Journal of Animal & Plant Sciences, 33(2): 2023, Page: 409-415
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2023.2.0630

WATERBIRD MIGRATION IN TAUDAHA LAKE, KATHMANDU, NEPAL: UNDERSTANDING FACTORS DRIVING MIGRATION AT A SMALL STOPOVER SITE

K. B. Khatri[1], H. B. Katuwal[2*], S. Sharma[1] and H. P. Sharma[1,3*]

[1]Central Department of Zoology, Institute of Science and Technology, Tribhuvan University, Kirtipur, Kathmandu, Nepal
[2]Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Mengla 666303, Yunnan, China
[3]Nepal Zoological Society, Kathmandu, Nepal
[*]Corresponding author's email: hembahadur@xtbg.ac.cn; hpsharma@cdztu.edu.np

ABSTRACT

Anthropogenic activities in the wetland and surrounding land are threatening the waterbirds. Population dynamics and waterbirds' arrival and departure dates are also influenced by wetland characteristics, food availability, and weather conditions. However, this information is rarely available for Taudaha Lake, a small stopover site in the Kathmandu Valley, Nepal, for many north-south migratory waterbirds. We observed the waterbird species, counted their number, and recorded their exact arrival date (October 2019) and departure date from January 2019 to April 2020. In addition, we recorded the air temperature and humidity of the lake during the monitoring time to identify the potential effects of these weathers on the arrival departure of migratory waterbirds. We developed a linear model to understand the factors influencing the arrival and departure of migratory waterbirds. Altogether we recorded ten migratory waterbird species, including one globally threatened species that used Taudaha as a stopover site during their migration. Arrival and departure times vary among the species. With increasing temperature, the migratory bird population decreases at the lake. Despite smaller area, Taudaha Lake at Kathmandu Valley acts as an important stopover site to facilitate the north-south migration of waterbirds. Therefore, we recommend local government to avoid concrete constructions on the lake.

Key words: Arrival and departure time, Bird migration, Stopover site, Temperature, Waterbirds

Published first online December 18, 2022 Published final March 24, 2023

INTRODUCTION

Migratory waterbirds use different flyovers (migratory routes) when migrating from breeding to non-breeding grounds. Many waterbirds use the Central Asian Flyover that includes Nepal (Palm *et al*., 2015; Prins and Namgail, 2017). Waterbirds use stopover sites during migration for rest, feeding, and avoiding harsh climatic conditions (Palm *et al*., 2015). However, habitat degradation and losses, recreational activities, intense human disturbance and encroachment, road construction, hunting, and changes in agricultural practices near the wetland threaten the waterbirds during their migration (Quesnelle *et al*., 2013; Martin *et al*., 2014; Wang *et al*., 2018).

The richness and abundance of waterbirds are influenced by the wetland characteristics, for example, depth variability, water quality, phyto and zooplankton, vegetation around the banks, invasive plants, area, water level fluctuation, and surrounding landscapes composition (Ma *et al*., 2010; Russel *et al*., 2014, Brandolin and Blendinger, 2016; Mischenko *et al*., 2020; Basaula *et al*., 2021). In addition, the seasonal food availability, temperature, and climate change also affect the population dynamics and arrival-departure dates of the waterbirds (Anguita and Simeone 2015; Donnelly *et al*., 2016; Park *et al*., 2017).

Taudaha Lake is only the potential stopover lake supporting winter migratory waterbirds in the Kathmandu Valley, Nepal. This small lake (4.20 ha) has experienced severe habitat destruction and human disturbances in the last decade (Riessen, 2017; Author personal observation). Many small hotels and huts for local visitors and a retention wall have been constructed, and people feed fish and birds. These activities have changed the natural setting of the lake, and the consequences of these changes can be observed in the migratory birds. However, detailed studies on how waterbirds utilize this highly disturbed lake during their north-south migration are lacking. Therefore, with increasing anthropogenic threats in the lake, it is necessary to understand how the bird populations are changing and the factors affecting their movement patterns. In this study, we aimed to understand, 1) the times of arrival and departure of winter migratory waterbirds in the lake, 2) whether their population changes or remains almost constant

throughout the migration period, 3) if the population changes, what drives them? We hypothesized that with decreasing temperature, waterbirds start to arrive at the lake from the breeding grounds in the north, and with increasing temperature, they depart to their breeding grounds.

MATERIALS AND METHODS

Study area: Taudaha Lake (27.6487° N, 85.2820° E) comprises 4.20 ha., and lies in the outskirts of the Kathmandu Valley (Fig. 1) at 1290 m elevation. It is a natural freshwater lake situated around 8 km from the central city on the bank of the Bagmati River. The maximum depth of the lake is 6 m. An ancient belief is that the lake was created by Manjushree as the home for serpents when he drained the water of Kathmandu Valley from Chovar. Taudaha is derived from the Newari language where '*Ta*' means snake and '*daha*' means lake. It is a sacred site belonging to the Hindu community, and many pilgrims visit during the festival of *Naag Panchami* (serpent festival), usually in June or July. It is still believed that *Karkotak* (King of Serpent) still lives in the middle of the lake. Most of the local people are from Newar ethnic communities, and farming is their primary occupation.

Methods: Both summer and winter visitor waterbirds come to Taudaha throughout the year. However, there are very few records of the summer visitors, for example, Black-crowned Night Heron (*Nycticorax nycticorax*), but now its stays throughout the year. So, we only monitored the long-distance winter migratory waterbirds, including different duck and cormorant species (see detail in Table 1; Fig. 2). The waterbirds were monitored from January 2019 to April 2020; however, they were recorded after their arrival in October 2019. We visited the lake twice a week, i.e., Saturday, where there are a higher number of visitors (average 955.41) and to avoid the influence of the people on Wednesday, when there are very few visitors (average 47.97). We monitored waterbirds for four hours (7.00 hrs to 11.00 hrs). Using binoculars, we directly counted all species seen in the lake and used field guide Birds of Nepal (Grimmett *et al*., 2000) for species identification when needed. We observed the species and counted their number at every 20 minutes intervals, so we recorded the data 12 times in an observation day. We recorded their exact departure date by continuous observation after their first-day absence. To confirm their complete departure date, we also searched them at 1 km periphery of the lake, i.e. the Bagmati River and the farmlands. In addition, we recorded the air temperature and humidity of the Taudaha Lake during the monitoring time to know the potential effects of these weather conditions on the arrival and departure of migratory waterbirds.

We used only the highest number of bird species counted in a day for analysis. The population data were log (x+1) transformed before analysis. We developed a linear model to understand the factors affecting the overall population change of the waterbirds in the lake (temperature, humidity, day of visit, and month). In addition, we performed the linear model to understand the impact of the same variables on four species of waterbirds having higher populations during our study periods, such as Great Cormorant (*Phalacrocorax carbo*), Gadwall (*Mareca strepera*), Mallard (*Anas platyrhynchos*), and Common Teal (*Anas crecca*). All analyses were performed in the R program (R Development Core Team, 2020).

RESULTS

We recorded 210 individuals of ten migratory waterbirds species in Taudaha from January 2019 to March 2020 (Table 1; Fig. 2). A higher number of individuals was found for Gadwall, followed by Common Teal, while single individuals of Northern Shoveler (*Spatula clypeata)*, Common Pochard (*Aythya ferina)*, and Indian Spot-billed Duck (*Anas poecilorhyncha*) were recorded during the study period (Table 1). Common Pochard is a globally threatened species (Vulnerable category).

Variables influence on the bird population migration: The waterbird started to arrive by October (first 1-10 individuals) and departed by the end of March (last 1-10 individuals) with the highest population in January (Table 1; Fig. 3). We found temperature and month as the most influencing factors for bird migration in Taudha Lake (Table 3). The waterbird population declined with increasing temperature (Fig. 4). Similarly, humidity also had a negative impact on the waterbird migration, but was not statistically significant (Table 2). A higher number of waterbirds was recorded on Saturday than Wednesday. Although the day of visit, temperature, month were influencing factors for Great Cormorant, for other birds (Gadwall, Common Teal, and Mallard), only the months had a significant role.

Table 1. Arrival and departure time of the waterbirds in Taudaha Lake. As we started monitoring from January 2019, the arrival time was calculated from October 2019.

Common name	Scientific name	First individual arrival date	Last individual departure date	Population range	IUCN Status
Great Cormorant	*Phalacrocorax carbo*	6 Nov 2019	23 March 2020	0-42	LC
Gadwall	*Mareca strepera*	26 Oct 2019	21 March 2020	0-75	LC
Mallard	*Anas platyrhynchos*	4 Dec 2019	18 March 2020	0-18	LC
Common Teal	*Anas crecca*	6 Nov 2019	21 March 2020	0-64	LC
Common Coot	*Fulica atra*	23 Oct 2019	21 March 2020	0-3	LC
Northern Shoveler	*Spatula clypeata*	4 Dec 2019	25 Dec 2019	0-1*	LC
Eurasian Wigeon	*Mareca penelope*	12 Jan 2019	20 Feb 2019	0-3*	LC
Indian Spot-billed Duck	*Anas poecilorhyncha*	23 Feb 2019	2 March 2019	0-1*	LC
Chinese Spot-billed Duck	*Anas zonorhyncha*	4 Jan 2020	29 Feb 2020	0-2*	LC
Common Pochard	*Aythya ferina*	1 Jan 2020	13 March 2020	0-1* #	VU

Note: *Some individual arrive and then depart and after some time another individual arrive and depart; # Bird was seen in January as earliest month and March as the last month. LC = Least Common, VU = Vulnerable

Table 2. Factors influencing the waterbirds migration in Taudaha Lake. Important variables are shown in bold.

Variables	Estimate	SE	*t*	*P*
(Intercept)	1.065	0.830	1.283	0.204
Humidity	-0.001	0.006	-0.234	0.815
Temperature	-0.057	0.025	-2.262	**0.027**
Day: Wednesday	-0.213	0.139	-1.527	0.132
Month: August	0.667	0.642	1.039	0.302
Month: December	4.520	0.526	8.584	**<0.001**
Month: February	4.704	0.507	9.277	**<0.001**
Month: January	4.637	0.519	8.927	**<0.001**
Month: July	0.498	0.612	0.814	0.418
Month: June	0.455	0.583	0.781	0.437
Month: March	3.723	0.503	7.396	**<0.001**
Month: May	0.215	0.590	0.366	0.716
Month: November	3.265	0.605	5.394	**<0.001**
Month: October	0.530	0.552	0.961	0.340
Month: September	0.590	0.640	0.922	0.360

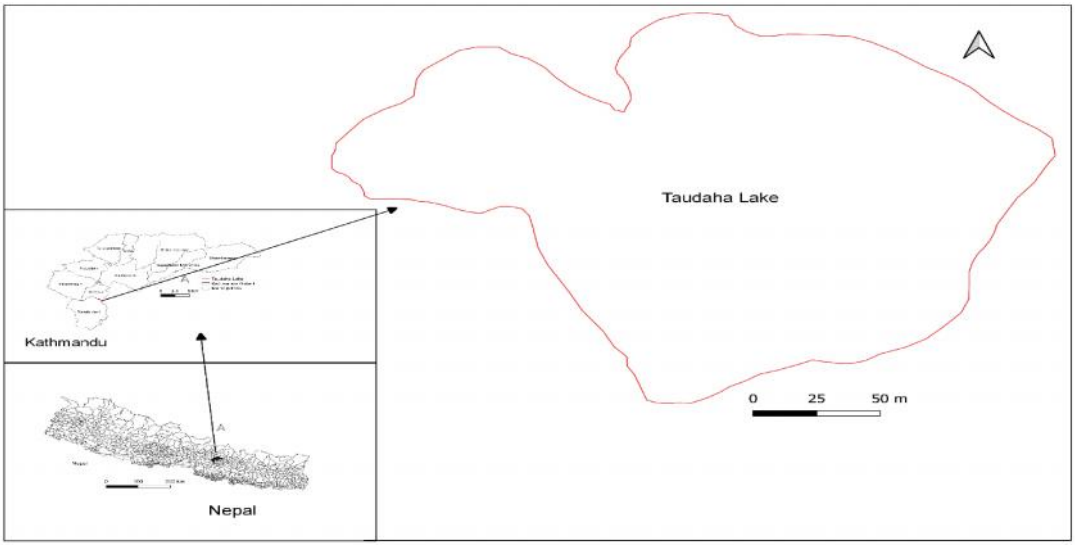

Fig. 1. Map of Taudha Lake, Kathmandu, Nepal.

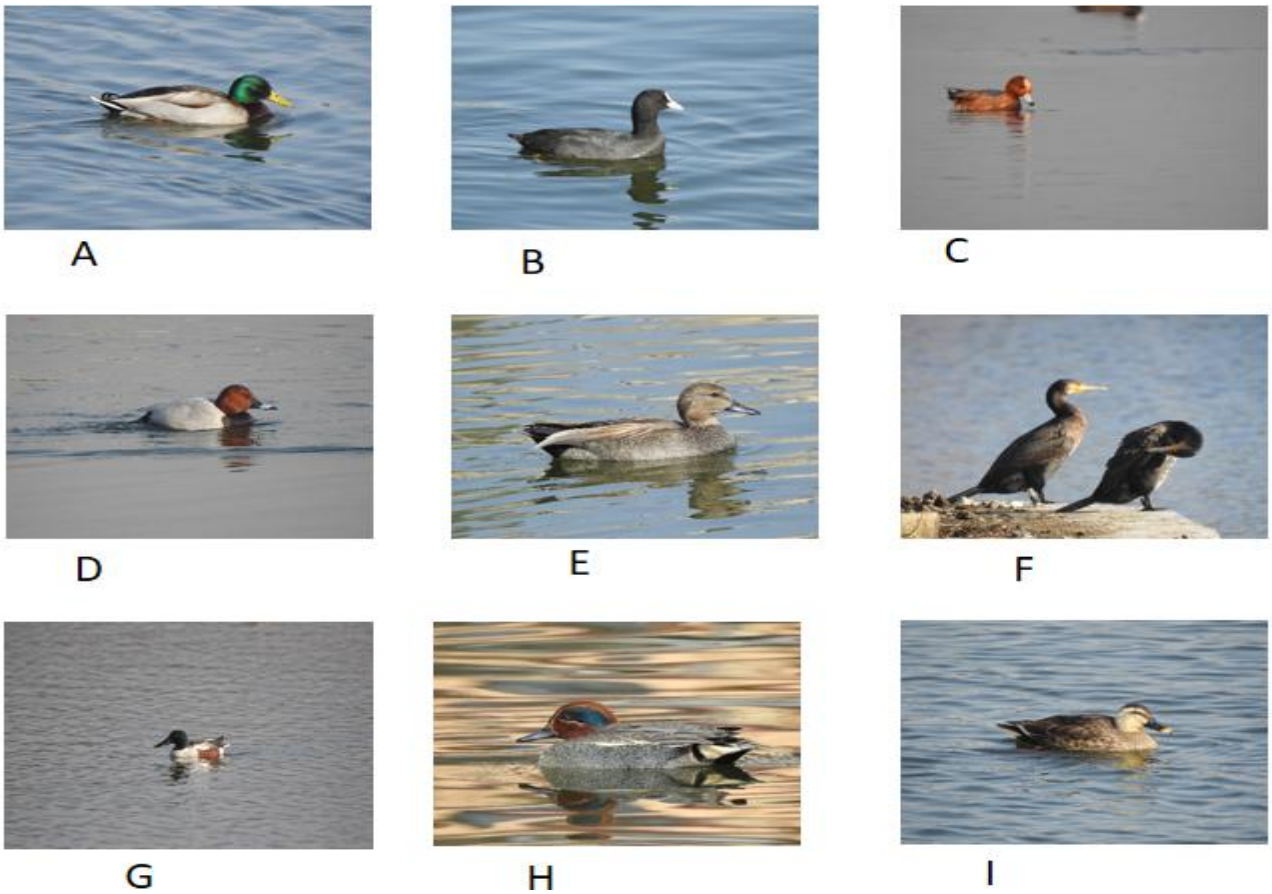

Fig. 2. Migratory water birds at Taudaha Lake. A- Mallard (*Anas platyrhynchos*), B- Common Coot (*Fulica atra*), C- Eurasian Wigeon (*Mareca penelope*), D- Common Pochard (*Aythya ferina*), E- Gadwall (*Mareca strepera*), F- Great Cormorant (*Phalacrocorax carbo*), G- Northern Shoveler (*Spatula clypeata*), H- Common Teal (*Anas crecca*), I- Chinese Spot-billed Duck (*Anas zonorhyncha*)

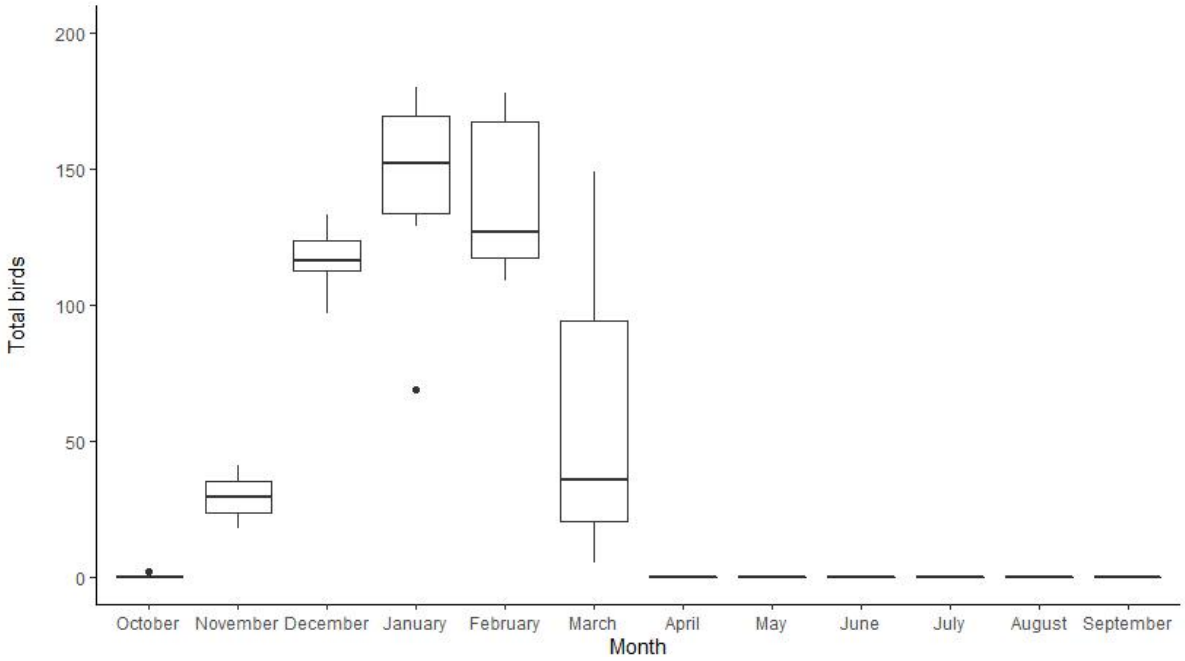

Fig. 3. Monthly waterbirds population in Taudaha Lake for the year 2019-2020

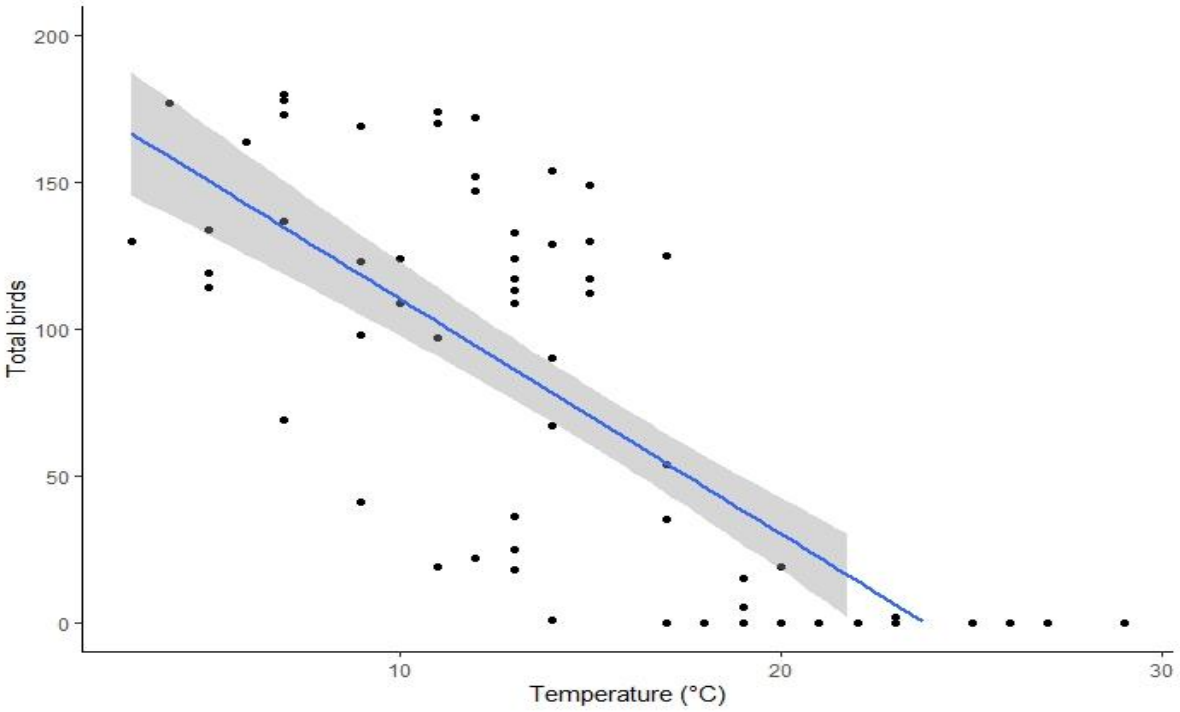

Fig. 4. Decline of waterbirds' population with increasing temperature in Taudaha Lake

DISCUSSION

Different migratory birds arrived and departed at Taudaha Lake at different time intervals. The variation in the timing of the migration of these waterbirds is primarily influenced by the weather system (Gunnarsson *et al*., 2006). With the start of decreasing temperature from October in Nepal, the winter migratory birds start to come to the lake, and with increasing temperature from March, the waterbirds start to depart from the lake, with the highest population recorded in January. This shows that the Taudaha Lake is a stopover site in Kathmandu for the long-distance winter migratory waterbirds.

The current record of ten species of waterbirds at Taudaha Lake for this year is low than in previous years (Riessen, 2017). Many factors such as using different routes far from Kathmandu Valley or anthropogenic activities might be acting on them. This species number represents around 7% of total migratory birds in Nepal. Although we counted 210 populations of waterbirds for the year, this number is very low compared to the previously recorded in the lake, almost 120% less than in 2007/8 and 30% less than in 2014-15 (Riessen, 2017). All waterbirds, especially Gadwall, Common Teal, and Mallard, had a higher population before, but now their population has declined rapidly (Riessen, 2017). In addition, Falcated Duck (*Mareca falcatae*), Tufted Duck (*Aythya fuligula*), and Garganey (*Spatula querquedula*) have not been recorded on the lake after 2003, 2008, and 2011, respectively (Riessen, 2017), which might be due to higher disturbances created by people (for example playing loud music players), concrete construction activities, lack of vegetation in and around the lake and land-use change within the lake periphery (Russel *et al*., 2014; Brandolin and Blendinger, 2016; Riessen, 2017; Authors personal observation). These birds are mainly herbivores feeding on seeds, grasses, leaves, and stems of aquatic vegetation supplemented by some invertebrates (Wilmon *et al*., 2014), and this food supply has been highly reduced in the lake and from the surrounding areas due to rapid construction works and land-use change. Not only in Taudaha, the population of waterbirds is declining throughout Nepal (Inskipp *et al*., 2016) and other Asian countries (Kasahara and Koyama, 2010; Wang *et al*., 2018). Although high human presence has a negative impact on the abundance of waterbirds (Martin *et al*., 2014; Zhang *et al*., 2017), we observed a slightly higher population in Saturday count (higher human presence day) as people used to feed the fish which might have attracted some of the birds like Mallard and Common Teal. But we firmly oppose feeding the birds in the lake as it might change their behavior, increases the chance of spreading diseases, and could affect their health (Wilcoxen *et al*., 2015; Hostetler *et al*., 2018; Evans and Gawlik, 2020).

The population of Common Pochard, Chinese Spot-billed Duck, Indian Spot-billed Duck, and Northern Shoveler at Taudaha Lake was low during this study as these waterbirds used Taudaha as a stopover site for a short duration during their migration to further south to

the lowland Nepal or India and vice versa (Inskipp *et al*., 2016; BirdLife International 2016 and 2019). The noticed population of Common Pochard in the lake is decreased since 2006 (Riessen, 2017). These birds are seen either during the arrival or departed time of migration or accidentally due to unfavorable weather condition.

Conclusions: Although a smaller area, Taudaha is the only stopover lake in Kathmandu for migratory waterbirds and is an important site. The migratory birds can be seen for a six-month period, which is highly regulated by the temperature of the study area. As the local government is further planning to develop additional infrastructures on the lake, we recommend local government not damage the further habitat of the lake as well as to control pollution on the Bagmati River near Taudaha Lake, as the river also provides shelter for the migratory waterbirds which are using the lake. In addition, Taudaha Lake could potentially be a place for watching birds for local and international tourists, but current disturbances and the feeding of waterbirds need to be highly restricted.

Acknowledgements: We thank Taudaha Lake Management Committee for providing free access and research permission to the sites. We are grateful to Hathan Chaudhary for bird identification and Arend van Riessen, and Kyle Tomlinson for providing suggestions on the research method and analysis. We thank anonymous reviewer for the constructive comments on the manuscript.

Authors' contribution: KBK, HBK and HPS conceived and designed the study; KBK collected data; KBK, HBK, SS and HPS analyzed the data; HBK and HPS wrote the first draft; and all authors revise and approve the final draft.

Conflict of interest: The authors declare there is no competing interests exist.

REFERENCES

Anguita, C. and A. Simeone (2015). Influence of seasonal food availability on the dynamics of seabird feeding flocks at a Coastal Upwelling Area. PloS ONE 10: e0131327.

Basaula, R., H.P. Sharma, J.L. Belant and K. Sapkota (2021). Invasive Water Hyacinth Limits Globally Threatened Waterbird Abundance and Diversity at Lake Cluster of Pokhara Valley, Nepal. Sustainability 13(24): 13700.

BirdLife International (2016). *Anas poecilorhyncha*. The IUCN Red List of Threatened Species: e.T22736541A95137190. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22736541A95137190.en. Accessed August 2020.

BirdLife International (2019). *Aythya ferina* (amended version of 2017 assessment). The IUCN Red List of Threatened Species : e.T22680358A155473754. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T22680358A155473754.en. Accessed August 2020.

Brandolin, P.G. and P.G. Blendinger (2016). Effect of habitat and landscape structure on waterbird abundance in wetlands of central Argentina. Wetl. Ecol. Manag. 24: 93–105.

Donnelly, A., R. Yu and H. Geyer (2016). Determining if Irish winter migrant waterbirds are changing their duration of stay as temperature warms. Biol. Environ - Proc. R. Ir. Acad. 116B: 75-86.

Evans, B.A., and Gawlik, D.E (2020). Urban food subsidies reduce natural food limitations and reproductive costs for a wetland bird. Sci. Rep. 10: 14021.

Grimmett, R., C. Inskipp and T. Inskipp (2000). Birds of Nepal. Helm field guide. New Delhi.

Gunnarsson, T.G., J.A. Gill, P.W. Atkinson, G. Gelinaud, P.M. Potts, R.E. Croger, A.G Gudmundsson, G.F. Appleton and W. J. Sutherland (2006). Population-scale drivers of individual arrival times in migratory birds. J. Anim. Ecol. 75: 1119-1127.

Hostetler, M.E., M.B. Main and M. Voigt (2018). Why shouldn't we feed water birds? U.S. Department of Agriculture, UF/IFAS Extension Service, University of Florida, IFAS, Florida A & M University Cooperative Extension Program, and Boards of County Commissioners Cooperating. https://edis.ifas.ufl.edu/pdffiles/UW/UW19300.pdf

Inskipp, C., H.S. Baral, S. Phuyal, T.R. Bhatt, M. Khatiwada, T. Inskipp, A.P. Khatiwada, S. Gurung, P. Singh, L. Murray, L.P. Poudyal and R. Amin (2016). The status of Nepal's Birds: The national red list series. Zoological Society of London, UK.

Kasahara, S. and K. Koyama (2010). Population trends of common wintering waterfowl in Japan: participatory monitoring data from 1996 to 2009. Ornithol. Sci. 9: 23-36.

Martin, B., S. Delgado, de la A. Cruz, S. Tirado and M. Ferrer (2014). Effects of human presence on the long-term trends of migrant and resident shorebirds: evidence of local population declines. Anim. Conserv. 18: 73-21.

Ma, Z., Y. Cai, B. Li and J. Chen (2010). Managing wetland habitats for waterbirds: an international perspective. Wetlands 30: 15-27.

Mischenko, A., A.D. Fox, S. Švažas, O. Sukhanova, A. Czajkowsi, S. Kharitonov, Y. Lokhman, O. Ostrovsky and D. Vaitkuviene (2020). Recent changes in breeding abundance and distribution of the Common pochard (*Aytha ferina*) in its eastern range. Avian. Res. 11: 1-14.

Palm, E.C., S.H. Newman, D.J. Prosser, X. Xiao, L. Ze, N. Batbayar, S. Balachandran and Y.Takekawa (2015). Mapping migratory flyways in Asia using dynamic Brownian bridge movement models. Mov. Ecol. 3:3.

Park, Y.W., H.G. Lee and J.K. Choi (2017). A study on the population fluctuation of wintering waterbirds on Wonju-Stream by the Temperature. Korean J. Environ. Ecol. 31: 135-151.

Prins, H.H.T. and T. Namgail (2017). Bird Migration across the Himalayas. Cambridge University Press, Cambridge, UK.

Quesnelle, P.E., L. Fahrig and K.E. Lindsay (2013). Effects of habitat loss, habitat configuration and matrix composition on declining wetland species. Biol. Conserv. 160:200-208.

R Development Core Team (2019). R: a language and environment for statistical computing. Vienna: R Foundation for Statistical Computing.

Riessen, A.V (2017). The Birds of the Bagmati and Taudaha Area, 2003-2016. Vajra books, Kathmandu, Nepal 362pp.

Russell, I.A., R.M. Randall, and N. Hanekom (2014). Spatial and temporal patterns of waterbird assemblages in the wilderness lakes complex, South Africa. Waterbirds 37: 1-18.

Wang, X., F. Kuang, K. Tan, and Z. Ma (2018). Population trends, threats, and conservation recommendations for waterbirds in China. Avian. Res. 9: 1-14.

Wilcoxen, T.E., D.J. Horn, B.M. Hogan, C.N. Hubble, S.J. Huber, J. Flamm, M. Knott, L. Lundstrom, F. Salik, S.J. Wassenhove, and E.R. Wrobel (2015). Effects of bird-feeding activities on the health of wild birds. Conserv. Physiol. 3: 1-13.

Wilman, H., J. Belmaker, J. Simpson, C. Rosa, M.M. Rivadeneira and W. Jetz (2014) EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals. Ecol. 95:2027.

Zhang, Y., S. Jiao, Y. Jia, Q. Zeng, D. Feng and G. Lei (2017). Spatial and temporal variations in waterbird communities and its implications for ecosystem management in a large temperate arid wetland of northwest P.R. China. Avian Biol. Res. 10: 119-128.