Sohil and Sharma *Ecological Processes* (2020) 9:49
https://doi.org/10.1186/s13717-020-00250-9

Ecological Processes

RESEARCH Open Access

# Assessing the bird guild patterns in heterogeneous land use types around Jammu, Jammu and Kashmir, India

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## Abstract

Land-use sprawl in the Himalayas has caused the conversion of natural habitat into human-modified habitats, thus degrading ecosystem health. Adaptation of birds to changing physical environment can be well understood by analyzing their habitat preferences, and foraging dynamics explored to a limited extent in the Himalayan region, as yet. To achieve a comprehensive understanding of avian guild structure, we used multivariate statistical techniques to classify bird species according to their similarities in foraging patterns and habitat preferences. Observations based on habitat and diet affinities accounted for rich avian diversity with a total of 208 bird species (about 15% of country's avifauna) recorded from six different sites during 1 year survey. Unweighted pair-group average cluster analysis performed on the families revealed ten feeding and fifteen habitat guilds among 63 bird families observed. Subtropical forests harbored more species followed by urban forests and agricultural landscapes. Insectivorous and omnivorous outnumbered other feeding guilds in the study area. Bird assemblages were richer in protected areas and semi-disturbed landscapes and did not show significant variation between the seasons. Results of the study revealed that different functional groups of birds behaved differently, primarily induced by choice of food. The site heterogeneity favored avifaunal persistence by providing favorable foraging, roosting, and nesting opportunities to birds. Composition of avian guilds indicated level of intactness and ecological integrity of ecosystems studied. This outcome thus sets the background for long-term analysis of bird-habitat relationship and their foraging dynamics. The study has the relevance for decision-makers to integrate avian guild structure as an essential ingredient in formulating conservation strategies.

**Keywords:** Avian guild, Food resource utilization, Habitat preference, Heterogeneous landscape, Eutrophic wetland, Protected area

## Introduction

Identification and analysis of ecological guilds have been fundamental to understand processes that determine the structure and organization of communities (González-Salazar et al. 2014; Kornan and Kropil 2014), and each species fulfills the ecological role according to its use of resources within a community (Ricklefs 2010). The best measure to understand bird community structure is to classify them into feeding guilds and habitat guilds (Thiollay 1995; Clough et al. 2009). Guilds are regulated by the food supply, vegetative cover, predators, and various other ecological factors reflecting temporal variations and diversity gradients (O'Connell 2000; Kissling et al. 2012; Katuwal et al. 2016). Application and utilization of guilds have been widely discussed in animal ecology (Blaum et al. 2011) and extensively studied in birds, among the other taxonomic groups (Sabo and Holmes 1983; Recher et al. 1985; Chettri et al. 2005; Perez-Crespo et al. 2013; González-Salazar et al. 2014; Koli 2014; Mukhopadhyay and Mazumdar 2019). Birds are potential predictors of the integrity and function of habitats (Mukhopadhyay and Mazumdar 2019), ecosystem health, and stress (MacArthur and MacArthur 1961; Taper et al. 1995), richness and

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conservation significance (Pearman 2002; Bensizerara et al. 2013). Bird species composition and guild structure vary spatially (Holmes et al. 1979; Holmes and Recher 1986) as they prefer to live in heterogeneous landscapes to best suit their nesting, perching, roosting, and foraging (Berg 2002; Aggarwal et al. 2008; Veech et al. 2011). The food availability and pattern of food exploitation (Rosenberg 1990; Albrecht and Gotelli 2001; Palmer et al. 2003) in a particular habitat determine bird distributions (Evans and Dugan 1984) and community structure (Gotelli and Colwell 2011; Bonilla et al. 2012). Knowledge of resource utilization (MacNally 1983; Winemiller and Pianka 1990; Bell 2001; Kattan and Franco 2004; López de Casenave et al. 2008) and assessment of foraging guilds and habitat preferences of avian species are vital to analyzing their responses to changing habitats and their conservation policies (Lawton et al. 1998; Sekercioglu 2006). Moreover, the association of birds with their habitats helps to decipher the influence of biotic interactions on bird species distributions (Jankowski et al. 2013).

Studies indicate that bird-habitat selection and its use is mainly governed by landscape structure (Fairbanks 2004; Titeux et al. 2004; Oja et al. 2005; Borges et al. 2017; Mahiga et al. 2019), food competition and availability (Petit and Petit 1996; Chatterjee and Basu 2017), variable climate and human activities (Davis et al. 2000). As different bird guilds respond differently to such changes (Barragan et al. 2011; Phalan et al. 2011; Newbold et al. 2014a), an understanding of such responses is essential to depict their resilience to the changing land use patterns (Chatterjee and Basu 2017). Man-altered environment influences bird communities in positive or negative ways depending on the biology of each functional group (Clough et al. 2009). A major threat to the persistence of birds is human-induced habitat loss and fragmentation driven by urbanization (Isaksson 2018). While several other species fail to persist in fragmented urban landscapes, the birds, because of their mobility and plasticity, have been successful at exploiting the urban habitats (Pennington and Blair 2012). Urban terrestrial bird communities colonize heterogeneous patches of crop fields, woodlands, wetlands, grasslands, and farms with suitable resources for their survival needs (Veech et al. 2011; Berg 2002). Aquatic bird communities with specialized habitat and foraging requirements (Andradea et al. 2018) are structurally more complex in interactions (Albrecht and Gotelli 2001; Palmer et al. 2003) and resource partitioning (López de Casenave et al. 2008). The forest specialists rely on the vegetation type and structure (Gabbe et al. 2002; Earnst and Holmes 2012) as a substrate for food and shelter (Lee and Rotenberry 2005). Generalists are particularly favored during the process of recolonization (Newbold et al. 2014b), while the specialists, being sensitive, become more prone to extinction in forest fragments (Henle et al. 2004).

The Northwestern Himalaya in the Indian Himalayan Region known for distinct physiography, climatic variability, and rich biodiversity (Kumar 2018) constitutes one of the significant ecological amplitudes in the world (Korner 2000; Myers et al. 2000). Erstwhile state of Jammu and Kashmir, home to 555 bird species (Suhail et al. 2020) forms a critical Endemic Bird Area (EBA 128) with 11 restricted-range species (Stattersfield et al. 1998). Status and number of bird species, birding hotspots, and their conservation ranking are currently under revision for the newly carved Union Territory of Jammu and Kashmir (India Code 2020), comprising the current study area. While the valley of Kashmir is home to many residents and migratory birds (Rahmani et al. 2016), the Jammu region holds a rich avifaunal diversity as well (Sharma et al. 2018; Sohil and Sharma 2019; Sohil and Sharma 2020). Though birds have primarily been surveyed for richness, diversity, and distribution (Pandotra and Sahi 2014; Sohil and Sharma 2019; Sohil and Sharma 2020), information on their guild structure and functions is scanty for the region. Intensive surveys were undertaken to enable understanding of habitat preferences and foraging dynamics of birds in mosaic landscapes around Jammu. This study focused on a central question: what are the foraging habits and habitat use of bird assemblages in different sites around Jammu, Jammu and Kashmir? For this study, we hypothesized that (a) bird assemblages vary in terms of their habitat and foraging preferences among different sites in a subtropical region, and (b) habitat choices of birds corresponded to their food preferences.

## Materials and methods

### Study area

The study was conducted in six different sites with varied physiography in urban-suburban-farmland landscapes around Jammu city (32° 34′ 29″ N to 32° 45′ 08″ N and 74° 40′ 06″ E to 74° 53′ 29″ E, elevation 260–470 m above msl) (Table 1, Fig. 1). Study sites included two aquatic (a) a distributary of river Tawi (Nikki Tawi, NT), and (b) a small eutrophic wetland (Gharana Wetland Conservation Reserve, GWCR) and four terrestrial habitats (c) a protected area (Ramnagar Wildlife Sanctuary, RWLS), (d) reserve forest (Bahu-Mahamaya Forest, BMF), (e) University of Jammu Campus (JU), and (f) suburban landscape comprised of agriculture and fallow land (Southern Open Plains, SOP) (Table 1). Study area is characterized by a typical subtropical climate with four distinct seasons, spring (February–March), summer (April–June), monsoon (July–September), and winter (November–January). The maximum summer temperature ranges between 36 and 42 °C and average

**Table 1** Characteristic features of sampling sites with details on geo-features, sampling size, and the level of disturbances

| Study Site | Location (acronym) | Lat/long | Grid size ($km^2$) | Elevation (m above msl) | Site description | Level of disturbance | Transects/PCS no./rad./length | Hours spent/ fortnight |
|---|---|---|---|---|---|---|---|---|
| 1 | Nikki Tawi (NT) | 32° 43′ 14″ N 74° 50′ 17″ E | 4 | 290–300 | A natural distributary of river Tawi bifurcated close to fourth Tawi bridge southwards of Jammu City with high municipal waste load (Sohil and Sharma 2020) | High | PCS-05 (25 m R*5) | 6.5 |
| 2 | Gharana Wetland Conservation Reserve (GWCR) | 32° 34′ 29″ N 74° 40′ 06″ E | 1 | 262 | A small eutrophic wetland (185 acres), a designated Important Bird Area (IBA) is home to a number of trans-boundary winter visitors | Moderate | PCS-04 (25 m R *4) | 7.0 |
| 3 | University of Jammu campus (JU) | 32° 43′ 08″ N 74° 51′ 58″ E | 2 | 320–335 | Sprawled in 118 acres, the campus provides a rich array of bird refuges in the form of lawns, plantations, and hedges with well-maintained botanical and cactus gardens | Moderate | LT-05 (100 m*5) | 7.5 |
| 4 | Ramnagar Wildlife Sanctuary (RWLS) | 32° 45′ 08″ N 74° 52′ 15″ E | 5 | 360–450 | A well-managed protected area (31 $km^2$) with intact deciduous forests offers a rich habitat to number of forest specialists | Low | LT-03 (100 m*2 and 300 m*1) | 8.0 |
| 5 | Bahu-Mahamaya forest (BMF) | 32° 43′ 43″ N 74° 53′ 29″ E | 4 | 350–470 | A typical subtropical mixed patch of deciduous forest (and exotic plantations), along the left bank of river Tawi is a favored bird's destination | Low | LT-03 (500 m*1 and 250 m*2) | 7.0 |
| 6 | Southern open plains (SOP) | 32° 45′ 32″ N 74° 48′ 26″ E | 4 | 260–270 | A mixed landscape interspersed with agriculture fields, fallow lands, water bodies, and habitations. An ideal habitat for the generalists, aquatic dependent birds and raptors | Moderate | LT-03 (200 m*3) | 8.0 |

*PCS* point count station (25 m radius), *LT* line transect

annual precipitation of ~ 1000 mm mostly received during monsoon season.

## Study design and birds surveys

Systematic surveys were conducted in 23 sampling units considered as permanent line transects and point count stations for all six sites (Table 1). For this study, 14 linear transects of varying lengths and 9 point count stations were established based on type of habitat, terrain, and access to the site (Table 1). Point count census was performed in a 25-m radius sampling plot (Bibby et al. 2000; Sutherland 2006). All transects were walked/sampled during early morning (30 min after dawn to 10:30 am) and in the late afternoon (from 4:00 pm to 30 min before dusk), twice a month from January 2017 to December 2017, following Bibby et al. (1992) and Karanth et al. (2016). We sampled 552 points in a sampling effort of 1050 h (Table 1). Line transects and point count stations were spaced at least 200 m apart to ensure the interdependence between sampling points. Data were collected during summer (April–June), monsoon (July–August), post-monsoon (September–October), and winter (November–January). No observations were made during inclement weather conditions. Birds were recorded for their species, number, food preferences and type of habitat use in the field by using binoculars and spotting scopes. The images were captured using telephoto mounted digital cameras. Bird identities were established by consulting the field guides (Ali 2002; Grimmett et al. 2011) besides using call and song notes (Grimmett et al. 2013; xeno-canto 2020).

## Guild classification

Based on their food preferences, bird species were categorized into mutually exclusive feeding guilds following Gray et al. (2006). These included insectivorous (species feeding on insects, earthworms, small crustaceans, arthropods, etc.), carnivorous (feeding on large animals, their dead bodies/carcasses, etc.), omnivorous (feeding both on animals and plants), granivorous (eating seeds and grains), nectarivorous (feeding on nectar), and frugivorous (fruit-eating species). Species were observed exclusively for the type of food consumed as their principal diet. Secondary online source HBW Alive (2020) was referred to ascertain their food priorities. Likewise, birds were classified into 13 principal habitat guilds corresponding to their habitat preferences limited to perching, feeding, nesting, and mating for this study. These included subtropical scrub forests, subtropical broadleaved forests, subtropical pine forests, urban forests, riverbed, fallow land, garbage dumps, aerial, carcass dump, agricultural fields, aquatic, urban buildings, and littoral zone of wetland. Notably, the foraging information and habitat preferences were used to produce the guild classification for birds.

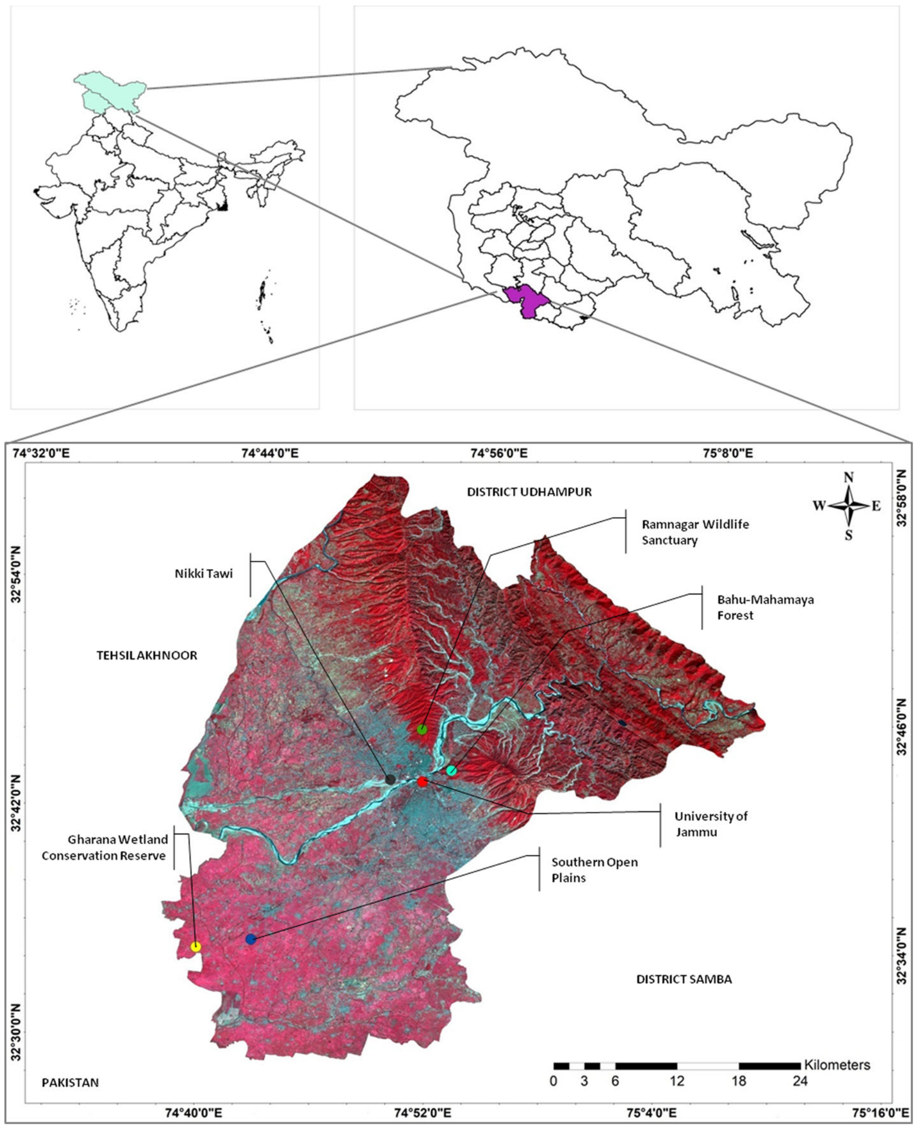


**Fig. 1** Map of the study area showing sampling sites

## Data analysis

Species richness was considered the pooled number of bird species occupying a particular guild. All birds observed, including the migrants, were considered for analysis as our observations were species oriented and not density driven. Feeding observations and habitat affinities noted for each bird species were consolidated family wise and then integrated into the respective guilds. We classified the bird guilds using the multivariate statistical techniques based on the shared resources (González-Salazar et al. 2014). Agglomerative hierarchical cluster (AHC) analysis was performed following Mukhopadhya and Mazumdar (2019) based on similarity matrix obtained using Jaccard's similarity coefficient (Krebs 1989; Manly 1994) and dendrograms were constructed using unweighted pair-group average (Hammer et al. 2001) to understand the extent of similarity.

Variations in species richness among seasons were compared using one-way ANOVA followed by Tukey's multiple comparison tests. The non-normal data (Shapiro-Wilk normality test $W$ = 0.92, df = 60, $p$ < 0.05) was transformed to logarithmic scale ($\log_{10}$) before analysis. An equivalent non-parametric Kruskal-Wallis test and Mann-Whitney $U$ test were applied for comparison of species richness ($W$ = 0.94, df = 72, $p$ = 0.03) among the study sites. Statistical analyses were performed using SPSS-25 and PAST-4.0 (Hammer et al. 2001) software packages and significance was tested at $p$ = 0.05.

## Results

### Species richness among study sites

Study area comprised of 208 bird species contained in 63 families and 16 orders, of which Ramnagar Wildlife Sanctuary harbored 113 bird species followed by Southern Open Plains (SOP, 109 species), Bahu-Mahamaya forest (BMF, 107 species), Gharana Wetland Conservation Reserve (GWCR, 106 species), University of Jammu Campus (JU, 98 species), and Nikki Tawi (NT, 65 species). Of all, 106 species (51%) belonged to order Passeriformes. The mean monthly species richness among study sites was accounted high for Gharana Wetland Conservation Reserve (Fig. 2).

Kruskal-Wallis test revealed that bird species richness among distinct study sites were significantly different ($H = 16.28$, df = 5, $p = 0.006$). Multiple pairwise comparisons (Mann–Whitney $U$ test) showed significant variations ($p < 0.05$) for NT-JU, NT-SOP, NT-BMF, RWLS-SOP, and BMF-SOP (Fig. 2). Family Muscicapidae with 17 species dominated all study sites followed by Accipitridae (12 species). Aquatic families, Anatidae and Scolopacidae (10 species each) were recorded exclusively from Gharana Wetland Conservation Reserve and Nikki Tawi. Mean species richness for different seasons was recorded high for summers and least for the monsoon. Results of one way ANOVA ($F = 1.39$, df = 3, $p = 0.253$) indicated that bird species richness did not show any significant variation among the seasons (Fig. 3).

### Observation-based guild structure

Birds observed during the study were placed in six diet categories. Insectivores contributed the maximum (90 species, 43.2%) followed by omnivores (55 species, 26.4%), carnivores (45 species, 21.6%), and granivores (10 species, 4.8%). Frugivores (6 species, 2.8%) and nectarivores (2 species, 0.9%) contributed the least. When compared site-wise, insectivores dominated the study area while carnivores were confined to aquatic ecosystems only. Omnivores, frugivores, granivores, and nectarivores occupied the terrestrial habitats (Fig. 4).

Based on the habitat preferences, birds were placed in 13 different habitat types classified as guilds. Among these, subtropical scrub (SS) recorded the highest number of species (115 species, 55.29%) followed by urban forests (UF, 113 species, 54.33%), subtropical broadleaved forests (BF, 104 species, 50%), agricultural fields (AF, 63 species, 30.29%), aquatic (AQ, 54 species, 25.96%), riverbed (RB, 47 species, 22.60%), subtropical pine forests (PF, 42 species, 20.19%), wetland littoral zone (LZ, 28 species, 13.46%), fallow land (FL, 15 species, 7.21%), aerial (AE, 13 species, 6.25%), garbage dump (GD, 6 species, 2.88%), and carcass dumps (CD, 5 species, 2.40%). Raptors, mostly scavengers, occupied the last two guilds. A hierarchical cluster dendrogram of habitat guilds resulted in three clusters, one comprising forest ecosystems (SS, UF, and BF) occupied mostly by the forest specialists. Second group included mixed habitats (LZ, FL, AE, GD, CD, and UB) shared by generalists and raptors while the third group (AF, AQ, RB, and PF) supported a wide variety, including the aquatic and water-dependent birds (Fig. 5).

### UPGA cluster analysis of guild habit

Family wise food preferences were derived by applying the UPGA cluster analysis (Jaksic and Medel 1990; Marti et al. 1993) based on Jaccard's similarity coefficient ≥ 0.54 (Fig. 6). Ten feeding guilds were recognized among 63 families and 208 species indicated in roman numerals as I-nectarivorous (N), II-granivorous (G), IV-insectivorous (I), V-carnivorous (C), Group VII-omnivorous (O), and IX-frugivorous (F). Group III, VI, VIII, and X shared more than one food resources thus categorized as insectivorous-granivorous (I/G),

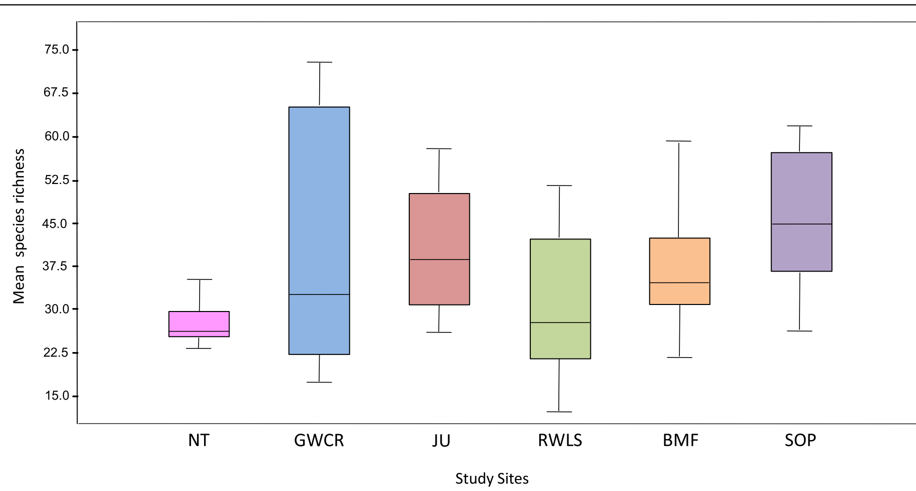


**Fig. 2** Observed bird species richness across study sites during the study period

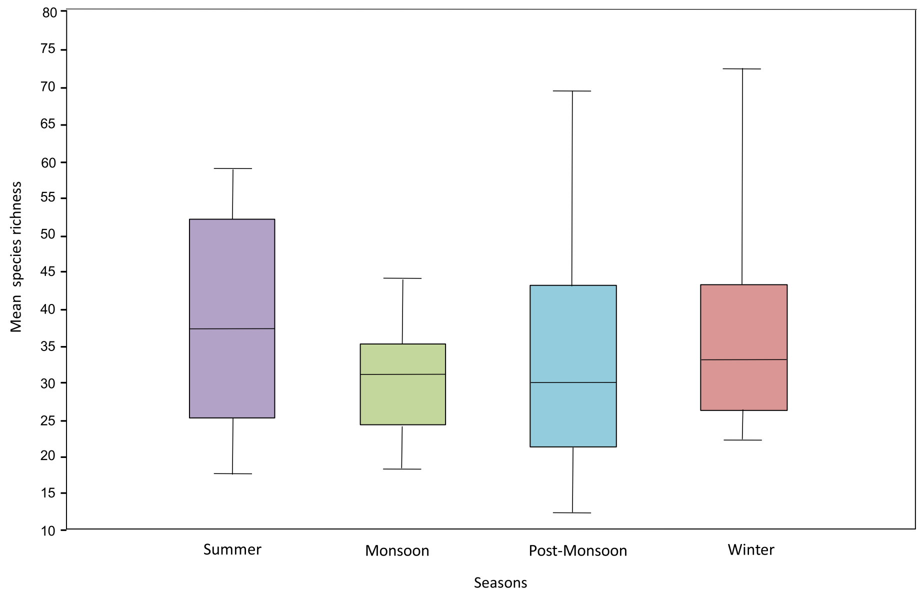


**Fig. 3** Observed bird species richness across different seasons during the study period

insectivorous-carnivorous (I/C), omnivorous-carnivorous (O/C), and frugivorous-omnivorous (F/O), respectively. Each food type varied among different feeding guilds but was similar among species belonging to the same guild. Insectivores belonging to 23 avian families constituted the dominant feeding guild in the study area, followed by omnivores (16 families). Bird familial affinities in different trophic guilds are represented in Fig. 6.

Guild response of birds to the type of habitat they belong was obtained using PCA (principal component analysis). Bottom axis of PCA accounts for the dominance of carnivores in aquatic and agriculture dominated landscapes, while the top right axis portrays prevalence of omnivores and insectivores in the terrestrial ecosystems. The granivores, frugivores, and nectarivores were least represented. PCA axes I and II accounted for 92% and 6% of the total variance, respectively (Fig. 7).

We obtained 15 habitat guilds based on the UPGA cluster analysis performed for habitat use with a mean distance of similarity (*J*) $\bar{x}$=0.63 (Fig. 8). Of these, guilds VIII and IX being used by 24 and 9 families were observed to be most occupied. Families Columbidae,

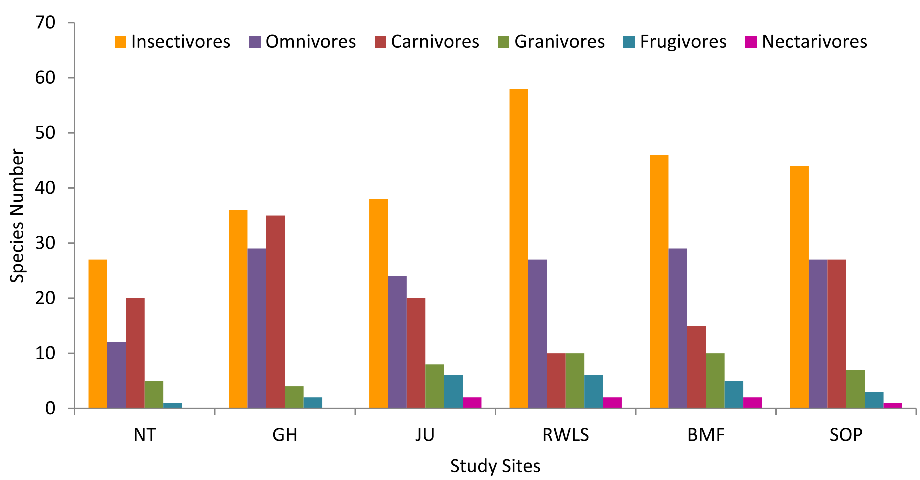


**Fig. 4** Bird trophic guilds in the order of dominance. Insectivores and carnivores in aquatic (NT and GWCR); insectivores and omnivores in terrestrial (JU, RWLS, and BMF) and insectivores followed by an equal proportion of omnivores and carnivores in Southern Open Plains (SOP), the mixed ecosystem

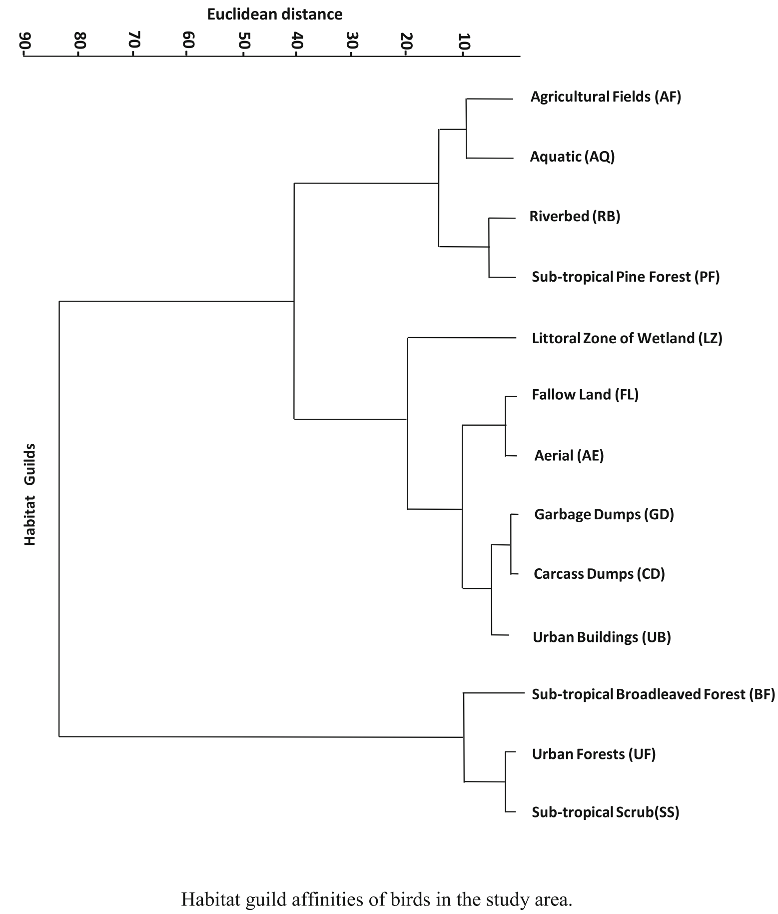


**Fig. 5** Habitat guild affinities of birds in the study area

Passeridae, Hirundinidae, Corvidae, Sturnidae, Motacillidae, Muscicapidae, and Accipitridae shared diverse habitat range among others. Waterbird families, Anatidae, Ciconiidae, Gruidae, Jacanidae, Phalacocoracidae, Podicipidae, Laridae, Recurvirostridae, Scolopacidae, Rallidae, Rostratulidae, and Threskiornithidae, mostly confined around the water bodies. Members of Coracidae and Ploceidae restricted to agricultural fields and fallows. These included birds like sunbirds, swallows, martins, prinias, terns, shank, stints, sandpipers, coots, raptors, babblers, egrets, herons in guilds I, II, IV, V, VI, VII, and IX. The aquatic, semi-aquatic, farmland, and forest birds were habitat-specific (guild I, II, III, IV, X, and XV). These included shanks, stints, ducks, geese, cranes, water hens, terns, larks, cormorants, ibises, wagtails, flycatchers, thrushes, babblers, starlings, warblers, redstarts, and buntings. Generalists shared more than one guild (V, VI, VII, VIII, IX, XI, XII, XIII, and XIV). These included the species like *Dicrurus macrocercus*, *Milvus migrans*, *Acridotheres tristis*, *Streptopelia decaocto*, *Merops orientalis*, *Pycnonotus leucogenis*, *Corvus splendens*, *Passer domesticus*, *Oenanthe fusca*, *Saxicola caprata*, *Pycnonotus cafer*, *Columba livia*, *Psittacula krameri*, and *Streptopelia chinensis*.

## Discussion

Results revealed that bird assemblages are regulated by the types of habitats rather than seasons. Different functional groups behaved differently in terms of preference, mainly mediated by choice of food. Protected areas shared more guilds than disturbed landscapes. In this study, a total of 15,918 individuals of 208 bird species to 63 families were recorded from diverse habitat types around Jammu. This high species richness may be attributed to the structural complexity, and diverse habitat types as heterogeneous areas are more likely to provide shelter and refuges to birds and promote avifaunal persistence (Seto et al. 2004; Kallimanis et al. 2010; Fjeldsa et al. 2012). Species-rich Ramnagar Wildlife Sanctuary comprises a wide variety of plant assemblages and a mosaic of vegetation types that offer foraging and nesting opportunities to birds (Sohil and Sharma 2020). It corroborates a general observation that vegetation type plays a crucial role in structuring bird communities

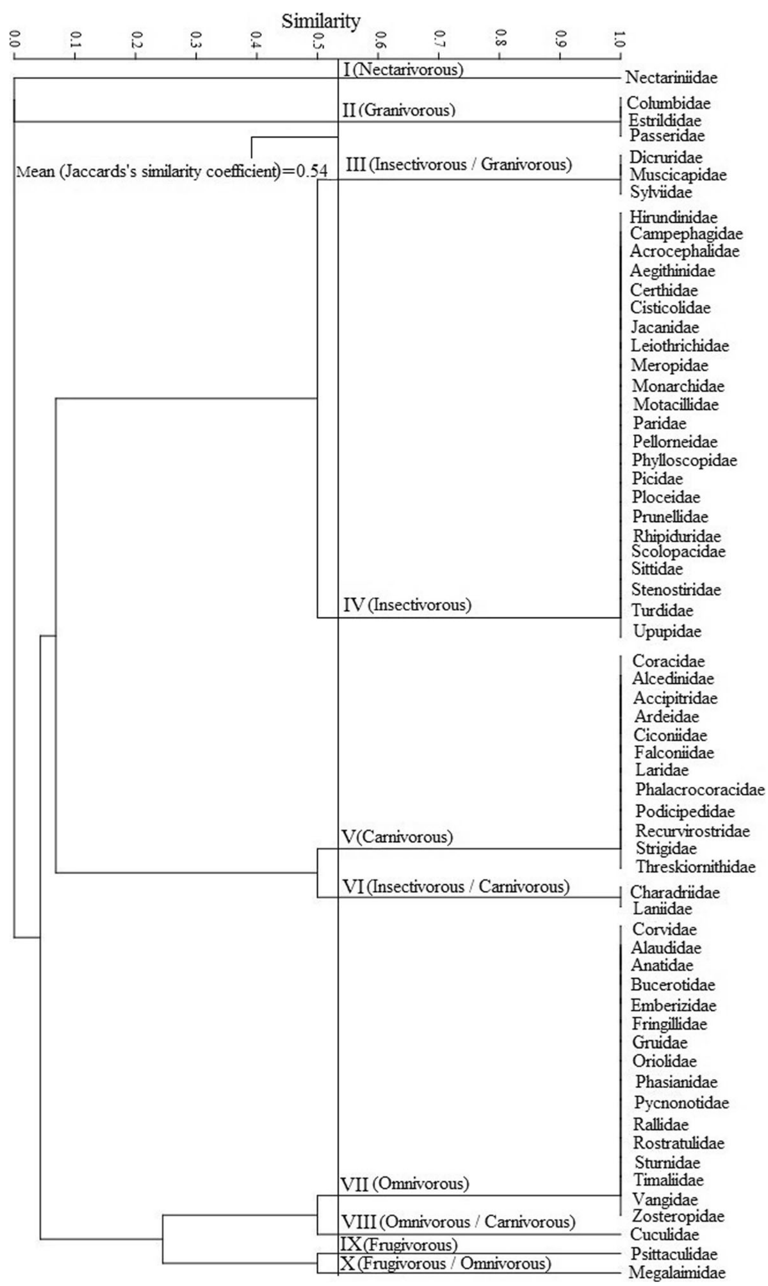


**Fig. 6** Jaccard's similarity dendrogram showing foraging guild structure among observed bird families in the study area

(Earnst and Holmes 2012; Draycott et al. 2008; Tanalgo et al. 2015) and maintaining their species richness (Jokimaki and Jokimaki 2012). Mosaic landscapes (Southern Open Plains) and Gharana Wetland Conservation Reserve were reasonably rich in species while Nikki Tawi shared the least. As observed by Melles et al. (2003), Husté et al. (2006), and Shwartz et al. (2008), urban-wetland interfaces are the ideal hotspots for avian communities. The aquatic habitats have been found to support more species as resident, wetland-dependent migratory, and wetland-associated avifauna (Mazumdar et al. 2007, 2008; Mukhopadhyay and Mazumdar 2019) while forested and agriculture landscapes accommodated terrestrial birds mainly the forest specialists and birds of prey. Availability of primary requirements such as food, shelter, resting, roosting, and nesting sites that primarily influence the bird populations (Vaclav et al. 2003; Rompre et al. 2007; Zhou et al. 2007) is not equally available in all the study sites throughout different seasons (Chauhan et al. 2008; Kumar et al. 2010). Low species richness noticed during monsoon is attributed to their dispersal in search of nesting sites (Urfi 1996, 1997; Mazumdar 2019).

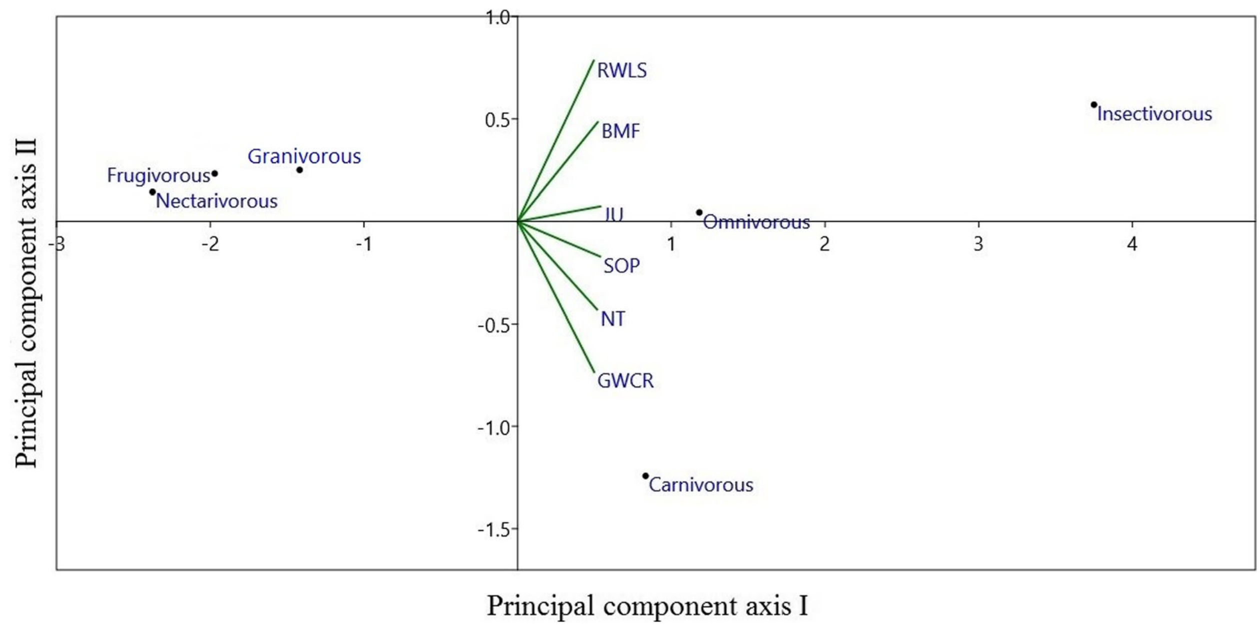


**Fig. 7** Representation of bird feeding guilds corresponding to habitat types along two principal component axis among the study sites

It is well known that environmental drivers of richness vary across feeding guilds (Ding et al. 2019). Insectivores emerged as dominant feeding guild in most of the study sites followed by either omnivores or carnivores, a trend observed in several other studies from subtropical habitats (Chatterjee et al. 2013; Kottawa-Arachchi et al. 2015; Mukhopadhyay and Mazumdar 2019). Insectivores constitute most species-rich feeding guild as observed by Styringa et al. (2011), Bonilla et al. (2012), Koli (2014), Kumbar and Ghadage (2014), Ding et al. (2015), and Ding et al. (2019). These are found abundantly in insect-rich landscapes which include streamside areas, forests, and informal settlements (Gatesire et al. 2014). Increased plant productivity reflects the abundance of insects and so the abundance of insectivores (Pettorelli et al. 2011). Increase in shrub canopy in urban areas creates a suitable environment for food and shelter and enhances richness in insectivore guild (Imai and Nakashizuka 2010; Pinotti et al. 2012; Perera et al. 2017; Ferger et al. 2014). Forested landscapes and plantations around Ramnagar Wildlife Sanctuary, Bahu-Mahamaya forest, and the University of Jammu Campus offered moist conditions, high tree density, and dense foliage that harbored abundant insect fauna. Prevalence of insectivores and carnivores in aquatic habitats is attributed to an adequate food base available in nutrient-rich water of Nikki Tawi and Gharana Wetland Conservation Reserve. Santiago-Alarcon (2011), Kumar and Gupta (2013), and Whittington et al. (2013) recorded similar observations in urban aquatic ecosystems. Wetland attracts waterfowl, waders, birds of prey, and several other wetland-dependent birds year-round due to abundant food availability such as insects, crabs, shrimps, molluscs, and indigenous fish (Mukhopadhyay and Mazumdar 2019; Sohil and Sharma 2020). The vast expanse of agricultural fields dotted with villages and water bodies in southern open plains attract many species of raptors. Farmlands and water reservoirs provide enhanced food supply to raptors in the form of diverse fauna including water snakes (Tingay et al. 2010), water birds (Mukherjee and Wilske 2006), and dead fish (Sánchez-Zapata et al. 2016). The omnivore guild appeared the dominant foraging guild for terrestrial birds next to insectivores as observed by Sultana (2013), Katuwal et al. (2016), and Mukhopadhyay and Mazumdar (2019) as well. Omnivores with a tendency to exploit a wide array of natural and novel food resources (Mukhopadhyay and Mazumdar 2019) have expanded their ranges with increased abundance in urban habitats (Jokimäki and Suhonen 1993; Clergeau et al. 1998; Sorace 2002). Granivores and omnivores have higher colonization rates in agricultural degraded landscapes (Frishkoff et al. 2014) and open habitats with larger seed banks (Díaz and Telleria 1996; Chettri et al. 2005). As frugivores are regulated by fruit-bearing plants (Trager and Mistry 2003; Kissling et al. 2007; Pinotti et al. 2012; Chatterjee and Basu 2015) and habitat intactness, their low numbers may be linked to less fruit plant diversity and high level of habitat fragmentation (Gomes et al. 2008). Nectarivores were related to open habitats with the prevalence of flowering plants (Laiolo 2003) strongly regulated by the blooming season (Abrahamczyk and Kessler 2010). Habitat

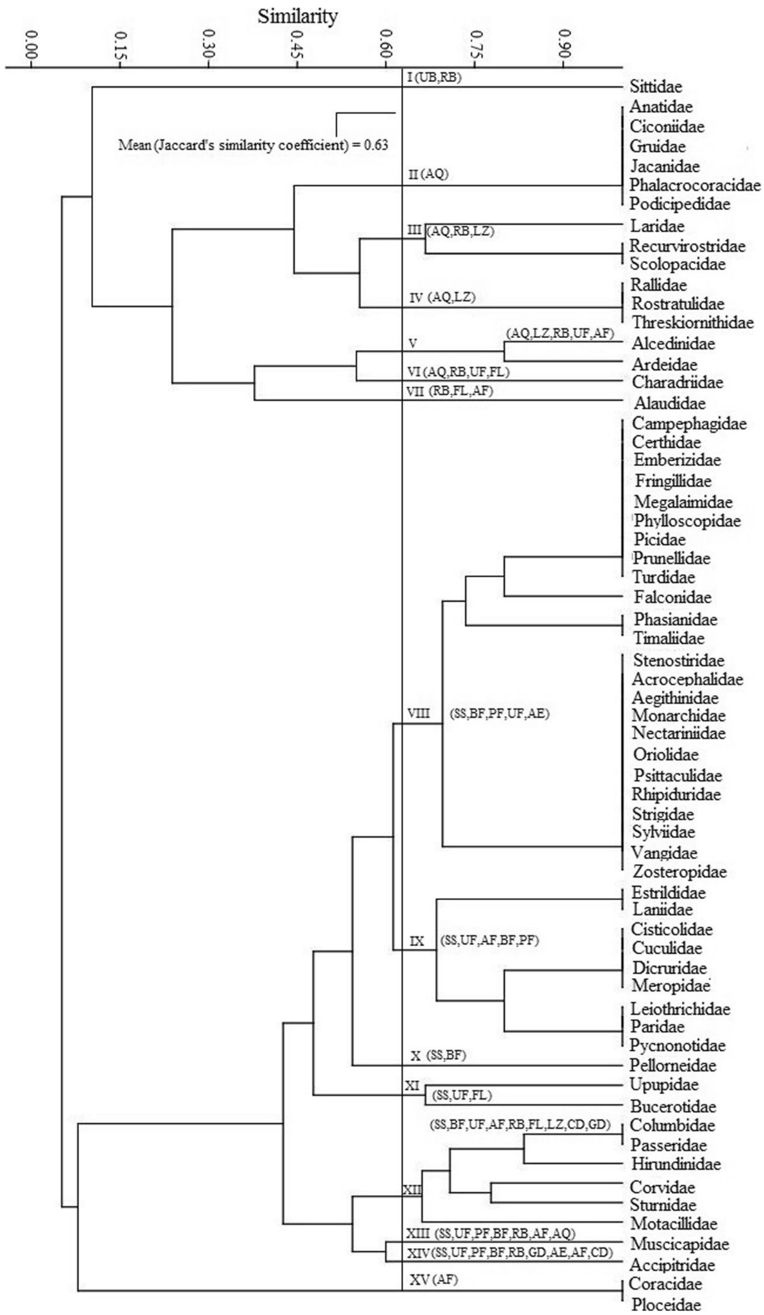


**Fig. 8** Jaccard's similarity dendrogram showing habitat guild structure among observed bird families in the study area. Roman numerals refer to guilds and mnemonics in brackets represent the habitat type (see Fig. 5)

interfaces mainly harbored the carnivores comprised of raptors and a few generalists. It may be due to an increased amount of microhabitats, visibility, and prey base (Kottawa-Arachchi et al. 2012; Wijesundara and Wijesundara 2014). It can be concluded that feeding guilds with more ecological tolerance and broader resource utilization respond positively to habitat heterogeneity, whereas the specialized guilds prefer specific habitats (Bonilla et al. 2012).

Thirteen major bird habitat guilds were identified during the surveys. Most of the bird species occupied protected areas, rich in forest cover, close to urban settlements. It is established that like many other animals, birds also require a variety of habitats to live, feed, and breed (Nagy et al. 2017; Ndanganga et al. 2013; Dahal et al. 2014; Morante-Filho et al. 2015, Sharma et al. 2018). Forest type, its size, structure, and limited anthropogenic disturbance play a vital role in avifaunal community richness and composition (Baral and Inskipp 2005). Subtropical forests were species rich, and the protected areas, Ramnagar Wildlife Sanctuary and Bahu-Mahamaya forest mostly harbored forest specialists. The urban forested areas attracted a large number of migratory as well as resident birds (Grimmett and Inskipp 2007; McKinney 2008; Evans et al. 2009) as the forest fragments (Donnelly and Marzluff 2004), gardens (Gaston et al. 2005; White et al. 2005), tree-lined avenues, and residential yards (Savard et al. 2000; Belaire et al. 2015; Tiwary and Urfi 2016) harbor more bird species. These natural habitats in urban matrix function as a refuge for woodland species (Croci et al. 2008), enhance the abundance of food resources, and provide nesting opportunities including cavities (Mörtberg and Wallentinus 2000). It is well known that birds form an essential part of biodiversity in urban wetlands and associated aquatic habitats (Andradea et al. 2018). Among aquatic habitats, Gharana Wetland Conservation Reserve and Nikki Tawi harbored a large number of aquatic and water-dependent birds. Wetlands provide critical foraging areas for many waterbird species (Chatterjee et al. 2020), and their high productivity enables different bird groups to use similar food resources (Weller 1999). Majority of birds observed in these wetlands were wintering visitors who are champions in resource partitioning (Polla et al. 2018). High prevalence of Anatidae and Accipitridae at Gharana Wetland Conservation Reserve indicated high ecosystem productivity and intactness (Jamwal et al. 2017). The higher number of carnivores and omnivores is attributed to the presence of a variety of aquatic invertebrates, small fishes, and aquatic plants (Sohil and Sharma 2020).

Analysis of resource utilization pattern through cluster analysis showed most of the species shared a wide range of habitat and food type. Generalists were more specious in comparison to the specialists in terms of their feeding affinities. Similar observations were recorded by Perez-Crespo et al. (2013) and Chatterjee et al. (2020). The species occupying a wide array of habitats are better accustomed to habitat changes than the species confined to a few habitat types (Goerck 1997). Specialized habitats in the form of intact forest patches, ecosystem interfaces, and smaller wetlands hence call immediate conservation attention in the region. In the given findings of this study, our hypothesis holds good to be considered. The study signifies that habitat choices govern bird assemblages and their foraging preferences viz-a-viz quality and time of the year, i.e., season. Bird groups with restricted resource utilization were considered specialists.

## Conclusions

It was observed that bird species responded differently to habitats in terms of choice of their food. Intact forest patches, protected areas, and wetlands with adequate food base and allied resources were species rich while the patchy landscapes were species scarce. Insectivores and omnivores emerged as the favored feeding guilds and protected areas as the preferred habitats. The findings of this study thus underline the importance of avian guild structure in regulating bird assemblages viz-a-viz their habitat improvement. The study further sets a background for intensive investigations on bird-habitat relationships, more specifically involving the species of high conservation interest. We recommend habitat conservation and improvement measures to be integrated into policy frameworks, especially those related to urban planning.

## Supplementary information

**Supplementary information** accompanies this paper at https://doi.org/10.1186/s13717-020-00250-9.

**Additional file 1.** Bird species distribution (common and binomial names, familial representation), guild structure and migratory status in mosaic landscapes around Jammu.

### Abbreviations

UPGA: Unweighted pair-group average; EBA: Endemic bird area; NT: Nikki Tawi; GWCR: Gharana Wetland Conservation Reserve; RWLS: Ramnagar Wildlife Sanctuary; BMF: Bahu-Mahamaya forest; JU: University of Jammu Campus; SOP: Southern open plains; HBW: Handbook of the birds of the wild; PCA: Principal component analysis; PAST: Paleontological statistics software; SS: Subtropical scrub; BF: Subtropical broadleaved forests; PF: Subtropical pine forests; U: Urban forests; RB: Riverbed; FL: Fallow land; GD: Garbage dumps; AE: Aerial; CD: Carcass dump; AF: Agricultural fields; AQ: Aquatic; UB: Urban buildings; LZ: Littoral zone of wetland; I: Insectivorous; G: Granivorous; C: Carnivorous; O: Omnivorous; F: Frugivorous; N: Nectarivorous

### Acknowledgements

Authors thankfully acknowledge the help and support provided by Rector, Bhaderwah Campus, and Head, Department of Environmental Sciences University of Jammu. Department of Wildlife Protection, Govt. of Jammu and Kashmir is also thanked for providing necessary permissions and local logistics during the surveys. We are obliged to Bushan Kumar, Mr. Muzaffar A Kichloo, Mr. Dinesh Singh, and Ms. Vandana Dutt, the researchers in IME for their help during the field surveys. The help rendered by Drinder Singh Manhas in map synthesis is duly acknowledged.

### Authors' contributions

NS conceptualized the study and edited the manuscript. AS collected and analyzed the data and wrote the manuscript. The authors read and approved the final manuscript.

### Funding

The study is self-financed

### Availability of data and materials

The checklist of the birds is provided as Additional file.

### Ethics approval and consent to participate

All requisite information and data was collected without disturbing the birds and their habitats. Photographic records were collected using a telephoto lens. Birds in nesting were not photographed.

### Consent for publication

Not applicable

**Competing interests**
The authors declare that they have no competing interests.

Received: 16 December 2019 Accepted: 9 August 2020
Published online: 26 September 2020

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