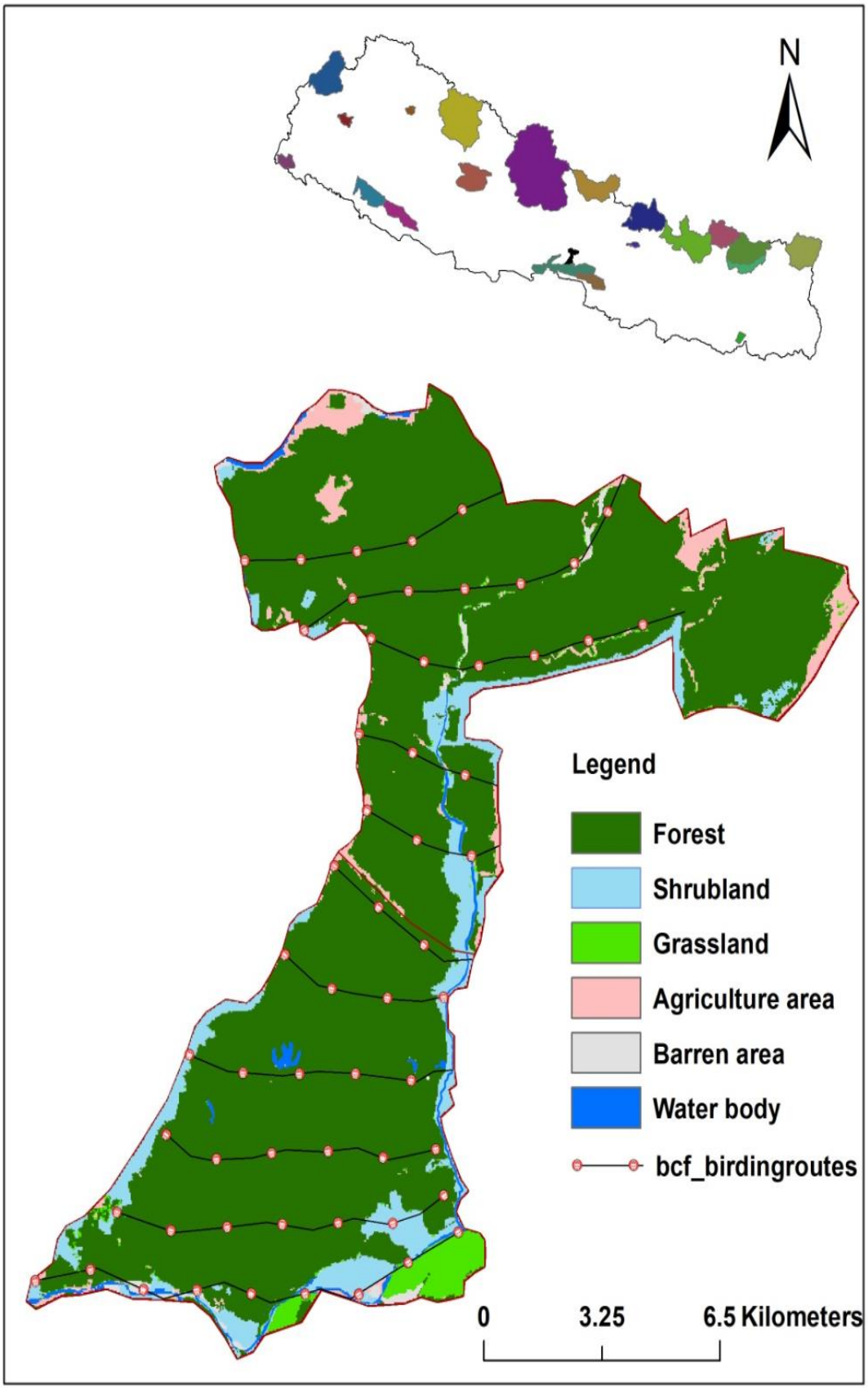

Figure 1. Map of Barandabhar Corridor Forest: the study area, showing major land cover types and eleven birding routes.

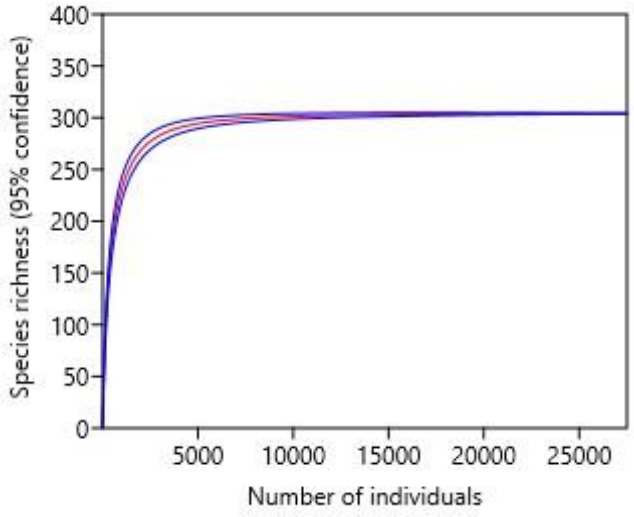

Figure 2. Species accumulation curve. The curve was generated by assuming an assemblage of 304 species whose relative abundances were created from a broken stick distribution[26]. The x axis is the number of individuals and the y-axis is the number of species observed of species richness at 95% confidence limit. The shape of this species accumulation curve is typical: it rises rapidly at first as the common species are initially encountered, and then continues to rise very slowly, as much more sampling is needed to encounter all of the rare species.

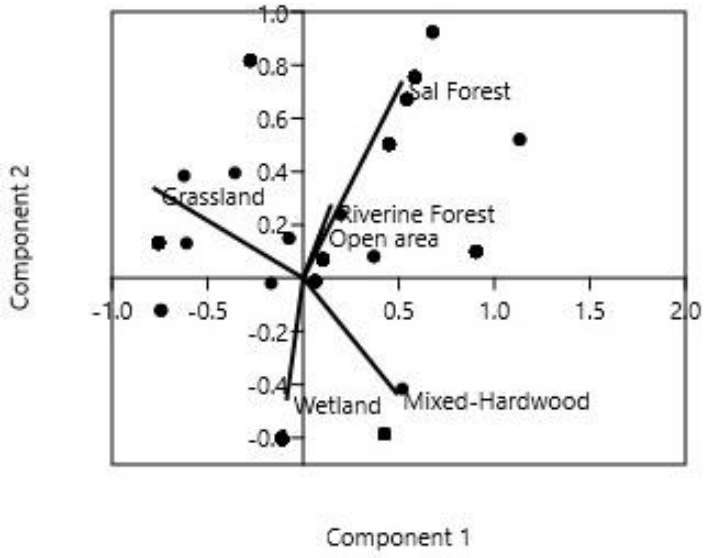

Figure 3. PCA of species distribution in various habitats showed that species were distributed in four distinct clusters: a) *Shorea* forest, riverine forest and open areas; b) Mixed hardwood forest; c) wetlands and d) grasslands.

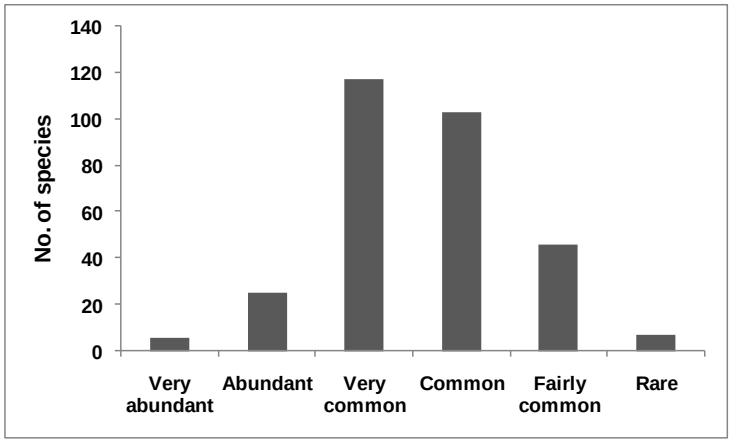

Figure 4. Local Status of birds in Barandabhar Corridor Forest

Figure 5. Photograph of birds of BCF with different IUCN categories, 1: Red-headed Vulture *Sarcogyps calvus* (CR), 2: White-rumped Vulture *Gyps bengalensis*(CR), 3: Egyptian Vulture *Neophron percnopterus* (EN), 4: Lesser Adjuntant Stork *Leptoptilos javanicus* (VU), 5: Grey-headed Fish Eagle *Icthyophaga ichthyaetus*, (NT), 6*:* Great Cormorant *Phalacrocorax carbo* (LC)

Table 1. Checklist of Birds of Barandabhar Corridor Forest. (Here, CR= Critically Endangered, EN= Endangered, VU=Vulnerable, NT= Near Threatened, LC= Least Concerned)

SN	English Name	Zoological Name	Family	IUCN Status
1	Crested Serpent Eagle	*Spilornis cheela*	Accipitridae	LC
2	Oriental Honey-buzzard	*Pernis ptilorhyncus*	Accipitridae	LC
3	Osprey	*Pandion haliaetus*	Accipitridae	LC
4	Black Kite	*Milvus migrans*	Accipitridae	LC
5	Grey-headed Fish Eagle	*Icthyophaga ichthyaetus*	Accipitridae	NT
6	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Accipitridae	VU
7	Red-headed Vulture	Sarcogyps calvus	Accipitridae	CR
8	Long-billed Vulture	*Gyps indicus*	Accipitridae	CR
9	White-rumped Vulture	*Gyps bengalensis*	Accipitridae	CR
10	Egyptian Vulture	*Neophron percnopterus*	Accipitridae	EN
11	Black- winged Kite	*Elanus caeruleus*	Accipitridae	LC
12	Long-legged Buzzard	*Buteo rufinus*	Accipitridae	LC
13	Eurasian Buzzard	*Buteo buteo*	Accipitridae	LC
14	White-eyed Buzzard	*Butastur teesa*	Accipitridae	LC
15	Black Baza	*Aviceda leuphotes*	Accipitridae	LC
16	Lesser Spotted Eagle	*Aquila pomarina*	Accipitridae	LC
17	Crested Goshawk	*Accipiter trivirgatus*	Accipitridae	LC
18	Eurasian Sparrowhawk	*Accipiter nisus*	Accipitridae	LC
19	Shikra	*Accipiter badius*	Accipitridae	LC
20	Steppe Eagle	*Aquila nipalensis*	Acciptridae	LC
21	Griffon Vulture	*Gyps fulvus*	Acciptridae	LC
22	Thick-billed Warbler	*Acrocephalus aedon*	Acrocephalidae	LC
23	Common Iora	*Aegithina tiphia*	Aegithinidae	LC
24	Bengal Bushlark	*Mirafra assamica*	Alaudidae	LC
25	Sand Lark	*Calandrella raytal*	Alaudidae	LC
26	Oriental Skylark	*Alauda gulgula*	Alaudidae	LC
27	Blue-eared Kinghfisher	*Alcedo meninting*	Alcedinidae	LC
28	Common Kingfisher	*Alcedo atthis*	Alcedinidae	LC
29	Pied Kingfisher	*Ceryle rudis*	Alcedinidae	LC
30	White-breasted Kingfisher	*Halcyon smyrnensis*	Alcedinidae	LC
31	Black-capped Kingfisher	*Halcyon pileata*	Alcedinidae	LC
32	Stork-billed Kingfisher	*Pelargopsis capensis*	Alcedinidae	LC
33	Ruddy Shelduck	*Tadorna ferruginea*	Anatidae	LC
34	Cotton Pigmy-goose	*Nettapus coromandelianus*	Anatidae	LC
35	Goosander	*Mergus merganser*	Anatidae	LC
36	Gadwall	*Anas strepera*	Anatidae	LC
37	Indian Spot-billed Duck	*Anas poecilorhyncha*	Anatidae	LC
38	Mallard	*Anas platyrhynchos*	Anatidae	LC
39	Common Teal	*Anas crecca*	Anatidae	LC
40	Northern Pintail	*Anas acuta*	Anatidae	LC
41	Ferruginous Duck	*Aythya nyroca*	Anatidae	NT
42	Lesser Whistling-duck	*Dendrocygna javanica*	Anatidae	LC
43	Oriental Darter*	*Anhinga melanogaster*	Anhingidae	NT

44	Silver-backed Niddletail	*Hirundapus cochinchinensis*	Apodidae	LC
45	White-rumped Needletail	*Zoonavena sylvatica*	Apodidae	LC
46	Himalayan Swiftlet	*Aerodramus brevirostris*	Apodidae	LC
47	Pacific Swift	*Apus pacificus*	Apodidae	LC
48	Little Swift	*Apus affinis*	Apodidae	LC
49	Black-crowned Night Heron	*Nycticorax nycticorax*	Ardeidae	LC
50	Intermediate Egret	*Ardea intermedia*	Ardeidae	LC
51	Yellow Bittern	*Ixobrychus sinensis*	Ardeidae	LC
52	Cinnamon Bittern	*Ixobrychus cinnamomeus*	Ardeidae	LC
53	Little Egret	*Egretta garzetta*	Ardeidae	LC
54	Great White Egret	*Casmerodius albus*	Ardeidae	LC
55	Green Backed Heron	*Butorides striatus*	Ardeidae	LC
56	Cattle Egret	*Bubulcus ibis*	Ardeidae	LC
57	Indian Pond Heron	*Ardeola grayii*	Ardeidae	LC
58	Purple Heron	*Ardea purpurea*	Ardeidae	LC
59	Grey Heron	*Ardea cinerea*	Ardeidae	LC
60	Ashy Woodswallow	*Artamus fuscus*	Artamidae	LC
61	Great Hornbill*	*Buceros bicornis*	Bucerotidae	NT
62	Oriental Pied Hornbill	*Anthracoceros albirostris*	Bucerotidae	LC
63	Eurasian Thick-knee	*Burhinus oedicnemus*	Burhinidae	LC
64	Rosy Minivet	*Pericrocotus roseus*	Campephagidae	LC
65	Scarlet Minivet	*Pericrocotus flammeus*	Campephagidae	LC
66	Small Minivet	*Pericrocotus cinnamomeus*	Campephagidae	LC
67	Black-winged Cuckooshrike	*Coracina melaschistos*	Campephagidae	LC
68	Black-headed Cuckooshrike	*Coracina melanoptera*	Campephagidae	LC
69	Indian Cuckooshrike	*Coracina macei*	Campephagidae	LC
70	Large-tailed Nightjar	*Caprimulgus macrurus*	Caprimuigidae	LC
71	Savanna Nightjar	*Caprimulgus affinis*	Caprimuigidae	LC
72	Yellow-wattled Lapwing	*Vanellus malarbaricus*	Charadriidae	LC
73	Red-wattled Lapwing	*Vanellus indicus*	Charadriidae	LC
74	River Lapwing	*Vanellus duvaucelii*	Charadriidae	NT
75	Grey-headed Lapwing	*Vanellus cinereus*	Charadriidae	LC
76	Little Ringed Plover	*Charadrius dubius*	Charadriidae	LC
77	Kentish Plover	*Charadrius alexandrines*	Charadriidae	LC
78	Golden-fronted Leafbird	*Chloropsis aurifrons*	Chloropseidae	LC
79	Lesser Adjuntant Stork*	*Leptoptilos javanicus*	Ciconiidae	V
80	Black Stork	*Ciconia nigra*	Ciconiidae	LC
81	Woolly-necked Stork	*Ciconia episcopus*	Ciconiidae	V
82	Asian Openbill Stork	*Anastomus oscitans*	Ciconiidae	LC
83	Ashy Prinia	*Prinia socialis*	Cisticolidae	LC
84	Plain Prinia	*Prinia inornata*	Cisticolidae	LC
85	Grey-breasted Prinia	*Prinia hodgsonii*	Cisticolidae	LC
86	Yellow-bellied Prinia	*Prinia flaviventris*	Cisticolidae	LC
87	Grey-crowned Prinia	*Prinia cinereocapilla*	Cisticolidae	V
88	Zitting Cisticola	*Cisticola juncidis*	Cisticolidae	LC
89	Common Tailorbird	*Orthotomus sutorius*	Cisticolidae	LC
90	Sri Lanka Green-pigeon	*Treron pompadora*	Columbidae	LC

91	Thick-billed Green Pigeon	*Treron curvirostra*	Columbidae	LC
92	Yellow-footed Green Pigeon	*Treron phoenicoptera*	Columbidae	LC
93	Orange-breasted Green Pigeon	*Treron bicincta*	Columbidae	LC
94	Red Turtle-dove	*Streptopelia tranquebarica*	Columbidae	LC
95	Oriental Turtle Dove	*Streptopelia orientalis*	Columbidae	LC
96	Eurasian Collared Dove	*Streptopelia decaocto*	Columbidae	LC
97	Eastern Spotted Dove	*Spilopelia chinensis*	Columbidae	LC
98	Grey-capped Emerald Dove	*Chalcophaps indica*	Columbidae	LC
99	Common wood Pigeon	*Columba palumbus*	Columbidae	LC
100	Oriental Dollarbird	*Eurystomus orientalis*	Coraciidae	LC
101	Indian Roller	*Coracias benghalensis*	Coraciidae	LC
102	Red-billed Blue Magpie	*Urocissa erythroryncha*	Corvidae	LC
103	Indian Paradise-flycatcher	*Terpsiphone paradise*	Corvidae	LC
104	Common Woodshrike	*Tephrodornis pondicerianus*	Corvidae	LC
105	Rufoush Treepie	Dendrocitta vagabounda	Corvidae	LC
106	Grey Treepie	*Dendrocitta formosae*	Corvidae	LC
107	House Crow	*Corvus splendens*	Corvidae	LC
108	Large-billed Crow	*Corvus macrorhynchos*	Corvidae	LC
109	Common Green Magpie	*Cissa chinensis*	Corvidae	LC
110	Greater Coucal	*Centropus sinensis*	Cuculidae	LC
111	Lesser Coucal	*Centropus bengalensis*	Cuculidae	LC
112	Square-tailed Drongo-cuckoo	*Surniculus lugubris*	Cuculidae	LC
113	Green-billed Malkoha	*Phaenicophaeus tristis*	Cuculidae	LC
114	Sirkeer Malkoha	*Phaenicophaeus leschenaultii*	Cuculidae	LC
115	Common Hawk Cuckoo	*Hierococcyx varius*	Cuculidae	LC
116	Western Koel	*Eudynamys scolopacea*	Cuculidae	LC
117	Indian Cuckoo	*Cuculus micropterus*	Cuculidae	LC
118	Common Cuckoo	*Cuculus canorus*	Cuculidae	LC
119	Jacobin Cuckoo	*Clamator jacobinus*	Cuculidae	LC
120	Chestnut-winged Cuckoo	*Clamator coromandus*	Cuculidae	LC
121	Banded Bay Cuckoo	*Cacomantis sonneratii*	Cuculidae	LC
122	Purple Sunbird	*Nectarinia asiatica*	Dicaeidae	LC
123	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	Dicaeidae	LC
124	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	Dicaeidae	LC
125	Yellow-vented Flowerpecker	*Dicaeum chrysorrheum*	Dicaeidae	LC
126	Thick-billed Flowerpecker	*Dicaeum agile*	Dicaeidae	LC
127	Crimson Sunbird	*Aethopyga siparaja*	Dicaeidae	LC
128	Lesser Racket-tailed Drongo	*Dicrurus remifer*	Dicruridae	LC
129	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	Dicruridae	LC
130	Black Drongo	*Dicrurus macrocercus*	Dicruridae	LC
131	Ashy Drongo	*Dicrurus leucophaeus*	Dicruridae	LC
132	Hair-crested Drongo	*Dicrurus hottentottus*	Dicruridae	LC
133	White-bellied Drongo	*Dicrurus caerulescens*	Dicruridae	LC
134	Crow-billed Drongo	*Dicrurus annectans*	Dicruridae	LC
135	Bronzed Drongo	*Dicrurus aeneus*	Dicruridae	LC
136	Crested Bunting	*Melophus lathami*	Emberizidae	LC
137	Yellow -breasted Bunting	*Emberiza aureola*	Emberizidae	LC

138	White-rumped Munia	*Lonchura striata*	Estrildidae	LC
139	Scaly-breasted Munia	*Lonchura punctulata*	Estrildidae	LC
140	Red Avadavat	*Amandava amandava*	Estrildidae	LC
141	Long-tailed Broadbill	*Psarisomus dalhousiae*	Eurylaimidae	LC
142	Collared Falconet	*Microhierax caerulescens*	Falconidae	LC
143	Common Kestrel	*Falco tinnunculus*	Falconidae	LC
144	Peregrine Falcon	*Falco peregrines*	Falconidae	LC
145	Common Rosefinch	*Carpodacus erythrinus*	Fringillidae	LC
146	Crested Treeswift	*Hemiprocne coronate*	Hemiprocnidae	LC
147	Collared Sand Martin	*Riparia riparia*	Hirundinidae	LC
148	African Plain Martin	*Riparia paludicola*	Hirundinidae	LC
149	Barn Swallow	*Hirundo rustica*	Hirundinidae	LC
150	Red-rumped Swallow	*Cecropis daurica*	Hirundinidae	LC
151	Bronze-winged Jacana	*Metopidius indicus*	Jacanidae	LC
152	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	Jacanidae	LC
153	Grey-backed Shrike	*Lanius tephronotus*	Laniidae	LC
154	Long-tailed Shrike	*Lanius schach*	Laniidae	LC
155	Brown Shrike	*Lanius cristatus*	Laniidae	LC
156	White -crested Laughingthrush	*Garrulax leucolophus*	Leiotrichidae	LC
157	Jungle Babbler	*Turdoides striatus*	Leiotrichidae	LC
158	Striated Babbler	*Argya earlei*	Leiotrichidae	LC
159	Bristled grassbird	*Chaetornis striatus*	Locustellidae	V
160	Great Barbet	*Megalaima virens*	Megalaimidae	LC
161	Lineated Barbet	*Megalaima lineate*	Megalaimidae	LC
162	Coppersmith Barbet	*Psilopogon haemacephalus*	Megalaimidae	LC
163	Blue-throated Barbet	*Psilopogon asiaticus*	Megalaimidae	LC
164	Great Barbet	*Psilopogon virens*	Megalaimidae	LC
165	Blue-bearded Bee-eater	*Nyctyornis athertoni*	Meropidae	LC
166	Blue-tailed Bee-eater	*Merops philippinus*	Meropidae	LC
167	Asian Green Bee-eater	*Merops orientalis*	Meropidae	LC
168	Chestnut-headed Bee-eater	*Merops leschenaultia*	Meropidae	LC
169	Black-naped Monarch	*Hypothymis azurea*	Monarchidae	LC
170	White-browed Wagtail	*Motacilla maderaspatensis*	Motacillidae	LC
171	Forest Wagtail	*Dendronanthus indicus*	Motacillidae	LC
172	Citrine Wagtail	*Motacilla citreola*	Motacillidae	LC
173	Grey Wagtail	*Motacilla cinerea*	Motacillidae	LC
174	White Wagtail	*Motacilla alba*	Motacillidae	LC
175	Paddyfield Pipit	*Anthus rufulus*	Motacillidae	LC
176	Rosy Pipit	*Anthus roseatus*	Motacillidae	LC
177	Richard's Pipit	*Anthus richardi*	Motacillidae	LC
178	Olive-backed Pipit	*Anthus hodgsoni*	Motacillidae	LC
179	Common Stonechat	*Saxicola torquata*	Muscicapidae	LC
180	White-tailed Stonechat	*Saxicola leucura*	Muscicapidae	LC
181	Grey Bushchat	*Saxicola ferrea*	Muscicapidae	LC
182	Pied Bushchat	*Saxicola caprata*	Muscicapidae	LC
183	Plumbeous Water Redstart	*Rhyacornis fuliginosus*	Muscicapidae	LC
184	Black Redstart	*Phoenicurus ochruros*	Muscicapidae	LC

185	Rufous-bellied Niltava	*Niltava sundara*	Muscicapidae	LC
186	Blue Whistling Thrush	*Myophonus caeruleus*	Muscicapidae	LC
187	Asian Brown Flycatcher	*Muscicapa dauurica*	Muscicapidae	LC
188	Bluethroat	*Calliope svecica*	Muscicapidae	LC
189	Himalayan Rubythroat	*Calliope pectoralis*	Muscicapidae	LC
190	Siberian Rubythroat	*Calliope calliope*	Muscicapidae	LC
191	Slaty-blue Flycatcher	*Ficedula tricolor*	Muscicapidae	LC
192	Red-throated Flycatcher	*Ficedula parva*	Muscicapidae	LC
193	Pygmy Blue Flycatcher	*Ficedula hodgsoni*	Muscicapidae	LC
194	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	Muscicapidae	LC
195	Verditer Flycatcher	*Eumyias thalassina*	Muscicapidae	LC
196	Black-backed Forktail	*Enicurus immaculatus*	Muscicapidae	LC
197	Pale-chinned Flycatcher	*Cyornis poliogenys*	Muscicapidae	LC
198	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	Muscicapidae	LC
199	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	LC
200	White-rumped Shama	*Kittacincla malabarica*	Muscicapidae	LC
201	White tailed Robin	*Myiomela leucura*	Muscicapidae	LC
202	White browed bush Robin	*Tarsiger indicus*	Muscicapidae	LC
203	White caped water Redstart	*Phoenicurus leucocephalus*	Muscicapidae	LC
204	Black-hooded Oriole	*Oriolus xanthornus*	Oriolidae	LC
205	Eurasian Golden Oriole	*Oriolus oriolus*	Oriolidae	LC
206	Great Tit	*Parus major*	Paridae	LC
207	Chestnut-shouldered Petronia	*Gymnoris xanthocollis*	Passeridae	LC
208	Eurasian Tree Sparrow	*Passer montanus*	Passeridae	LC
209	House Sparrow	*Passer domesticus*	Passeridae	LC
210	Puff-throated Babbler	*Pellorneum ruficeps*	Pellorneidae	LC
211	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	LC
212	Indian Peafowl	*Pavo cristatus*	Phasianidae	LC
213	Red Junglefowl	*Gallus gallus*	Phasianidae	LC
214	Black Francolin	*Francolinus francolinus*	Phasianidae	LC
215	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	Phylloscopidae	LC
216	Whistler's Warbler	*Phylloscopus whistleri*	Phylloscopidae	LC
217	Golden-spectacled Warbler	*Phylloscopus burkii*	Phylloscopidae	LC
218	Greenish Warbler	*Phylloscopus trochiloides*	Phylloscopidae	LC
219	Blyth's Leaf Warbler	*Phylloscopus reguloides*	Phylloscopidae	LC
220	Western Crowned Warbler	*Phylloscopus occipitalis*	Phylloscopidae	LC
221	Large-billed Leaf Warbler	*Phylloscopus magnirostris*	Phylloscopidae	LC
222	Dusky Warbler	*Phylloscopus fuscatus*	Phylloscopidae	LC
223	Smokey Warbler	*Phylloscopus fuligiventer*	Phylloscopidae	LC
224	Common Chiffchaff	*Phylloscopus collybita*	Phylloscopidae	LC
225	Tickell's Leaf Warbler	*Phylloscopus affinis*	Phylloscopidae	LC
226	Blyth's Reed Warbler	*Acrocephalus dumetorum*	Phylloscopidae	LC
227	Fulvous-breasted Woodpecker	*Dendrocopos macei*	Picidae	LC
228	Streak-throated Woodpecker	*Picus xanthopygaeus*	Picidae	LC
229	Scaly-bellied Woodpecker	*Picus squamatus*	Picidae	LC
230	Greater Yellownape	*Chrysophlegma flavinucha*	Picidae	LC
231	Lesser Yellownape Woodpecker	*Picus chlorolophus*	Picidae	LC

232	Grey-headed Woodpecker	*Picus canus*	Picidae	LC
233	Eurasian Wryneck	*Jynx torquilla*	Picidae	LC
234	Himalayan Flameback	*Dinopium shorii*	Picidae	LC
235	Black-rumped Flameback	*Dinopium benghalense*	Picidae	LC
236	Yellow-crowned Woodpecker	*Dendrocopos mahrattensis*	Picidae	LC
237	Grey-capped Pigmy Woodpecker	*Dendrocopos canicapillus*	Picidae	LC
238	Greater Flameback	*Chrysocolaptes lucidus*	Picidae	LC
239	Hooded Pitta	*Pitta sordid*	Pittidae	LC
240	Indian Pitta	*Pitta brachyuran*	Pittidae	LC
241	Baya Weaver	*Ploceus philippinus*	Ploceidae	LC
242	Black-breasted Weaver	*Ploceus benghalensis*	Ploceidae	LC
243	Black-necked Grebe	*Podiceps nigricollis*	Podicipedidae	LC
244	Rose-ringed Parakeet	Psittaciformes	Psittacidae	LC
245	Slaty-headed Parakeet	*Psittacula himalayana*	Psittacidae	LC
246	Alexandrine Parakeet	*Psittacula eupatria*	Psittacidae	NT
247	Plum-headed Parakeet	*Psittacula cyanocephala*	Psittacidae	LC
248	Red-breasted Parakeet	*Psittacula alexandri*	Psittacidae	NT
249	Black-crested Bulbul	*Pycnonotus melanicterus*	Pycnonotidae	LC
250	Himalayan Bulbul	*Pycnonotus leucogenys*	Pycnonotidae	LC
251	Red-whiskered Bulbul	*Pycnonotus jocosus*	Pycnonotidae	LC
252	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	LC
253	Black Bulbul	*Hypsipetes leucocephalus*	Pycnonotidae	LC
254	Ruddy-breasted Crake	*Porzana fusca*	Rallidae	LC
255	Common Moorhen	*Gallinula chloropus*	Rallidae	LC
256	Common Coot	*Fulica atra*	Rallidae	LC
257	White-breasted Waterhen	*Amaurornis phoenicurus*	Rallidae	LC
258	Brown Crake	*Amaurornis akool*	Rallidae	LC
259	Purple Swaphen	*Porphyrio porphyrio*	Rallidae	LC
260	Black-winged Stilt	*Himantopus himantopus*	Recurvirostridae	LC
261	White-browed Fantail	*Rhipidura aureola*	Rhipiduridae	LC
262	White-throated Fantail	*Rhipidura albicollis*	Rhipiduridae	LC
263	Greater Painted-snipe	*Rostratula benghalensis*	Rostratulidae	LC
264	Eurasian Woodcock	*Scolopax rusticola*	Scolopacidae	LC
265	Common Redshank	*Tringa tetanus*	Scolopacidae	LC
266	Green Sandpiper	*Tringa ochropus*	Scolopacidae	LC
267	Common Greenshank	*Tringa nebularia*	Scolopacidae	LC
268	Wood Sandpiper	*Tringa glareola*	Scolopacidae	LC
269	Temminck's Stint	*Calidris temminckii*	Scolopacidae	LC
270	Common Sandpiper	*Actitis hypoleucos*	Scolopacidae	LC
271	Aberrant Bush Warbler	*Horornis flavolivaceus*	Scotocercidae	LC
272	Velvet-fronted Nuthatch	*Sitta frontalis*	Sittidae	LC
273	Chestnut-bellied Nuthatch	*Sitta castanea*	Sittidae	LC
274	Collared Scops Owl	*Otus bakkamoena*	Strigidae	LC
275	Collared Owlet	*Glaucidium brodiei*	Strigidae	LC
276	Brown Hawk Owl	*Ninox scutulata*	Strigidae	LC
277	Brown Fish Owl	*Ketupa zeylonensis*	Strigidae	LC
278	Jungle Owlet	*Glaucidium radiatum*	Strigidae	LC

279	Asian Barred Owlet	*Glaucidium cuculoides*	Strigidae	LC
280	Spotted Owlet	*Athene brama*	Strigidae	LC
281	Brahminy Starling	*Sturnus pagodarum*	Sturnidae	LC
282	Chestnut-tailed Starling	*Sturnus malabaricus*	Sturnidae	LC
283	Spot-winged Starling	*Saroglossa spilopterus*	Sturnidae	LC
284	Hill Myna	*Gracula religiosa*	Sturnidae	LC
285	Common Myna	*Acridotheres tristis*	Sturnidae	LC
286	Bank Myna	*Acridotheres ginginianus*	Sturnidae	LC
287	Jungle Myna	*Acridotheres fuscus*	Sturnidae	LC
288	Asian Pied Starling	*Gracupica contra*	Sturnidae	LC
289	Black Ibis	*Pseudibis papillosa*	Threskiornithidae	LC
290	Chestnut-capped Babbler	*Timalia pileata*	Timaliidae	LC
291	Striped Tit Babbler	*Macronous gularis*	Timaliidae	LC
292	Scaly Thrush	*Zoothera dauma*	Turdidae	LC
293	Orange-headed Thrush	*Geokichla citrina*	Turdidae	LC
294	Blue Rock Thrush	*Monticola solitarius*	Turdidae	LC
295	Alpine Thrush	*Zoothera mollissima*	Turdidae	LC
296	Tickell's Thrush	*Turdus unicolor*	Turdidae	LC
297	Rufous-throated Thrush	*Turdus ruficollis*	Turdidae	LC
298	Grey-winged Blackbird	*Turdus boulboul*	Turdidae	LC
299	Small Buttonquail	*Turnix sylvatica*	Turnicidae	LC
300	Common Hoopoe	*Upupa epops*	Upupidae	LC
301	Large Woodshrike	*Tephrodornis virgatus*	Vangidae	LC
302	Bar-winged Flycatcher-shrike	*Hemipus picatus*	Vangidae	LC
303	White-bellied Yuhina	*Yuhina zantholeuca*	Vireonidae	LC
304	Oriental White-eye	*Zosterops palpebrosus*	Zosteropidae	LC

Table 2. Species diversity and dominance indices of birds at BCF.

Order	Species richness	No. of Family	No of individual	Dominance_D	Simpson=1-D	Shannon_H	Evenness_e
Accipitriformes	21	1	402	0.08579	0.9142	2.678	0.6928
Anseriformes	10	1	835	0.1422	0.8578	2.076	0.7971
Bucerotiformes	4	3	138	0.47	0.53	0.9769	0.664
Caprimulgiformes	8	3	950	0.3203	0.6797	1.401	0.5074
Charadriiformes	19	7	1458	0.06628	0.9337	2.807	0.8714
Ciconiiformes	4	1	362	0.6045	0.3955	0.7235	0.5154
Columbiformes	10	1	416	0.4276	0.5724	1.374	0.3951
Coraciiformes	12	3	444	0.1318	0.8682	2.212	0.761
Cuculiformes	12	1	589	0.1285	0.8715	2.245	0.7867
Falconiformes	3	1	66	0.4137	0.5863	0.9838	0.8915
Galliformes	3	1	118	0.5549	0.4451	0.7102	0.6781
Gruiformes	6	1	514	0.2158	0.7842	1.629	0.85
Passeriformes	155	38	18840	0.01487	0.9851	4.572	0.6239
Pelecaniformes	12	2	1144	0.1617	0.8383	2.093	0.676
Piciformes	17	2	412	0.07564	0.9244	2.7	0.875
Psittaciformes	5	1	810	0.3506	0.6494	1.275	0.7156
Suliformes	2	1	118	0.6862	0.3138	0.4933	0.8188
Total	304	69	27660	0.008608	0.9914	5.169	0.5781

Table 3. β-diversity of birds in different habitats of BCF. The results showed the habitat association between different habitats. The highlighted (Welch-t test for two samples) showed the significant association between different habitats. One way ANOVA for several unequal variables showed the significant results between different β-diversity tests (Welch F-test *F=167.3, df =31.86, p<0.00001*). Here, SF=Sal Forest, RF = Riverine Forest, MF=Mixed hardwood Forest, GL=Grassland, WL= Wetland, OA=Open Area.

Associations	**β-Whitaker**	**β-Soren**	**β-Routledge**	**β-Harrison 2**	**β-Williams**	**Welch-t test**	**p-value**
SF/RF	0.73846	0.261538	0.2014	0.32941	0.24779	4.02	0.0001
SF/MF	0.7125	0.2875	0.21364	0.61176	0.37956	0.9201	0.3579
SF/GL	0.87978	0.120219	0.26374	0.7551	0.43023	1.1488	0.2511
SF/WL	0.95588	0.044118	0.27403	0.56471	0.3609	**3.3337**	**0.0009**
SF/OA	0.75806	0.241935	0.19759	0.28235	0.22018	**4.706**	**0.00001**
RF/MF	0.91667	0.083333	0.26223	0.53333	0.34783	3.0755	0.002
RF/GL	0.93007	0.06993	0.24943	0.40816	0.28986	**5.17**	**0.00001**
RF/WL	0.97917	0.020833	0.29391	0.86275	0.46316	0.6665	0.5054
RF/OA	0.7619	0.238095	0.22825	0.64444	0.39189	0.7043	0.4815
MF/GL	0.96532	0.034682	0.28674	0.73469	0.42353	2.0712	0.0388
MF/WL	0.9999	0	0.2931	0.68	0.40476	2.4088	0.0163
MF/OA	0.91228	0.087719	0.25259	0.45333	0.31193	**3.7781**	**0.0002**
GL/WL	0.93289	0.067114	0.25885	0.46939	0.31944	**4.4974**	**0.00001**
GL/OA	0.91241	0.087591	0.23304	0.33673	0.25191	**5.8784**	**0.00001**
WL/OA	0.91111	0.088889	0.2704	0.68627	0.40698	1.3703	0.1711

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