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COMMUNICATION

AVIFAUNAL DIVERSITY OF SOME SELECTED WATER BODIES OF KHANAPUR TALUKA, BELAGAVI DISTRICT, KARNATAKA, INDIA

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Avifaunal diversity of some selected water bodies of Khanapur Taluka, Belagavi District, Karnataka, India

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Abstract: An observation on avian species composition, density, and diversity was carried out at three selected water bodies of Khanapur Taluka, Belagavi District, for a period of 11 months in 2014. During the study, a total of 28 species belonging to 12 families from five orders were recorded. Of these, Ciconiiformes was represented by seven families followed by Coraciiformes by two families while Anseriformes, Charadriiformes and Gruiformes were represented by one family each. Among the three water bodies studied, maximum species composition (26 species) was recorded from Nandgad pond which also hosts Lesser Adjutant Stork and Woolly-necked Stork categorized as 'Vulnerable' and Painted Stork, River Tern and Oriental White Ibis as 'Near Threatened' by the IUCN Red List. Bidi Minor Irrigation Tank stands second with 17 species while the minimum was recorded at Hebbal Minor Irrigation Tank with 11 species. Based on our observation, a smaller habitat with habitat heterogeneity can attract more assemblages of avifauna and also result in increased species richness and diversity.

Keywords: Birds, richness, relative abundance, wetland birds.

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Author contribution: GK has played a crucial role in monitoring and guiding the work. HN has carried out field survey, analysis and documentation.

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INTRODUCTION

Birds occupy a significant position in ecology and human society and play prominent and diverse roles as pollinators, seed dispersers, pest controlling agents, bio-indicators of an ecosystem, and also in religion & culture. Since time immemorial, they have been a source of food, medicine, feathers for ornaments, and amusements. Presently, they are confronting various threats from climate change and human interferences such as loss of habitat through inflow of domestic and industrial effluents, agricultural runoffs, degradation of wetlands, agricultural expansion, overgrazing of the grasslands, and urbanization leading to deforestation (Grimmett et al. 2011). Diversity of avifauna is one of the most important ecological indicators to evaluate the quality of habitats.

In Karnataka, most of the work is being concentrated on survey, distribution, diversity studies, and status of avifauna. Rajashekara & Venkatesha (2010) recorded diversity and abundance of water birds from Bangalore City lakes, Basavarajappa (2006) has studied avifauna of agro-ecosystems from maidan region of Davangere. Diversity studies in and around Shivamogga District has been carried out by workers like Nazneen et al. (2001) and Dinesh et al. (2007) at Kuvempu University campus, Shivamogga and checklist of avifauna from Gudavi Bird Sanctuary by Dayananda (2009). Distribution and diversity from Lakkavalli range forest of Bhadra Wildlife Sanctuary by Harisha & Hosetti (2009) have studied diversity of Shivamogga City. Assessment and status, diversity, and threats of loss of wetlands of Davangere District by Harisha & Hosetti (2018). Barve & Warriar (2013) have conducted a study on bird diversity from Sharavathy landscape. Bhat et al. (2009) have studied diversity of wetland bird species in Anekere wetland of Karkala. Manjunath & Joshi (2012) have observed species composition, relative abundance and avian classification based on feeding guilds around Chandrampalli Dam of Chincholi from Gulbarga region. Birasal (2015) has studied on occurrence of terrestrial birds in Haveri and neighboring districts. Diversity, richness and conservational threats of migratory wetland birds of Magadi Bird Sanctuary, Gadag District was studied by Kaulgud et al. (2016).

Publications on avifaunal status and diversity from Belagavi District can be traced from the surveys by Patil & Hiragond (2013) along Ghataprabha River near Shettihalli. The objective of the present work was to study species composition, diversity, and status of the wetland birds in some water bodies of Khanapur Taluk.

MATERIALS AND METHODS

Study Area

Khanapur Taluk is located towards the western part of Belagavi District of Karnataka. It is about 26km away from district headquarters. The total geographical area of the taluk is 1726.11km² with geographical co-ordinates of 15.63° N 74.52° E. It has an average area elevation of 649m. The study was carried out from February to December 2014 from three lentic water bodies, namely, Bidi Minor Irrigation Tank (MIT) (15.583°N, 74.640°E), Nandgad pond (15.580°N & 74.583°E), and Hebbal MIT (15.752°N & 74.563°E) located on the State Highway 93 of Khanapur Taluka (Figure 1). The two minor irrigation tanks were constructed by minor irrigation department of Government of Karnataka while Nandgad pond was constructed in 2010 under Jala Samvardhane Yojana Sangha, a registered society established by the Department of Water Resources, Government of Karnataka for community-based tank management.

Methods

Survey of birds was conducted early morning 06.00–09.30 h during the first week of every month from February to December, 2014. Observations of the birds were made with the help of Olympus binocular (OLYMPUS 10X50 DPS I, Field 6.5°) and CANON EOS 600D lens kit was used for photography. Birds observed during the study period were classified into families and orders as per Grimmett et al. (2011). The density of the birds was counted using fixed-radius point count method with the expression; Density: $D^{\wedge} = n/a = n/k\pi w^2$, where, D = density, A = size of the survey region, k = number of points in the region, n = number of birds counted, and $a = k\pi w^2$, the total size of the survey plots. Six circular point count sites each with a 20-m radius were selected. The total area of each point count site was 1,257m². The density of birds was expressed as total birds/ha. The point count sites were selected based on the roosting, feeding sites, and accessibility (Buckland et al. 2008) and during certain times counts were made with the help of photographs taken during the study (Whitworth et al. 2007).

Relative abundance of all bird species was calculated by the expression

$$\text{Relative abundance} = \frac{\text{No. of individuals of the species}}{\text{Total no. of individuals of all species}} \times 100$$

The diversity and evenness was calculated by using Shannon-Weiner diversity index and the formulae are expressed as

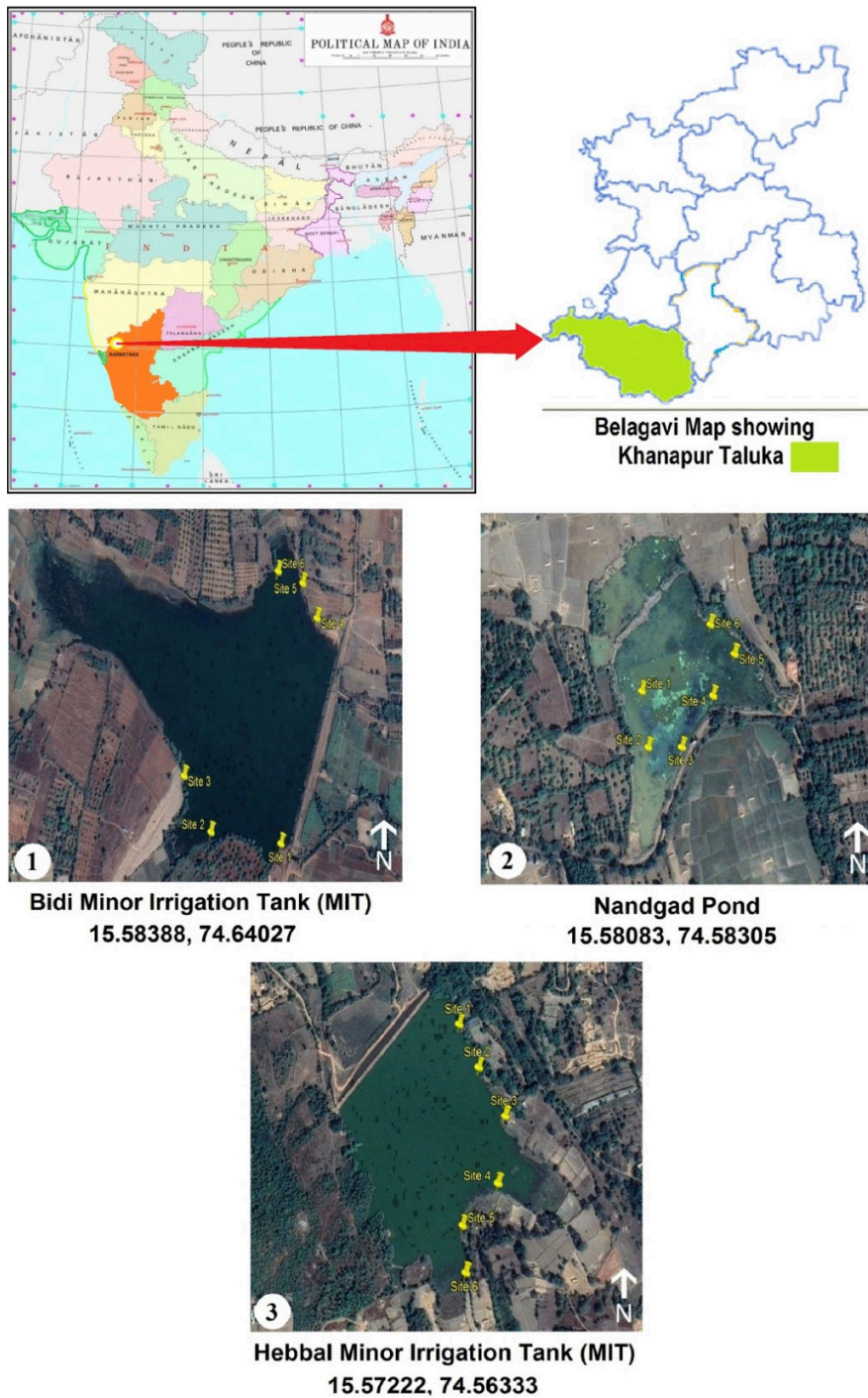


Figure 1. Map of study area showing the three selected water bodies of Khanapur Taluk, Belagavi District, Karnataka State, India.

S

$$H' = - \sum_{i=1}^S (P_i * \ln p_i)$$

$i = 1$

where, p_i = fraction of entire population made up of species 'i', \ln = natural log and \sum = sum from species 1 to species S . Shannon-Weiner evenness index: $E_H = H'/H_{\max}$ where, H' = Shannon-Weiner diversity index, and H_{\max} is the $\ln S$ where S is the number of species encountered in the group.

RESULTS

Species Composition, Abundance, Density and Relative Abundance

During the study, a total of 28 species belonging to 12 families from five orders were recorded. Of these, Ciconiiformes was represented with seven families followed by Coraciiformes with two families while Anseriformes, Charadriiformes, and Gruiformes were

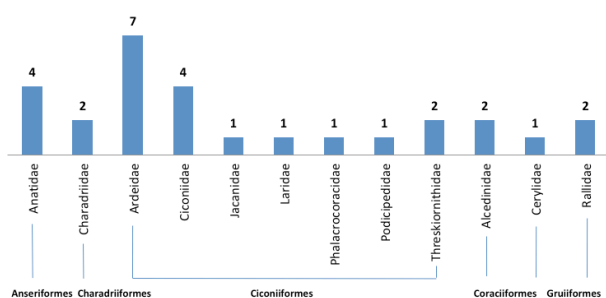


Figure 2: Number of avian species represented from each families and their respective orders at three selected water bodies of Khanapur taluka during 11 month study.

represented with one family each. Among them, family Ardeidae dominated with seven species, followed by Anatidae and Ciconiidae with four species each. Families Charadriidae, Threskiornithidae, Alcedinidae, and Rallidae were represented with two species each while Laridae, Phalacrocoracidae, Podicipedidae, Cerylidae, and Jacaniidae were represented with one species each (Figure 2). Maximum species composition was recorded from Nandgad pond with 26 species followed by 17 species of birds from Bidi minor irrigation tank and 11 species from Hebbal minor irrigation tank.

Site 1: Bidi Minor Irrigation Tank (MIT)

The species composition at Bidi MIT reveals a total of 17 species representing eight families belonging to four orders from this pond (Table 1). Order Ciconiiformes dominated with 12 species belonging to five families namely, Ardeidae represented with five species, Ciconiidae with three species, Threskiornithidae with two species, Laridae and Phalacrocoracidae representing with one species each. Order Anseriformes represented with two species from family Anatidae and Order Charadriiformes also with two species belonging to family Charadriidae. Order Coraciiformes, however, was represented by only one species belonging to family Cerylidae. The periodicity of Indian Spot-billed Duck in this water body was found prominent as it was observed continuously for seven months (March–October 2014) followed by Little Egret *Egretta garzetta* and Cattle Egret *Bubulcus ibis* that were recorded in five months. Great Egret *Casmerodius albus*, Asian Openbill Stork *Anastomus oscitans*, Painted Stork *Mycteria leucocephala*, Eurasian Spoon Bill *Platalea leucorodia*, Pied Kingfisher *Cerylerudis travancoreensis* were spotted only once during the study period.

Asian Openbill Stork was the only migrant while Bronze-winged Jacana *Metopidius indicus* was recorded as a resident bird. The rest of the birds were either

residents or local migrants. As per the IUCN Red List, Lesser Adjutant Stork *Leptoptilos javanicus* is categorized as 'Vulnerable', Painted Stork *Mycteria leucocephala*, River Tern *Sterna aurantia* and Oriental White Ibis *Threskiornis melanocephalus* are Near Threatened (NT), and the remaining species are grouped as 'Least Concern'. All the birds that were observed during the study period were of schedule IV of WPA, 1972 except Eurasian Spoonbill *Platalea leucorodia* which is included in Schedule I (Table 4).

At Bidi MIT, the abundance and density (birds/ha) of Indian Spot-billed Duck *Anas poecilorhyncha* of Anatidae family was the maximum (72 individuals and 95.45 birds/ha) throughout the study period. Statistics for other birds are provided in Table 1.

In this water body, Indian Spot-billed Duck showed the highest relative abundance (41%) followed by Lesser Adjutant Stork (16%), and Cattle Egret (12%). Minimum relative abundance was recorded by Oriental White Ibis (9%) and River Tern (7%). The rest of the species like Little Egret, Eurasian Spoonbill, Red-wattled Lapwing, and Little Ringed Plover, Black-crowned Night Heron, Great Egret, Median Egret, Little Cormorant recorded the least (1%) relative abundance (Figure 3).

The mean density of Lesser Adjutant Stork (*Leptoptilos javanicus*, 33.14 ± 19.50) was the maximum followed by Indian Spot-billed Duck (*Anas poecilorhyncha*, 23.8 ± 28.94), Oriental White Ibis (*Threskiornis melanocephalus*, 18.56 ± 8.57), Comb Duck (*Sarkidiornis melanotos*, 9.935 ± 4.823), Cattle Egret (*Bubulcus ibis*, 9.542 ± 10.998), River Tern (*Sterna aurantia*, 8.83 ± 6.726), Eurasian Spoonbill (*Platalea leucorodia*, 6.62 ± 1.996), Great Egret (*Casmerodius albus*, 2.65 ± 0.799), Median Egret (*Mesophoyx intermedia*, 2.645 ± 1.223) and Little Egret (*Egretta garzetta*, 1.852 ± 1.071) while the minimum was recorded by Red-wattled Lapwing (*Vanellus indicus*, 1.32 ± 0.637), Little Ringed Plover (*Charadrius dubius*, 1.32 ± 0.556), Black-crowned Night Heron (*Nycticorax nycticorax*), and Little Cormorant (*Phalacrocorax niger*) (1.32 ± 0.533), respectively. Asian Openbill Stork (*Anastomus oscitans*), Painted Stork (*Mycteria leucocephala*), and Pied Kingfisher (*Ceryle rudis travancoreensis*) recorded mean density of 1.32 ± 0.397 , respectively (Table 5).

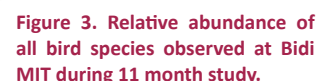
Diversity (H) and Equitability or Evenness (E)

During the 11 month study, the highest diversity ($H' = 2.2315$) was recorded during June, followed by July 2014 ($H' = 1.56064$), while it was minimum ($H' = 0.24491$) in October 2014. Highest evenness ($E_H = 0.96968$) was observed in July while it was lowest ($E_H = 0.32372$) in

Table 1. Species composition, monthly abundance and density (birds/ha) of birds recorded at Bidi minor irrigation tank from February to December 2014. (N=305).

| Order | Family | Common name | F | M | A | M | J | J | A | S | O | N | D |
|-----------------|-------------------|---------------------------|---|--------------------|--------------------|--------------------|------------------|------------------|------------------|---|--------------------|--------------------|------------------|
| Anseriformes | Anatidae | Comb Duck | - | 3 3.97 | 12 15.90 | - | - | - | - | - | - | - | - |
| | | Indian Spot-billed Duck | - | 26 34.46 | 72 95.45 | 18 23.86 | 4 5.30 | 2 2.65 | 2 2.65 | - | 2 2.65 | - | - |
| Charadriiformes | Charadriidae | Red-wattled Lapwing | - | - | - | 1 1.32 | 1 1.32 | 1 1.32 | - | - | - | - | - |
| | | Little ringed Plover | - | - | - | - | 1 1.32 | 1 1.32 | - | - | - | - | - |
| Ciconiiformes | Ardeidae | Black Crowned Night Heron | - | - | - | - | 1 1.32 | - | - | - | - | 1 1.32 | - |
| | | Cattle Egret | - | 2 2.65 | 4 5.30 | 1 1.32 | 1 1.32 | - | - | - | 28 37.12 | - | - |
| | | Great Egret | - | - | - | - | 2 2.65 | - | - | - | - | - | - |
| | | Little Egret | - | 2 2.65 | 1 1.32 | 2 2.65 | 1 1.32 | 1 1.32 | - | - | - | - | - |
| | | Median Egret | - | - | - | - | 3 3.97 | 1 1.32 | - | - | - | - | - |
| | | Asian Openbill Stork | - | - | - | - | - | - | - | - | - | 1 1.32 | - |
| Ciconiiformes | Ciconiidae | Lesser Adjutant Stork | - | - | 49 64.96 | - | - | - | - | - | - | - | 1 1.32 |
| | | Painted Stork | - | 1 1.32 | - | - | - | - | - | - | - | - | - |
| | | River Tern | - | - | 17 22.53 | 2 2.65 | 1 1.32 | - | - | - | - | - | - |
| | | Little Cormorant | - | 1 1.32 | - | - | 1 1.32 | - | - | - | - | - | - |
| Ciconiiformes | Threskiornithidae | Oriental white Ibis | - | 7 9.28 | - | - | - | - | - | - | - | 21 27.84 | - |
| | | Eurasian Spoon bill | - | - | 5 6.62 | - | - | - | - | - | - | - | - |
| | | Pied Kingfisher | - | - | - | - | 1 1.32 | - | - | - | - | - | - |
| 4 | 8 | 17 | 0 | 42 | 160 | 24 | 17 | 6 | 2 | 0 | 30 | 23 | 1 |

Note: The numerical values given in **BOLD** are the **abundance** and those mentioned in decimal are the density values (birds/ha). -Birds not found.



minimum of one species in December 2014. Out of 26 species, Order Ciconiiformes was represented by 17 species distributed in seven families; Ardeidae represented with seven species, Ciconiidae with four species and two species from Threskiornithidae. Jacanidae, Laridae, Phalacrocoracidae, and Podicipedidae represented with one species each. Family Anatidae was the only family from order Anseriformes

Twenty-six species of birds representing 12 families were observed at Nandgad pond (Table-2). Maximum species (16) were recorded in the month of June and

Table 2. Species composition, monthly abundance, and density (birds/ha) of birds recorded at Nandgad Pond from February to December 2014. (N=357).

| Order | Family | Common name | F | M | A | M | J | J | A | S | O | N | D |
|---------------|------------|---------------------------|-----------|-------------|-------------|------------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|
| Anseriformes | Anatidae | Cotton Teal | - | - | - | - | - | - | - | 2 2.65 | - | - | - |
| | | Indian Spot-billed Duck | - | - | - | - | 5 6.62 | 1 1.32 | - | - | 1 1.32 | 12 15.90 | - |
| | | Lesser Whistling Duck | - | - | - | - | 4 5.30 | - | 3 3.97 | 4 5.30 | - | 2 2.65 | - |
| | | Red wattled Lapwing | - | - | - | - | - | - | - | 2 2.65 | 2 2.65 | 4 5.30 | - |
| Ciconiiformes | Ardeidae | Black Crowned Night Heron | - | - | - | - | 4 5.30 | 1 1.32 | - | - | - | - | - |
| | | Cattle Egret | 3 3.97 | 12 15.90 | 18 23.86 | 9 11.93 | 3 3.97 | - | - | 1 1.32 | 1 1.32 | 19 25.18 | - |
| | | Great Egret | - | - | 3 3.97 | - | - | - | - | - | - | - | - |
| | | Grey Heron | 1 1.32 | - | 2 2.65 | 1 1.32 | - | 1 1.32 | - | 1 1.32 | - | 1 1.32 | - |
| | | Little Egret | - | - | 4 5.30 | - | 1 1.32 | - | - | 1 1.32 | - | - | - |
| | | Median Egret | - | - | 2 2.65 | - | 3 3.97 | - | - | - | - | 18 23.86 | - |
| | | Indian Pond heron | - | - | 1 1.32 | 2 2.65 | 1 1.32 | - | - | 1 1.32 | - | - | - |
| | | Asian Openbill Stork | - | - | 1 1.32 | - | 1 1.32 | 7 9.28 | 6 7.95 | - | 2 2.65 | 2 2.65 | - |
| | | Lesser Adjutant Stork | - | - | - | - | - | 1 1.32 | - | - | - | 1 1.32 | - |
| | | Painted Stork | 3 3.97 | - | 1 1.32 | - | 1 1.32 | - | - | - | - | - | - |
| Ciconiiformes | Ciconiidae | Woolly necked Stork | 5 6.62 | - | - | - | 1 1.32 | - | - | - | 1 1.32 | 7 9.28 | 2 2.65 |

| Order | Family | Common name | F | M | A | M | J | J | A | S | O | N | D |
|---------------|-------------------|---------------------------|------------------|------------------|------------------|------------------|------------------|--------------------|------------------|------------------|------------------|--------------------|---|
| Ciconiiformes | Jacaniidae | Bronze winged Jacana | 1 1.32 | - | 5 6.62 | 2 2.65 | 2 2.65 | 2 2.65 | - | 2 2.65 | 1 1.32 | 9 11.93 | - |
| | Laridae | River Tern | - | - | 2 2.65 | 1 1.32 | 1 1.32 | 1 1.32 | - | 1 1.32 | 1 1.32 | - | - |
| | Phalacrocoracidae | Little Cormorant | - | - | 1 1.32 | - | 1 1.32 | 1 1.32 | 1 1.32 | 6 7.95 | 1 1.32 | 4 5.30 | - |
| | Podicipedidae | Little Grebe | - | - | - | - | - | - | 1 1.32 | - | 2 2.65 | - | - |
| | Threskiornithidae | Oriental white Ibis | - | - | 2 2.65 | - | - | - | - | - | 3 3.97 | 38 50.37 | - |
| | | Eurasian Spoon bill | - | 4 5.30 | 6 7.95 | 1 1.32 | 1 1.32 | 6 7.95 | - | 1 1.32 | - | - | - |
| | | Common Kingfisher | 1 1.32 | - | - | - | 2 2.65 | - | - | - | - | - | - |
| Coraciiformes | Alcedinidae | White throated Kingfisher | - | - | 1 1.32 | - | - | - | - | - | - | - | - |
| | Cerylidae | Pied Kingfisher | 1 1.32 | 1 1.32 | - | - | 2 2.65 | 1 1.32 | - | - | 2 2.65 | - | - |
| | | Eurasian Coot | - | - | - | - | - | 13 17.23 | 1 1.32 | 5 6.62 | 4 5.30 | 3 3.97 | - |
| Gruiformes | Rallidae | Purple Swamp hen | - | - | - | - | - | 3 3.97 | 2 2.65 | 1 1.32 | 1 1.32 | 7 9.28 | - |
| | 12 | 26 | 15 | 17 | 49 | 20 | 30 | 33 | 14 | 28 | 22 | 127 | 2 |

Note: The numerical values given in **BOLD** are the abundance and those mentioned in decimal are the density values (birds/ha).
- Birds not found

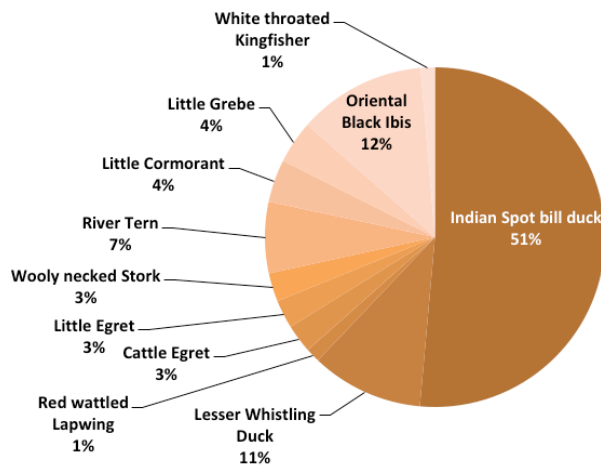


Figure 5. Relative abundance of all bird species observed at Hebbal MIT during 11 month study.

with three species. Coraciiformes was represented with three species from two families, Alcedinidae family with two species and one species from Cerylidae family, Gruiformes and Charadriiformes represented by Rallidae with two species and Charadriidae with one species.

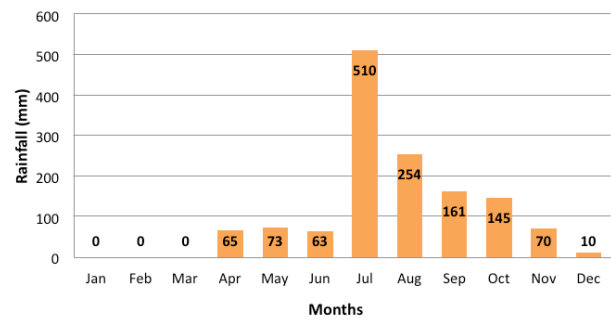
Avifauna of Nandgad pond is similar to that of Bidi MIT except for the presence of the Woolly-necked Stork *Ciconia episcopus* categorized as 'Vulnerable' (Table 4). Most of the species recorded maximum density during the post monsoon season (November) (see Table 1).

The relative abundance of the birds at Nandgad pond shows that, Cattle Egret was highest with 18% followed by Oriental White Ibis 12%, Eurasian Coot recorded 7%, Bronze winged Jacana 6%, Indian Spot bill Duck, Asian Open bill Stork and Eurasian Spoon bill 5% each, Lesser Whistling Duck, Purple Swamp hen, Little Cormorant and Woolly necked Stork 4% each, Red wattled Lapwing, Little Egret, River tern, Pied Kingfisher recorded 2% each whereas, Cotton Teal, Black crowned Night Heron, Great Egret, Indian Pond Heron, Lesser Adjutant Stork, Painted Stork, Little Grebe, Common Kingfisher recorded 1% each (Figure 4).

The maximum mean density at Nandgad Pond was recorded by Oriental White Ibis (*Threskiornis melanocephalus*, 18.996 ± 15.048), followed by others (Table 5).

Diversity (H) and Equitability or Evenness (E_H)

Shannon-Weiner diversity index (H) and Equitability (E_H) of avifauna of Nandgad pond are given in Table 6. Maximum diversity ($H'=2.58955$) was recorded in June followed by October ($H'=2.43694$) and September ($H'=2.31407$) 2014. Minimum was recorded during



Source: Annual Rainfall Report of 2014, Directorate of Economics & Statistics, Bangalore, Govt. of Karnataka, May, 2015.

Figure 6. Monthly variation in rainfall recorded from three selected waterbodies of Khanapur taluk from February to December, 2014.

March ($H'=0.75294$) 2014. Highest evenness was recorded in October ($E_H=0.95009$) followed by June ($E_H=0.93398$) and September ($E_H=0.90219$) 2014 and minimum ($E_H=0.68535$) during March 2014. Species richness was observed to be a maximum of 16 species in June 2014 followed by April and November with 14 species each. Least species richness (1 species) was recorded in December 2014.

Site 3: Hebbal Minor Irrigation Tank (MIT)

A total of 11 species belonging to nine families was recorded from Hebbal MIT (Table 3). Maximum species (6) were recorded during April and June while minimum of one species during February, July and December 2014. Of which, Ciconiiformes were represented with a maximum of seven species distributed into six families i.e.: Ardeidae (2) and Ciconiidae, Laridae, Phalacrocoracidae, Podicipedidae, and Threskiornithidae were represented with one species each. Minimum numbers of species were represented from Charadriiformes and Coraciiformes (Table 4).

The abundance and density (birds/ha) at Hebbal MIT was comparatively less than other two water bodies (Table 3). Out of 11 species recorded, Indian Spot-billed Duck *Anas poecilorhyncha* of Anatidae was observed with the highest density (30 individuals and 39.77 birds/ha) in April and a minimum (8 and 10.60 birds/ha) in May 2014 (Table 3).

The relative abundance of all birds of Hebbal MIT reveals that, Indian Spot-billed Duck was maximum (51%) followed by Oriental White Ibis (12%) and Lesser Whistling Duck (11%). Little Grebe and Little Cormorant recorded 4% each and Woolly necked Stork, Little Egret and Cattle Egret (3% each) recorded minimum abundance. White throated kingfisher and Red wattled Lapwing recorded least relative abundance (Figure 5).

Table 3. Species composition, monthly abundance, and density (birds/ha) of birds recorded at Hebhal minor irrigation tank from February to December 2014. (N=74).

| Order | Family | Common Name | F | M | A | M | J | J | A | S | O | N | D |
|-----------------|-------------------|---------------------------|------------------|---|--------------------|-------------------|------------------|------------------|---|---|---|---|------------------|
| Anseriformes | Anatidae | Indian Spot-billed Duck | - | - | 30 39.77 | 8 10.60 | - | - | - | - | - | - | - |
| | | Lesser Whistling Duck | - | - | - | 8 10.60 | - | - | - | - | - | - | - |
| Charadriiformes | Charadriidae | Red wattled Lapwing | - | - | - | - | 1 1.32 | - | - | - | - | - | - |
| Ciconiiformes | Ardeidae | Cattle Egret | - | - | - | 1 1.32 | 1 1.32 | - | - | - | - | - | - |
| | | Little Egret | - | - | 2 2.65 | - | - | - | - | - | - | - | - |
| | Ciconiidae | Woolly necked Stork | - | - | 2 2.65 | - | - | - | - | - | - | - | - |
| Ciconiiformes | Laridae | River Tern | - | - | - | - | 1 1.32 | 2 2.65 | - | - | - | - | 2 2.65 |
| | Phalacrocoracidae | Little Cormorant | - | - | 1 1.32 | 1 1.32 | 1 1.32 | - | - | - | - | - | - |
| | Podicipedidae | Little Grebe | - | - | 2 2.65 | 1 1.32 | - | - | - | - | - | - | - |
| | Threskiornithidae | Oriental white Ibis | 1 1.32 | - | 7 9.28 | - | 1 1.32 | - | - | - | - | - | - |
| Gruiformes | Alcedinidae | White throated Kingfisher | - | - | - | - | 1 1.32 | - | - | - | - | - | - |
| 4 | 9 | 11 | 1 | 0 | 44 | 19 | 6 | 2 | 0 | 0 | 0 | 0 | 2 |

Note: The numerical values given in BOLD are the abundance and those mentioned in decimal are the density values (birds/ha). - Birds not found.

Table 4. Status and Occurrence of wetland birds of three water bodies of Khanapur Taluk.

| Common name & Scientific name | Residential status* | IUCN Status* | WPA, 1972 Schedule ** | Bidi MIT | Nandgad Pond | Hebbal MIT |
|---|---------------------|--------------|-----------------------|----------|--------------|------------|
| Comb Duck <i>Sarkidiornis melanotos</i> | R/LM | LC | IV | ✓ | - | - |
| Cotton Teal <i>Nettapus coromandelianus</i> | R/LM | LC | IV | - | ✓ | - |
| Indian Spot-billed Duck <i>Anas poecilorhyncha</i> | R/LM | LC | IV | ✓ | ✓ | ✓ |
| Lesser Whistling Duck <i>Dendrocygna javanica</i> | R/LM | LC | IV | - | ✓ | ✓ |
| Red wattled Lapwing <i>Vanellus indicus</i> | R/LM | LC | IV | ✓ | ✓ | - |
| Little Ringed Plover <i>Charadrius dubius</i> | R/WM | LC | IV | ✓ | - | - |
| Black-crowned Night Heron <i>Nycticorax nycticorax</i> | R/LM | LC | IV | ✓ | ✓ | - |
| Cattle Egret <i>Bubulcus ibis</i> | R/AM | LC | IV | ✓ | ✓ | - |
| Great Egret <i>Casmerodius albus</i> | R/LM | LC | IV | ✓ | ✓ | - |
| Grey Heron <i>Ardea cinerea</i> | R/WM | LC | IV | - | ✓ | - |
| Little Egret <i>Egretta garzetta</i> | R/LM | LC | IV | ✓ | ✓ | ✓ |
| Median Egret <i>Mesophox intermedia</i> | R/LM | NR | IV | ✓ | ✓ | - |
| Indian Pond Heron <i>Ardeola grayii</i> | R/LM | LC | IV | - | ✓ | - |
| Asian Openbill Stork <i>Anastomus oscitans</i> | M/LR/Ic | LC | IV | ✓ | ✓ | - |
| Lesser Adjutant Stork <i>Leptoptilos javanicus</i> | R/LM | VU | IV | ✓ | ✓ | - |
| Painted stork <i>Mycteria leucocephala</i> | R/LM | NT | IV | ✓ | ✓ | - |
| Wooly-necked Stork <i>Ciconia episcopus</i> | R/LM | VU | IV | - | ✓ | ✓ |
| Bronze winged Jacana <i>Metopidius indicus</i> | R | LC | IV | - | ✓ | - |
| River Tern <i>Sterna aurantia</i> | R/LM | NT | IV | ✓ | ✓ | ✓ |
| Little Cormorant <i>Phalacrocorax niger</i> | R/LM | LC | IV | ✓ | ✓ | ✓ |
| Little Grebe <i>Tachybaptus ruficollis</i> | R/LM | LC | IV | - | ✓ | ✓ |
| Oriental White Ibis <i>Threskiornis melanocephalus</i> | R/LM | NT | IV | ✓ | ✓ | ✓ |
| Eurasian Spoon bill <i>Platalea leucorodia</i> | R/LM | LC | I | ✓ | ✓ | - |
| Common Kingfisher <i>Alcedo atthis taprobana</i> | R/WM/SM | LC | IV | - | ✓ | - |
| White-throated Kingfisher <i>Halcyon smyrnensis</i> | R/LM | LC | IV | - | ✓ | ✓ |
| Pied Kingfisher <i>Ceryle rudis travancorensis</i> | R/LM | LC | IV | ✓ | ✓ | - |
| Eurasian Coot <i>Fulica atra</i> | R/WM | LC | IV | - | ✓ | - |
| Purple Swampphen <i>Porphyrio porphyrio</i> | R/LM | LC | IV | - | ✓ | - |

Note: LC—Least Concern | VU—Vulnerable | NT—Near Threatened | NR—Not Recognized | Ra—Rare | ✓ Present; - Absent, R—Resident | M—Migrant | LM—Local Migrant | WM—Winter Migrant | Com—Common | LCom—Locally Common | VCom—Very Common | MIT—Minor Irrigation Tank | *—Handbook of Indian Wetland Birds and their Conservation, ZSI (2005) | ** Wildlife Protection Act, (1972) – Schedule Species Birds Database.

Table 5. Mean density of birds recorded at three water bodies of Khanapur Taluk from February to December 2014.

| Common names | Scientific Names | BIDI MIT | | NANDGAD POND | | HEBBAL MIT | |
|---------------------------|-------------------------------------|----------|--------|--------------|--------|------------|--------|
| | | MEAN | SD | MEAN | SD | MEAN | SD |
| Comb Duck | <i>Sarkidiornis melanotos</i> | 9.935 | 4.823 | - | - | - | - |
| Cotton Teal | <i>Nettapus coromandelianus</i> | - | - | 2.65 | 0.799 | - | - |
| Indian Spot-bill Duck | <i>Anas poecilorhyncha</i> | 23.86 | 28.949 | 6.29 | 4.925 | 25.185 | 12.096 |
| Lesser Whistling Duck | <i>Dendrocygna javanica</i> | - | - | 4.305 | 2.280 | 10.6 | 3.196 |
| Red wattled Lapwing | <i>Vanellus indicus</i> | 1.32 | 0.637 | 3.533 | 1.786 | 1.32 | 0.397 |
| Little Ringed Plover | <i>Charadrius dubius</i> | 1.32 | 0.556 | - | - | - | - |
| Black Crowned Night Heron | <i>Nycticorax nycticorax</i> | 1.32 | 0.533 | 3.31 | 1.607 | - | - |
| Cattle Egret | <i>Bubulcus ibis</i> | 9.542 | 10.998 | 10.93 | 9.686 | 1.32 | 0.533 |
| Great Egret | <i>Casmerodius albus</i> | 2.65 | 0.799 | 3.97 | 1.197 | - | - |
| Grey Heron | <i>Ardea cinerea</i> | - | - | 1.541 | 0.891 | - | - |
| Little Egret | <i>Egretta garzetta</i> | 1.852 | 1.071 | 2.646 | 1.675 | 2.65 | 0.799 |
| Median Egret | <i>Mesophoyx intermedia</i> | 2.645 | 1.223 | 10.16 | 7.124 | - | - |
| Indian Pond heron | <i>Ardeola grayii</i> | - | - | 1.652 | 0.935 | - | - |
| Asian Openbill Stork | <i>Anastomus oscitans</i> | 1.32 | 0.397 | 4.195 | 3.305 | - | - |
| Lesser Adjutant Stork | <i>Leptoptilos javanicus</i> | 33.14 | 19.550 | 1.32 | 0.556 | - | - |
| Painted Stork | <i>Mycteria leucocephala</i> | 1.32 | 0.397 | 2.203 | 1.235 | - | - |
| Woolly-necked Stork | <i>Ciconia episcopus</i> | - | - | 4.238 | 3.156 | 2.65 | 0.799 |
| Bronze winged Jacana | <i>Metopidius indicus</i> | - | - | 4.162 | 3.653 | - | - |
| River Tern | <i>Sterna aurantia</i> | 8.833 | 6.726 | 1.586 | 0.909 | 2.206 | 1.086 |
| Little Cormorant | <i>Phalacrocorax niger</i> | 1.32 | 0.533 | 3.088 | 2.741 | 1.32 | 0.616 |
| Little Grebe | <i>Tachybaptus ruficollis</i> | - | - | 1.985 | 0.856 | 1.985 | 0.856 |
| Oriental White Ibis | <i>Threskiornis melanocephalus</i> | 18.56 | 8.578 | 18.996 | 15.048 | 3.973 | 2.769 |
| Eurasian Spoon bill | <i>Platalea leucorodia</i> | 6.62 | 1.996 | 4.191 | 3.194 | - | - |
| Common Kingfisher | <i>Alcedo atthis taprobana</i> | - | - | 1.985 | 0.856 | - | - |
| White throated Kingfisher | <i>Halcyon smyrnensis</i> | - | - | 1.32 | 0.397 | 1.32 | 0.397 |
| Pied Kingfisher | <i>Ceryle rudis travancoreensis</i> | 1.32 | 0.397 | 1.852 | 1.071 | - | - |
| Eurasian Coot | <i>Fulica atra</i> | - | - | 6.888 | 5.276 | - | - |
| Purple Swamp Hen | <i>Porphyrio porphyrio</i> | - | - | 3.708 | 2.848 | - | - |

– indicates birds not found.

Table 6. Analysis of diversity (H), equitability (E_H), and species richness (SR) from three water bodies of Khanapur Taluk from February to December 2014.

| Sites | Diversity, Equitability & Sp. richness | F | M | A | M | J | J | A | S | O | N | D |
|------------------------------|--|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---|
| Bidi Minor Irrigation Tank | H | - | 1.25178 | 1.38641 | 0.8947 | 2.2315 | 1.56064 | 0 | - | 0.24491 | 0.35565 | 0 |
| | E_H | - | 0.64328 | 0.71247 | 0.55591 | 0.93060 | 0.96968 | 0 | - | 0.35333 | 0.32372 | 0 |
| | SR | - | 7 | 7 | 5 | 11 | 5 | 1 | - | 2 | 3 | 1 |
| Nandgad pond | H | 1.73204 | 0.75294 | 2.15257 | 1.59104 | 2.58955 | 1.64755 | 1.53663 | 2.31407 | 2.43694 | 2.16523 | 0 |
| | E_H | 0.89009 | 0.68535 | 0.81566 | 0.81763 | 0.93398 | 0.79230 | 0.85761 | 0.90219 | 0.95009 | 0.82045 | 0 |
| | SR | 7 | 3 | 14 | 7 | 16 | 8 | 6 | 13 | 13 | 14 | 1 |
| Hebbal Minor Irrigation Tank | H | 0 | - | 1.06103 | 1.19328 | 1.79166 | 0 | - | - | - | - | 0 |
| | E_H | 0 | - | 0.59217 | 0.74143 | 0.99994 | 0 | - | - | - | - | 0 |
| | SR | 1 | - | 6 | 5 | 6 | 1 | - | - | - | - | 1 |

- indicates birds not found.

Maximum mean density was observed in Indian Spotbill Duck (25.185 ± 12.096) and followed by others (Table 5).

Diversity (H) and Equitability or Evenness (E)

Shannon-Weiner diversity index and Equitability of avifauna of Hebbal MIT is given in Table 6. Highest diversity ($H'=1.79166$) and equitability ($E_H=0.99994$) was observed in June, while minimum diversity ($H'=1.06103$) and evenness ($E_H=0.59217$) was recorded in April 2014. Diversity and evenness was zero during February and December 2014, as only one species was recorded.

Based on the monthly rainfall data, the rains had begun in the month of April 2014 (63mm) and slightly fluctuated till June. Maximum rainfall (510mm) was recorded in July 2014 while the minimum (10mm) was in December 2014 (Figure 6).

DISCUSSION

Habitat heterogeneity, climatic conditions, rainfall and vegetation cover are the factors that govern the composition, density, abundance and diversity of the avifauna (Gonzalez et al. 2009 & Lorenzon et al. 2016). Habitat selection plays a prominent role in bringing variations in the distribution of avifauna. The food resources, roosting and nesting grounds for local and migratory species might influence their diversity and distribution (Paracuellos 2006). In the present study the two minor irrigation tanks are quite identical with respect to the water spread area and depth but vary in vegetation cover. The eastern side of the bund at Hebbal minor irrigation tank has *Acacia auriculiformes* trees in majority while at the western side there is a hillock surrounded with shrubs and small tree species. The water body did not support any kind of vegetation nor topographic variation that could attract birds other than waterfowls and a few storks. Indian Spot-billed Ducks recorded maximum density (30 individuals) and relative abundance (51%) during mid-summer and Lesser Whistling Ducks (11%). Little cormorants, Little Grebe, Woolly-necked Stork, River Tern, and Oriental White Ibis made an occasional presence. The species composition and diversity at Hebbal MIT is considered to be fewer when compared with the two other water bodies. Hence the diversity and evenness was low during mid-summer while it gradually increased during May and reached its maximum diversity, evenness and species richness during the monsoon (June 2014). No birds were recorded for the rest of the period. The minor

irrigation tank just acted as feeding grounds as it lacked proper vegetation cover and roosting sites as well.

Bidi MIT is shallower than Hebbal MIT. It has a few elevated patches in the middle of the tank. During the dry season the water level recedes to expose land to form temporary islands. During mid-summer (April) Indian Spotbill Ducks and Lesser Adjutant Storks were recorded maximum with respect to their density and relative abundance of 41% and 16% respectively when compared with the two other water bodies. The diversity and evenness appeared quite fluctuating along with the variation in the rainfall. During the onset of summer (March) the diversity and evenness was quite low. A slight increase in diversity and evenness was observed with the beginning of the rains (65mm) in April but decreased again in May 2014 though there was an increase in rainfall. In June, however, with a slight decline in rainfall (63mm) the diversity and species richness rose to its highest value. In the month of July, the rainfall was 510mm which was maximum during which there was decline of avifaunal diversity and species richness.

Shallow water bodies with variations in depth might be the factor for aggregation of birds compared to deeper tank and support more species and greater densities (Helmers 1992; Colwell & Taft 2000). Nandgad pond is smaller as well as shallower than other two water bodies and with varied depths. It is not only surrounded by orchards and paddy fields but also harbors rooted and emergent plants. It provides suitable site for the wetland birds with respect to their roosting, feeding and nesting needs. Vegetation like *Nymphaea* sp., *Nymphoides indica* was more prevalent in most part of the pond that attracted waders like, Bronze-winged Jacanas, egrets, herons, storks and ibises. Submerged vegetation includes: *Charasp.*, *Vallisneria* sp., *Ceratophyllum* spp that are preferred by Eurasian Coot, Purple Swamp Hen. It also attracted swimming and diving birds like Cotton Teal, Indian Spot-billed Duck, Little Cormorants as well. High vegetation cover forms a suitable habitat for breeding birds and also for overall species richness (Porej 2004). Cattle Egret (*Bubulcus ibis*) reported with highest relative abundance of 18% and was more frequently sighted. This is due to its ability of exploring various kinds of feeding grounds and adaptability to different habitats as suggested by Seedikkoya et al. (2007) & Patankar et al. (2007). Based on the diversity values, maximum diversity was observed during monsoon (June) in all three water bodies. Nandgad Pond witnessed the highest diversity and species richness. The increase in avian diversity at Nandgad pond is attributed to the heterogeneity in the flora that provides vegetation

cover for feeding and nesting purposes. This factor has attracted high assemblages of wetland birds than in the two other minor irrigation tanks. Similar observations were also made by Kottawa-Arachchi & Gamage (2015). The conditions at Nandgad pond appeared similar to Bidi minor irrigation tank with respect to reduction of species richness and diversity status during monsoon season. The species richness reduced to half and a drastic decline was seen in the diversity and evenness value in July and continued till August, 2014. Increase in rains had flooded the floating vegetation and reduced the riparian area of the pond which acted as roosting as well as feeding sites of most of the birds. Similar observations have been made by Canepuccia et al. (2007). The scenario gradually changed during the end of the monsoon (September) with increase in diversity, evenness and species richness. The post monsoon season (October) recorded a slight increase in diversity and species richness while the birds were more evenly distributed than in any other month. With the decline of the rainfall the pond witnessed growth of *Eleocharis* sp. and *Cyperus* sp. at the riparian zone and submerged vegetation which resulted in the assemblage of birds like Indian Spot-billed Duck, Eurasian coots, Oriental White Ibis, Red-wattled Lapwing, Asian Openbill Stork, Woolly necked Stork, Purple Swampphen, and Bronze-winged Jacana which depend on floating and emergent vegetation.

According to Paracuellos (2006) & Gonzalez et al. (2009), in larger water bodies, with more habitat types, all species have access to their preferred feeding zones in long shores or wide inner areas of deep open water. In smaller water bodies, however, due to the proximity of the shore to the centre of the pond, the birds that usually feed close to the shore probably continue having available resources in shallow waters with abundant emergent vegetation, whereas those which also frequently select inner zones lose proportionally more feeding space and therefore, have less resource availability. In the present study, Nandgad pond with diverse emergent, submerged and floating vegetation attracted more aggregation, diversity as well as species richness of birds. Similar reports are made by Fairbairn & Dinsmore (2001); Lorenzon et al. (2016).

CONCLUSION

The study on avifaunal diversity of three water bodies of Khanapur Taluk suggests that water bodies support a good number of residential, local migratory

and migratory birds. The two minor irrigation tanks witness less disturbances as they are away from the state highway whereas, Nandgad pond lies next to it and is prone to frequent anthropocentric activities like; release of clay idols and other related wastes during festivals, discharge of non-biodegradable wastes, washing clothes and heavy vehicles, pumping of waters during the dry seasons. It also suffers from siltation, which results in low water holding capacity. Unscientific excavations at the riparian area can become a stress factor on the pond ecosystem as well as the avifauna. Proper attention is needed from the public as well as the local governing bodies towards the protection and conservation of these habitats so that they can be promising sites for resident as well as migratory birds and other aquatic fauna. In addition there is a need for assessment of water quality and trophic status, and characteristic plankton population which influence the abundance and diversity of the wetland birds.

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