Pakistan J. Zool., pp 1-9, 2022. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20220224070218

Avian Diversity, Abundance and Habitat Suitability Index for Threatened Species in Selected Areas of Northern Pakistan

Rida Ahmad[1,2]*, Zulfiqar Ali[2]*, Farkhanda Manzoor[1], Usman Ahmad[3], Safdar Sidra[4], Irfan Zainab[2], Muhammad Furqan[2], Aliza Batool[1,2] and Zaidi Zona[2]

[1]*Department of Zoology, Lahore College for Women University, Lahore, Pakistan*
[2]*Environmental Health and Wildlife Laboratory, Institute of Zoology, University of the Punjab, Lahore, Pakistan*
[3]*College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan*
[4]*Department of Wildlife and Ecology, University of Veterinary and Animal Sciences, Lahore, Pakistan*

Article Information
Received 24 February 2022
Revised 05 May 2022
Accepted 24 May 2022
Available online 21 July 2022
(early access)

Authors' Contribution
ZA and RA conceptualized the study. RA, ZA, UA, IZ, MF, ZZ, AB and SS collected the data from field. RA, SS and ZA compiled the data. RA, UA, FM and MF drafted the manuscript. ZA reviewed and improved the manuscript.

Key words
Avian diversity, Habitat suitability, Land use, Steppe eagle, Western tragopan

ABSTRACT

Land use type changes the carrying capacity of habitats to support species diversity and maintain viable population. Avian studies provide substantial information about these changes as birds are predictor of ecological disturbances. The current research explored the avian diversity, richness, abundance and their feeding habit in selected habitats of Khyber Pakhtunkhwa (KP) and Gilgit Baltistan (GB). Data were collected from May 2017 to October 2017 using point count technique. Thirty points were selected from each habitat. A total of 175 species and 24,933 individuals belonging to 16 orders and 55 families were recorded. Human settlements had the highest species richness (106) while Dry Temperate habitat had the highest value of species diversity (H'=3.71). The most abundant species were Common Myna *Acridotheres tristis* (RA=8.599), Carrion Crow *Corvus corone* (7.486), Large-billed Crow *Corvus macrorhynchos* (6.240). Two threatened bird species Steppe Eagle *Aquila nipalensis* and Western Tragopan *Tragopan melanocephalus* were observed. Habitat suitability index (HSI) of former species was maximum in rangelands (0.82) even though it was also observed in six habitats. Furthermore, Western Tragopan was found only in moist temperate habitat with HSI 0.70. The current study revealed that suitable habitat of these species is shrinking mainly due to habitat loss, its fragmentation and hunting pressure. Species prefer habitat with specific characteristics and this paper provides recommendations for the conservation and management of Steppe Eagle and Western Tragopan. Primary and secondary data based further studies are needed to manage the population of threatened species.

INTRODUCTION

The association between different habitat types and avian diversity is an important topic and for that matter, various researchers have explored the avian diversity in different rural and urban areas (Strohbach *et al*., 2013; Barth *et al*., 2015) and forestland (Mikusiński *et al*., 2001). With the time, overexploitation, pollution, habitat destruction and climate change have caused reduction in biodiversity (Butchart *et al*., 2005), and comparative analysis of different geographical regions gives perceptions to the mechanisms involved with the change in biodiversity (Dornelas *et al*., 2014).

In avian studies, species richness and relative abundance are common to measure the diversity (Harisha and Hosetti, 2009) along with metrics that take relative abundance into account (Dornelas *et al*., 2014). Furthermore, species richness is an important factor for biological community and the factors affecting biodiversity need to be understood (Hurlbert, 2004). It must also be kept in mind that species richness has various technical limitations to be considered as a metric for biodiversity change (Hillebrand *et al*., 2017). In the current study, we have used it to report number of species in different habitats sampled within the same time period.

* Corresponding author: ridaahmad411@gmail.com, zali.zool@pu.edu.pk
0030-9923/2022/0001-0001 $ 9.00/0

Furthermore, to study the spatial ecology, it is important to understand the relationship between species diversity and habitat heterogeneity (de Bonilla *et al*., 2012), as the latter is important predictor of species richness (Koh *et al*., 2006) and affects the ecological processes in many ways (Fahrig and Nuttle, 2005). It includes increase or decrease in size of species population (Cramer and Willing, 2005) and fluctuations in the composition of feeding guilds (Sekercioglu *et al*., 2004).

Bird abundance and composition vary with the change in vegetation and habitat characteristics (Blake, 2007). Habitat structure influences diet, microhabitat and body size; feeding guilds can be used to predict the impact of habitat change on species (Raman, 1998). Furthermore, habitat structure is an important factor that contributes to fluctuations in species richness, diversity, distribution and habitat selection (Watson *et al*., 2004; Mohd-Azlan *et al*., 2015). Habitat is a vital component for the survival of any species and as ecosystems are experiencing a variety of challenges such as, deforestation, over exploitation, over grazing and loss of natural habitat (Baig and Al-Subaiee, 2009), their extent needs to be studied and evaluation of status and patterns of these ecological systems in different geographic regions is also important. Habitat suitability Index helps in assessing the capacity of a specific habitat to support a particular species in existing conditions (Theuerkauf and Lipcius, 2016).

Pakistan is blessed with a variety of vegetation, climatic conditions and endemic species and classified among the countries that support more than 400 migratory bird species per year (Galbraith, 2014). Kohistan meaning "The Land of Mountains", in Khyber Pakhtunkhwa province of Pakistan is having the most diverse geomorphic mountainous terrains, as it is located in an area where the Eurasian land plate and Indian subcontinent collide (Food and Agriculture Organization, 2017). The current research was focused on avian species distribution in eleven habitats of the study area, which are defined on the basis of land cover which is extracted from Pakistan Forest Institute "Land Cover Atlas of Pakistan" (Bukhari *et al*., 2012) and to study the habitat suitability of threatened species in the area.

MATERIALS AND METHODS

Study area

The study area extends from Raikot Bridge to Thakot Bridge downstream of River Indus in Gilgit Baltistan (GB) and KP province of Pakistan. The study was primarily focused along the River Indus and Karakoram Highway (KKH) along with associated valleys with elevation range of 871 to 3668m above sea level and it traverses district Diamer of Gilgit Baltistan and Kohistan and Shangla districts of Khyber Pakhtunkhwa. Geographically, the study area lies between 35.75510 N and 74.38260 E, and is very diverse in geomorphological terms. The annual mean temperature ranges from 2.15 to 18.55°C in different habitats of the study area. The range of precipitation is 344.94 to 922.12 mm while elevation varies from 871.99 to 3668.82 m.

Equipment

The equipment used for this study included GPS, binoculars, digital camera (Nikon p-900), spotting scope and field Guides of Roberts (1991, 1992); Mirza and Wasiq (2007) and Grimmett *et al*. (2008).

Survey method

Point count method (Verner, 1985) was used to observe species in different habitats of study area (Fig. 1). Around 330 survey points (thirty points from each habitat) were covered during the course of six months covering a total area of 11,407 km^2. The surveys were conducted mainly at dawn and dusk. All habitat types were covered in each visit and repeated sampling was done during the course of six months. At each point, we spent ten minutes for observation. Area of each habitat is given in Table I. During the survey, species name, time, count and location were recorded on the field data sheets.

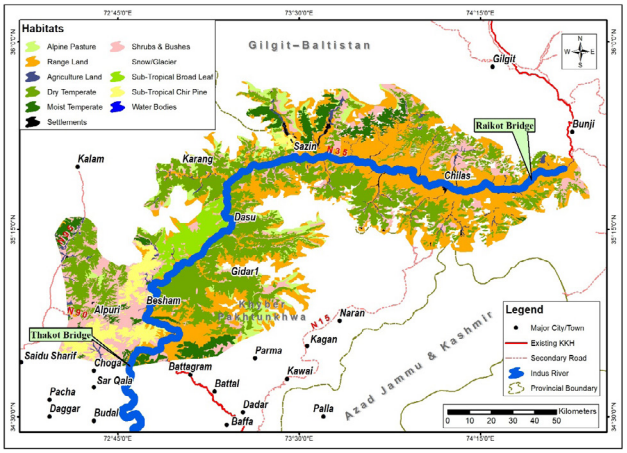

Fig. 1. Different habitat types in the study area.

In addition, targeted surveys were conducted for threatened species based on the known distribution areas available through literature. Western Tragopan *Tragopan melanocephalus* was of major concern, being a range-restricted species. Total 130 interviews were also conducted with regional wildlife department officials and local community to acquire information about different species.

Table I. Environmental parameters of each habitat.

Sr. No.	Habitat	Area (km^2)	Temperature (^oC)	Precipitation mm	Elevation (m)	
					Min.	Max.
1	Rangeland	3,700	9.91	531.55	464.53	4783.88
2	Dry temperate	3,446	9.04	641.94	668.33	4213.61
3	Shrubs and Bushes	1,596	10.48	721.47	504.26	4391.93
4	Moist temperate	619	9.87	687.26	512.62	4120.36
5	Alpine pasture	525	3.76	633.08	1542.27	4632.75
6	Sub-tropical chir pine	501	12.98	922.12	566.35	3775.09
7	Snow and glaciers	396	2.15	524.81	1935.27	4955.56
8	Sub-tropical broad-leaved	350	12.09	705.61	700.83	3806.62
9	Agriculture land	175	13.49	544.94	566.43	3194.10
10	Settlements	55	15.97	344.97	511.77	3773.23
11	Water bodies	45	18.55	462.69	461.77	1279.13

The feeding habits of the species were acquired from available published literature and the species status and trends from official website of International Union for Conservation of Nature (IUCN).

Habitat types

For current study, eleven habitat types (Fig. 1) were selected after consulting Pakistan Forest Institute land use from Land Cover Atlas of Pakistan (Bukhari *et al*., 2012). These habitats include Agriculture Land, Alpine Pastures, Dry Temperate forests, Moist Temperate forests, Rangelands, Settlements, Shrubs and Bushes, Snow and Glaciers, Sub-tropical Broad-leaved forest, Sub-tropical Chir Pine forest and Water Bodies (see details in Supplementary Table SI).

Data analysis

Relative abundance (RA) was calculated by dividing number (count) of individual birds by total number of birds in the area.

Shannon wiener index (H' was calculated using the following formula.

$H' = [\Sigma\ pi\ ln\ pi]$

Where pi is the ratio of individual species count and total number of individuals observed in the area.

Habitat suitability index of threatened species was estimated using the following formula (Hess and Bey, 2000):

$HSI= (SI_1+SI_2+SI_3+SI_4\ldots\ldots\ldots\ldots+SI_n)/n$

The score ranged from 0 (least suitable) to 1 (highly suitable). Further categorization of the score is given in Table II. Different parameters were selected for each species to calculate the index. Parameters for Steppe Eagle included cultivated land, presence of lake/wetland, food availability, vegetation cover, presence of scattered trees/grassland, disturbances, geographic location and presence of breeding sites. On the other hand, for Western Tragopan the variables included, influence of human population, water availability, food availability, vegetation cover, hunting pressure, habitat fragmentation, disturbance and presence of breeding sites. The weightage for each parameter was assigned based on sightings, filed observations, species biology and wildlife experts' opinion (Möltgen *et al*., 1999).

Table II. Habitat suitability index score categorization.

Category	HSI score	Suitability
Poor	< 0.50	Least suitable
Below average	0.50 - 0.59	
Average	0.60 - 0.69	Less suitable
Good	0.70 - 0.79	Moderately suitable
Excellent	> 0.8	Highly suitable

RESULTS

A total of 24,933 individuals of 175 species (Supplementary Table SII) were observed in the study area belonging to 16 orders (Fig. 2) and 55 families. Species richness was maximum (106) in settlements followed by agriculture land (Fig. 3). Maximum abundance was observed in rangelands (4,387/24,933, 17.59%) followed by settlements (4,357/24,933, 17.47%) while least number of individuals were observed in snow and glaciers (21/24,933, 0.08%). The bird abundance in descending order is given as: rangeland > settlements > agriculture land > dry temperate > moist temperate > alpine pasture > sub-tropical broad-leaved > shrubs and bushes > sub-tropical chir pine > water bodies > snow and glaciers. The

details of environmental parameters such as elevation, temperature and precipitation of each habitat are provided in Table I. The most abundant species in the study area were common myna *Acridotheres tristis* (RA=8.599), carrion crow *Corvus corone* (7.486), large-billed crow *Corvus macrorhynchos* (6.240), Himalayan bulbul or white-cheeked bulbul *Pycnonotus leucogenys* (5.905) and red-vented bulbul *Pycnonotus cafer* (5.801). Dry temperate had the highest species diversity values (H'=3.71) followed by settlements (H'=3.53) (Fig. 4). According to the current study, the area supports 71 summer breeders, 51 year-round resident, 35 winter migrants, 17 passage migrants while status of one species is unknown.

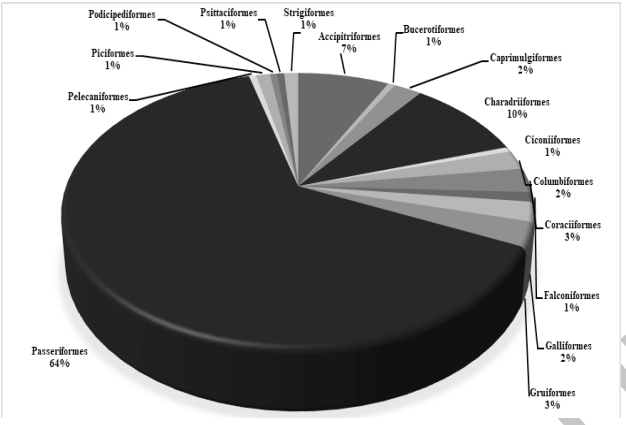

Fig. 2. Species distribution based on taxonomic orders.

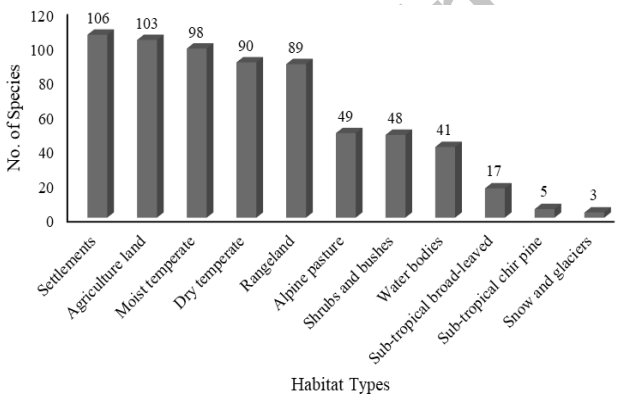

Fig. 3. Species richness in various habitats of study area.

Different species have different vegetation preferences. Some species were found in more than one selected habitat while some species were found in only one habitat. Plumbeous water redstart *Phoenicurus fuliginosus* and red-vented bulbul were common in ten habitats while four species were common in nine habitats that included common myna, grey wagtail *Motacilla cinerea*, white wagtail *Motacilla alba* and Yellow-billed Blue Magpie *Urocissa flavirostris*. Forty-three species were recorded in only one habitat (Supplementary Table SII).

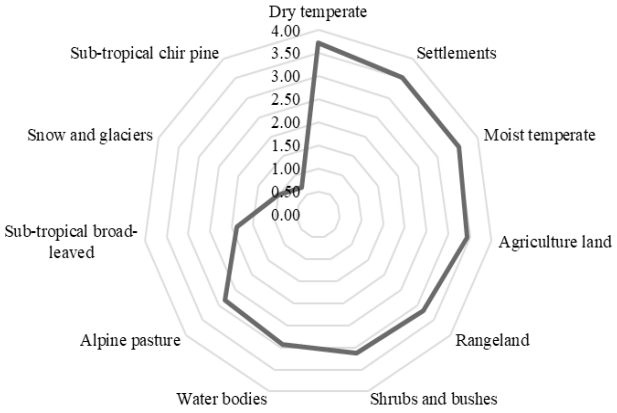

Fig. 4. Shannon wiener diversity index of elven habitats.

The foraging habits of birds were assessed to find the variation in avifauna composition in various habitat types. Among five feeding habits assessed in the study, insectivorous species were the most abundant specially in settlements followed by agriculture land. Out of total, 50% species were insectivorous while 20% species were granivorous followed by 14% carnivorous. Only 10% species were omnivorous while only 6% frugivorous species were found in the study area.

The abundance and number of species varied with reference to habitat, because food availability and diversity changed with habitat. Distribution of species on the basis of food habits is provided in Table III.

According to the IUCN Red list, 168 species are least concern while five species are near threatened and two are endangered. Among threatened species, Western Tragopan is categorized as vulnerable and steppe eagle is endangered. The habitat suitability index was also estimated for these two species. During the study, Steppe eagle was observed in six habitats including agriculture land, moist temperate, rangeland, settlements, shrubs and bushes and sub-tropical broad leaved forest. Rangeland was estimated to be highly suitable with value 0.82 followed by agriculture land (0.78, suitable) and shrubs and bushes (0.61, less suitable). Settlements was the least suitable habitat while sub-tropical broad-leaved and moist temperate fell under the "poor" category with score 0.48 and 0.45, respectively.

Western tragopan is a range-restricted species and it was found only in one habitat (moist temperate). The HSI was estimated to be 0.70 suggesting that the habitat was moderately suitable for the species.

Table III. Species distribution on the basis of food habit in different land use types.

Habitat	Feeding guild				
	Carni-vore	Frugi-vore	Grani-vore	Insec-tivore	Omni-vore
Agriculture land	13	5	20	54	11
Alpine pasture	4	1	10	29	5
Dry temperate	9	5	15	50	11
Moist temperate	12	4	21	51	10
Rangeland	9	5	17	50	8
Settlements	12	4	19	57	14
Shrubs and Bushes	7	2	11	22	6
Snow and Glaciers	0	0	1	2	0
Sub-tropical broad-leaved	3	1	2	8	3
Sub-tropical chir pine	0	1	1	1	2
Water bodies	6	3	3	25	4

DISCUSSION

Determining the relationship among various habitats and avian diversity is a very important aspects of research. Among the selected habitats, maximum number of species were recorded in human settlements. Gatesire *et al*. (2014) also recorded maximum number of species in informal settlements in Northern Rwanda. The presence of maximum species in a habitat depends on variety of factors, primarily food availability, shelter or security and nesting-space. Settlements provide abundant food and more scavenging opportunities (Girma *et al*., 2017). In the study area, agriculture land also supports many resident and migratory birds. High abundance of birds in agriculture landscape has also been observed in other studies (Muñoz-Sáez *et al*., 2017). Topographic variability along with geomorphological variation of the habitats can be a significant factor for variability in species richness and diversity in different habitats (McCain, 2009). Also, diversity in grazing-patterns in different habitats is one of the factors in varying species richness (Benton *et al*., 2003).

Results showed that rangelands supported maximum number of individuals while snow and glaciers supported the least number of individuals. The reason of the least number being the small proportion of snow and glaciers terrain within the overall study area as compared to other habitats. Change in vegetation and urban developments impact the species richness and diversity causing threat to some species (Lerman *et al*., 2014; Tu *et al*., 2020). The most abundant species of study area were common myna, carrion crow, large-billed crow and Himalayan bulbul. These species were also reported by Roberts (1992) in the study area. Aforementioned species were found in all habitats due to their stability in various habitats and these must survive the changes in the habitat (Goerck, 1997). It has also been observed that structure of vegetation impacts the species diversity and there is positive correlation between species diversity, richness and vegetation structure (Lewis and Starrzomski, 2015). Fluctuation in species richness and decrease in number of individuals can be due to threat of predation, lower heterogeneity or diversity of habitat and absence of adequate foraging trees (Shochat *et al*., 2010; Pennington and Blair, 2011). According to McWethy *et al*. (2009) and Correia *et al*. (2020), bird abundance can also decrease due to canopy cover in forests.

Insectivorous birds were the most abundant especially in agriculture land, as birds play an important role as predators of insect pests in agriculture land as natural helpers of farmers (Jedlicka *et al*., 2011; Barbaro *et al*., 2012; Kross *et al*., 2016). In accordance with the current study, Girma *et al*. (2017) have also observed that maximum abundance of granivores was also found in agriculture land. The habitat provided vegetation cover for breeding, foraging and resting for different avian species. Inputs or intensification by the workers maintaining the agriculture landscape can also cause an increase in bird richness and diversity in forest areas (Kremen and Miles, 2012; Tuck *et al*., 2014).

Alpine pastures are found at relatively higher elevation i.e., above tree-line, support diverse vegetation and invertebrate species providing the food for mammals, reptiles and birds. Western tragopan was also observed in the study area by Raja *et al*. (1999) according to IUCN red list (IUCN, 2018). These pheasants were found in internationally recognized biodiversity hotspot in the study area i.e., Palas valley, which is also an important bird area. This species is restricted range (Grimmett *et al*., 2008) and such species are more likely to get extinct due to loss of respective habitats (McKinney, 1997). The habitat suitability index of western tragopan was estimated to be 0.70 and the major factors that caused decline in HSI were habitat loss and hunting pressure.

Rangelands supported a great number of individuals because of its temperature and habitat conditions for various plant, animal, reptile and invertebrate species making the area appropriate for bird foraging, resting and breeding (Warren and Baines, 2004; Krausman *et al*., 2009). Shrubs and bushes provided foraging, breeding and resting habitat for avian species and suggested that these could also serve as important foraging habitats (Stevenson and Fanshawe, 2004). Steppe eagle is a globally endangered species

(IUCN, 2018) found also in the two aforementioned habitats because of their varied vegetation height, sedges, forbs and grasses (Cody, 1968; Wiens, 1969; Fisher and Davis, 2010).

Although steppe eagle was found in six habitats but only one habitat (rangeland) fell under the category of highly suitable as per HSI score. The species prefers the habitat with scattered trees, open country, bare lands and feeds on lizards, insects etc., (Roberts, 1991). As compared to other habitats Rangelands fulfil most of these requirements. The major factor that may decrease the HSI score of this habitat would be reduction in breeding sites and increase in disturbance.

Moreover, Water bodies was one of the main habitats of the study area that provided food for various insectivorous and carnivorous species (Masifwa *et al*., 2001; Meerhoff *et al*., 2003; Toft *et al*., 2003). Information about relationship of bird abundance and their association with habitat based on habitat preference is lacking in previous studies (Rajpar and Zakaria, 2011). However, studies have provided the linkage of species distribution with water bodies (Brown and Dinsmore, 1986). It was noticed that the structure of habitat and its vegetation is the key determinant of habitat selection for birds (Lancaster *et al*., 1979; Lee and Rotenberry, 2005). Birds associated with water bodies have adapted to specific vegetation structure and composition that also influences the species diversity and richness of specific habitat (Rajpar and Zakaria, 2011).

CONCLUSIONS

In conclusion, the study area is diversity rich and efforts are needed to explore it further. Species vary in different habitats based on their specific requirements for food, shelter, breeding grounds etc. It is important to conserve their natural habitat for species conservation.

RECOMMENDATIONS

The following recommendations have been devised for threatened species on the basis of extensive baseline surveys of the study area and the species ecology.

Western Tragopan is a range restricted species and there must be law enforcement to reduce the habitat destruction and illegal hunting. This species is very shy and for that matter, it is important to minimize the disturbance in its core habitat and awareness campaigns may be an initiative.

Steppe eagle was found in six habitats; the species became endangered mainly because of reduced breeding sites and habitat fragmentation. The safety of breeding sites must be ensured by officials of wildlife department and through community awareness campaign because the community is not aware of this species and its significance.

Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20220224070218

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Baig, M.B. and Al-Subaiee, F.S., 2009. Biodiversity in Pakistan: Key issues. *Biodiversity*, **10**: 20-29. https://doi.org/10.1080/14888386.2009.9712858

Barbaro, L., Brockerhoff, E.G., Giffard, B. and van Halder, I., 2012. Edge and area effects on avian assemblages and insectivory in fragmented native forests. *Landsc. Ecol.,* **27**: 1451-1463. https://doi.org/10.1007/s10980-012-9800-x

Barth, B.J., Gibbon, S.I. and Wilson, R.S., 2015. New urban developments that retain more remnant trees have greater bird diversity. *Landsc. Urban Plan.,* **136**: 122-129. https://doi.org/10.1016/j.landurbplan.2014.11.003

Benton, T.G., Vickery, J.A. and Wilson, J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol. Evol.,* **18**: 182-188. https://doi.org/10.1016/S0169-5347(03)00011-9

Blake, J.G. 2007. Neotropical forest bird communities: A comparison of species richness and composition at local and regional scales. *Condor,* **109**: 237-255. https://doi.org/10.1093/condor/109.2.237

Brown, M. and Dinsmore, J.J., 1986. Implications of marsh size and isolation for marsh bird management. *J. Wildl. Manage.,* **50**: 392-397. https://doi.org/10.2307/3801093

Bukhari, S., Haider, A. and Laeeq, M., 2012. *Land cover atlas of Pakistan: Pakistan Forest Institute Peshawar*. The Printman Peshawar, Pakistan.

Butchart, S.H.M. Stattersfield, A.J., Bennun, L.A., Akçakaya, H.R., Baillie, J.E.M., Stuart, S.N., Hilton-Taylor, C. and Mace, G.M., 2005. Using Red List Indices to measure progress towards the 2010 target and beyond. *Philos. Trans. R. Soc. Lond. B Biol. Sci.,* **360**: 255–268. https://doi.org/10.1098/rstb.2004.1583

Cody, M.L., 1968. On the methods of resource division in grassland bird communities. *Am. Nat.,* **102**: 107-147. https://doi.org/10.1086/282531

Correia, I., do Nascimento, E.R. and Gouveia, S.F.,

2020. Effects of climate and land use gradients on avian phylogenetic and functional diversity in a tropical dry forest. *J. Arid Environ.,* **173**: 104024. https://doi.org/10.1016/j.jaridenv.2019.104024

Cramer, M.J. and Willig, M.R., 2005. Habitat heterogeneity, species diversity and null models. *Oikos,* **108**: 209-218. https://doi.org/10.1111/j.0030-1299.2005.12944.x

de Bonilla, E.P. León-Cortés, J.L. and Rangel-Salazar, J.L., 2012. Diversity of bird feeding guilds in relation to habitat heterogeneity and land-use cover in a human-modified landscape in southern Mexico. *J. trop. Ecol.,* **28**: 369-376. https://doi.org/10.1017/S026646741200034X

Dornelas, M., Gotelli, N.J., McGill, B., Shimadzu, H., Moyes, F., Sievers, C. and Magurran, A.E., 2014. Assemblage time series reveal biodiversity change but not systematic loss. *Science,* **344**: 296-299. https://doi.org/10.1126/science.1248484

Fahrig, L. and Nuttle, W.K., 2005. Population ecology in spatially heterogeneous environments. In: *Ecosystem function in heterogeneous landscapes* (eds. G.M. Lovett, M.G. Turner, C.G. Jones and K.C. Weathers). Springer, New York.

Fisher, R.J. and Davis, S.K., 2010. From Wiens to Robel: a review of grassland-bird habitat selection. *J. Wildl. Manage.,* **74**: 265-273. https://doi.org/10.2193/2009-020

Food and Agriculture Organization, 2017. *Land cover atlas of Pakistan: The Punjab Province, the Khyber Pakhtunkhwa Province and federally administered tribal areas*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Galbraith, C.A., 2014. *A review of migratory bird flyways and priorities for management*. Bonn, Germany: UNEP/CMS Secretariat.

Gatesire, T., Nsabimana, D., Nyiramana, A., Seburanga, J. and Mirville, M., 2014. Bird diversity and distribution in relation to urban landscape types in Northern Rwanda. *Sci. World J.,* Article ID 157824. https://doi.org/10.1155/2014/157824

Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T., 2017. Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south-central Ethiopia. *Ecol. Evol.,* **7**: 3397-3405. https://doi.org/10.1002/ece3.2926

Goerck, J.M., 1997. Patterns of rarity in the birds of the Atlantic forest of Brazil. *Biol. Conserv.,* **11**: 112-118. https://doi.org/10.1046/j.1523-1739.1997.95314.x

Grimmett, R., Roberts, T.J., Inskipp, T. and Byers, C., 2008. *Birds of Pakistan*. A and C Black.

Harisha, M. and Hosetti, B., 2009. Diversity and distribution of avifauna of Lakkavalli range forest, Bhadra wildlife sanctuary, Western Ghat, India. *Ecoprint. Int. J. Ecol.,* **16**: 21-27. https://doi.org/10.3126/eco.v16i0.3469

Hess, G. R. and Bay, J. M., 2000. A regional assessment of windbreak habitat suitability. *Environ. Monit. Assess.,* **6**: 239-256. https://doi.org/10.1023/A:1006175323330

Hillebrand, H., Blasius, B., Borer, E.T., Chase, J.M., Downing, J.A., Eriksson, B.K., Filstrup, C.T., Harpole, W.S., Hodapp, D., Larsen, S. and Lewandowska, A.M., 2018. Biodiversity change is uncoupled from species richness trends: Consequences for conservation and monitoring. *J. appl. Ecol.,* **55**: 169-184. https://doi.org/10.1111/1365-2664.12959

Hurlbert, A.H., 2004. Species energy relationships and habitat complexity in bird communities. *Ecol. Lett.,* **7**: 714-720. https://doi.org/10.1111/j.1461-0248.2004.00630.x

IUCN, 2018. *The IUCN red list of threatened species. Version 2018-1*. International Union for Conservation of Nature and Natural Resources. Available at: https://www.iucnredlist.org/ (assessed on 24 June 2018)

Jedlicka, J.A., Greenberg, R., and Letourneau, D.K., 2011. Avian conservation practices strengthen ecosystem services in California vineyards. *PLoS One,* **6**: e27347. https://doi.org/10.1371/journal.pone.0027347

Koh, C.N., Lee, P.F. and Lin, R.S., 2006. Bird species richness patterns of northern Taiwan: Primary productivity, human population density, and habitat heterogeneity. *Divers. Distrib.,* **12**: 546-554. https://doi.org/10.1111/j.1366-9516.2006.00238.x

Krausman, P.R., Naugle, D.E., Frisina, M.R., Northrup, R., Bleich, V.C. and Block, W.M., 2009. Livestock grazing, wildlife habitat, and rangeland values. *Rangelands,* **31**: 15-19. https://doi.org/10.2111/1551-501X-31.5.15

Kremen, C. and Miles, A., 2012. Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecol. Soc.,* **17**: 40. https://doi.org/10.5751/ES-05035-170440

Kross, S.M., Kelsey, T.R., McColl, C.J. and Townsend, J.M., 2016. Field-scale habitat complexity enhances avian conservation and avian-mediated pest-control services in an intensive agricultural crop. *Agric. Ecosyst. Environ.,* **225**: 140-149. https://doi.org/10.1016/j.agee.2016.03.043

Lancaster, R.K. and Rees, W.E., 1979. Bird communities

and the structure of urban habitats. *Can. J. Zool.,* **57**: 2358-2368. https://doi.org/10.1139/z79-307

Lee, P.Y. and Rotenberry, J.T., 2005. Relationships between bird species and tree species assemblages in forested habitats of eastern North America. *J. Biogeogr.,* **32**: 1139-1150. https://doi.org/10.1111/j.1365-2699.2005.01254.x

Lerman, S.B., Nislow, K.H., Nowak, D.J., DeStefano, S., King, D.I. and Jones-Farrand, D.T., 2014. Using urban forest assessment tools to model bird habitat potential. *Landsc. Urban Plan.,* **122**: 29-40. https://doi.org/10.1016/j.landurbplan.2013.10.006

Lewis, K.P. and Starzomski, B.M., 2015. Bird communities and vegetation associations across a treeline ecotone in the Mealy Mountains, Labrador, which is an understudied part of the boreal forest. *Can. J. Zool.,* **93**: 477-486. https://doi.org/10.1139/cjz-2014-0309

Masifwa, W.F., Twongo, T. and Denny, P., 2001. The impact of water hyacinth, *Eichhornia crassipes* (Mart) Solms on the abundance and diversity of aquatic macroinvertebrates along the shores of northern Lake Victoria, Uganda. *Hydrobiologia,* **452**: 79-88. https://doi.org/10.1023/A:1011923926911

McCain, C.M., 2009. Global analysis of bird elevational diversity. *Glob. Ecol. Biogeogr.,* **18**: 346-360. https://doi.org/10.1111/j.1466-8238.2008.00443.x

McKinney, M.L., 1997. How do rare species avoid extinction? A paleontological view. *Biol. Rarity Springer Dordrecht,* **17**: 110-129. https://doi.org/10.1007/978-94-011-5874-9_7

McWethy, D.B., Hansen, A.J. and Verschuyl, J.P., 2009. Edge effects for songbirds vary with forest productivity. *For. Ecol. Manage.,* **257**: 665-678. https://doi.org/10.1016/j.foreco.2008.09.046

Meerhoff, S.M., Mazzeo, B.N., Moss, B. and Rodríguez-Gallego, L., 2003. The structuring role of free-floating versus submerged plants in a subtropical shallow lake. *Springer Nat.,* **37**: 377–391. https://doi.org/10.1023/B:AECO.0000007041.57843.0b

Mikusiński, G., Gromadzki, M. and Chylarecki, P., 2001. Woodpeckers as indicators of forest bird diversity. *Conserv. Biol.,* **15**: 208-217. https://doi.org/10.1111/j.1523-1739.2001.99236.x

Mirza, Z. and Wasiq, H., 2007. *A field guide to birds of Pakistan Bookland*. Lahore.

Mohd-Azlan, J., Noske, R.A., and Lawes, M.J., 2015. The role of habitat heterogeneity in structuring mangrove bird assemblages. *Diversity,* **7**: 118-136. https://doi.org/10.3390/d7020118

Möltgen, J., Schmidt, B. and Kuhn, W.,1999. *Landscape editing with knowledge-based measure deductions for ecological planning*. International Workshop on Integrated Spatial Databases, Springer, pp. 139-152. https://doi.org/10.1007/3-540-46621-5_9

Muñoz-Sáez, A., Perez-Quezada, J.F. and Estades, C.F., 2017. Agricultural landscapes as habitat for birds in central Chile. *Rev. Chil. Hist. Nat.,* **90**: 3. https://doi.org/10.1186/s40693-017-0067-0

Pennington, D.N. and Blair, R.B., 2011. Habitat selection of breeding riparian birds in an urban environment: untangling the relative importance of biophysical elements and spatial scale. *Divers. Distrib.,* **17**: 506-518. https://doi.org/10.1111/j.1472-4642.2011.00750.x

Raja, N.A., Davidson, P., Bean, N., Drijvers, R., Showler, D. and Barker, C., 1999. *The birds of Palas, North-West Frontier Province, Pakistan*. Forktail, pp. 77-86.

Rajpar, M.N. and Zakaria, M., 2011. Bird species abundance and their correlationship with microclimate and habitat variables at Natural Wetland Reserve, Peninsular Malaysia. *Int. J. Zool.,* Article ID 758573. https://doi.org/10.1155/2011/758573

Raman, T.S., 1998. Recovery of tropical rainforest avifauna in relation to vegetation succession following shifting cultivation in Mizoram, north-east India. *J. appl. Ecol.,* **35**: 214-231. https://doi.org/10.1046/j.1365-2664.1998.00297.x

Roberts, T.J., 1991. *The birds of Pakistan, Non-Passeriformes.* Oxford Univ. Press, Karachi, 1: 598.

Roberts, T.J., 1992. *Birds of Pakistan, The passeriformes: Pittas to buntings*. Oxford University Press.

Sekercioglu, C.H., Daily, G.C. and Ehrlich, P.R., 2004. Ecosystem consequences of bird declines. *Proc. natl. Acad. Sci. U.S.A.*, **101**:18042-18047. https://doi.org/10.1073/pnas.0408049101

Shochat, E., Lerman, S. and Fernández-Juricic, E., 2010. Birds in urban ecosystems: Population dynamics, community structure, biodiversity, and conservation. *Urban Ecosyst.,* **55**: 75-86. https://doi.org/10.2134/agronmonogr55.c4

Stevenson, T. and Fanshawe, J., 2004. *Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi*. A and C Black.

Strohbach, M.W., Lerman, S.B. and Warren, P.S., 2013. Are small greening areas enhancing bird diversity? Insights from community-driven greening projects in Boston. *Landsc. Urban Plan.,* **114**: 69-79. https://doi.org/10.1016/j.landurbplan.2013.02.007

Theuerkauf, S.J. and Lipcius, R.N., 2016. Quantitative validation of a habitat suitability index for oyster

restoration. *Front. Mar. Sci.,* **3**: 64. https://doi.org/10.3389/fmars.2016.00064

Toft, J.D. Simenstad, C.A., Cordell, J.R. and Grimaldo, L.F., 2003. The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. *Estuaries,* **26**: 746-758. https://doi.org/10.1007/BF02711985

Tu, H.M., Fan, M.W. and Ko, J.C.J., 2020. Different habitat types affect bird richness and evenness. *Sci. Rep.,* **10**: 1-10. https://doi.org/10.1038/s41598-020-58202-4

Tuck, S.L. Winqvist, C., Mota, F., Ahnström, J., Turnbull, L.A. and Bengtsson, J., 2014. Landuse intensity and the effects of organic farming on biodiversity: A hierarchical meta analysis. *J. appl. Ecol*., **51**: 746-755. https://doi.org/10.1111/1365-2664.12219

Verner, J., 1985. In: *Current ornithology: Assessment of counting techniques.* Plenum. Press, **2**: 247-302. https://doi.org/10.1007/978-1-4613-2385-3_8

Warren, P. and Baines, D., 2004. Black grouse in northern England: stemming the decline. *Br. Birds,* **97**: 183-189.

Watson, J.E.M., Whittaker, R.J. and Dawson, T.P., 2004. Avifaunal response to habitat fragmentation in the threatened littoral forest of south-eastern Madagascar. *J. Biogeogr.,* **31**: 1791–1807. https://doi.org/10.1111/j.1365-2699.2004.01142.x

Wiens, J.A., 1969. An approach to the study of ecological relationships among grassland birds. *Ornithol. Monogr.,* **8**: 1-93. https://doi.org/10.2307/40166677

Pakistan J. Zool., pp 1-9, 2022. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20220224070218

Supplementary Material

Avian Diversity, Abundance and Habitat Suitability Index for Threatened Species in Selected Areas of Northern Pakistan

Rida Ahmad[1,2]*, Zulfiqar Ali[2]*, Farkhanda Manzoor[1], Usman Ahmad[3], Safdar Sidra[4], Irfan Zainab[2], Muhammad Furqan[2], Aliza Batool[1,2] and Zaidi Zona[2]

[1]Department of Zoology, Lahore College for Women University, Lahore, Pakistan
[2]Environmental Health and Wildlife Laboratory, Institute of Zoology, University of the Punjab, Lahore, Pakistan
[3]College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan
[4]Department of Wildlife and Ecology, University of Veterinary and Animal Sciences, Lahore, Pakistan

* *Corresponding author: ridaahmad411@gmail.com, zali.zool@pu.edu.pk*
0030-9923/2022/0001-0001 $ 9.00/0

Supplementary Table SI. Description of habitat types.

Sr. #	Habitat type	Description
1	Alpine pastures	Alpine Pastures are located in Northern areas of Pakistan such as, Hazara and Malakand division, Diamer district, GB. These comprised of alpine meadows at around '1542.27' to '4632.75' masl with vegetation of one to three meter and dense cover. Alpine Pastures were found above the tree line and these are grazing lands of various mammals specifically Markhor.
2	Dry temperate forests	Dry Temperate Forests contained bare soil (except of availability of extra moisture). Xerophytic vegetation is found in the area with grayish foliage having aromatic shrubs and small leaves. The dominating vegetation was *Artemisia* and the root system of the vegetation found in this habitat was quite extensive. Mostly small grasses and forbs were part of this habitat along with some climbers.
3	Moist temperate forest	Moist temperate forest was found in Palas valley and some other valleys with '1,500' to '3,000' m elevation. It contains gentle slopes and deep soil in the Northern aspect.
4	Sub-tropical chir pine	Sub-tropical Chir Pine were often without shrub layer and found between 800 and '1,700' m elevation in Western Himalayas. Thakot Bridge, Allai Khwar, Khan Khwar and Chakki harbor this type of habitat.
5	Sub-tropical broad-leaved	Sub-tropical Broad-Leaved forest types were found in Thakot, Nandihar Khwar and Allai Khwar.
6	Agriculture land	Agriculture Land was the one used for crop cultivation.
7	Shrubs and bushes	Shrubs and Bushes were the woody plant habitat with low height (less than 3 m tall). They are recognized by various stems arising from the same stem.
8	Rangelands	Rangelands contained natural/native vegetation of herbs and grasses mainly utilized for grazing by livestock and wild animals.
9	Snow and glaciers	Snow and Glaciers are found at the higher altitudes of Western Himalayas and 70-80% of water is coming from the aforementioned habitat to Indus Delta.
10	Settlements	Settlements are assemblages of dwellings making a community or where a communal society is residing.
11	Water bodies	Water bodies included nullahs, lakes or river in the area.

Supplementary Table SII. Distribution of species in various habitats.

S. #	Species						Habitats										
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Agriculture Land	Alpine Pasture	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Snow and Glaciers	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine	Water Bodies
1	Alpine accentor (*Prunella collaris*)	G	LC	WM	9	3	3			2	4						
2	Alpine swift (*Tachymarptis melba*)	I	LC	SB	290	7	47	127	29	5	39	21	22				
3	Ashy drongo (*Dicrurus leucophaeus*)	I	LC	SB	10	2	7						3				
4	Asian house martin (*Delichon dasypus*)	I	LC	SB	44	4		26			7	10	1				
5	Asian-barred Owlet (*Glaucidium cuculoides*)	I	LC	YRR	5	3	1					1				3	
6	Baillon's crake (*Porzana pusilla*)	I	LC	WM	6	2			2								4
7	Bank myna (*Acridotheres ginginianus*)	O	LC	YRR	47	5	12		27	4		3	1				

Table continue on next page.....

S. #	Species	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Habitats											
	Common name (Scientific name)						Agriculture Land	Alpine Pasture	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Glaciers Snow and	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine		Water Bodies
9	Bar-tailed Treecreeper (*Certhia himalayana*)	I	LC	WM	103	3			25		67	11						
10	Black crested tit (*Periparus melanolophus*)	I	LC	YRR	66	5	7		12	1	3				43			
11	Black drongo (*Dicrurus macrocercus*)	I	LC	SB	155	7	89		10	11	3	18	23					1
12	Black kite (*Milvus migrans*)	C	LC	YRR	63	7	31		3	6	5	12	5					1
13	Black redstart (*Phoenicurus ochruros*)	I	LC	WM	91	7	12	4	43	6	9	13		4				
14	Black stork (*Ciconia nigra*)	C	LC	PM	4	1												4
15	Black winged cuckooshrike (*Coracina melaschistos*)	I	LC	SB	1	1							1					
16	Black-crowned night heron (*Nycticorax nycticorax*)	C	LC	SB	16	2						4			12			
17	Black-shouldered kite (*Elanus caeruleus*)	C	LC	SB	1	1				1								
18	Black-throated tit (*Aegithalos concinnus*)	I	LC	SB	35	3				1	9	25						
19	Blue capped rockthrush (*Monticola cinclorhynchus*)	I	LC	SB	180	6	12	7	14	12	13	122						
20	Blue rock thrush (*Monticola solitarius*)	I	LC	SB	24	2			7			17						
21	Blue whistling thrush (*Myophonus caeruleus*)	I	LC	SB	535	8	75	10	67	24	195	187						7
22	Blunt-winged warbler (*Acrocephalus concinens*)	I	LC	SB	8	2	1					7						
23	Blyth's reed warbler (*Acrocephalus dumentorum*)	I	LC	PM	13	2	12		1									
24	Booted eagle (*Hieraaetus pennatus*)	C	LC	YRR	10	2	9		1									
25	Brahminy starling (*Sturnia pagodarum*)	I	LC	YRR	283	6	1		143	11	16	68	14					
26	Brook's leaf warbler (*Phylloscopus subviridis*)	I	LC	SB	41	6	5		6	24	1	2	3					
27	Brown dipper (*Cinclus pallasii*)	I	LC	YRR	354	7	67		111	67	17	78	1					13
28	Brown rock chat (*Cercomela fusca*)	I	LC	SB	32	4		5	7		11	9						
29	Brown-fronted woodpecker (*Dendrocopos auriceps*)	O	LC	SB	5	1						5						

Table continue on next page.....

S. #	Species						Habitats										
	Common name (Scientific name)	**Feeding Habit***	**IUCN Status****	**Occurrence*****	**Total no. of Individuals**	**No. of Common Habitats**	**Agriculture Land**	**Pasture**	**Alpine**	**Dry Temperate**	**Moist Temperate**	**Rangeland**	**Settlements**	**Shrubs and Bushes**	**Snow and Glaciers**	**Sub-Tropical Broad-leaved**	**Sub-Tropical Chir Pine**	**Water Bodies**
31	Caspian tern (*Sterna capsica*)	C	LC	PM	38	3	2		34									2
32	Chestnut thrush (*Turdus rubrocanus*)	I	LC	YRR	56	6	15	8	13	7	12	1						
33	Chukar (*Alectoris chukar*)	I	LC	YRR	100	5	27		17	36	8	12						
34	Cinereous vulture (*Aegypius monachus*)	C	NT	WM	2	1							2					
35	Citerine wagtail (*Motacilla citreola*)	I	LC	SB	38	7		2	7	21	4	1						3
36	Collared owlet (*Glaucidium brodiei*)	C	LC	SB	5	2				4		1						
37	Common buzzard (*Buteo buteo*)	C	LC	WM	11	4	3			1		3	4					
38	Common chiffchaff (*Phylloscopus collybita*)	I	LC	WM	71	7	12	1	22	14	13	9						
39	Common hoopoe (*Upupa epops*)	I	LC	SB	44	6			20	10	9	1	4					
40	Common house-martin (*Delichon urbicum*)	I	LC	SB	20	2					3							17
41	Common kestrel (*Falco tinnunculus*)	C	LC	WM	7	4				3	1	2	1					
42	Common myna (*Acridotheres tristis*)	O	LC	YRR	2309	10	813	678	201	92	131	323	54			1		16
43	Common ringed plover (*Charadrius hiaticula*)	O	LC	WM	3	1						3						
44	Common rosefinch (*Carpodacus erythrinus*)	O	LC	SB	8	1						8						
45	Common sandpiper (*Actitis hypoleucos*)	I	LC	WM	231	7	73	39		30		13				43		33
46	Common starling (*Sturnus vulgaris*)	O	LC	WM	125	5			13	35	32	45						
47	Common stonechat (*Saxicola torquata*)	I	LC	SB	26	3		3	12		11							
48	Common swift (*Apus apus*)	I	LC	SB	30	2					4	26						
49	Common tailor bird (*Orthotomus sutorius*)	I	LC	SB	9	4			1	3	4	1						
50	Crested bunting (*Melophus lathami*)	G	LC	SB	10	2	4						6					
51	Crested lark (*Galerida cristata*)	O	LC	YRR	675	9	64	89	7	209	267	12	8					19

Table continue on next page.....

S. #	Species						Habitats										
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Agriculture Land	Pasture Alpine	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Glaciers Snow and	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine	Water Bodies
53	Eurasian blackbird (*Turdus merula*)	G	LC	YRR	2	1			2								
54	Eurasian collared dove (*Streptopelia decaocto*)	G	LC	SB	44	4	16			4	9	15					
55	Eurasian coot (*Fulica atra*)	O	LC	WM	22	2				12							10
56	Eurasian crag martin (*Ptyonoprogne rupestris*)	I	LC	SB	5	2					4	1					
57	Eurasian curlew (*Numenius arquata*)	O	NT	SB	7	1						7					
58	Eurasian golden oriole (*Oriolus oriolus*)	G	LC	SB	3	1	3										
59	Eurasian hobby (*Falco subbuteo*)	I	LC	SB	30	5	13			11	2	4					
60	Eurasian magpie (*Pica pica*)	O	LC	SB	36	4	11			8		17					
61	Eurasian nightjar (*Caprimulgus europaeus*)	I	LC	SB	4	1				4							
62	Eurasian skylark (*Alauda arvensis*)	G	LC	WM	61	6	11	1	9	1	13	26					
63	Eurasian sparrowhawk (*Accipiter nisus*)	C	LC	SB	75	3	3			29		43					
64	Eurasian tree sparrow (*Passer montanus*)	G	LC	YRR	390	7	29	5	54	1	87	198	16				
65	Eurasian treecreeper (*Certhia familiaris*)	I	LC	YRR	5	1					5						
66	European Bee-eater (*Merops apiaster*)	I	LC	SB	29	4		3	5	17		4					
67	European goldfinch (*Carduelis carduelis*)	G	LC	WM	83	6	3	54	9	4	6	7					
68	European roller (*Coracias garrulus*)	I	LC	PM	45	6	9	11	2	10		13					
69	Golden eagle (*Aquila chrysaetos*)	C	LC	YRR	28	6	17	1	3	1	4	2					
70	Great crested flycatcher (*Myiarchus crinitus*)	I	LC	Unknown	13	2	2			11							
71	Great crested grebe (*Podiceps cristatus*)	C	LC	WM	6	2				4	2						
72	Great rosefinch (*Carpodacus rubicilla*)	G	LC	WM	3	1						3					
73	Great tit (*Parus major*)	I	LC	WM	79	8	27	21	14	10	1	3					3

Table continue on next page.....

S. #	Species						Habitats										
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Agriculture Land	Pasture	Alpine	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Glaciers	Snow and	Broad-leaved Sub-Tropical	Chir Pine Sub-Tropical	Water Bodies
75	Greater Short-toed lark (*Calandrella brachydactyla*)	G	LC	PM	24	3				5	14	5							
76	Green bee-eater (*Merops orientalis*)	I	LC	SB	19	2			11	8									
77	Green sand piper (*Tringa ochropus*)	I	LC	WM	6	2	3												3
78	Green shank (*Tringa nebularia*)	C	LC	WM	9	1													9
79	Green shrike-babbler (*Pteruthius xanthochlorus*)	G	LC	SB	1	1						1							
80	Greenish warbler (*Phylloscopus trochiloides*)	I	LC	WM	53	6		23	4	2		18	4	2					
81	Grey breasted prinia (*Prinia hodgsonii*)	I	LC	YRR	10	2						7	3						
82	Grey bushchat (*Saxicola ferreus*)	G	LC	SB	31	4			3	6			13	9					
83	Grey wagtail (*Motacilla cinereal*)	I	LC	SB	1005	10	132	98	67	186	265	126	91			26			14
84	Hen harrier (*Circus cyaneus*)	C	LC	WM	40	6	3		1	22	11		2			1			
85	Himalayan bulbul (*Pycnonotus leucogenys*)	G	LC	YRR	1711	8	198	176	131	164	556	381	105						
86	Himalayan griffon (*Gyps himalayensis*)	C	NT	YRR	59	7	7	14	10		10	8	9						1
87	Himalayan woodpecker (*Dendrocopos himalayensis*)	I	LC	YRR	43	3	15		1			27							
88	House crow (*Corvus splendens*)	O	LC	YRR	981	9	402	16	25	75	98	208	117			40			
89	House sparrow (*Passer domesticus*)	G	LC	SB	556	8	111	15	115	5	57	145	101						7
90	Hume's lark (*Calandrella acutirostris*)	G	LC	SB	19	1	19												
91	Hume's warbler (*Phylloscopus humei*)	I	LC	SB	14	2	8						6						
92	Hume's wheatear (*Oenanthe albonigra*)	I	LC	YRR	260	7	28	98	115	9	7	3							
93	Indian Paradise-flycatcher (*Terpsiphone paradisi*)	I	LC	SB	50	5	9			11	5	12	13						
94	Indian robin (*Saxicoloides fulicata*)	I	LC	YRR	5	4	1		1	2		1							
95	Indian roller (*Coracias benghalensis*)	I	LC	SB	101	6	34			19	8	13	21	6					

Table continue on next page.....

S. #	Species	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Habitats										
	Common name (Scientific name)						Agriculture Land	Alpine Pasture	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Snow and Glaciers	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine	Water Bodies
97	Koklas pheasent (*Pucrasia macrolopha*)	G	LC	YRR	1	1				1							
98	Large billed crow (*Corvus macrorhynchos*)	O	LC	YRR	1839	9	357	11	418	124	432	373	6			118	
99	Laughing dove (*Streptopelia senegalensis*)	G	LC	SB	186	8	54	16	25	41	24	11	15				
100	Lesser sand-plover (*Charadrius mongolus*)	I	LC	SB	10	2	9					1					
101	Lesser whitethroat (*Sylvia curruca*)	I	LC	SB	166	5		65	81	5	8	7					
102	Little crake (*Porzana parva*)	G	LC	WM	7	3	1		5								1
103	Ilittle Forktail (*Enicurus scouler*)	I	LC	YRR	253	7	41	17	46	7	28	97					17
104	Little ringed plover (*Charadrius dubius*)	I	LC	WM	1	1	1										
105	Little stint (*Calidris minuta*)	I	LC	PM	26	4	6					3	9				8
106	Little swift (*Apus affinis*)	I	LC	SB	29	2			21	8							
107	Long billed pipit (*Anthus similis*)	G	LC	YRR	15	6	1		3	1	1	7					2
108	Long-legged Buzard (*Buteo rufinus*)	C	LC	WM	1	1					1						
109	Long-ttiled minivet (*Pericrocotus ethologus*)	I	LC	SB	6	1	6										
110	Long-tailed shrike (*Lanius schach*)	I	LC	SB	116	6	31		21	5	25	3	31				
111	Marsh sandpiper (*Tringa stagnatilis*)	I	LC	WM	37	2	8										29
112	Monal pheasent (*Lophophorus impejanus*)	G	LC	YRR	1	1				1							
113	Mountain chiffchaff (*Phylloscopus sindianus*)	I	LC	SB	17	4	3			4	5	5					
114	Northern goshawk (*Accipiter gentilis*)	C	LC	PM	1	1			1								
115	Oriental Magpie-robin (*Copsychus saularis*)	I	LC	SB	1	1	1										
116	Oriental skylark (*Alauda gulgula*)	G	LC	SB	14	1	14										
117	Oriental white eye (*Zosterops palpebrosus*)	F	LC	YRR	7	1			7								

Table continue on next page.....

S. #	Species						Habitats											
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Agriculture Land	Alpine Pasture	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Snow and Glaciers	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine	Water Bodies	
119	Pied bushchat (*Saxicola caprata*)	I	LC	SB	67	6	18	7	28	11			3					
120	Pied wheatear (*Oenanthe pleschanka*)	F	LC	PM	48	3	15		26								7	
121	Plain mountain finch (*Leucosticte nemoricola*)	G	LC	YRR	12	1					12							
122	Plumbeous water redstart (*Phoenicurus fuliginosus*)	G	LC	SB	785	11	132	28	175	77	53	207	53	11	21	28		
123	Purple sunbird (*Cinnyris asiaticus*)	F	LC	SB	1	1					1							
124	Raven (*Corvus corax*)	O	NT	YRR	120	3	23		11	86								
125	Alpine thrush (*Zoothera mollissima*)	G	LC	YRR	3	1						3						
126	Red crossbill (*Loxia curvirostra*)	G	LC	SB	15	4	7	1		1		6						
127	Red fronted serin (*Serinus pusillus*)	G	LC	YRR	2	1					2							
128	Red shank (*Tringa tetanus*)	I	LC	PM	10	1											10	
129	Red vented bulbul (*Pycnonotus cafer*)	F	LC	YRR	1695	11	254	4	67	34	66	116	46		544	486	78	
130	Red-backed Shrike (*Lanius collurio*)	C	LC	PM	6	1						6						
131	Red-throated Pipit (*Anthus cervinus*)	I	LC	PM	55	5	14		9	6		5	21					
132	Red-throated Thrush (*Turdus ruficollis*)	F	LC	WM	4	1	4											
133	Red-wattled Lapwing (*Vanellus indicus*)	I	LC	YRR	392	3	15								243		134	
134	Rock bunting (*Emberiza cia*)	F	LC	SB	447	6	19		53	165	176	34						
135	Rock pigeon (*Columba livia*)	G	LC	YRR	178	8	21	17	43	43	29	21	4					
136	Rook (*Corvus frugilegus*)	O	LC	WM	12	2			4		8							
137	Rose-ringed Parakeet (*Psittacula krameria*)	G	LC	YRR	21	2						17	4					
138	Rosy minivet (*Pericroco tusroseus*)	I	LC	YRR	6	1	6											
139	Rosy pipit (*Anthus roseatus*)	G	LC	SB	4	2			1	3								

Table continue on next page.....

S. #	Species						Habitats											
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Land Agriculture	Pasture Alpine	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Snow and Glaciers	Sub-Tropical Broad-leaved	Sub-Tropical Chir Pine	Water Bodies
141	Ruff (*Philomachus pugnax*)	I	LC	PM	4	1			4								
142	Rufous treepie (*Dendrocitta vagabunda*)	O	LC	YRR	18	5	1		5		6	5					1
143	Rufous-naped tit (*Parus rufonuchalis*)	G	LC	YRR	30	4	4		8	7					11		
144	Russet sparrow (*Passer rutilans*)	G	LC	YRR	6	2					3	3					
145	Shikra (*Accipiter badius*)	C	LC	SB	13	5	6	2	1	1		3					
146	Spanish sparrow (*Passer hispaniolensis*)	G	LC	PM	261	7	58	8	41	16	38	73	27				
147	Spotted crake (*Porzana porzana*)	I	LC	PM	15	3	3		6								6
148	Spotted dove (*Streptopelia chinensis*)	G	LC	SB	18	2	5			13							
149	Spotted red shank (*Tringa erythropus*)	I	LC	WM	12	2	5										7
150	Steppe eagle (*Aquila nipalensis*)	C	EN	WM	65	7	19			4	3	4	1		29		5
151	Streaked laughing thrush (*Trochalopteron lineatum*)	F	LC	YRR	219	6	37		17	16	145	4					
152	Sulphur-bellied warbler (*Phylloscopus griseolus*)	I	LC	SB	1	1					1						
153	Tawny pipit (*Anthus campestris*)	I	LC	WM	11	1					11						
154	Tickell's thrush (*Turdus unicolor*)	F	LC	SB	3	1						3					
155	Ultramarine flycatcher (*Ficedula superciliaris*)	I	LC	SB	33	4	17	6	9	1							
156	Variable wheatear (*Oenanthe picata*)	I	LC	SB	284	7	18	104	14	116	19	13					
157	Wall creeper (*Tichodroma muraria*)	I	LC	WM	118	7	3	87	9	14	3	2					
158	Water rail (*Rallus aquaticus*)	O	LC	WM	32	2	5		27								
159	Western tragopan (*Tragopan melanocephalus*)	G	VU	YRR	1	1				1							
160	Whistler's warbler (*Seicercus* (*whistleri*)	I	LC	SB	2	1						2					
161	White throated kingfisher (*Halcyon smyrnensis*)	I	LC	YRR	18	5	3			4	5		2				4

Table continue on next page.....

S. #	Species						Habitats											
	Common name (Scientific name)	Feeding Habit*	IUCN Status**	Occurrence***	Total no. of Individuals	No. of Common Habitats	Agriculture Land	Pasture	Alpine	Dry Temperate	Moist Temperate	Rangeland	Settlements	Shrubs and Bushes	Snow and Glaciers	Broad-leaved	Sub-Tropical Chir Pine	Sub-Tropical	Water Bodies
163	White-bellied redstart (*Hodgsonius phoenicuroides*)	F	LC	YRR	9	3					1	7							1
164	White-browed fantail (*Rhipidura aureola*)	I	LC	SB	83	2				76			7						
165	White-browed wagtail (*Motacilla maderaspatensis*)	I	LC	YRR	114	7		27	18		5	21	19			23			1
166	White-capped water redstart (*Phoenicurus leucocephalus*)	I	LC	SB	703	8	14	117	98		178	156	121						19
167	White-cheeked Tit (*Aegithalos leucogenys*)	I	LC	YRR	22	1							22						
168	White-throated dipper (*Cinclus cinclus*)	I	LC	YRR	367	5				233	6	5	123						
169	White-throated tit (*Aegithalos niveogularis*)	I	LC	YRR	91	7	9	5	19		12	13	24	9					
170	White-winged tern (*Chlidonias leucopterus*)	C	LC	PM	19	1	19												
171	Winter wren (*Troglodytes hiemalis*)	I	LC	YRR	2	2					1	1							
172	Wire-tailed swallow (*Hirundo smithii*)	I	LC	SB	130	8	42	4	43		12	13	15	1					
173	Yellow wagtail (*Motacilla flava*)	I	LC	PM	323	6		78	76		3		31			131			4
174	Yellow-billed blue magpie (*Urocissa flavirostris*)	O	LC	YRR	108	10	23	7	39		10	1	12	13		2	1		
175	Yellow-eyed babbler (*Chrysomma sinense*)	F	LC	SB	1	1								1					
							4,191	2,396	3,394		2,802	4,387	4,357	955	21	1,251	636		543

* G, Granivore; I, Insectivore; C, Carnivore; F, Frugivore; O, Omnivore. ** LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered.
*** WM, Winter Migrant; SB, Summer Breeder; YRR, Year Round Resident; PM, Passage Migrant.