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

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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.

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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.

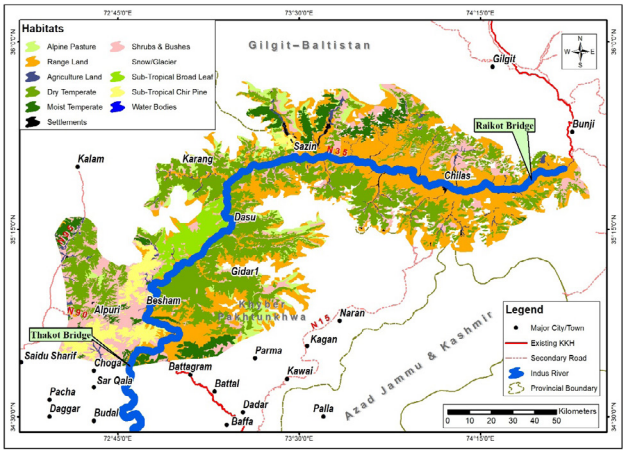

Fig. 1. Different habitat types in the study area.

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.

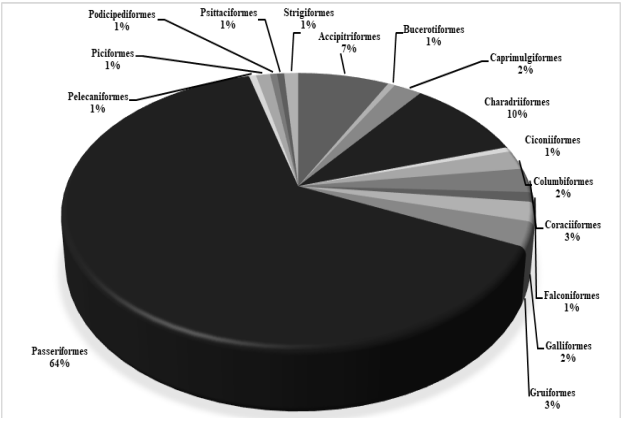

Fig. 2. Species distribution based on taxonomic orders.

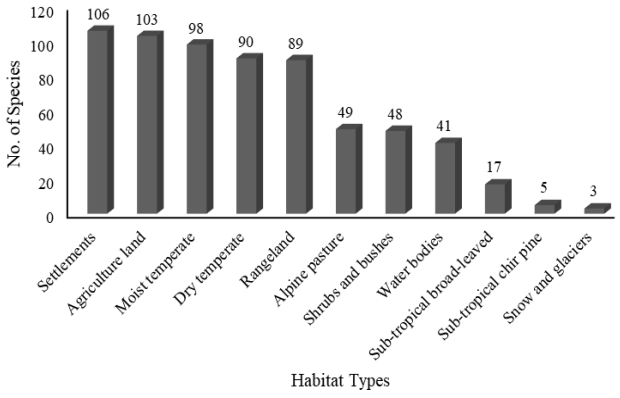

Fig. 3. Species richness in various habitats of study area.

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).

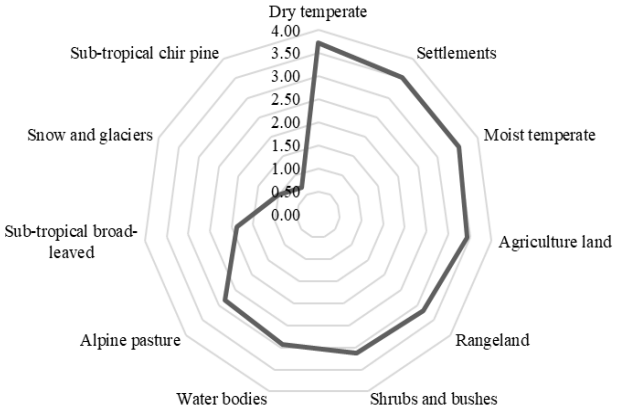

Fig. 4. Shannon wiener diversity index of elven habitats.

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.

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