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SEASONAL VARIATION ON THE ABUNDANCE AND DIVERSITY OF WATERBIRDS IN PHEWA WETLAND POKHARA, NEPAL

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ABSTRACT

Wetlands are taken as the transition zone between aquatic and terrestrial habitats and are essential natural territory for numerous faunae, especially for waterbirds. The habitats for waterbirds in Phewa lake are degrading due to various anthropogenic pressures and excessively spreading invasive weeds. We applied the point count method using 12 points from Phewa dam to Pame phant to collect the seasonal data of waterbirds in the Phewa wetland during Summer 2019 and Winter 2020. We compared the abundance and diversity of waterbirds between the Summer and Winter seasons. A total of 937 individuals of 43 waterbird species from 14 families were recorded from Phewa lake during the study period. The abundance of waterbirds was found higher during Winter ($U = 46$, $p = 0.04$). The Winter season was found to be more divergent than the Summer. Shannon Wiener diversity index (H') ranged from 0.5 - 2.51 during Summer and from 0.64 - 3.18 during Winter. Distance to forest (m) was responsible for the change in the abundance of waterbirds ($\beta = 0.26$, $p = 0.03$). Distance to forest (m) and distance to road (m) were responsible for the change in H' ($\beta = 0.005$, $p = 0.006$ and $\beta = -0.004$, $p = 0.03$ respectively) and Distance to forest (m) was responsible for the change in species richness (S) ($\beta = 0.06$, $p = 0.01$) in Phewa wetland. So planting trees and devoid road construction may increase the abundance of waterbirds in Phewa wetland.

Key words: Anthropogenic, Invasion, Threats, Waterbirds, Wetland.

INTRODUCTION

Wetlands are taken as the transition zone between aquatic and terrestrial habitats and are essential natural territory for numerous flora and fauna (IUCN, 2016). Wetlands are the most productive ecosystems and rich in biodiversity. Wetlands regulate water and water quality and they are the source of water and nutrients necessary for biological productivity and humans. Wetlands provide resting, roosting, foraging and nesting habitat for resident and migratory waterbird species (Erwin, and Beck, 2007; Kumar *et al*., 2016). However, wetlands are facing many threats globally, the greatest loss of wetlands is seen mainly in Asia due to degradation and fragmentation of habitat and biological invasion, resulting in a declining the population of many waterbirds (Ma *et al*., 2010,

Inskipp *et al*., 2013; Inskipp *et al*., 2016).

Waterbirds are an indicator of environmental health and water quality because they can easily detect environmental change (Aynalem and Bekele, 2008). Waterbirds also provide ecosystem functional services of freshwater lakes placed in the higher trophic level with diverse feeding adaptations such as herbivorous, piscivorous, insectivorous, and omnivorous (Swanson *et al*., 1974). The species richness, abundance, and diversity of waterbirds depend upon the vegetation composition of the lake which is the major form of habitat and availability of food resources (Bolduc *et al*., 2004). The variation of water depth also affects the distribution and abundance of the waterbirds. The dividing birds (such as cormorants and grebes) require water depth of >25 cm, large wading birds (such as herons, egrets, and ibis) forage up to 30 cm, and small shorebirds (such as sandpipers) in water less than 5 cm. Out of 886 bird species of Nepal, Phewa wetland provides home to 43 waterbirds (BCN and DNPWC, 2018; MoFE, 2018).

Phewa wetland is vulnerable and facing great anthropogenic pressure including eutrophication, siltation, sedimentation, industrial and chemical pollution, encroachment, deforestation, over-fishing and invasion of non-native invasive weeds such as water hyacinth, water lettuce, cut grass, etc. (Sharma *et al*., 2015; Watson *et al*., 2019). Therefore, the wetland habitats are degrading speedily and impacting resulting the adversely on the structure and diversity of the waterbird communities. As a result, the foraging and nesting sites for the waterbirds in Phewa wetland are narrowing these days and the population of waterbirds, particularly the winter migratory birds, are declining these days. There is a regular census of waterbirds during the Winter season by Bird Conservation Nepal and other conservation organisations. However, the scientific study of the seasonal abundance and diversity of waterbirds is waranted in Phewa lake areas. A separate checklist of the waterbird species of Phewa lake has not been developed since the checklist provided by Gautam and Kafle (2008). Therefore, we aimed to compare the seasonal abundance and diversity of waterbirds around the Phewa lake. We also provided the updated checklist of waterbirds in Phewa lake areas. Our findings will be the baseline for the future researcher and conservationists for the conservation of waterbirds in Phewa wetland.

MATERIALS AND METHODS

1.1. Study Area

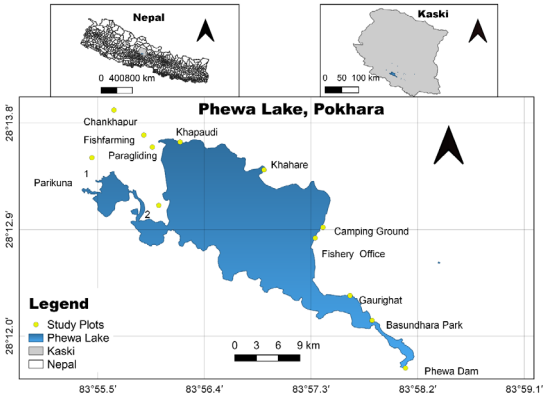

Figure 1 Study Area

Phewa is a natural freshwater lake located in the south of the Pokhara Valley (Figure 1). It is the second largest lake in Nepal, located at an altitude of 784 m with an area of 4.33 km^2 water surface and an extreme depth of water is 22.5 m (MoFE, 2018). Phewa lake is an important part of the Lake Cluster of Pokhara Valley. Lake Cluster of Pokhara Valley is the latest and largest ecologically important Ramsar site consisting of nine lakes (MoFE, 2018). Phewa lake is surrounded by sub-tropical broad-leaved sal forest (*Shorea robusta*) in the south, riparian forests (*Acacia catechu* and *Dalbergia sisoo*)

along the banks of Seti river and its tributaries, and *Schima-Castanopsis* forests in the north and west. The invasive species found around Phewa wetland are Tilapia (*Tilapia nilotica*), African catfish (*Clarias gariepinus*), Parthenium (*Parthenium hysterophorus*), Mikania (*Mikania micrantha*), Water hyacinth (*Eichornia crasssipes*), Southern cut grass (*Leerisa hexandra*), and Water lettuce (*Pistia stratiotes*) (MoFE, 2018). The Phewa wetland is the natural home for several threatened species such as critically endangered Baer's pochard (*Aythya baeri*); Indian vulture (*Gyps indicus*); vulnerable Ferruginous duck (*Aythya nyroca*); Spiny babbler (*Turdoides nepalensis*), Nepal wren babbler (*Pnoepyga immaculate*), Comb duck (*Sarkidiornis melanotos*), threatened mammals like as Clouded leopard (*Neofelis nebulosa*), Common leopard (*Panthera pardusfusca*) and Indian pangolin (*Manis crassicaudata*) (MoFE, 2018).

1.2. Methods

A total of 12 sampling plots each of a 50 m circular radius was established in Phewa lake wetland from *Phewa dam* to *Pame Phant* areas based on the hot spots of waterbirds habitat. The distance between the two plots was not less than 200 metres. The coordinates of each plot were recorded from the centre using GPS (Garmin eTrex Touch 35). The nearest distance to forest, road and settlement from each plot was determined using a measuring tape. Species and the number of waterbirds in each plot were observed within a 50 m radius from 7.00 AM to 11.00 AM. Waterbirds were observed four times: two times during Summer 2019 (July and August) and two times during Winter 2020 (January and February). Waterbirds were counted through direct observation using binoculars following Bibby *et al*. (2000). In each plot, 30 minutes were spent on the observation of waterbirds, and the maximum number of individuals and species of the waterbirds recorded within the given period were used for data analysis. All the observed birds were identified using available reference keys/experts following the taxonomic monographs (Grimmett *et al*., 2016; Inskipp, *et al*., 2016).

1.3. Data Analysis

Shannon-Weiner diversity (H') (Shannon and Weaver, 1949), Pielou's species evenness (J) (Pielou, 1966) and species richness (S) of the waterbirds during Summer and Winter were calculated. All waterbirds were categorised into four feeding guilds: piscivorous, insectivorous, omnivorous, and herbivorous (Grimmett *et al*., 2016; Katuwal *et al*., 2018). The abundance and diversity of waterbirds during the Summer and Winter seasons were compared using Mann– Whitney tests because the data were not normally distributed. Multiple linear regression (MLR) analysis was used to identify the factors affecting waterbird abundance and species diversity of waterbirds in Phewa lake wetland. All data were analysed using vegan (Oksanen *et al*., 2013); ggplot2 and ggpubr (Wickham *et al*., 2016) packages in the R program (R Core Team, 2020). We used Microsoft Excel 2019 also for graphical representation of the results.

2. RESULTS AND DISCUSSION

2.1. Abundance and diversity of waterbirds

A total of 937 individuals (Summer 2019, N = 230 and Winter 2020, N = 707) of 43 waterbird species from 14 families were

recorded in Phewa wetland during the study period (Table 1, Figure 2). Out of 14 families, family Anatidae had the highest species richness (14 species) which was followed by family Ardeidae (6 species), family Rallidae (4 species) and family Passeridae (3 species) (Figure 2). Gautam and Kafle (2008) also recorded 43 species of waterbirds from Phewa lake but they did not record seven species that were recorded during this study. These birds were Black-headed Gull, Blue-eared Kingfisher, Crested Kingfisher, Common Snipe, Grey Heron, Black-corwned Night Heron and White Wagtail. Similarly, we did not record seven species of waterbirds during our study but were recorded by Gautam and Kafle (2008). These birds were Common Shelduck (*Tadorna tadorna*), Garganey (*Anas querquedula*), Falcated Duck (*Anas falcata*), Cotton Pygmy-goose (*Nettapus coromandelianus*), Darter (*Anhinga melanogaster*), Great Egret (*Casmerodius albus*) and Marsh Sandpiper (*Tringa stagnatilis*). Other seven species which were not recorded during our study are Greater Painted-snipe (*Rostratula benghalensis*), Jack Snipe (*Lymnocryptes minimus*), Green Sandpiper (*Tringa ochropus*), Common Redshank (*Tringa totanus*), Great White Egret (*Ardea alba*), Goosander (*Mergus merganser*) and Greylag Goose (*Anser anser*) but these species were recorded from Phewa lake during the winter water bird census in 2017 (Nepal and Thapa, 2018). 39 species of waterbirds from 17 families were reported by Giri and Chalise (2008) but they did not record the species such as Baer's Pochard (*Aythya baeri*), Bar-headed Goose (*Anser indicus*), Comb Duck (*Sarkidiornis melanotos*), Common Golden-eye (*Bucephala clangula*), Darter (*Anhinga melanogaster*), Little Cormorant (*Phalacrocorax niger*) and Purple swamphen (*Porphyrio porphyrio*). 148 species of birds from 44 families were recorded by Khatri *et al*. (2019) from the Phewa watershed area, out of which 63 species were wetland-dependent birds. Similarly, Dhakal *et al*. (2020) reported 101 species of birds from 34 families in Khaste lake complex, out of which 33 species were waterbirds.

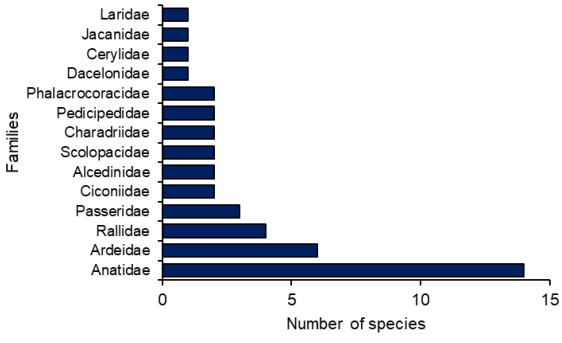

Figure 2 Families of waterbirds with number of species recorded during Summer 2019 and Winter 2020 in Phewa wetland of Pokhara Valley, Nepal

The greatest number of waterbirds (N = 60) was recorded in plot number 5: Tilapia Farming Area Khapaudi and the lowest (N = 5) was recorded in plot number 7: Fish Cage Culture Khapaudi during Summer 2019. Similarly, the greatest number of waterbirds (N = 143) was recorded in plot number 11: Pame Phant Parikuna 1, and lowest (N = 3) in plot number 3: Gaurighat (Figure 3). Plots 1, 2, 3, 4, and 5 were found most disturbed areas for waterbirds and observed a lower abundance and diversity because there

was very limited open water access and an absence of a vegetated wetland; these plots were closer to the road, settlement, temple, and parks. It could be attributed the human exploitation and habitat degradation of waterbirds. Plots 6, 7, and 8 were found to be more abundant and diverse because these plots were less disturbed and had more open water access in comparison to plots 1, 2, 3, 4, and 5. Additionally, plots 9, 10, 11, and 12 were found most abundant and diverse in the Phewa wetland; it could be due to large areas with open water access and wetland areas with emergent and floating vegetation. In addition, the habitats such as swamp areas, open water bodies, patches of shrubs and forest edges provide abundant food resources, such as insects, worms, mollusks, and grains as well as safe roosting and breeding sites (Hanson and Butler, 1994).

Table 1. Waterbirds recorded around Phewa wetland, Pokhara, Nepal, 2019–2020. IUCN status: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concerned (LC). *SC-Summer count, WC-Winter count.

SN	Scientific name	Common name	Family	IUCN Status	Feeding guilds	SC	WC
1	*Anas strepera* Forster, 1781	Gadwall	Anatidae	LC	Omnivore	13	0
2	*(Mareca) Anas penelope* Linnaeus, 1758	Eurasian Wigeon	Anatidae	LC	Herbivore	8	0
3	*Anas platyrhynchos* Linnaeus, 1758	Mallard	Anatidae	LC	Omnivore	12	0
4	*(Spatula) Anas clypeata* Linnaeus, 1758	Northern Shoveler	Anatidae	LC	Omnivore	10	0
5	*Anas acuta* Linnaeus, 1758	Northern Pintail	Anatidae	LC	Omnivore	8	0
6	*Anas creeca* Linnaeus, 1758	Common Teal	Anatidae	LC	Omnivore	7	0
7	*Tadorna ferruginia* Pallas, 1764	Ruddy Shelduck	Anatidae	LC	Omnivore	19	0
8	*Rhodoessa rufina* Pallas, 1773	Red- crested Pochard	Anatidae	LC	Omnivore	3	0
9	*Aythya baeri* Güldenstädt, 1770	Baer's Pochard	Anatidae	CR	Omnivore	7	0
10	*Aythya ferina* Linnaeus, 1758	Common Pochard	Anatidae	VU	Omnivore	8	0
11	*Aythya nyroca Guldenstadt*, 1770	Ferruginous Pochard	Anatidae	NT	Omnivore	5	0
12	*Aythya fuligula* Linnaeus, 1758	Tufted Duck	Anatidae	LC	Omnivore	5	0
13	*Anser indicus* Latham, 1990	Bar-headed Goose	Anatidae	LC	Herbivore	17	0
14	*Dendrocygna javanica* Horsfield, 1821	Lesser Whistling Duck	Anatidae	LC	Omnivore	20	0
15	*Ciconia episcopus* Boddaert, 1783	Woolly Necked Stork	Ciconiidae	NT	Piscivore	7	0
16	*Ciconia nigra* Linnaeus, 1758	Black Stork	Ciconiidae	LC	Piscivore	5	0
17	*Alcedo atthis* Linnaeus, 1758	Common Kingfisher	Alcedinidae	LC	Piscivore	3	2
18	*Alcedo meninting* Horsfield, 1821	Blue-eared Kingfisher	Alcedinidae	LC	Piscivore	2	1
19	*Halcyon smyrnensis Linnaeus*, 1758	White-throated Kingfisher	Dacelonidae	LC	Piscivore	19	18
20	*Megaceryl lugubris* Temminck, 1834	Crested Kingfisher	Cerylidae	LC	Piscivore	2	0

21	*Amaurornis phenicurus* Pennant, 1769	White-breasted Waterhen	Rallidae	LC	Omnivore	7	7
22	*Gallinula chloropus Linnaeus*, 1758	Common Moorhen	Rallidae	LC	Omnivore	24	13
23	*Fulica atra* Linnaeus, 1758	Common Coot	Rallidae	LC	Omnivore	25	21
24	*Prorphyrio prophyrio Linnaeus*, 1758	Purple Swamphen	Rallidae	LC	Omnivore	185	27
25	*Metopidius indicus Latham*, 1790	Bronze-winged Jacana	Jacanidae	LC	Omnivore	15	10
26	*Gallinago gallinago* Linnaeus, 1758	Common Snipe	Scolopacidae	LC	Insectivore	3	0
27	*Actitis hypoleucos* Linnaeus, 1758	Common Sandpiper	Scolopacidae	LC	Insectivore	5	0
28	*Charadrius dubius* Scopoli, 1786	Little Ringed Plover	Charadriidae	LC	Insectivore	18	0
29	*Vanellus indicus* Boddaert, 1783	Rde-wattled Lapwing	Charadriidae	LC	Insectivore	15	0
30	*Larus ridibundus* Linnaeus, 1766	Black-headed Gull	Laridae	LC	Omnivore	3	0
31	*Tachybaptus ruficollis* Pallas, 1764	Little Grebe	Pedicipedidae	LC	Insectivore	11	0
32	*Podiceps cristatus* Linnaeus, 1758	Great Crested Grebe	Pedicipedidae	LC	Piscivore	2	0
33	*Phalacrocorax carbo Linnaeus*, 1758	Great Cormorant	Phalacrocoracidae	LC	Piscivore	60	0
34	*Phalacrocorax niger* Gmelin, 1789	Little Cormorant	Phalacrocoracidae	LC	Piscivore	18	0
35	*Bubulcus ibis* Linnaeus, 1766	Cattle Egret	Ardeidae	LC	Insectivore	50	48
36	*Egretta grazetta* Linnaeus, 1766	Little Egret	Ardeidae	LC	Insectivore	17	12
37	*Mesophoyx intermedia* Wagler, 1829	Intermediate Egret	Ardeidae	LC	Insectivore	8	10
38	*Ardea cinerea* Linnaeus, 1758	Grey Heron	Ardeidae	LC	Piscivore	8	0
39	*Ardiola grayii* Sykes, 1832	Indian Pond Heron	Ardeidae	LC	Insectivore	20	19
40	*Nyctycorax nycticorax* Linnaeus, 1758	Black-crowned Night Heron	Ardeidae	LC	Insectivore	3	0
41	*Motacilla maderaspatensis* Gmelin, 1789	White-browed Wagtail	Passeridae	LC	Insectivore	14	22
42	*Motacilla cinerea* Tunstall, 1771	Grey wagtail	Passeridae	LC	Insectivore	5	5
43	*Motacilla alba Linnaeus*, 1758	White Wagtail	Passeridae	LC	Insectivore	11	15
	Total count					707	230

Among the observed birds, all were in the least concern category except four species: the critically endangered Baer's pochard (*Aythya baeri*), the vulnerable Common pochard (*Aythya ferina*) and two near threatened Woolly necked stork (*Ciconia episcopus*) and Ferruginous pochard (*Aythya nyroca*) (Table 1). The areas with open water access containing submerged and emergent vegetation were preferred by ducks and geese including globally threatened water birds in Phewa wetland. However, the uppermost portion of Phewa lake near Khapaudi was invaded with invasive weeds like water hyacinth (*Eichhornia crassipes*), bush morning glory (*Ipomoea cornia*), southern cut grass (*Leersia hexandra*), water lettuce (*Pistia stratoides*) and alligator weed (*Alternanthera philoxeroides*) (MoFE, 2018). The invasive weeds decreased the open water access and it could be the cause for the decline in the population of winter migratory waterbirds and globally threatened

waterbirds in Phewa lake during these years. Furthermore, the residential birds like Purple swamphen, Common moorhen, Bronze-winged jacana, Egrets and Herons were benefited from these weeds as they provide the best shelter as well as foraging, nesting and hiding places for these birds (Villamagna *et al*., 2012).

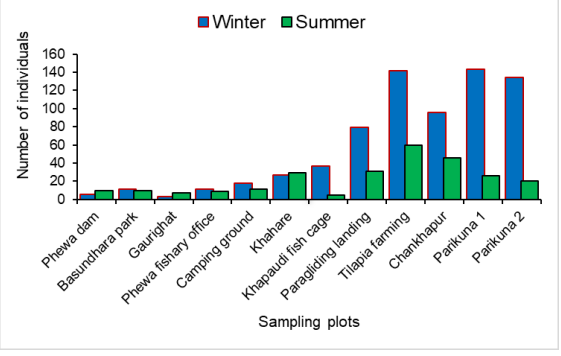

Figure 3 Samling points and the total number of waterbirds during Summer 2019 and Winter 2020 in Phewa wetland of Pokhara Valley, Nepal

Table 2 Comparison of the abundance and diversity of water birds between Summer 2019 and Winter 2020 in Phewa wetland of Pokhara Valley, Nepal

Variables	Summer		Winter		Mann Whitney test	p
	Median	Range	Median	Range		
Abundance	32	5-45	14	3-143	U = 46	**0.04**
Piscivorous birds	2	0-5	4	0-31	U = 24.5	**0.005**
Insectivorous birds	10.5	0-23	13	2-31	U = 58.5	0.4
Omnivorous birds	4.5	0-19	10.5	0-100	U = 52	0.2
Shannon index (H')	1.73	0 . 5 - 2.51	1.94	0 . 6 4 - 3.18	U = 56	0.3
Species richness (S)	7	2-15	10	2-39	U = 49.5	0.2
Evenness (J)	0.92	0.72-1	0.89	0 . 6 1 - 0.96	U = 89.5	0.3

According to the feeding behaviour of the birds, 41.86 % of species (n = 18) were omnivorous, 30.23% of species (n = 13) were insectivorous, 23.26% of species (n = 10) were piscivorous and 4.65% of species (n = 2) were herbivorous waterbirds (Figure 4). The abundance of waterbirds was found higher during Winter (U = 46; p = 0.04) than in Summer (Table 2). A similar type of abundance of insectivorous and omnivorous birds was found during both Winter and Summer seasons however the abundance of piscivorous was found different (U = 24.5; p = 0.005) between the seasons (Table 2). The Winter season was found to be more diverged than the Summer. H' ranged (from 0.5 - 2.51) during Summer and (from 0.64 - 3.18) during Winter. Similarly, S ranged (from 2 - 15) during Summer and (from 2 - 39) during Winter. The Winter season was more evenly distributed than the Summer, J ranged (from 0.72 - 1) Summer and (from 0.61 - 0.96) during Winter (Table 2). The Summer season had more similarity in the community composition of waterbirds in comparison to the Winter season (Giri and Chalise, 2008). This similarity probably was due to the absence of winter migratory waterbirds during the Summer season. The greater abundance and diversity of waterbirds during the Winter season were probably because of the arrival of winter migratory waterbirds from different regions of the world in the Phewa wetland to pass their winter (Giri and Chalise, 2008; Adhikari *et al*., 2019). It could be due to the higher mobility of winter migratory waterbirds in response to factors like cold, food resources and change in water levels

2.2. Factors affecting the abundance and diversity of waterbirds

The abundance, H' and S were used as response variables whereas the distance to forest (m), distance to road (m) and distance to settlement (m) were used as predictor variables in MLR analysis. The results

indicated that any one of response variable was responsible for the change in abundance ($F = 3.165$; $df = 20$ and $p = 0.04$), in H' ($F = 6.22$; $df = 20$ and $p = 0.003$) and in S ($F = 5.65$; $df = 20$ and $p = 0.005$) (Table 3). Distance to forest (m) was responsible for the change in the abundance of waterbirds ($\beta = 0.26$; $p = 0.03$), Distance to forest (m) and distance to road (m) were responsible for the change in H' ($\beta = 0.005$; $p = 0.006$ and $\beta = -0.004$; $p = 0.03$ respectively) and Distance to forest (m) was responsible for the change in S ($\beta = 0.06$; $p = 0.01$) in Phewa wetland (Table 3). Food availability is taken as one of the vital factors for the abundance and diversity of birds, the abundance and species richness of waterbirds were positively associated with the distance to the forest, the Shannon-Wiener diversity index was positively associated with distance to the forest and negatively associated with distance to the road. Similar types of results were explained by Adhikari *et al*. (2019) on threatened birds of Chitwan National Park, Nepal and Neupane *et al*. (2020) on the avifauna of Kaligandaki River Basin, central Himalaya, Nepal.

Table 3 Multiple linear regression showing the factors affecting the abundance and diversity of waterbirds during Summer 2019 and Winter 2020 in Phewa wetland of Pokhara Valley, Nepal

Abundance of waterbirds	Estimate	Std. Error	t-value	P
Intercept	28.18	17.97	1.56	0.13
Distance to forest (m)	0.26	0.12	2.19	**0.03**
Distance to road (m)	-0.21	0.12	-1.70	0.10
Distance to settlement (m)	-0.02	0.01	-1.06	0.30
F-statistic: 3.165				0.04
Shannon-Weiner Diversity Index	Estimate	Std. Error	t-value	P
Intercept	1.392	0.25	5.44	**< 0.001**
Distance to forest (m)	0.005	0.001	3.07	**0.006**
Distance to road (m)	-0.004	0.001	-2.31	**0.03**
Distance to settlement (m)	-0.0008	0.0002	-0.31	0.75
F-statistic: 6.222				0.003
Species richness of waterbirds	Estimate	Std. Error	t-value	P
Intercept	6.61	3.67	1.79	0.08
Distance to forest (m)	0.06	0.02	2.60	**0.01**
Distance to road (m)	-0.04	0.02	-1.84	0.07
Distance to settlement (m)	-0.003	0.004	-0.85	0.4
F-statistic: 5.659				0.005

Phewa wetland is facing remarkable anthropogenic pressure which can greatly influence the structure of the bird community. The main threats to waterbirds in Phewa wetland are habitat degradation due to the construction of roads, recreational activities like fishing, boating, swimming and paragliding, pollution due to domestic sewage, human encroachment, rapid urbanisation, siltation, cattle grazing and invasion of unwanted weeds like water hyacinth, water lettuce, cut grass, etc. (Gautam and Kafle, 2008; MoFE, 2018; Khatri *et al*., 2019).

CONCLUSION

The present study recorded 937 individuals of waterbird from 43 species belonging to 14 families. The family Anatidae was the dominant family with the greatest species richness. All the observed birds were in the least concern category except four globally threatened species. The Winter season was found more abundant with diverse bird species in comparison to the Summer season. The last four plots near Khapaudi and around Pame Phant were more abundant and diverse in Phewa wetland. Phewa lake is rich in waterbird species and more species can be expected from the open area of Khapaudi and Pame phant. Therefore, we recommended a regular survey of waterbirds for their conservation and updating the checklist as well

as the management of invasive weeds like water hyacinth. Organising the awareness program about the conservation of waterbirds including globally threatened waterbirds and mitigation of the major threats by NGOs/ INGOs, local government and different organisations related to birds in schools, colleges and local people living in the catchment areas of the lake is essential.

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