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Research Article

Avifaunal diversity of local and peripheral ecosystem of two high altitude wetlands in West Sikkim, India

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ABSTRACT

In the current investigation, the diversity, abundance, and conservation status of avian species was documented from May 2023 to August 2023 at Kathok and Khecheopalri Lake, West Sikkim, India. Data was collected using direct observation and point count method. A total of 155 birds from 22 different families and 56 species were reported at the study sites during the periodic visits. The maximum number of the species observed both at Kathok Lake (n=5) and Khecheopalri Lake (n=6) belongs to the family Leiotrichidae. Summer migrants include Verditer flycatcher and Barn swallow at Khecheopalri Lake. The Verditer flycatcher, however, was also observed as a summer visitor at Kathok Lake. For the conservation status, all the recorded species were categorized as "Least Concern" in the IUCN Red List and for the Wildlife Conservation Act, 1972, the recorded species were classified under Schedule IV. The Shannon-Weiner diversity index value was found to be 2.52 and 3.27 for Kathok Lake and Khecheopalri Lake, respectively, thus indicating the higher bird diversity at Khecheopalri lake in comparison to Kathok Lake. Consequently, an understanding of the composition and diversity of bird communities is necessary to assess the importance of local or regional landscapes for avian conservation. Further studies in different seasons mainly focusing on how seasonal interactions drive population change in different bird species, are required for better understanding and monitoring of the birds.

Key words: Birds, Conservation, Diversity, Wetlands, Kathok, Khecheopalri

INTRODUCTION

Wetlands are described as constructed or natural, temporary or permanent waterbodies containing standing or flowing water that might be salty, fresh, or brackish and whose depth doesn't exceed 6m during low tide (Kumar & Kanaujia, 2014). Wetlands are significant landscape elements that offer both humans and wildlife a variety of useful services (Hu *et al*., 2017). They are sometimes referred to be the "kidneys of the landscape" since they are the primary recipients of waste and water from natural as well as human sources (Mitsch & Gooselink, 2000). Wetlands play a significant role in maintaining the avian communities by providing an abundance of resources. Unfortunately, wetlands across the globe are still disappearing (Davidson, 2014), and human-caused climate change is altering the habitats that are available to different bird species (Haig *et al*., 2019). Wetland birds are very sensitive to their surroundings; therefore, it is reasonable to anticipate that they will react adversely to any changes to the wetland's features (Haig *et al*., 2019). Birds are employed as surrogates to evaluate the influence of habitat alteration (Chettri *et al*., 2001; Veraart *et al*., 2004) because of their quick responsiveness to changing environments. They are also considered effective indicators of the quality of the habitat, stability, and productivity (Vallecillo *et al*., 2016). Monitoring the abundance of different species, their habitat preference, and the relations between the abundance of species and their habitation provide fundamental evidence about the descriptive factors of changing bird populations (Norvell *et al*., 2003) as well as data for the protection of endangered species (Sauer & Link, 2002).

Sikkim, a small but ecologically diverse state with a geographical area of 7096 km^2 nestled in the Himalayan region of India, boasts a remarkable array of avian species (Rawat & Tambe, 2011). In terms of the entire geographic region, Sikkim has the highest bird richness, with 574 species from 253 genera and 55 families belonging to 16 avian orders (Acharya & Vijayan, 2010). All of Sikkim's natural inland wetlands fall under the lake and pond category. These lakes are fed by rivers as well as snow. Changu (Tsomgo), Khecheopalri, Memencho, Gurudongmar, Cholamu, Lampokhari, Samiti, etc. are among the state's most prominent lakes (Crowder & Bristow, 1988). Khecheopalri Lake is one of the 534 lakes situated in West Sikkim and is considered one of the best birding areas as the lake serves as the pit stop for the Trans- Himalayan birds from and to Himalayan areas. Between the years 1996 and 1999, Khecheopalri Lake underwent its most recent assessment (Chettri *et al*., 2005). As a result, the wetland remains unaffected in terms of the study of avian variety. Khangchendzonga biosphere reserve: Yuksom, Dubdi and Kathok Lake a sacred water body located in

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the western region of Sikkim, India. These regions hold significant importance for study of avian diversity due to the geographical location of Yuksom and its proximity to the Kanchenjunga National Park, a UNESCO World Heritage Site, contributing to its rich diversity and making it a hotspot for avifauna (Rai, 2017). Moreover, there has been little research on the avian diversity in the wetlands of West Sikkim, despite the fact that the avian diversity in the wetlands of North Sikkim has been the subject of numerous studies. Keeping in view the lacunae, the current study was conducted to document the diversity, and abundance status of bird species, in two different wetlands (Khecheopalri and Kathok lake) of West Sikkim. Monitoring the avifaunal abundance provides useful information that is widely utilized in managing endangered bird populations as well as in bird conservation.

METHODOLOGY

Area of study

The current research was conducted to in the local and peripheral areas of two wetlands of West Sikkim viz. Khecheopalri lake (27^0 20' 56.47" N Lat & 88^0 11' 18.18" E Long) and Kathok lake (27^0 22' 17.40" N Lat & 88^0 13' 20.18" E Long) are located in the village of Khecheopalri and Yuksom, respectively (Figure 1). West Sikkim shares its border with Nepal to the east and the Darjeeling district of West Bengal to the south. Kathok Lake lies within the buffer zone of Khangchendzonga National Park which has been inscribed in the UNESCO World Heritage site list under the mixed category of "Nature and Culture" (Figure 2). Khecheopalri Lake (also known as KhachoedpalriPemachenTsho or Tsho-Shu Tsho) is a Buddhist pilgrimage place located 147 kilometers (91 mi) west of Gangtok and sits at an elevation of 6,100-6,500 feet. The major source of water is rainwater which nourishes the wetland (Figure 3). 24 °C (75 °F) is the hottest temperature recorded, while 4 °C (39 °F) is the lowest (Evershed & Fish, 2006). Bordered by lush green jungle, the lake supports a diverse range of birds, mammals, insects, and flora. Broad-leaved forests in the Khecheopalri watershed are dominated by canopy species like *Castanopsis* and *Machilus* with a dense understorey of secondary species such as *Symplocos, Viburnum*, and *Edgeworthia* (Chettri *et al.,* 2005). The catchment region, or Ramam Mountain, surrounds the lake; the valley is also known as Ramam Valley. The extra water in the Lake is constantly drained by a little stream. Birds traveling to and from Himalayan regions pause at the Lake route.

Field survey

The wetlands and surrounding areas were surveyed every week (Saturday and Sunday) in a month from May 2023 to August 2023. Surveys were conducted in the morning (06:00 am to 10:00 am) and in the afternoon (03:00 pm to 06:00 pm) depending upon the seasonal visibility of birds. Data was recorded using the direct observation and point count method (Bibby *et al.*, 2000). Every bird heard or sighted within a 50-meter radius at each location was recorded on the data sheet during every field visit. The birds of particular species were observed using Olympus binoculars (8 x 42 mm), while field guides and standardized handbooks (Ali & Ripley, 2007; Grimmett *et al*., 2016) were utilized for identification of respective birds. A Canon EOS 200 digital camera was used to snap pictures of certain birds that were hard to identify in order to identify them afterward. In accordance with Grimmett *et al*. (2014), the Residential Status of birds was divided into three categories: Resident (R), Winter Migrant (WM), and Summer Migrant (SM) categories. The documented bird species' abundance Status was classified as Common (C),

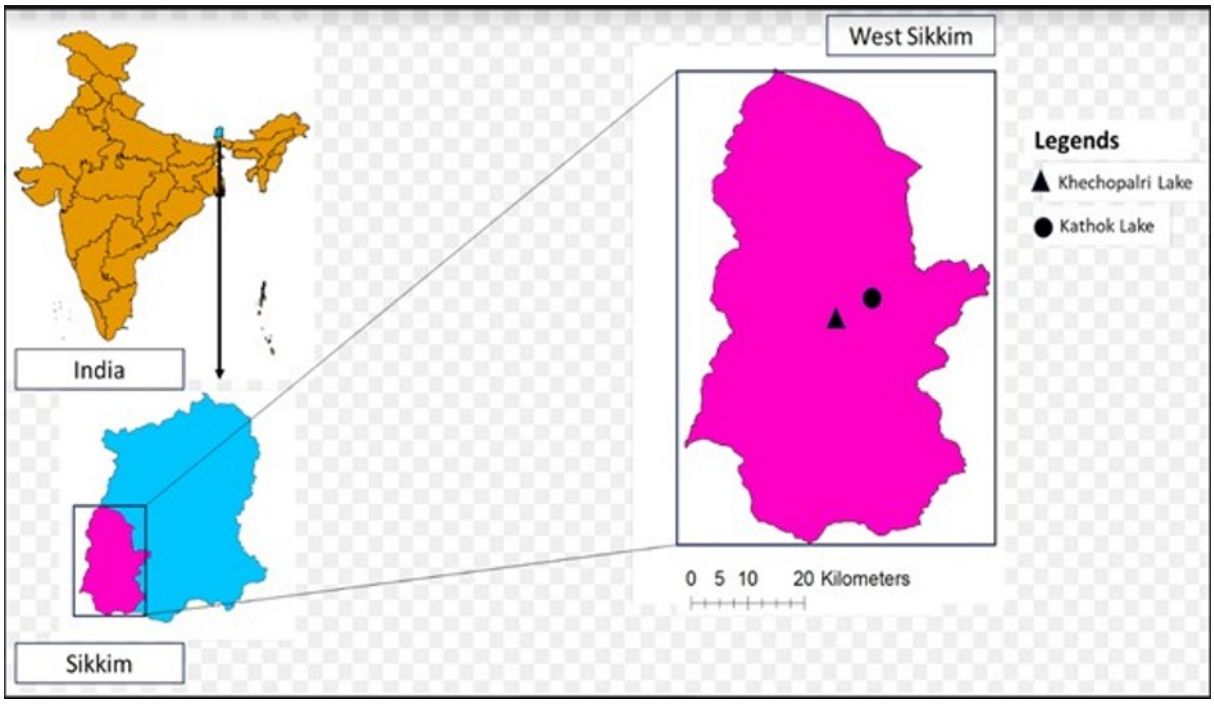

Figure 1. Map of study area showing two different study sites (Kathok and Khecheopalri Lake), West Sikkim, India (Source: ArcGIS 10.8).

Figure 2. Aerial map showing the study area, Kathok Lake, West Sikkim (Source: Google Earth Pro)

Figure 3. Aerial map showing the study area, Khecheopalri Lake, West Sikkim (Source: Google Earth Pro)

Fairly Common (FC), Uncommon (UN), and Rare (RA) in accordance with Kumar &Gupta, 2009. The assessment of the conservation status of the species was based on the different Red List Categories of IUCN, 2021 that deal with the global conservation status of animal and plant species. From the red list of IUCN, the global population trend of every bird species-whether be declining, increasing, stable, or unknown-was also determined.

Data analysis

The following parameters were obtained by organizing the data.

Relative diversity index (RDi): The formula below was used to determine the relative diversity of reported bird groups in the research area (La Torre-Cuadros *et al*., 2007).

RDi= Number of bird species in a family/Total number of bird species in all family ×100

Shannon-Weiner index (H'): Shannon-Weiner formula (H'=-[ΣPi*LN(Pi)]) was used for assessing diversity among recorded bird species based on the abundance of species (Hutcheson, 1970).

Species Evenness: The Shannon evenness index was computed using the following equation to ascertain whether species are dispersed equally in the researched area:

$$E = H' / \ln S$$

Where, S represents species richness and H' is Shannon-Wiener's diversity index.

RESULTS AND DISCUSSION\

Periodic visits conducted at the two selected wetlands yielded documentation of 56 bird species, representing 22 families (Table 1 & Table 2) during the entire study period. The maximum number of the species recorded both at Kathok lake (n=5) and Khecheopalri lake (n=6) belongs to the family Leiotrichidae which mainly includes songbirds commonly known as laughingthrushes. This is followed by family Muscicapidae (n=5) and Corvidae (n=4) at Kathok lake and Dicruridae and Corvidae (n=3) at Khecheopalri lake, respectively.

All the species of bird recorded were categorized as "Least Concern" in the IUCN Red list which signifies that the species are evaluated as having a low risk of extinction. Hence this category is used for species that are widespread and abundant with stable populations and no immediate threat of significant decline (Table 1 & 2). As far as IUCN population trend is concerned, at Kathok lake, 3 species showed increasing, 8 decreasing, 7 stable and population trends for 8 species was unknown. Similarly, at Khecheopalri lake 4 species showed increasing, 9 decreasing, 11 stable and population trends for 6 species was unknown. These trends help to determine the conservation status of species and inform about the conservation strategies that need to be operated. The Wildlife Protection Act of 1972 classifies animals under different schedules based on their level of protection. The bird species recorded during the current study are all listed under Schedule IV in which endangered species are not included but hunting is banned. Moreover, The Convention on International Trade in Endangered Species of wild fauna and flora (CITES, 2022) included none of the recorded species under any appendix.

Khecheopalri Lake's seasonal distribution of avifauna was found to be 6.6% summer breeders, 0% winter migrants, and 93.3% year-round residents during the entire study period.

Summer migrants include Verditer flycatcher and Barn swallow. The Verditer flycatcher was also observed as a summer visitor at Kathok lake. The area lacked winter migrants as the study was carried out during the summer and early monsoon seasons, respectively. Insectivores dominate the bird community; this is a common pattern that has also been noticed by earlier research in the Himalaya (Khan *et al.,*1993; Sultana *et al.,*2007). Nectarivores and carnivores are typically underrepresented due to their specialised diets and the limited availability of chosen food resources (Wiens, 1989). A particular species of bird may emerge, grow or decline, and vanish as the habitat shifts due to as vegetation changes along intricate biological and environmental gradients (Lee & Rotenberry, 2005). Results of current study revealed that around 50% of the species were common in abundance i.e., they were sighted in almost every visit, 43% of the species were fairly common and around 6.6% of the species were uncommon at Khecheopalri lake. Lesser Yellownape and Great Barbet were found to be fairly common in our findings despite their lower abundance in earlier research (Chettri *et al*., 2005). At Kathok lake, 73.3% of the total species observed were common and 26.6% species were fairly common. However, no uncommon species was observed at study area of Kathok lake. The β-diversity value of

Table 1. Avian diversity observed at Kathok lake.

S. No.	Common Name	Scientific Name	Family	Conservation status (IUCN)	Population trend (IUCN)	Residential status	Abundance status
1.	Bronzed drongo	*Dicrurus aeneus*	Dicruridae	LC	?	R	C
2.	Ashy drongo	*Dicruurus leucophaeus*		LC	?	R	C
3.	Black drongo	*Dicrurus macrocerus*		LC	?	R	C
4.	Blue whistling thrush	*Myophonus caeruleus*	Musciicapidae	LC	?	R	C
5.	Verditer flycatcher	*Eumyias thalassinus*		LC	→	SM	FC
6.	Greater necklaced laughingthrush	*Pterorhinus pectoralis*	Leiothrichidae	LC	?	R	C
7.	Rufous sibia	*Heterophasia capistrara*		LC	?	R	C
8.	Red- billed leiothrix	*Leiothrix lutea*		LC	↓	R	FC
9.	White crested laughingthrush	*Garrukax leucolophus*		LC	↓	R	FC
10.	Red-tailed minla	*Minla ignotincta*		LC	↑	R	FC
11.	Green- backed tit	*Parus monticolus*	Paridae	LC	→	R	C
12.	Green-tailed sunbird	*Aethopyga nipalensis*	Nectariniidae	LC	→	R	C
13.	Grey treepie	*Dendrocitta formosae*	Corvidae	LC	↓	R	C
14.	Common Green Magpie	*Cissa chinensis*		LC	↓	R	FC
15.	Large- billed crow	*Corvus macrorhynchos*		LC	→	R	C
16.	House swift	*Apus nipalensis*	Apodidae	LC	↑	R	C
17.	Indian white eye	*Zosterops palpebrosus*	Zosteropidae	LC	↓	R	C
18.	Russet sparrow	*Passer cinnamomeus*	Passeridae	LC	→	R	C
19.	White throated fantail	*Rhipidura albicollis*	Rhipiduridae	LC	→	R	C
20.	White browed fulvetta	*Fulvetta vinipectus*	Paradoxornithidae	LC	↓	R	C
21.	Grey- chinned minivet	*Pericrocotus solaris*	Campephagidae	LC	→	R	FC
22.	Great barbet	*Megalaima virens*	Megalaimidae	LC	↓	R	FC
23.	Rock pigeon	*Columba livia*	Columbidae	LC	↑	R	C
24.	Oriental turtle dove	*Streptopelia orientalis*		LC	?	R	C
25.	Great crested grebe	*Podiceps cristatus*	Podicipedidae	LC	?	R	C
26.	Velvet-fronted nuthatch	*Sitta frontalis*	Sittidae	LC	↓	R	C

R: Resident, SM: Summer Migrant, WM: Winter Migrant, C: Common, FC: Fairly Common, UN: Uncommon, RA: Rare; Sch IV: Schedule IV; LC: Least concern

?: Population trend Unknown

→: Population trend stable

↑: Population trend increasing

↓: Population trend decreasing

Table 2. Avian diversity observed at Khecheopalri lake during the study period.

S. No.	Common Name (n)	Scientific Name	Family Name	Conservation status (IUCN)	Population trend (IUCN)	Residential status	Abundance status
1	Little Pied Flycatcher	*Ficedula westernanni*	Muscicapidae	LC	↓	R	C
2	Verditer Flycatcher	*Eumyias thalassinus*		LC	→	SM	FC
3	Golden Bush Robin	*Tarsiger chrysaeus*		LC	→	R	FC
4	Grey Bushchat	*Saxicola ferreus*		LC	?	R	FC
5	Blue Whistling thrush	*Myophonus caeruleus*		LC	?	R	C
6	Red Tailed Minla	*Minla ignotincta*	Leiothrichidae	LC	↓	R	FC
7	Blue Winged Minla	*Actinodura cyanouroptera*		LC	?	R	UN
8	Rufous Sibia	*Heterophasia capistrata*		LC	?	R	C
9	Red Billed Leiothrix	*Leiothrix lutea*		LC	↓	R	FC
10	Striated Laughingthrush	*Garrulax striatus*		LC	↓	R	C
11	White Crested Laughingthrush	*Garrulax leucolophus*		LC	↓	R	FC
12	Grey Treepie	*Dendrocitta formosae*	Corvidae	LC	↓	R	C
13	Common Green Magpie	*Cissa chinensis*		LC	↓	R	FC
14	House Crow	*Corvus splendens*		LC	→	R	C
15	Northern Raven	*Corvus corax*		LC	↑	R	C
16	Green Backed Tit	*Parus monticolus*	Paridae	LC	→	R	C
17	Coal Tit	*Periparus ater*		LC	↓	R	FC
18	Barn Swallow	*Hirundo rustica*	Hirundinidae	LC	→	SM	UN
19	Common Myna	*Acridotheres tristis*	Sturnidae	LC	↑	R	C
20	Chestnut Winged Cuckoo	*Clamator coromandus*	Cuculidae	LC	→	R	C
21	Great Barbet	*Megalaima virens*	Megalaimidae	LC	↓	R	FC
22	Lesser Yellownape	*Picus chlorolophus*	Picidae	LC	→	R	FC
23	White Throated Fantail	*Rhipidura albicoilis*	Rhipiduridae	LC	→	R	C
24	Black Drongo	*Dicrurus macrocercus*	Dicruridae	LC	?	R	C
25	Red Vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	LC	↑	R	C
26	Mountain Bulbul	*Ixos mcclellandii*		LC	→	R	FC
27	Grey Chinned Minivet	*Pericrocotus solaris*	Campephagidae	LC	→	R	FC
28	House Sparrow	*Passer domesticus*	Passeridae	LC	↑	R	C
29	Long Tailed Shrike	*Lanius schach*	Lariidae	LC	?	R	FC
30	Common Pigeon	*Columba livia*	Columbidae	LC	→	R	C

Table 3: Shannon-Weiner's Index and species evenness index

Study Site	Shannon- Weiner's Diversity Index (H')	Evenness Index (E_H)
Kathok lake	2.52	0.77
Khecheopalri lake	3.27	0.96

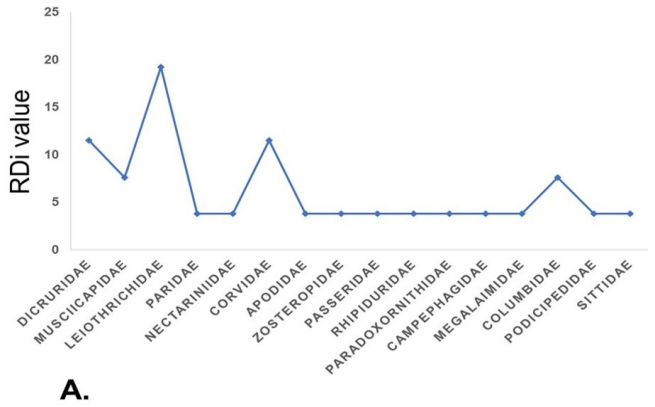

Figure 4. Relative diversity index values per family observed at Kathok lake

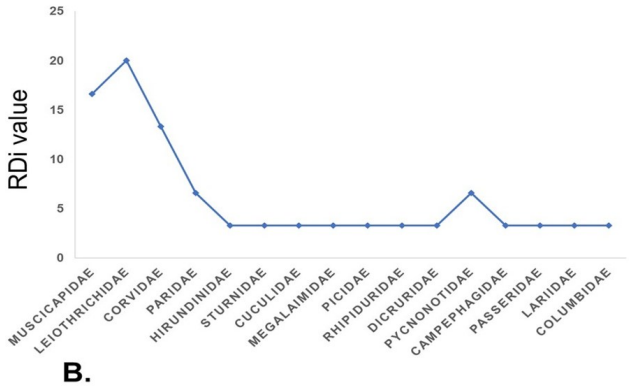

Figure 5. Relative diversity index values per family observed at Khecheopalri lake

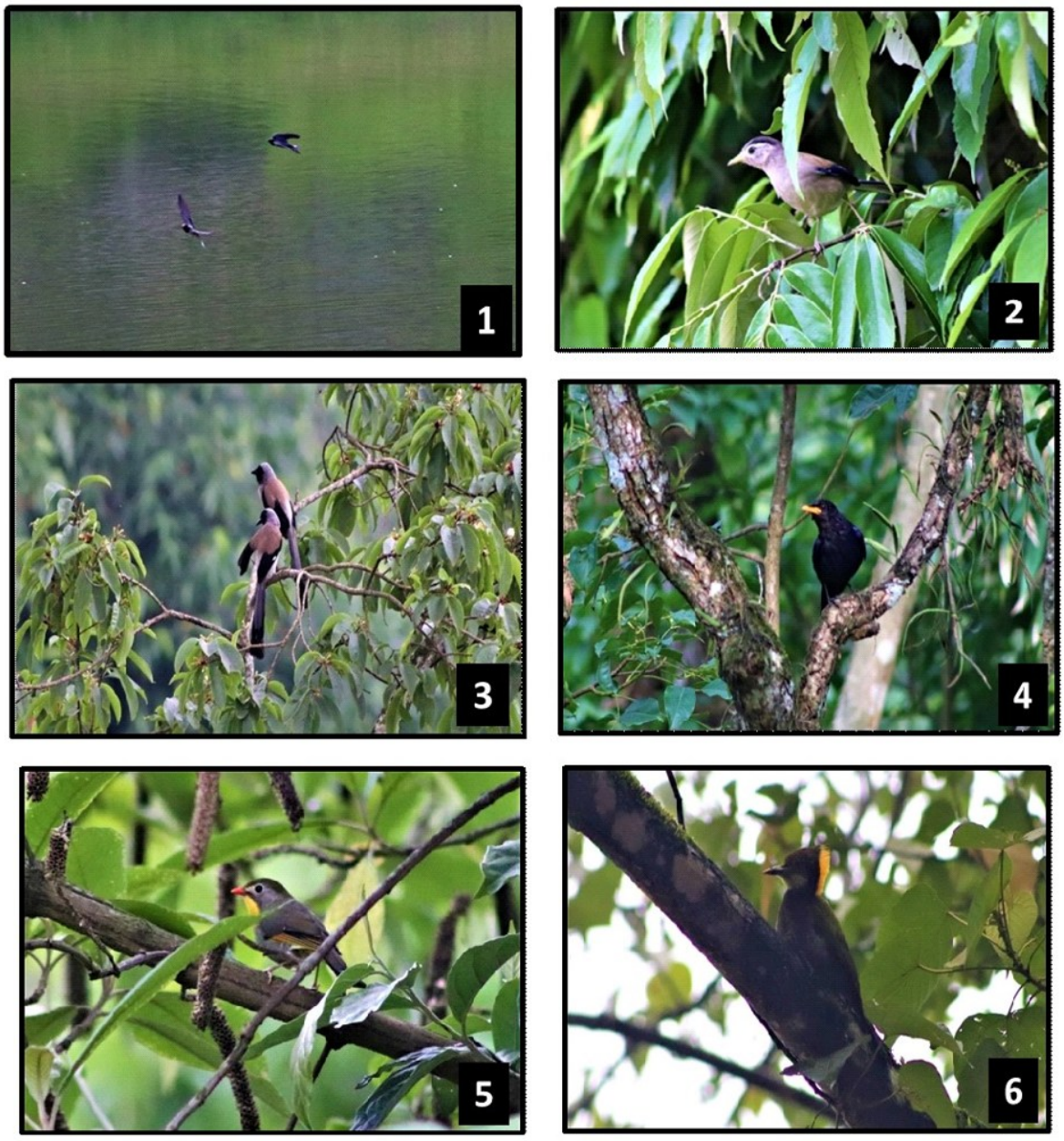

Figure 6. Photographs of some birds observed at Khecheopalri lake, West Sikkim, India:1-Barn Swallow | 2-Blue Winged Minla | 3-Grey Treepie | 4-Blue Whistling Thrush | 5-Red Billed Leiothrix | 6-Lesser Yellownape.

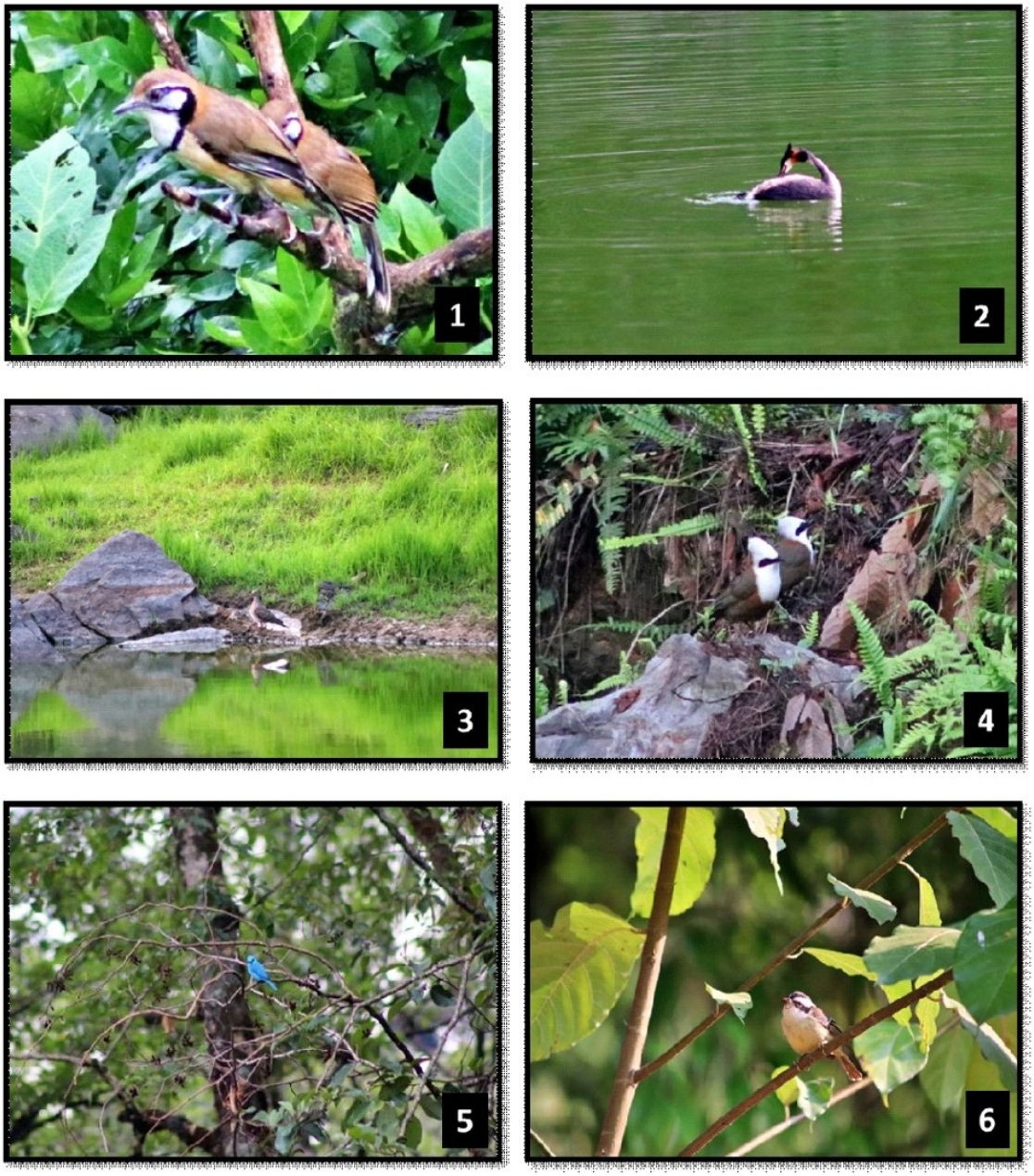

Figure 7. Photographs of some birds observed at Kathok lake, West Sikkim, India:1-Greater Necklaced Laughingthrush | 2- Great Crested Grebe | 3-Oriental Turtle Dove | 4-White Crested Laughingthrush | 5-Verditer Flycatcher | 6-Red-Tailed Minla

the two study sites was 12 i.e., among all the bird species observed at two study sites, 12 species were different between the two lakes, while rest of the species were common to both the sites. The Shannon-Weiner's Index and species evenness index values are given in table 3. The relative diversity of birds was also determined. The relative diversity of different bird species may be influenced by the species' nesting season, habitat quality, and food availability. The relative diversity index (RDi) values for different families of birds at two study sites are shown in Figure 4 and 5. The different range of food sources and secure places are responsible to increase the avian diversity and habitat (Joshi, 2014).

CONCLUSION

The presence of rich diversity at both the study sites (Figure 6 & 7) indicates that these wetlands provide rich source of food and shelter to the bird species. Overall, conservation efforts should be implemented to preserve and protect the avian diversity in wetland ecosystem. This includes maintaining the lakes water quality, preserving its surrounding habitats, and mitigating human activities that could disrupt the natural balance. Engaging local communities, raising awareness about the importance of bird conservation, and implementing sustainable tourism practices are vital steps towards ensuring the long-term survival of avian diversity at Kathok and Khecheopalri lake. Our study only covered one season; therefore, future research must link other fields of study, concentrate on more comparative analysis, and take an integrative approach at multiple time and seasonal scales. Additionally, it needs to take into account for the migratory bird species that use the lake as a stopover point. Effective policy and cultural change that

prioritise lowering risks to breeding and non-breeding habitats must be combined with targeted research to identify limiting variables. Thus, by safeguarding this diverse bird population and their habitats; we can protect the delicate balance of nature and maintain the beauty and integrity of these natural lakes for generations to come.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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