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



Temporal changes in species richness of waterfowl (Anseriformes) community in D'Ering Memorial Wildlife Sanctuary, Arunachal Pradesh, India

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Abstract: We conducted five yearly field surveys to assess long-term changes in the species richness, abundance, and composition of waterfowl populations (Anseriformes) in the D'Ering Memorial Wildlife Sanctuary, a significant staging area on migratory flyways with one of the largest concentrations of waterfowl in Arunachal Pradesh, especially during winter. A total of 8,040 birds belonging to 17 species of Anatidae were recorded, including two threatened species. The most abundant species were *Tadorna ferruginea*, *Anas poecilirhyncha*, and *Bucephala clangula*, with relative abundances of 29%, 10%, and 9.4%, respectively. Species richness was highest in winter ($H' = 2.40$; January $H' = 2.43$) and lowest in the monsoon ($H' = 1.48$; August, $H' = 1.12$). Seasonal difference in species richness was noticed for winter visitors, but not for year-round residents. We observed a major declining trend for seven species. Findings from this study can be used for further ecological assessment of the waterfowl community of the sanctuary.

Keywords: Anatidae, Critically Endangered, diversity indices, Near Threatened, Ramsar Site, Vulnerable.

Adi abstract: Ngolu diitak-diitak pe takngo aping lok Asi pejab (Anseriformes) kanam, alumnam delokke jabdum-jabrum e kae-kakur namem kenkipe emla, Bomong kiibung Giite kone solok gai yalumna jablimoduk giiko delokke digin toodi em Asi pejab boje yalum pe yedum suko D'Ering Memorial Wildlife Sanctuary (DEMWS) lo sabgong la poribomto. Tani among sokke Nyokdak kena Jablum annyi ko sabtak sula, 17 Jablum Anatidae emnam erang lokke ke bodum e 8040 pejab kope sabto. Takam lokke bojeyalum ne Jabling *Tadorna ferruginea* (29%), lbung-atak-gena Pejab *Anas poecilirhyncha* (10%) delokke Amik-yegena Pejab *Bucephala clangula* (9.4%) kope ido. Sabgong ko solo Jablum e digin toodi lo bojeyape kado ($H' = 2.40$; Bising polo $H' = 2.43$) delokke dojeng toodi lo anyong yape kado ($H' = 1.48$; Tanlo polo, $H' = 1.12$). Digin toodi em Jabli modukla ana pejab kidar si Jablum kanam e todi-todi lo angu-angu do idakla ditak rubung em dusina Jablum kidar solo todi-todi em Jablum angunan kapamado. Ngolu Jablum kinit ko bojerupe diitak-diitak lo anyong yayang idope sabgap toh. Sim sabgap la rilen tunam sim sanctuary solok Asi pejab turgang-yegang em aimonam lo ager gerna laye.

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Author details: TAPAK TAMIR is a PhD scholar with an interest in bird communities, ecology, and species distribution patterns, and DR. DANIEL MIZE is an Associate Professor with a specialisation in birdlife, wildlife status, and conservation issues with an interest in education and awareness needed to conserve wildlife.

Author contributions: TT did the field survey, data collection, and manuscript preparation, while DM supervised the field data collection and gave important inputs for the study. Both authors contributed towards writing the manuscript.

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INTRODUCTION

Habitat is a fundamental unifying entity and concept in wildlife ecology and conservation (Block & Brennan 1993), its use and selection vary seasonally, especially for migratory species (Kaminski & Elmberg 2014). Habitat configuration and composition of the landscape affect the occurrence of species and richness (Guadagnin & Maltchik 2007; Mora et al. 2011; Xu et al. 2014; Zhang et al. 2018), and the seasonal distributions of waterbirds are influenced by various conditions like habitat types, climatic conditions, resource stability, and immediate human impact. Availability of water bodies, wetland size, and wetland connectivity positively affect waterfowl species occurrence and richness (Guadagnin & Maltchik 2007; Zhang et al. 2018). There is about 75,819 km² of wetlands in India, which make up 5% of the world's wetland area (AWB & WWF-India 1993), covering 4.1 million hectares and corresponding to 18.4% of the country's land area (MoEF 2003). A total of 2,175 wetlands, covering a total area of 1.5 million hectares, are natural, and 65,254 are manmade, with a total area of 2.6 million hectares (Chatrath 1998). At present, 46 sites in India have been designated as wetlands of international importance, especially as waterfowl habitats (Ramsar Sites) covering an area of 1,083,322 hectares (Ramsar Sites Information Service, 2021).

D'Ering Memorial Wildlife Sanctuary (DEMWS) is the only wildlife sanctuary with subtropical forest, grassland, riverine, and inland water body habitats in Arunachal Pradesh, harbouring a variety of waterfowl species and other birds. Birdlife International has declared DEMWS an Important Bird Area (IBA). Covering an area of 190 km², the entire area is a riverine plain criss-crossed by the rivers Siang and Sibia, forming several riverine islands. The sanctuary's dominant grasses are *Arundo donax*, *Eriarthus ravannae*, *Imperata cylindrica*, *Phragmites karka*, *Saccharum spontaneum*, *S. arundinaceum*, & *Neyraudia rennaudiana* and dominant tree species are *Albizia procera*, *Amoora wallichii*, *Bombax ceiba*, *Dalbergia sisoo*, *Daubanga grandiflora*, *Dillenia indica*, *Lagerstroemia speciosa*, & *Terminalia myriocarpa*. The altitudinal gradient of the sanctuary ranges 135–140 m, which gradually decreases from north to south. Within a 10-km radius of the sanctuary are 22 villages with a population of 40,065 (2011 census). The whole sanctuary is surrounded by river water on all sides, making it suitable for various migratory waterfowl.

The term 'waterfowl' has been applied to the members of the family Anatidae, popularly known as

ducks, geese, swans, and smaller teals (Delacour 1974). The Ramsar Convention, on the other hand, defines waterfowl as birds 'ecologically dependent on wetlands', and in the second edition of Wetlands International and Waterfowl Population Estimates, waterfowl was defined more precisely as all species of the 33 families (WI 2002). Among these 33 families, eight families are found in DEMWS (Mize et al. 2014), viz., Phalacrocoracidae, Anhingidae, Ardeidae, Ciconiidae, Anatidae, Charadriidae, Scolopacidae, and Laridae.

Various works done by Osmaston (1922), Singh (1929), Ali (1932), Ghazi (1962), Kannan (1980), Mujumdar (1984), Davidar (1985), Newton et al. (1986), Jhingran (1988), Ghosal (1995), Wadatkar & Kasambe (2002), Kulkarni et al. (2005), and Harney (2014) have studied waterbird communities for seasonal variations in abundance and species composition from different freshwater bodies of India but such study is yet to be unveiled in DEMWS. Only a few studies like population status and distribution of Bengal Florican (Rahmani et al. 1991), the population status of Swamp Francolin (Singh 1995), 113 species of bird including 14 species of waterfowl (Barman 1996), the occurrence of White-winged Wood Duck *Asarcornis scutulata* (Choudhury 1996, 2002), records of 55 species of birds and Near Threatened Cinereous Vulture *Aegypius monachus* (Mize et al. 2016), and recent records of Swamp Grass Babbler *Laticilla cinerascens* (Hussain et al. 2019) had been done here.

As per our preliminary field investigations and interactions with hunters of the villagers residing near the sanctuary area, we have found that waterfowl belonging to the family Anatidae (ducks, geese, and swans, hereinafter 'waterfowl') are frequently hunted for meat and traded by them. Considering this vital information and the significance of DEMWS, an effort has been made to investigate the long-term temporal changes, species richness, and species abundance of the waterfowl (Anseriformes) community in DEMWS. This information will be useful for better understanding the underlying mechanisms of how seasonal variation affects different migratory species of waterfowl in the sanctuary, so that targeted conservation strategies can be developed. The study will also add to the existing information on the previous checklist of birds of DEMWS and stimulate interest in waterfowl watching, which will help the wildlife division and researchers.

STUDY AREA AND METHODS

Study Area

The study was carried out in the D'Ering Memorial Wildlife Sanctuary (DEMWS) in the East Siang District of the state of Arunachal Pradesh, northeastern India. The sanctuary area is divided into three managerial ranges, namely, the Anchalghat Range, the Sibiamukh Range, and the Borguli Range (Figure 1). It is located at latitudes ranging from 27.850–28.083 N and longitudes from 95.366–95.483 E. In terms of topography, 80% of the sanctuary is grassland, with the remaining being riverine forest patches with mixed bamboo and secondary forests. The region has climatic conditions that are sub-tropical with average temperature variations of 5 °C during winter to 45 °C during summer and comprises four seasons, taking mean climatic conditions into account, viz., pre-monsoon (March–May), monsoon (June–August), post-monsoon (September–November), and winter (December–February). The lowest rainfall occurs in January with an average of 41.80 mm, and the highest rainfall occurs in July with an average of 1,433.20 mm.

Field Surveys

Five-year field surveys were carried out from March

2015 to February 2020, dividing the year into four seasons. For the waterfowl survey, a modified point count method—vantage points counts—was used (Bhupathy et al. 1998). A total of 15 vantage points were designated, covering the whole of the Anchalghat Range and Sibiamukh Range of DEMWS, based on the best visibility of the site from where the fixed-area was scanned for waterfowl flocks (Figure 1). Due to logistical constraints, the Borguli Range of the Sanctuary was excluded for the study. Each vantage point was visited at least once every month on foot on days with suitable weather, avoiding rainy days because rain interferes with visibility (Ralph et al. 1993). Twenty minutes were spent at each vantage point recording waterfowl in the water or on the shoreline and its vicinity using binoculars (8 × 56 and Olympus 10 × 50); almost 65% of our observations were photo-documented with a DSLR camera (NIKON, D5200 with 70–300 mm lens). Waterfowl species were identified following Grimmett et al. (2011) and Ali & Ripley (1995); and we followed the classification used in the checklist of the birds in the Oriental Region, Oriental Bird Club (Inskipp et al. 2001) for species' systematic position (order, family), common name, and scientific name. A Garmin GPS device with a mobile app was used to record the locations for conducting the waterfowl survey at that particular sampling vantage

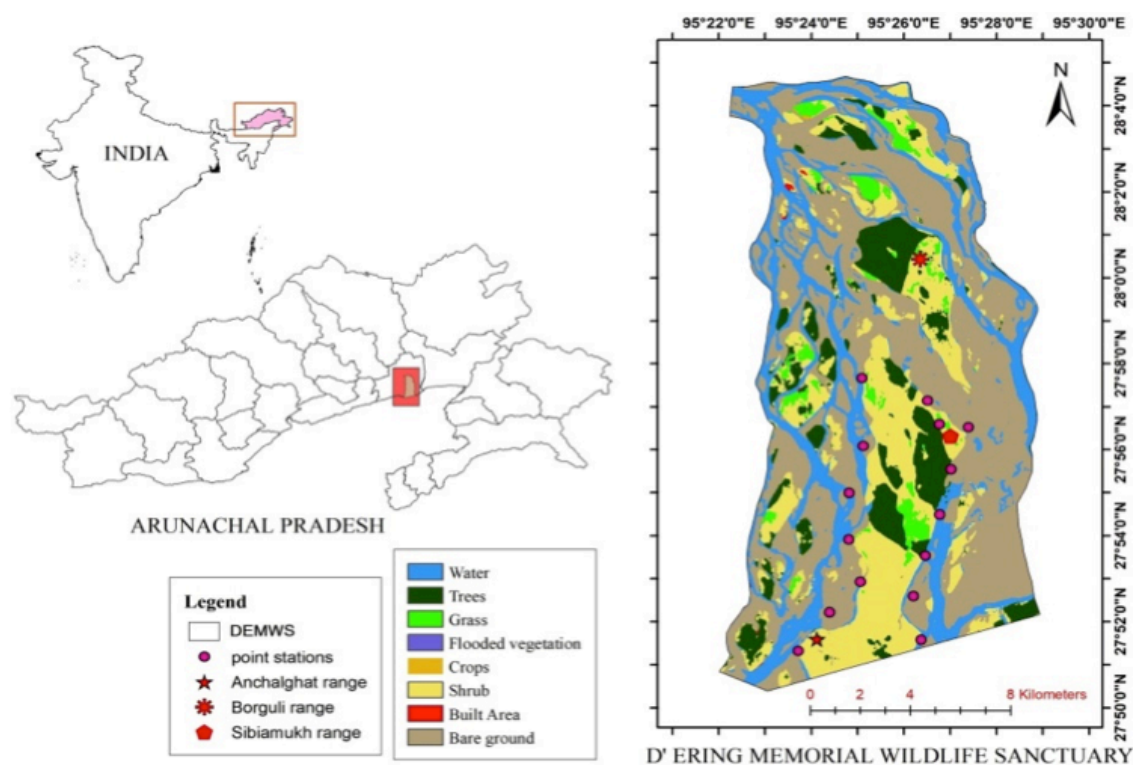


Figure 1. Map of study area (Developed by using Arc GIS Version 10.4).

point. Waterfowl were found active the most after sunrise to midmorning and before sunset; therefore, the timing was adjusted depending on the day length of the seasons, viz., late sunrise in winter and post-monsoon observation was done (0600–1100 h) and (1400–1630 h) and early sunrise in pre-monsoon and monsoon observation was done (0500–1000 h) and (1430–1730 h). The count period covered all the seasons, but the most extensive data was collected in the years 2018–2020, and less frequent counts occurred in 2015–2017, when counts were not able to cover all three months of the monsoon seasons due to heavy rainfall and heavy floods along the Siang River, as already mentioned in the study area.

Data Analysis

The relative abundance of a species is its percentage among all species utilising the same habitat (Simon & Okoth 2016; Walag & Canencia 2016; James et al. 2017). By assessing the relative abundance of species, one can identify the most common or rare species in a given area. The relative abundance (%) of waterfowl species was determined using the following formula:

$$\text{Relative Abundance} = \frac{ni}{N} \times 100$$

Where, ni = total number of waterfowl of each species and N = total numbers of waterfowl of all species detected in DEMWS following (Bibby et al. 2000; Hubbell 2001; McGill et al. 2007).

Strictly regarding study area, based on presence or absence of species throughout the study periods, we have distinguished four categories of relative seasonal occurrence and residential status of waterfowl as: (a) year-round residents—waterfowl recorded throughout the year; (b) winter visitors—waterfowl recorded in abundance during winter seasons; (c) monsoon migrants—species that occur only during the monsoon; and (d) passage migrants—waterfowl that stay for a short time in the sanctuary during the study period. The abundance status of the recorded waterfowl species was established, viz., common (C), fairly common (FC), uncommon (UC), and rare (RA), based on frequency of sighting following (Kumar & Gupta 2009). The conservation status and global trend were assessed according to IUCN (2021). The diversity indices were determined as follows: Simpson's diversity index (1-D) (Simpson 1949), Shannon-Wiener index for alpha diversity (Shannon & Wiener 1949), Margalef index for species richness (Margalef 1958), and Pielou's evenness index for species evenness (Pielou 1966):

Simpson's diversity index (1-D): was calculated using

the formula

$$D = \frac{1}{\sum(Pi^2)}$$

Where D = Simpson's index

P = total proportion of each species in sample

Shannon-Wiener index: Measures the average diversity of a sample and is given by equation:

$$H' = -\sum Pi \ln(Pi)$$

Where H' = Shannon-Wiener index

P = total proportion of each species in sample

Margalef's diversity index: M is calculated by using the formula

$$M = \frac{(S - 1)}{\ln N}$$

Where, M = Margalef's diversity index

S = number of species

N = number of individuals

Pielou's evenness index: Measures evenness with which individuals were distributed among the species.

$$J = \frac{H'}{\ln S}$$

Where S = number of observed species

H' = Shannon-Wiener index

All survey data were compiled using Microsoft Excel Version 2010. The yearly observations and diversity index data were pooled together within four seasons to test the seasonal pattern of the waterfowl assemblage in DEMWS. The data was further subjected to non-parametric Kruskal-Wallis tests with subsequent post-hoc Tukey's HSD (Honestly Significant Difference) tests, performed separately to determine the seasonal difference between species richness across all the seasons in DEMWS as well as between year-round residents, winter visitors, monsoon migrants, and passage migrants. Statistical tests were computed using PALEontological STatistics Version 4.03. All statistical tests were set at a significance level of $p < 0.05$.

RESULTS

During the five-year study in DEMWS, we have recorded 8,040 birds of waterfowl belonging to 17 species of the family Anatidae of the Order Anseriformes at a rate of 1,608 birds per year (Table 1, Image 1–12). The most abundant species are Ruddy Shelduck *Tadorna ferruginea*, followed by Indian Spot-billed Duck *Anas poecilorhyncha* and Common Goldeneye *Bucephala clangula*, with relative abundances of 28.96%, 10.24%, and 9.38%, respectively (Table 1). The relative seasonal and residential status of different waterfowl species

Table 1. Checklist and status of waterfowl found in DEMWS from March 2015–February 2020.

	Common name	Species (Scientific name & authors)	IUCN status	Relative abundance %	Residential status	Abundance status	Global trend
1	Baer's Pochard	<i>Aythya baeri</i> (Radde, 1863)	CR	2.28%	WV	RA	Dec
2	Common Goldeneye	<i>Bucephala clangula</i> (Linnaeus, 1758)	LC	9.38%	WV	FC	Stable
3	Goosander	<i>Mergus merganser orientalis</i> (Gould, 1845)	LC	2.95%	YRR	FC	Unknown
4	Common Pochard	<i>Aythya ferina</i> (Linnaeus, 1758)	VU	5.00%	WV	UC	Dec
5	Common Teal	<i>Anas crecca</i> (Linnaeus, 1758)	LC	4.40%	WV	UC	Unknown
6	Cotton Pygmy-goose	<i>Nettapus coromandelianus</i> (J.F. Gmelin, 1789)	LC	2.40%	WV	RA	Stable
7	Ferruginous Duck	<i>Aythya nyroca</i> (Güldenstädt, 1770)	NT	4.76%	WV	UC	Dec
8	Fulvous Whistling-duck	<i>Dendrocygna bicolor</i> (Vieillot, 1816)	LC	0.37%	PM	RA	Dec
9	Gadwall	<i>Mareca strepera</i> (Linnaeus, 1758)	LC	6.60%	WV	FC	Inc
10	Indian Spot-billed Duck	<i>Anas poecilorhyncha</i> (J.R. Forster, 1781)	LC	10.24%	YRR	C	Dec
11	Lesser Whistling-duck	<i>Dendrocygna javanica</i> (Horsfield, 1821)	LC	0.87%	MM	RA	Dec
12	Mallard	<i>Anas platyrhynchos</i> (Linnaeus, 1758)	LC	6.28%	YRR	C	Inc
13	Northern Pintail	<i>Anas acuta</i> (Linnaeus, 1758)	LC	4.29%	YRR	C	Dec
14	Red-breasted Merganser	<i>Mergus serrator</i> (Linnaeus, 1758)	LC	0.39%	WV	RA	Stable
15	Red-crested Pochard	<i>Netta rufina</i> (Pallas, 1773)	LC	6.69%	WV	FC	Unknown
16	Ruddy Shelduck	<i>Tadorna ferruginea</i> (Pallas, 1764)	LC	28.96%	YRR	C	Unknown
17	Tufted Duck	<i>Aythya fuligula</i> (Linnaeus, 1758)	LC	4.14%	WV	UC	Stable
Total 17 Species			Total	100.00%			

Legends: IUCN—International Union for Conservation of Nature | LC—Least Concerned | NT—Near Threatened | VU—Vulnerable | CR—Critically Endangered | YRR—Year Round Resident | WV—Winter Visitor | MM—Monsoon migrant | PM—Passage Migrants | C—Common | FC—fairly common | UC—Uncommon | RA—Rare | Inc—Increasing | Dec—Decreasing | Unk—Unknown.

revealed that 10 species (59%) were winter visitors, five species (29%) were year-round residents, one species (6%) was a monsoon migrant, and one species (6%) was a passage migrant (Figure 2). The waterfowl species richness was highest in January ($H' = 2.43$) and lowest in August ($H' = 1.12$) (Figure 3). Similarly, the overall seasonal species richness is highest in winter ($H' = 2.40$) and lowest in the monsoon ($H' = 1.48$) (Figure 4). The Shannon-Weiner species richness index was highest in winter ($H' = 2.398$) and lowest in the monsoon ($H' = 1.483$), but the Simpson dominance index and Margalef species richness index were highest in the pre-monsoon ($1-D = 0.8817$) and ($M = 2.024$), respectively, and lowest in the monsoon ($1-D = 0.7371$) and ($M = 0.8138$), respectively, whereas Pielou's evenness index was highest in the monsoon ($J = 0.7343$) and lowest in the post-monsoon ($J = 0.5744$), showing the high temporal variations of various diversity indices. The present study shows an increasing trend in the yearly total population of waterfowl (Figure 6), and a major declining trend of population of seven species (Figures 7 & 8). The non-parametric Kruskal-Wallis test results in no significant seasonal variation in species richness of year-round resident waterfowl (Kruskal-Wallis

test: $K = 7.769$, $df = 3$, $p = 0.051$), which remains almost similar throughout the study period. On the other hand, a significant seasonal difference was noticed in the case of winter visitors (Kruskal-Wallis test: $K = 16.65$, $df = 3$, $p < 0.05$). The Fulvous Whistling Duck *Dendrocygna bicolor* was the only passage migrant species that was observed only in May in a very small population. Similarly, the sanctuary's only single monsoon migrant, the Lesser Whistling Duck *Dendrocygna javanica* has been observed mostly during June, with the largest flock of 20 in 2015. The number of winter visitors significantly increased in October–November (post-monsoon season), reached its peak in January (winter) and then sharply declined in the pre-monsoon (Figure 5). The results of the Tukey's HSD post-hoc tests using the Lund-Lund (1983) procedure also revealed that the species richness of year-round residents varies insignificantly (Table 2), whereas the species richness of winter visitors varies significantly ($p < 0.05$) (Table 3). The Tukey's HSD Multiple Comparison test among all seasons also shows significant at $p < 0.05$; winter vs pre-monsoon ($p = 0.000591$), winter vs monsoon ($p = 0.000225$), and winter vs post-monsoon ($p = 0.000465$) (Table 4).

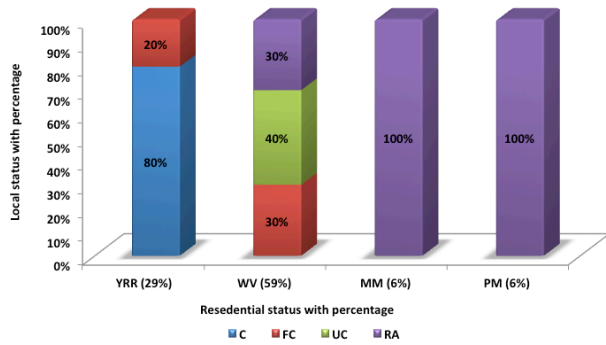


Figure 2. Comparison of percentage of residential and local abundance status of waterfowl in DEMWS from March 2015–February 2020.

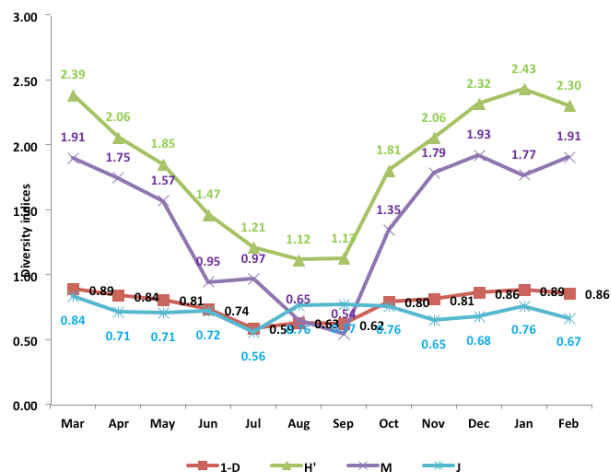


Figure 3. Monthly trend of diversity indices of waterfowl in DEMWS from March 2015–February 2020.

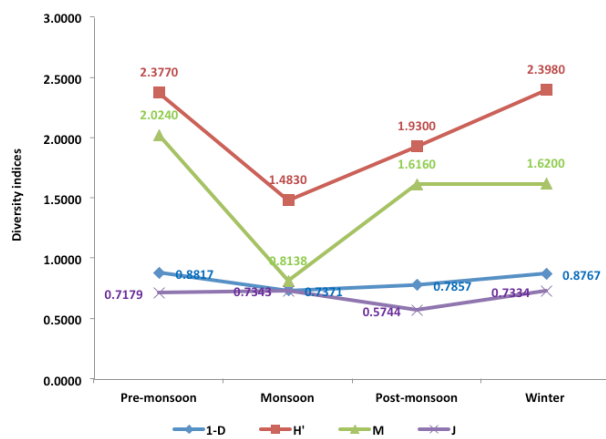


Figure 4. Diversity indices of waterfowl in different season in DEMWS from March 2015–February 2020.

Table 2. Tukey's HSD multiple comparison test among all season of YRR ($p < 0.05$).

	Pre-monsoon	Monsoon	Post-monsoon	Winter
Pre-monsoon		0.998	1.000	0.225
Monsoon	0.269		0.990	0.165
Post-monsoon	0.160	0.429		0.268
Winter	2.845	3.114	2.685	

Table 3. Tukey's HSD multiple comparison test among three season of WV ($p < 0.05$, significant in bold).

	Pre-monsoon	Post-monsoon	Winter
Pre-monsoon		0.9149	0.000131
Post-monsoon	0.5692		0.000128
Winter	8.492	9.061	

Table 4. Tukey's HSD multiple comparison test among all season ($p < 0.05$, significant in bold).

	Pre-monsoon	Monsoon	Post-monsoon	Winter
Pre-monsoon		0.9608	0.9997	0.000591
Monsoon	0.6948		0.9788	0.000225
Post-monsoon	0.1343	0.5604		0.000465
Winter	5.952	6.647	6.087	

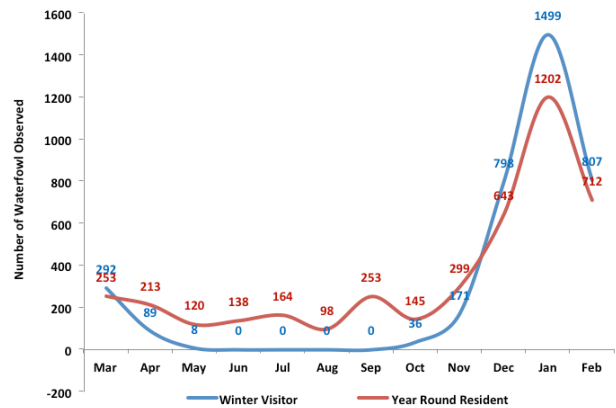


Figure 5. Monthly Population variation of YRR & WV in DEMWS from March 2015–February 2020.

DISCUSSION AND CONCLUSION

The results showed the presence of 17 species of waterfowl (Anseriformes) in DEMWS. This includes the first-time reports of three species from DEMWS: Baer's Pochard *Aythya baeri*, Fulvous Whistling Duck *Dendrocygna bicolor*, and Red-breasted Merganser *Mergus serrator*. These species were not reported from the sanctuary by early observations (e.g., Rahmani et al. 1991; Singh 1995; Barman 1996; Choudhury 1996, 2002; Mize et al. 2014; Hussain et al. 2019). The other 13 species were already recorded and cited earlier (Barman 1996; Borang 2013; Mize et al. 2014). The present study shows high temporal changes in the waterfowl community, as shown in the results. In contrast to the increasing trend of the total population of waterfowl in the study area (Figure 6), there is a major declining trend among the seven species of waterfowl (Figure 6). This includes one Critically Endangered species Baer's Pochard *Aythya baeri*, Common Merganser *Mergus merganser*, Common Pochard *Aythya ferina*, Fulvous Whistling Duck *Dendrocygna bicolor*, Lesser Whistling Duck *Dendrocygna javanica*, Red-breasted Merganser *Mergus serrator*, and Red-crested Pochard *Netta ruffina*. Year-wise records of declining waterfowl populations are provided in Figure 7.

Globally, 28% of all assessed species are threatened with extinction (IUCN 2021), confirming the importance of monitoring species' abundance. Baer's Pochard *Aythya baeri*, Common Pochard *Aythya ferina* and Ferruginous Pochard *Aythya nyroca* are the Critically Endangered, Vulnerable and Near Threatened waterfowl species, respectively, recorded in DEMWS (IUCN 2021). Baer's Pochard was classified as vulnerable in 1994 but, following an assessment that probably fewer than 1,000 individuals remained, it was listed as Endangered in 2008 (Wang et al. 2012). It was upgraded to Critically Endangered (BirdLife International 2021). The largest flock of 30 birds was observed in January 2016. The last observation was flocks of six birds diving almost 2 km away from the observer near the Sibiamukh range in February 2020. Baer's Pochard is extremely difficult to find anywhere in its range (Richard et al. 2013) hence, this observation needs attention from the scientific world as this globally threatened bird has a serious contraction in wintering distribution and is heading for extinction in the wild (Chowdhury et al. 2012; Wang et al. 2012; Richard et al. 2013). The Common Pochard *Aythya ferina* a globally threatened waterfowl breeds largely in freshwater to the south of the tundra region across the Palearctic, from Iceland to the steppe lakes of Mongolia and the Daurian

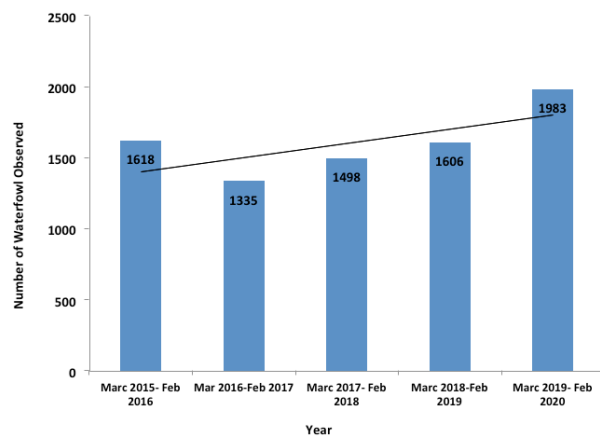


Figure 6. Yearly trend of total number of waterfowl observed in DEMWS from March 2015–February 2020.

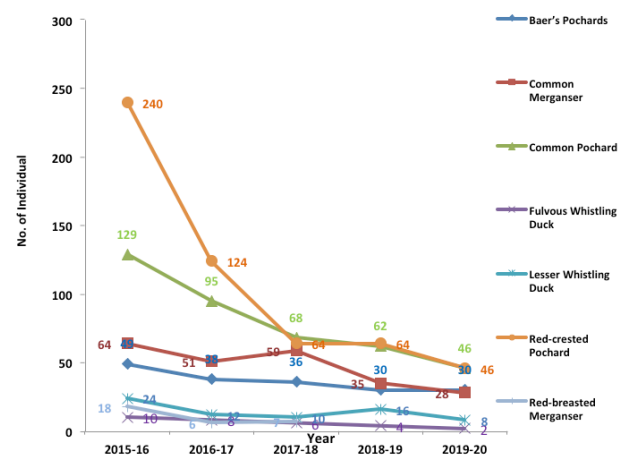


Figure 7. Year-wise decreasing trend of seven species of waterfowl in DEMWS.

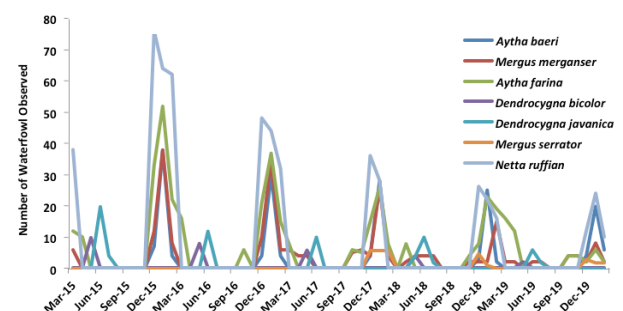


Figure 8. Monthly decreasing trend of seven species of waterfowl population in DEMWS from March 2015–February 2020.

region (Kear 2005). However, due to rapid population decline across the majority of the range, it has therefore been uplisted to Vulnerable (BirdLife International 2021). During the study periods, a total of 400 adult individuals



Image 1. Common Goldeneye *Bucephala clangula*.



Image 2. Common merganser *Mergus merganser orientalis*.



Image 3. Common Pochard *Aythya ferina*



Image 4. Common Teal *Anas crecca*.



Image 5. Ferruginous Duck *Aythya nyroca*.



Image 6. Gadwal *Anas strepera*.



Image 7. Indian Spot-billed Duck *Anas poecilirhyncha*.



Image 8. Lesser Whistling Duck *Dendrocygna javanica*.



Image 9. Mallard *Anas platyrhynchos*.



Image 10. Red-crested Pochard *Netta rufina*.



Image 11. Ruddy Shelduck *Tadorna ferruginea*.



Image 12. Tufted Duck *Aythya fuligula*.

were observed, i. e., 2015–16 (129 individuals), 2016–17 (95 individuals), 2017–18 (68 individuals), 2018–19 (62 individuals), and 2019–20 (46 individuals). The largest flock of 52 was seen in January 2016 and the last record was a pair of adults in February 2020. Ferruginous Pochard is a winter visitor to the Indian subcontinent and has been subjected to a variety of human-induced disturbances for

a long time (Islam 2003). During the second half of the 20th century, its population underwent a global, large, long-term decline due to habitat destruction and hunting (BirdLife International 2021). The species is not only listed as Near Threatened, but it is a priority species across four prominent international conservation treaties: the European Union Bird Directive, the Bern Convention, the

Bonn Convention, and the African Eurasian Migratory Waterbird Agreement (Robinson & Hughes 2003). During the study periods, a total of 383 adult individuals were observed, i.e., 2015–16 (61 individuals), 2016–17 (66 individuals), 2017–18 (77 individuals), 2018–19 (82 individuals), and 2019–20 (97 individuals). The largest flock of 38 was seen in January 2020.

Throughout the five years of waterfowl surveys in the sanctuary, we did not encounter the White-winged Duck *Asarcornis scutulata*, an endangered species recorded earlier from the sanctuary (Barman 1996; Choudhury 1996, 2002). There have been no sighting records of this waterfowl in the sanctuary for the last eight years, the last being November 2012 (Mize et al. 2014). However, this bird has been reported from various locales including Nameri National Park, Assam (Saikia & Saikia 2011; Das & Deori 2012); Pakke Tiger Reserve, Arunachal Pradesh (Selvan et al. 2013); in Hologapar Gibbon Sanctuary, Assam (Sharma et al. 2015); at Hkakabo Razi Landscape, Kachin State, Myanmar (Lin et al. 2018). Although we made an extra effort to locate this waterfowl in suitable areas by following (Saikia & Saikia 2011), it was in vain. Field staff reports and the extent of suitable habitat in the study area suggest that this species is perhaps not seen in DEMWS, as all the suitable habitat for this waterfowl has been destroyed by the frequent flooding of Siang Rivers and changing watercourses.

Long-term monitoring of population numbers, population structure, and demographic rates improves our understanding of the biological reasons for population trends (Nichols 1991; Thomas & Martin 1996). DEMWS seems an important staging place on migratory flyways and has one of the highest populations of waterfowl in Arunachal Pradesh, especially during the winter. Furthermore, some globally threatened waterfowl like Baer's Pochard *Aythya baeri*, Common Pochard *Aythya ferina*, and Ferruginous Pochard *Aythya nyroca* are also supported in this sanctuary. Due to logistic issues as well as monsoon floods on the Siang River, it was difficult to cover whole areas of DEMWS and all months of the year. Nonetheless, in this study, we have attempted to cover all the months of various seasons in the most suitable ranges of the sanctuary. Our findings on the temporal changes of waterfowl in this sanctuary can be used for further ecological assessment of the waterfowl community. Nevertheless, detailed studies should be undertaken, focusing especially on the habitat use, nesting, breeding, and foraging ecology of these waterfowl, to understand their critical role in performing various ecosystem services and the underlying causes of the variation in trends.

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