*Zoodiversity*, **56**(1): 67–82, 2022
DOI 10.15407/zoo2022.01.067

UDC 598.2:(2-22:540.13)

# FACTORS AFFECTING AVIFAUNAL DIVERSITY IN SELECTED AGRO-ECOSYSTEMS OF HIMACHAL PRADESH AGRICULTURAL UNIVERSITY, PALAMPUR, HIMACHAL PRADESH, INDIA

**J. D. Kottawa-Arachchi[1,2*], G. Thakur[2], A. Dwivedi[2], R. Tshering[3], H. M. Samimi[4], Y. Chaudhary[5], H. K. Chaudhary[2]**

[1]*Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka*
[2]*Department of Genetics and Plant Breeding, Collage of Agriculture, Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh, India*
[3]*National Veterinary Hospital, Motithang, Thimphu, Bhutan*
[4]*Ahmad Shah Baba Mena, Kabul, Afghanistan*
[5]*School of Engineering, University of Leicester, LE1 7RH, United Kingdom*
**Corresponding author*
*E-mail: jeevan.dananjaya@gmail.com*

J. D. Kottawa-Arachchi (https://orcid.org/0000-0001-8498-07)
G. Thakur (https://orcid.org/0000-0002-4054-2176)
H. K. Chaudhary (https://orcid.org/0000-0002-3125-7795)

**Factors Affecting Avifaunal Diversity in Selected Agro-Acosystems of Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh, India. Kottawa-Arachchi, J. D., Thakur, G., Dwivedi, A., Tshering, R., Samimi, H. M., Chaudhary, Y., Chaudhary, H. K.** — Avifaunal diversity in eight different habitats of Himachal Pradesh Agricultural University, Palampur was studied in order to find factors affecting the occurrence of bird species. Bird populations were sampled in different agro-ecosystems such as farm fields (experimental and organic), wetland, abandoned tea plantation, administration area, playground, secondary forest and stream vegetation. A total of 125 species of birds belonging to 51 families, including 33 winter visitors and 27 summer visitors have been recorded. Among them, 78 insectivores followed by 18 carnivores were recorded. The abandoned tea field was a diverse habitat that maintained the highest species richness (50 species), followed by stream vegetation and organic farm. Seasonal variations and habitat heterogeneity play crucial role in shaping species richness. Plant diversity, vegetation structure and microhabitats support different feeding guilds and provide temporary refuge and migratory route which result in increased bird diversity. Based on different feeding guilds, the cluster analysis revealed two distinct clusters of habitats. The first cluster containing playground, experimental farm and wetland whereas cluster II contained habitats *viz*. abandoned tea plantation, organic farm, stream vegetation, administration area and secondary forest. Several conservation measures such as increasing plant diversity, conducting regular and long-term systematic studies, introducing bird friendly management plan are recommended to conserve and enhance avifaunal diversity in the university.
Key words: Biodiversity, habitat complexity, Himachal Pradesh, stream vegetation, tea plantation.

## Introduction

Birds are suitable taxa to study for understanding the response of animals to anthropogenic disturbance because they are sensitive to it (Chazdon et al., 2009). Birds are key players in ecosystems by providing important ecosystem services (MEA, 2005), such as controlling populations of invertebrate and vertebrate pests, pollinating flowers and dispersing plant seeds, scavenging carcasses and waste, affording cultural services, being ecosystem engineers etc. Recent studies confirmed the concept of "using birds as indicators for recognizing land ecosystems rich in biological diversity" (O'Connell et al., 2000; Niemi & McDonald 2004) and landscape disturbance (Morelli, 2015). It is well recognized that the protected areas including world heritage sites, wildlife sanctuaries, national parks, biodiversity and nature reserves are critical to support biodiversity and play a key role in essential ecological functions (Sekercioglu, 2006).

In addition to natural ecosystems, several agroforestry systems such as agrisilviculture, silvipasture, agrisilvipasture, homegardens, tea gardens, shelterbelts, forested riparian buffers support avifauna (Harvey & Villalobos, 2007; Ulman et al., 2016). These ecosystems provide many opportunities to sustainable bird life by contributing nesting sites, temporary refuge and migratory route, protective or escape cover against predators, access to breeding territory and food resources in all seasons (Griffith, 2000; Buck et al., 2004; Maas et al., 2015). Presently, they are confronting various threats from climate change and human interferences such as loss of habitat through inflow of domestic and industrial effluents, agricultural runoffs, degradation of wetlands, agricultural expansion, overgrazing of the grasslands, and urbanization leading to deforestation (Scharlemann et al., 2004; Aratrakorn et al., 2006).

Himachal Pradesh, India, the mountainous state is well known for its natural wealth. It is situated between 30°22'40» to 33°12'40» N latitude and 75°45'55» to 79°04'20» E longitude in the Western Himalayas. Various environmental factors have a profound influence on the biological diversity and distribution, especially in the Himalayas with extreme climatic conditions (Mahabal & Sharma, 1992). In the complex folded mountain chain like Himalayas the altitudinal variations, topographical and climatic conditions have greatly influenced the biological diversity and its distribution. The state is mountainous (ranging between 460 and 6600 m a. s. l.), drained by a number of snow-fed perennial rivers. It has a complex geography and habitats and encompasses a rich temperate flora and fauna (Kumar, 2018). There are six major forest types in Himachal Pradesh: tropical dry deciduous, sub-tropical pine, sub-tropical dry evergreen, Himalayan moist temperate, Himalayan dry temperate, and subalpine and alpine. Himachal Pradesh is extremely important for the protection of many species of pheasants and forest birds (Narwade et al., 2006).

During the last few decades, a number of studies have been carried out by various workers on various aspects of avifauna of the region especially their diversity, threatened status, conservation measures in addition to geographical and altitudinal distribution pattern. The birds of Himachal Pradesh have been well studied by Ali and Ripley, (1983) including areas like Shimla, Dalhousie, Dharamshala. Previous avifaunal studies recorded 77 and 103 species in Khajjiar lake and catchment of Ravi river in district Chamba, Himachal Pradesh respectively (Singh, 2011; Singh & Banyal, 2013). Total of 169 and 95 species were recorded in two wetland ecosystems in Kangra and Mandi districts, respectively (Singh et al., 2014; Sharief et al., 2018).

Even though several studies have been conducted on birds in and around protected areas in Kangra district, Himachal Pradesh, the role of human-modified land uses in conservation of birds has not been thoroughly studied in an agricultural landscape. The present study aims to identify the habitats, which are beneficial to bird life in agro-ecosystems, quantify the present status of avifaunal diversity, behavioural patterns and identify the factors affecting the distribution of avifauna in Himachal Pradesh Agricultural University, Palampur. This information could be of importance in formulating effective strategies to conserve the agro-ecosystems, to develop further studies and in particular to understand the factors affecting the natural avifaunal diversity in agricultural landscape.

## Study area and methods

### Study area

The study area is located in Himachal Pradesh Agricultural University, Palampur, India (32.103° N and 76.551° E) and comprises about 397 hectares of undulating terrain (fig. 1). The average elevation is 1250 m a. s. l. The agro-ecosystems in the university are dominated by agricultural experimental fields with various field cops such as rice, wheat, maize, legumes and forages followed by secondary forests, abandoned tea plantations with high shade trees *Grevillea robusta*, *Pinus* spp. and *Eucalyptus* spp. in addition to small orchards under multi-species of fruits including apple, peaches, kiwi fruit, nectarine. There are segments of land with multi-species cultivation of vegetables managed by various departments of the university. Several stream vegetation patches observed along seasonal streams dominated with non-deciduous trees and bamboo species. *Callistemon viminalis*, *Salix babylonica*, *Cedrus deodara* and *Jacaranda mimosifolia* dominated roadsides as ornamental trees. Trees belonging to genus *Pinus*, *Albizia procera*, *Jacaranda mimosifolia, Acacia leucophloea* and *Grevillea robusta* have been planted surrounding the playground as shade trees. Local climate is classified as subtropical, and shows well-marked winter (October–February), summer (March–June) and monsoon (July–September) seasons throughout the year. The minimum temperature is 5 °C in January (winter) and maximum 40 °C in June (summer). The annual rainfall in this zone varies from 1500 mm to 1800 mm.

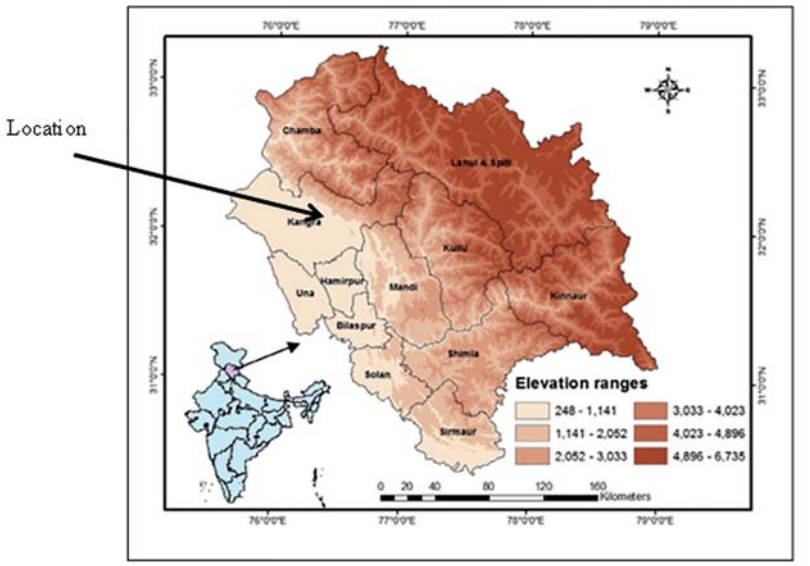


Fig. 1. Location of the study area. Himachal Pradesh Agricultural University, Palampur, India.

A thorough field survey was undertaken to identify different habitats in the University and based on the complexity of habitat structure, eight habitats (organic farm (OF), experimental farm (EF), administration area (AA), playground (PG), secondary forest (FR), wetland (WT), stream vegetation (SV) and abandoned tea plantation (AT)) were chosen for the present study.

### Sampling Procedure

The field survey was conducted from January 2019 to April 2020 covering three distinct seasons, winter (October–February), summer (March–June) and monsoon (July–September). Line transect of 100 m length and 20 m width on either side of centre line was marked in all selected habitats for bird count (Javed & Kaul, 2002). The intensity of observations was two days per month and 20 minutes was spent at each habitat. The field surveys were done for three hours starting from 06h00 or 07h00 and 15h30 or 15h00 depending on the day length in summer and winter seasons, respectively. The time of monitoring of each habitat was planned in such a way to ensure that each habitat was monitored both in the morning as well as in the evening. During the field work, birds were recorded by species, number, food preferences and type of habitat used in the field by field binocular (8 × 40). The identification of species was carried out with the help of the field guide on the birds of Northern India by Grimmett and Inskipp (2003) besides using call and song notes from online bird database HBW Alive (2021). A pre-designed data sheet was used for the purpose of recording.

The checklist of the birds of the study was prepared according to the last version of BirdLife International-HBW list of the birds of the world (http://datazone.birdlife.org). Conservation status of the species has been incorporated in the study (IUCN 2014). Birds sighted during the survey have been categorized based on their migratory nature according to the literatures with presence/absence method as follows: R = resident, SV = summer visitor, WV = winter visitor, WV/PM = winter visitor and passage migrant.

### Feeding guild classification

Based on their food preferences, bird species were categorized into insectivorous, carnivorous, omnivorous, granivorous, nectarivorous and frugivorous. The feeding guilds were classified exclusively for the type of food consumed as their principal diet. Besides, habitat preferences and behaviour of the birds such as perching, feeding, nesting, and mating were recorded.

### Statistical Analysis

Species diversity parameters such as total abundance, species richness, species heterogeneity using Shannon-Wiener diversity index (H'), Simpson's index and Fisher alpha were calculated using PAST 3 software. Meanwhile, the Pielou's evenness index was used to estimate similarities in habitat utilization based on presence/absence of each taxon in each habitat type. To assess degree of similarity in bird communities among habitat types surveyed, Sorensen similarity index was used. A heatmap was generated based on feeding guilds data for clustering different habitats using ClustVis, freely available online software at http://biit.cs.ut.ee/clustvis. The data was ln (x+1) transformed, and similarity assessment for clustering was based on the Euclidean distance and Ward's linkage clustering method.

## Results and discussion

### Avian species diversity

During the study period, a total of 125 species of birds belonging to 51 families have been recorded (Supplementary table 1). The most dominant family which is famous for its migratory nature was Muscicapidae which represents 16 species, followed by family Accipitridae which represents 7 species and family Phylloscopidae and Cisticolidae with 6 species each. Results revealed that 81 species (64.8 % of the total recorded) were passerine (Order Passeriformes) birds belonging to 32 families, comprised of various groups such as shrikes, minivets, babblers, drongos, crows, flycatchers, tits, bulbuls, warblers, prinias, redstarts, thrushes, starlings, sunbirds, pipits and sparrows. Three bird species, Alexandrine Parakeet (*Palaeornis eupatria*), Great Tit (*Parus major*) and Himalayan Bulbul (*Pycnonotus leucogenys*), were observed in all eight habitats and the most common bird species was the Alexandrine Parakeet. Among the birds recorded during the survey, single sighting of Egyptian Vulture (*Neophron percnopterus*) and Lesser Fish-eagle (*Icthyophaga humilis*) were recorded. Those two species are belonging to endangered (EN) and near threatened (NT) categories, respectively.

Diversity and species composition parameters showed a considerable variation among eight different habitats selected (table 1). The results indicated that abandoned tea field is a diverse habitat that maintains the highest species richness, comprising 50 bird species that represent 40 % of all species recorded in the survey (H' = 3.19, Fisher alpha = 13.87, Simpson's index (1-D) = 0.935). Although both Shannon (H') and Simpson's index (1-D) consider the proportional abundance of species, H' is more sensitive to rare species, whereas 1-D puts emphasis on the common species (Roy et al., 2011). Besra (*Accipiter virgatus*), Yellow-bellied Fairy-fantail (*Chelidorhynx hypoxanthus*), Grey-headed Canary-flycatcher (*Culicicapa ceylonensis*), Green-backed Tit (*Parus monticolus*), Ashy-throated Warbler (*Phylloscopus maculipennis*), Whistler's Warbler (*Seicercus whistleri*), Rusty-tailed Flycatcher (*Ficedula ruficauda*), Slaty-blue Flycatcher (*Ficedula tricolor*) and Crimson Sunbird (*Aethopyga siparaja*) were restricted to the abandoned tea field.

Stream vegetation is the second most diverse habitat where 42 species were recorded (H' = 3.06, Fisher alpha = 13.57). Black Drongo (*Dicrurus macrocercus*), Crow-billed Drongo (*Dicrurus annectens*), Jungle Prinia (*Prinia sylvatica*), Blue-throated Blue-flycatcher (*Cyornis rubeculoides*), Little pied Flycatcher (*Ficedula westermanni*), Plumbeous Water-redstart (*Phoenicurus fuliginosus*), White-capped Water-redstart (*Phoenicurus leucocephalus*) and Chestnut-tailed Starling (*Sturnia malabarica*) were recorded only in this habitat.

A total of 40 bird species was recorded in organic farm (H' = 3.02, Fisher alpha = 9.59). Great Barbet (*Psilopogon virens*), Alexandrine Parakeet, Himalayan bulbul and Indian White-eye (*Zosterops palpebrosus*) were very common in this habitat whereas Collared Owlet (*Glaucidium brodiei*) and White-tailed Nuthatch (*Sitta himalayensis*) observed as single record each.

**Table 1. Avifaunal richness and diversity indices of different habitats surveyed**

| Parameters | OF | EF | AA | PG | FR | WT | SV | AT |
|---|---|---|---|---|---|---|---|---|
| No. of species | 40 | 38 | 22 | 35 | 29 | 33 | 42 | 50 |
| Individuals | 611 | 489 | 440 | 599 | 237 | 300 | 286 | 496 |
| Shannon (H') | 3.02 | 2.86 | 2.53 | 2.68 | 2.61 | 2.81 | 3.06 | 3.19 |
| Simpson 1-D | 0.927 | 0.915 | 0.899 | 0.902 | 0.885 | 0.912 | 0.926 | 0.935 |
| Pielou's Evenness (J) | 0.819 | 0.793 | 0.831 | 0.755 | 0.775 | 0.805 | 0.818 | 0.817 |
| Fisher alpha | 9.593 | 9.292 | 4.592 | 8.110 | 8.673 | 9.462 | 13.571 | 13.872 |

Note. OF — organic farm, EF — experimental farm, AA — administration area, PG — playground, FR — secondary forest, WT — wetland, SV — stream vegetation, AT — abandoned tea plantation.

Banded bay Cuckoo (*Cacomantis sonneratii*), Yellow-billed blue Maqpie (*Urocissa flavirostris*), Asian Brown Flycatcher (*Muscicapa dauurica*) and Blue-fronted Redstart (*Phoenicurus frontalis*) were observed only in the secondary forest habitat. Although secondary forest habitat comprised of diverse tree species, a smaller number of bird species were observed. Low visibility due to more canopy cover, less open places for various feeding guilds than surrounding farm fields could be the reasons for detecting low avifaunal diversity (29 species, H' = 2.61, Fisher alpha = 8.67). Small birds such as warblers and white-eyes preferred this habitat for their feeding and hiding place during day time.

The administration area demonstrated the lowest species abundance (22 species) and Shannon index (H' = 2.53), but the highest evenness (J = 0.831) was observed in the habitat. Common bird species including Rock Dove (*Columba livia*), House Swift (*Apus nipalensis*), Great Barbet, Alexandrine parakeet, Large-billed Crow (*Corvus macrorhynchos*), Barn Swallow (*Hirundo rustica*), Red-rumped Swallow (*Cecropis daurica*) and House Sparrow (*Passer domesticus*) are recorded in higher numbers. They were sighted either perched on buildings or perched on *Cedrus deodara*, *Jacaranda mimosifolia* and *Pinus* trees. A total of 35 bird species was recorded in playground habitat. Most of the birds were sighted either as flocks of different species or perched on *Jacaranda mimosifolia*, *Albizia procera*, and *Grevillea robusta* trees. In addition to the lowest tree diversity in both these habitats, human disturbances around this area have resulted in the lowest bird diversity.

Although, the diversity of shade trees is low, the experiment farm field hosted 38 avian species. In addition to higher numbers of insectivores, raptors such as Egyptian Vulture, Oriental Honey-buzzard (*Pernis ptilorhynchus*), Lesser Fish-eagle (*Ichthyophaga humilis*), Mountain Hawk-eagle (*Nisaetus nipalensis*) were observed only in this habitat.

The wetland habitat is a hydrologically influenced woodland, which is prone to regular floods during the monsoon. A total of 33 bird species was recorded in this habitat. White-breasted Waterhen (*Amaurornis phoenicurus*), Indian Cormorant (*Phalacrocorax fuscicollis*) were recorded at this site regularly. Common Sandpiper (*Actitis hypoleucos*), Grey Heron (*Ardea cinerea*), Great White Egret (*Ardea alba*), Brown Dipper (*Cinclus pallasii*) and White-breasted Kingfisher (*Halcyon smyrnensis*) were restricted to the wetland. The species richness was low during winter while it gradually increased during early summer (March–April) and reached its maximum value in summer.

The Sorensen's similarity index (SI) gives greater weight to matches in species composition between the two samples than mismatches. Sorensen's similarity indices depicted higher similarity between habitats AT and OF (Cs = 0.605) followed by habitats SV and OF (SI = 0.540) indicating higher than half of their species in common (table 2). Habitat OF showed higher Sorensen's indices with PL, SF, SV and AT indicating more common species shared between these habitats. The most distinct habitat was the EF compared with SV (SI = 0.112) and FR (SI = 0.149), indicating for a very high dissimilarity, implying further that these habitat types have quite distinct species composition.

**Table 2. Pairwise Sorensen index depicts the species similarities among habitats**

| | OF | EF | AA | PG | FR | WT | SV | AT |
|---|---|---|---|---|---|---|---|---|
| OF | 1 | | | | | | | |
| EF | 0.301 | 1 | | | | | | |
| AA | 0.329 | 0.356 | 1 | | | | | |
| PL | 0.481 | 0.255 | 0.453 | 1 | | | | |
| FR | 0.425 | 0.149 | 0.306 | 0.293 | 1 | | | |
| WT | 0.365 | 0.347 | 0.272 | 0.259 | 0.238 | 1 | | |
| SV | 0.540 | 0.112 | 0.233 | 0.374 | 0.468 | 0.262 | 1 | |
| AT | 0.605 | 0.218 | 0.309 | 0.300 | 0.430 | 0.349 | 0.485 | 1 |

Note. OF — organic farm, EF — experimental farm, AA — administration area, PG — playground, FR — secondary forest, WT — wetland, SV — stream vegetation, AT — abandoned tea plantation.

**Factors affecting avian diversity**

Habitat complexity

In an agro-ecosystem, bird diversity is more strongly associated with crop or landscape diversity (Kleijn et al., 2006; Poggio et al., 2010). Even though the numbers of bird species observed in organic farm and experimental farm are very close, the number of individuals is significantly higher for organic farm. Conventional agricultural management involving use of inorganic nitrogen fertilizers, regular re-seeding, early and repeated mowing, fewer species and less structural diversity, provides poorer food resources and reduced nesting opportunities for a few bird species (Vickery et al., 2004). Conversely, the organic farms tended to hold higher densities of birds than conventional farms (Chamberlain et al., 1999). Organic management typically employs crop rotations involving nitrogen-building leys to maintain soil fertility. Pest and weed control are sought through careful use of mechanical techniques. Organic farms may thus be expected to support higher densities of birds associated with the management system such as non-crop habitats, hedge rows, ponds, cattle shelters, green manure crops, compost yards etc. Present study has indicated that farming practices which are characteristic of organic agriculture such as crop rotation, zero usage of synthetic pesticides and fertilizers would benefit bird communities more than conventional system (experimental farm).

Abandoned tea plantations offer opportunities for understanding ecological processes in modified forest ecosystems (Chetana & Ganesh, 2012). Unlike monoculture plantations, tea is maintained as a shrub with various shade trees. The abandoned tea field is heterogeneous with different high shade species like *Albizia procera*, *Grevillea robusta*, woody lianas and understory species but mainly the tea plants *Camellia sinensis*, that provided more niches and food sources for birds. Several studies reported higher abundance of birds in the tea gardens in India as compared to that of the surrounding forests and agroforestry habitats (Sidhu et al., 2010; Ahmed & Dey 2014; Ulman et al., 2016).

Increasing plant diversity could be considered as a good boost to enhance avian species diversity, because the habitat diversity is associated with an increase of niche availability for the bird species (Morelli, 2015). The secondary forest is a well wooded habitat but the lowest number of individuals and moderate diversity values (both Shannon and Fisher alpha) were recorded in this habitat among all habitats. This contradicts the idea that is given by several avifaunal surveys, as it provides high degree of species richness and biodiversity when vegetation cover is denser (Raman, 2006; Roy et al., 2011). Possible causes for the lowest diversity observed in the present study could be low visibility and thick understory in forest habitat. The stream vegetation is structured with numerous microhabitats like tall shade trees with decaying branches, fallen trees, bank vegetation along streams and understory vegetation with several species of grasses. Hence, wide variation of microhabitats is vital for foraging, feeding, nesting and breeding grounds of birds. Similarly, Bellanthudawa et al. (2019) observed an increase in the detection of more bird species in ecosystems with wide varieties of microhabitats.

Ding et al., (2019) found that the habitat heterogeneity had a large influence on the richness pattern. Present study indicates that the habitat heterogeneity plays crucial role in shaping species richness, probably because a greater structural complexity in vegetation can yield more resources and therefore support a larger number of species.

Distribution of feeding guilds

The richness of animal species is determined by the abundance, distribution and diversity of food resources. The present study shows a good representation of all categories of feeding guilds. This is expected because of the represented diverse habitats of the agro-ecosystems, providing structural and compositional complex of tree species, scattered fruiting and shade trees, annual crops, water sources, etc. which offer food resource for birds belonging to various feeding guilds. among 125 species recorded in the study period, insectivores contributed the maximum (78 species, 62.4 %) followed by carnivores

(18 species, 14.4 %), omnivores (11 species, 8.8 %), and granivores (9 species, 7.2 %). Frugivores (8 species, 6.4 %) and nectarivores (1 species, 0.8 %) contributed the least (fig. 2). Similarly, out of 89 species of the birds, 38 insectivores followed by 16 omnivorous species were recorded in Dhauladhar Nature Park, Himachal Pradesh (Chandel et al., 2014). When compared sitewise, insectivores dominated the study area while carnivores preferred open areas including farmlands and aquatic ecosystems. Omnivores, frugivores and granivores were more or less equally distributed. Nectarivores were confined to abandoned tea land during the study period.

Insectivores emerged as dominant feeding guild in most of the study sites followed by either omnivores or carnivores (fig. 2). Similar trends observed in several other studies from different ecosystems including agroforestry, agricultural fields, suburban-farmland, tea plantation, wetlands in Indian subcontinent (Hossain & Aditya, 2016; Kottawa-Arachchi & Gamage, 2015; Mukhopadhyay & Mazumdar, 2019; Sohil & Sharma, 2020; Ulman et al., 2016) and Himachal Pradesh (Singh et al., 2014; Singh & Banyal, 2013) specifically. The facilitative role of shade trees in the tea plantation in attracting canopy insectivores and frugivores is important in terms of densities of shade trees (Chetana & Ganesh, 2012). The high record of insectivorous species in abandoned tea plantation is probably due to the high availability of insects and pests which serve as a food resource for the birds in the study area. Granivores and ground-feeding species demonstrated stronger associations with open habitats such as experimental farm, where plants showed high rates of reproduction and produced large seed crops. A recent study found a positive interaction between habitat heterogeneity and insectivore richness, and a negative interaction with the richness of ground-feeding birds (Ding et al., 2019).

Carnivores including raptors (hawks, eagles and kites) were found to be the second largest guild in wetland and experiment farm whereas omnivores and frugivores were associated with well wooded habitats such as stream vegetation and secondary forest. Similarly, Barlow et al. (2007) observed an increase in the detection of canopy frugivores and seed predators during the peak flowering and fruiting in primary forests.

## Pattern of seasonal distribution of avifauna

Himalayan mountain range is an important destination for migratory birds and stopover for a number of passage migrants, owing to its geographical position and supporting habitats. Status of migratory birds of the region is documented by several

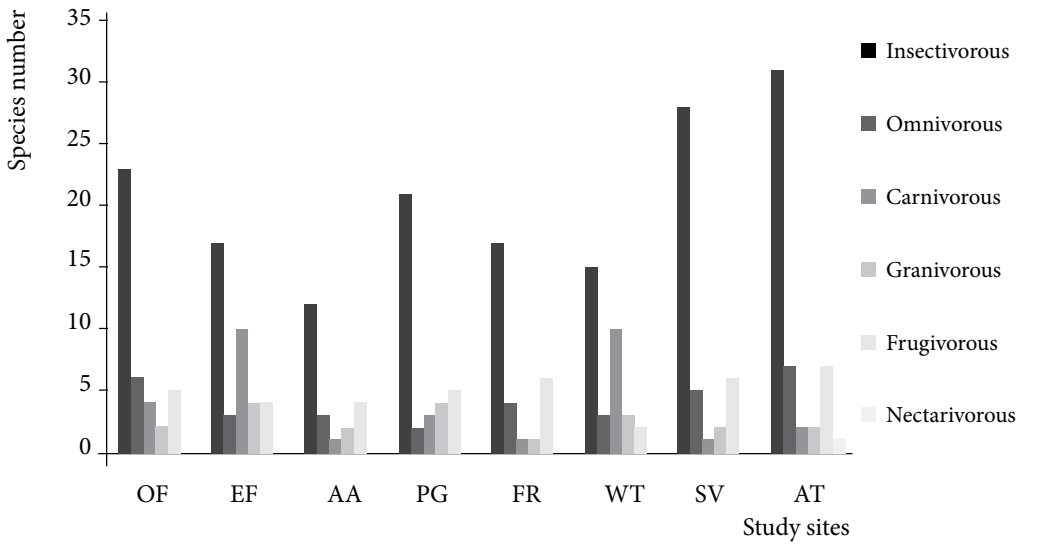


Fig. 2. Feeding guilds in the order of dominance.

researchers in Jammu, Himachal Pradesh and Uttarakhand states. During summer, some species which are migrating from other parts of the country, mainly from southern India, eastern India and Gangetic plains to breed in Western Himalayas were treated as summer migrants (Kumar, 2018). During winter, some species which are moving from high altitude to low elevation due to snowfall were treated as winter visitors or altitudinal migrants.

Among 125 bird species, 65 species (52 %) were categorized as resident, followed by winter visitors (33 species, 26 %) and summer visitors (27 species, 22 %). Present studies show similar results with the earlier works of Sharief et al. (2018) and Singh & Banyal (2013) from different biogeographical regions in Himachal Pradesh. Interestingly, the percentage of total migratory species (48 %) recorded in this study exactly tally with the results of recent study in Western Himalayas (Kumar, 2018).

The resident birds showed irregular trend of sighting and population fluctuations throughout the period. During January–February in both years (2019 and 2020) higher number of the species of resident birds were recorded whereas in October–November the lowest number was recorded (fig. 3). Several resident bird species move locally according to availability of food, rather than temperature. Present investigation revealed that higher number of species of winter visitors was recorded while summer visitors were near zero in winter and spring seasons (October–March) and vice versa for summer and monsoon seasons (April–September). In monsoon, the richness and the diversity of birds were low. This was due to the high rainfall which decreases the activity of birds and the nesting behaviour (Panda et al., 2021).

Agro-ecosystems in the university supported bird species of three resident/migratory statuses in differential pattern of abundance (fig. 4). The high number of resident species was recorded in abandoned tea plantation, experimental farm and organic farm whereas more species of winter visitors was observed in stream vegetation and abandoned tea plantation. All study sites provide more or less equal support to summer visitors than winter visitors. Experimental farm and administration area showed the lowest number of species of winter visitors,single species each. Winter visitors such as flycatchers (Family Muscicapidae) and warblers (Family Phylloscopidae and Cettiidae) were observed in higher numbers in stream vegetation and abandoned tea plantation regularly.

The different feeding guilds were used to determine the diversity of habitats by hierarchical cluster analysis. Considering the heatmap generated using Euclidean distance and Ward's linkage clustering method, habitats studied were grouped into two main clusters (fig. 5). Among eight selected habitats, PG, EF and WT were grouped in cluster I whereas cluster II represented habitats AT, OF, SV, AA and FR, indicating the similarity of

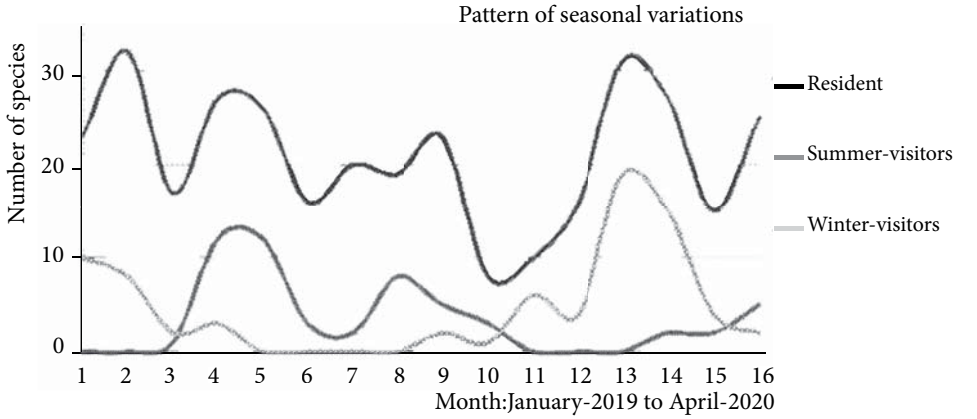


Fig. 3. Distribution pattern of resident/migratory status of avifauna across seasons during the study period from January 2019 to April 2020.

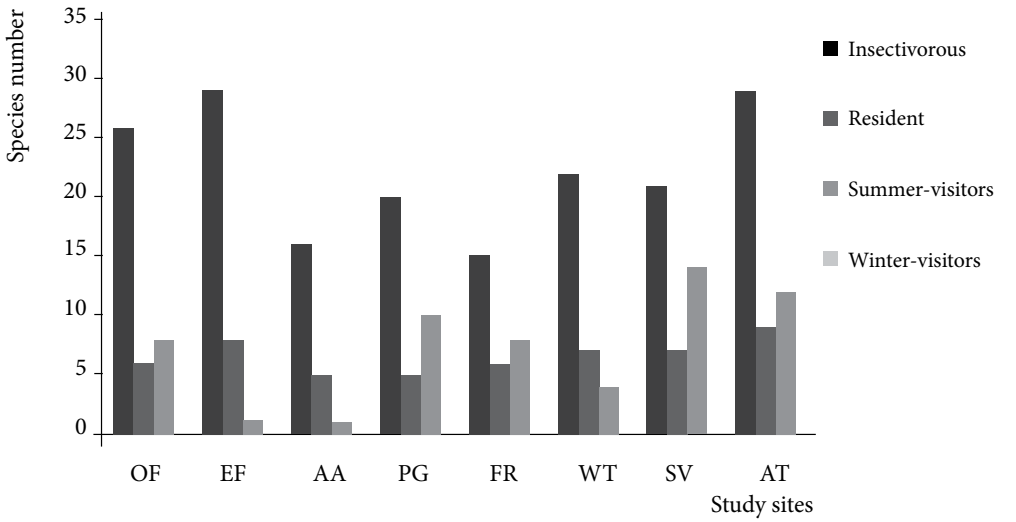


Fig. 4. Comparative resident/migratory status and relative abundance of birds at Himachal Pradesh Agricultural University study site.

habitat types. The carnivores and granivores contributed positively for grouping of habitats in cluster I. Further, insectivores, omnivores and frugivores contributed positively for grouping of habitats in cluster II.

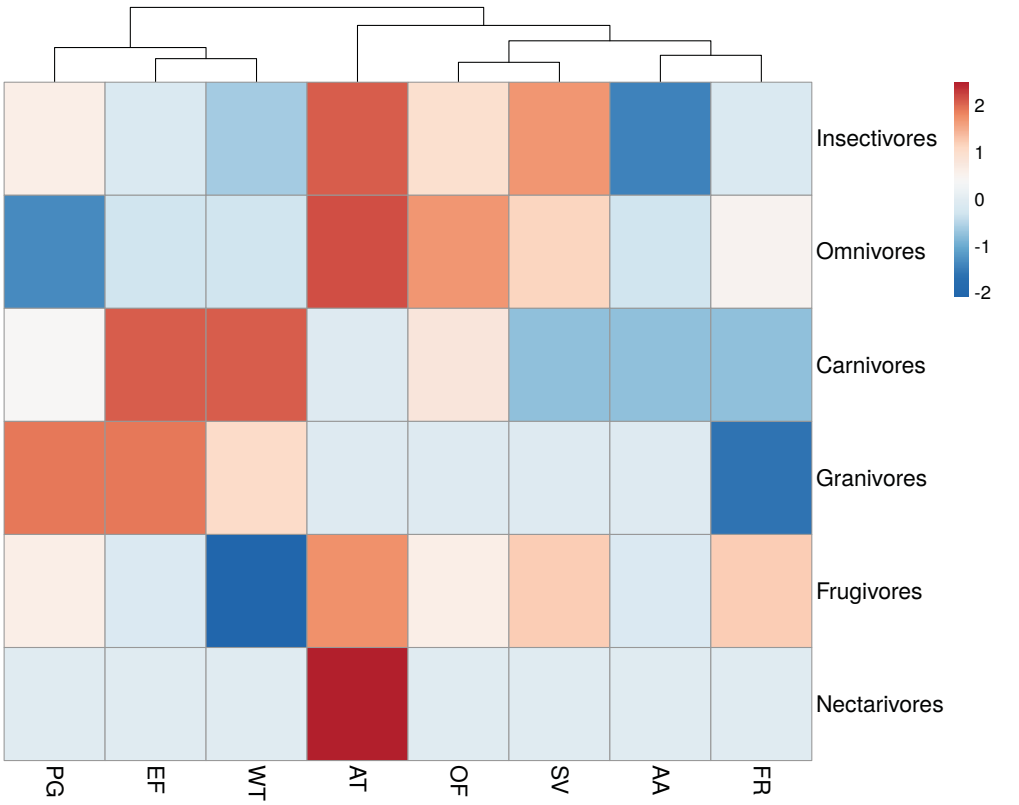


Fig. 5. The heatmap transformed data shows the contributions of different feeding guilds of bird species for clustering of habitats. Blue colour represents negative contribution while red represents positive contribution.

### Conservation issues and implications

Increased anthropogenic activities resulting in habitat destruction, degradation and fragmentation are some of the major threats to avian diversity in different ecosystems (Datta, 2011). Particularly, habitats associated with water bodies (like permanent and seasonal wetland and stream vegetation) support higher number of avian species in this area. Although, the university is maintaining an appreciable environment conservation policy, several anthropogenic activities were observed.

The accumulation of plastic and polythene is a serious threat to the wetland and stream vegetation habitats which can negatively influence the feeding ground of birds. The abandoned tea plantation is facing anthropogenic disturbances due to adjacent residential area and accumulation of garbage inside the habitat, which can greatly influence the structure of bird community. Regular human movement and noises from vehicles may have affected the behaviour of forest birds in secondary forest and stream vegetation.

The various agro-ecosystems of the university support high number of avifauna and, therefore, might be considered as a promising focus for ornithological research. The results revealed that the key habitats such as organic farm, abandoned tea plantation, stream vegetation and secondary forest support higher number of avian species. Those habitats host a number of winter visitors, summer visitors and passage migrants. An increase in plant diversity with native species and fruit-bearing plants in identified areas, home gardens and road side could contribute to the rise of avifaunal diversity.

## Conclusion

The present study is an effort towards the assessment of avian species richness in relation to habitat, within an agro-ecosystem of Himachal Pradesh Agricultural University, India. Out of the eight habitats selected for this study at Himachal Pradesh Agricultural University, abandoned tea plantation stand out as the best site for birds, followed by the stream vegetation and organic farm. This study would serve as an important baseline to assess the impact of habitat diversity and complexity, seasonal change on avifauna by comparing the gathered data with the results of future surveys on species richness in those habitats of the university. Therefore, the results revealed the importance of regular and long-term systematic studies on the avifauna emphasizing their conservation status, feeding and breeding ecology and resource use pattern in different habitats to foster sustainable and bird friendly management plan for the university.

#### Declarations

The authors declare no conflict of interests.

**Supplementary Table 1. List of bird species recorded at Himachal Pradesh Agricultural University with their status**

| No. | Family and Common name | Scientific name | Feeding | Status | OF | EF | AA | PG | FR | WT | SV | AT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Order Galliformes**<br>**Family Phasianidae** | | | | | | | | | | | |
| 1 | Black Francolin | *Francolinus francolinus* | O | R | | + | + | | | | | |
| 2 | Red Junglefowl | *Gallus gallus* | O | R | + | | | | | | | + |
| | **Order Suliformes**<br>**Family Phalacrocoracidae** | | | | | | | | | | | |
| 3 | Indian Cormorant | *Phalacrocorax fuscicollis* | C | R | | + | | | | + | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Order Pelecaniformes Family Ardeidae** | | | | | | | | | | | |
| 4 | Grey Heron | *Ardea cinerea* | C | SV | | | | | | + | | |
| 5 | Indian Pond-heron | *Ardeola grayii* | C | R | | | | | | + | | |
| 6 | Great White Egret | *Ardea alba* | C | SV | | | | | | + | | |
| 7 | Cattle Egret | *Bubulcus ibis* | C | SV | + | + | | + | | + | | |
| | **Order Accipitriformes Family Accipitridae** | | | | | | | | | | | |
| 8 | Egyptian Vulture | *Neophron percnopterus* | C | R/EN | | + | | | | | | |
| 9 | Oriental Honey-buzzard | *Pernis ptilorhynchus* | C | R | | + | | | | | | |
| 10 | Lesser Fish-eagle | *Icthyophaga humilis* | C | R/NT | | + | | | | | | |
| 11 | Mountain Hawk-eagle | *Nisaetus nipalensis* | C | R | | + | | | | | | |
| 12 | Shikra | *Accipiter badius* | C | R | | + | | | + | | | |
| 13 | Besra | *Accipiter virgatus* | C | R | | | | | | | | + |
| 14 | Black Kite | *Milvus migrans* | C | R | + | + | + | + | | + | | |
| | **Order Gruiformes Family Rallidae** | | | | | | | | | | | |
| 15 | White-breasted Waterhen | *Amaurornis phoenicurus* | C | R | | | | | | + | + | |
| | **Order Charadriiformes Family Charadriidae** | | | | | | | | | | | |
| 16 | Red-wattled Lapwing | *Vanellus indicus* | C | R | | + | | | | + | | |
| | **Family Scolopacidae** | | | | | | | | | | | |
| 17 | Common Sandpiper | *Actitis hypoleucos* | I | SV | | | | | | + | | |
| | **Order Columbiformes Family Columbidae** | | | | | | | | | | | |
| 18 | Rock Dove | *Columba livia* | G | R | | + | + | | | | | |
| 19 | Grey-capped Emerald Dove | *Chalcophaps indica* | G | R | | | | + | + | | + | |
| 20 | Oriental Turtle-dove | *Streptopelia orientalis* | G | R | | | | + | | | | |
| 21 | Eastern Spotted Dove | *Spilopelia chinensis* | G | R | + | + | | | | + | | + |
| | **Order Cuculiformes Family Cuculidae** | | | | | | | | | | | |
| 22 | Banded Bay Cuckoo | *Cacomantis sonneratii* | I | SV | | | | | + | | | |
| 23 | Common Hawk-cuckoo | *Hierococcyx varius* | I | SV | | + | | | | | | |
| 24 | Indian Cuckoo | *Cuculus micropterus* | I | SV | | + | | | | | | |
| 25 | Western Koel | *Eudynamys scolopaceus* | F | SV | | | | | | | + | + |
| 26 | Greater Coucal | *Centropus sinensis* | I | R | | | | | | + | | + |
| | **Order Strigiformes Family Strigidae** | | | | | | | | | | | |
| 27 | Asian Barred Owlet | *Glaucidium cuculoides* | C | R | + | | | + | | + | | + |
| 28 | Collared Owlet | *Glaucidium brodiei* | C | R | + | | | | | | | |
| | **Order Apodiformes Family Apodidae** | | | | | | | | | | | |
| 29 | House Swift | *Apus nipalensis* | I | R | | | + | | | | | |
| | **Order Coraciiformes Family Alcedinidae** | | | | | | | | | | | |
| 30 | White-breasted Kingfisher | *Halcyon smyrnensis* | C | R | | | | | | + | | |
| | **Family Meropidae** | | | | | | | | | | | |
| 31 | Blue-tailed Bee-eater | *Merops philippinus* | I | SV | | | | + | | | | |
| | **Family Upupidae** | | | | | | | | | | | |
| 32 | Common Hoopoe | *Upupa epops* | I | R | | + | + | | | | | |
| | **Family Bucerotidae** | | | | | | | | | | | |
| 33 | Indian Grey Hornbill | *Ocyceros birostris* | O | R | + | | | | + | + | + | + |
| | **Order Piciformes Family Megalaimidae** | | | | | | | | | | | |
| 34 | Blue-throated Barbet | *Psilopogon asiaticus* | F | R | + | | + | + | + | | + | + |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | Coppersmith Barbet | *Psilopogon haemacephalus* | F | R | | | | + | + | | | + |
| 36 | Great Barbet | *Psilopogon virens* | F | R | + | | + | + | + | | + | + |
| | **Family Picidae** | | | | | | | | | | | |
| 37 | Speckled Piculet | *Picumnus innominatus* | I | R | + | | | | | | + | + |
| 38 | Fulvous-breasted Woodpecker | *Dendrocopos macei* | I | R | + | | | + | | | + | |
| 39 | Grey-capped Woodpecker | *Picoides canicapillus* | I | R | + | | | + | + | | + | |
| 40 | Grey-faced Woodpecker | *Picus canus* | I | R | + | | | + | | | + | |
| 41 | Scaly-bellied Woodpecker | *Picus squamatus* | I | R | | | + | + | | | | |
| | **Order Falconiformes Family: Falconidae** | | | | | | | | | | | |
| 42 | Common Kestrel | *Falco tinnunculus* | C | SV | | + | | | | | | |
| | **Order Psittaciformes Family Psittacidae** | | | | | | | | | | | |
| 43 | Alexandrine Parakeet | *Palaeornis eupatria* | F | R | + | + | + | + | + | + | + | + |
| 44 | Plum-headed Parakeet | *Himalayapsitta cyanocephala* | F | R | | + | | | + | | | |
| | **Order Passeriformes Family Pittidae** | | | | | | | | | | | |
| 45 | Indian Pitta | *Pitta brachyura* | I | SV | | | | | + | | | + |
| | **Family Campephagidae** | | | | | | | | | | | |
| 46 | Long-tailed Minivet | *Pericrocotus ethologus* | I | R | | | | + | | | | |
| 47 | Scarlet Minivet | *Pericrocotus flammeus* | I | R | + | | | | | | | + |
| 48 | Small Minivet | *Pericrocotus cinnamomeus* | I | R | + | | | | | | | + |
| | **Family Laniidae** | | | | | | | | | | | |
| 49 | Brown Shrike | *Lanius cristatus* | I | SV | | | + | | + | + | | |
| 50 | Long-tailed Shrike | *Lanius schach* | I | R | | + | | | | | | |
| | **Family Dicruridae** | | | | | | | | | | | |
| 51 | Ashy Drongo | *Dicrurus leucophaeus* | I | SV | + | | | | | | + | + |
| 52 | Black Drongo | *Dicrurus macrocercus* | I | R | | | | | | | + | |
| 53 | Crow-billed Drongo | *Dicrurus annectens* | I | SV | | | | | | | + | |
| 54 | Hair-crested Drongo | *Dicrurus hottentottus* | I | SV | + | | + | + | + | | + | + |
| | **Family Rhipiduridae** | | | | | | | | | | | |
| 55 | White-throated Fantail | *Rhipidura albicollis* | I | R | | | | | | + | + | + |
| | **Family Stenostiridae** | | | | | | | | | | | |
| 56 | Yellow-bellied Fairy-fantail | *Chelidorhynx hypoxanthus* | I | WV | | | | | | | | + |
| 57 | Grey-headed Canary-flycatcher | *Culicicapa ceylonensis* | I | SV | | | | | | | | + |
| | **Family Monarchidae** | | | | | | | | | | | |
| 58 | Indian Paradise-flycatcher | *Terpsiphone paradisi* | I | SV | + | | | | + | | + | + |
| | **Family Corvidae** | | | | | | | | | | | |
| 59 | Black-headed Jay | *Garrulus lanceolatus* | I | WV | | | | + | | | | |
| 60 | Red-billed blue Magpie | *Urocissa erythroryncha* | O | R | + | | + | | + | | + | + |
| 61 | Yellow-billed blue Magpie | *Urocissa flavirostris* | O | WV | | | | | + | | | |
| 62 | Large-billed Crow | *Corvus macrorhynchos* | O | R | + | + | + | + | | | | + |
| | **Family Alaudidae** | | | | | | | | | | | |
| 63 | Indian Bushlark | *Mirafra erythroptera* | I | R | | + | | | | | | |
| 64 | Oriental Skylark | *Alauda gulgula* | I | R | | + | | + | | | | |
| | **Family Hirundinidae** | | | | | | | | | | | |
| 65 | Barn Swallow | *Hirundo rustica* | I | SV | | + | + | + | | | | |
| 66 | Red-rumped Swallow | *Cecropis daurica* | I | SV | | | + | + | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Family Paridae** | | | | | | | | | | | |
| 67 | Black-lored Tit | *Machlolophus xanthogenys* | I | WV | | | | | | | + | + |
| 68 | Great Tit | *Parus major* | I | R | + | + | + | + | + | + | + | + |
| 69 | Green-backed Tit | *Parus monticolus* | I | WV | | | | | | | | + |
| | **Family Aegithalidae** | | | | | | | | | | | |
| 70 | Black-throated Tit | *Aegithalos concinnus* | I | WV | + | | | + | | | + | |
| | **Family Sittidae** | | | | | | | | | | | |
| 71 | White-tailed Nuthatch | *Sitta himalayensis* | I | WV | + | | | | | | | |
| | **Family Certhiidae** | | | | | | | | | | | |
| 72 | Bar-tailed Treecreeper | *Certhia himalayana* | I | WV | + | | | + | | | + | |
| | **Family Cinclidae** | | | | | | | | | | | |
| 73 | Brown Dipper | *Cinclus pallasii* | I | WV | | | | | | + | | |
| | **Family Pycnonotidae** | | | | | | | | | | | |
| 74 | Black Bulbul | *Hypsipetes leucocephalus* | O | R | + | | | | + | | | + |
| 75 | Himalayan Bulbul | *Pycnonotus leucogenys* | F | R | + | + | + | + | + | + | + | + |
| 76 | Red-vented Bulbul | *Pycnonotus cafer* | F | SV | + | + | | | | | + | + |
| | **Family Cettiidae** | | | | | | | | | | | |
| 77 | Brownish-flanked Bush-warbler | *Horornis fortipes* | I | WV | | | | | + | + | | + |
| 78 | Grey-sided Bush-warbler | *Cettia brunnifrons* | I | WV | + | | | + | | | | + |
| | **Family Phylloscopidae** | | | | | | | | | | | |
| 79 | Ashy-throated Warbler | *Phylloscopus maculipennis* | I | WV | | | | | | | | + |
| 80 | Blyth's leaf Warbler | *Phylloscopus reguloides* | I | WV/ PM | | | | | + | + | | |
| 81 | Grey-hooded Warbler | *Phylloscopus xanthoschistos* | I | WV | + | | | | + | | + | + |
| 82 | Greenish Warbler | *Phylloscopus trochiloides* | I | WV/ PM | | | | | + | | + | |
| 83 | Lemon-rumped Leaf-warbler | *Phylloscopus chloronotus* | I | WV | + | | | | + | | | + |
| 84 | Whistler's Warbler | *Phylloscopus whistleri* | I | WV | | | | | | | | + |
| | **Family Acrocephalidae** | | | | | | | | | | | |
| 85 | Blyth's Reed-arbler | *Acrocephalus dumetorum* | I | WV/ PM | | | | | + | | + | |
| | **Family Cisticolidae** | | | | | | | | | | | |
| 86 | Common Tailorbird | *Orthotomus sutorius* | I | R | + | | | | | | + | + |
| 87 | Ashy Prinia | *Prinia socialis* | I | R | | | | | + | | + | + |
| 88 | Grey-breasted Prinia | *Prinia hodgsonii* | I | R | + | + | | | | + | | |
| 89 | Jungle Prinia | *Prinia sylvatica* | I | R | | | | | | | + | |
| 90 | Plain Prinia | *Prinia inornata* | I | R | | + | | | | | | |
| 91 | Striated Prinia | *Prinia crinigera* | I | R | | + | | | | | | |
| | **Family Paradoxornithidae** | | | | | | | | | | | |
| 92 | Yellow-eyed Babbler | *Chrysomma sinense* | I | R | | + | | | | | | |
| | **Family Timaliidae** | | | | | | | | | | | |
| 93 | Black-chinned Babbler | *Cyanoderma pyrrhops* | I | R | | | | + | | | | + |
| | **Family Leiothrichidae** | | | | | | | | | | | |
| 94 | Rufous Sibia | *Heterophasia capistrata* | O | WV | | | | + | | | + | |
| | **Family Zosteropidae** | | | | | | | | | | | |
| 95 | Indian White-eye | *Zosterops palpebrosus* | I | R | + | | | | + | + | + | + |
| | **Family Muscicapidae** | | | | | | | | | | | |
| 96 | Asian Brown Flycatcher | *Muscicapa dauurica* | I | SV | | | | | + | | | |
| 97 | Rusty-tailed Flycatcher | *Ficedula ruficauda* | I | WV | | | | | | | | + |
| 98 | Blue-throated Blue-flycatcher | *Cyornis rubeculoides* | I | WV | | | | | | | + | |
| 99 | Little pied Flycatcher | *Ficedula westermanni* | I | WV | | | | | | | + | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | Rufous-gorgeted Flycatcher | *Ficedula strophiata* | I | WV | | | | + | | | + | |
| 101 | Slaty-blue Flycatcher | *Ficedula tricolor* | I | WV | | | | | | | | + |
| 102 | Verditer Flycatcher | Eumyias thalassinus | I | WV | | | | | | | + | + |
| 103 | Oriental Magpie-robin | *Copsychus saularis* | I | R | | + | + | + | | + | | + |
| 104 | Blue-fronted Redstart | *Phoenicurus frontalis* | I | WV | | | | | + | | | |
| 105 | Plumbeous Water-redstart | *Phoenicurus fuliginosus* | I | WV | | | | | | | + | |
| 106 | White-capped Water-redstart | *Phoenicurus leucocephalus* | I | WV | | | | | | | + | |
| 107 | Chestnut-bellied Rock-thrush | *Monticola rufiventris* | I | WV | | | | + | | | | |
| 108 | Blue whistling Thrush | *Myophonus caeruleus* | I | R | | | + | | | + | | |
| 109 | Common Stonechat | *Saxicola torquatus* | I | WV | + | + | | | | | | |
| 110 | Grey Bushchat | *Saxicola ferreus* | I | R | + | | | + | | + | | + |
| 111 | Pied Bushchat | *Saxicola caprata* | I | SV | | + | | | | | | |
| | **Family Turdidae** | | | | | | | | | | | |
| 112 | Grey-winged Blackbird | *Turdus boulboul* | I | R | + | | | | | | + | + |
| | **Family Sturnidae** | | | | | | | | | | | |
| 113 | Chestnut-tailed Starling | *Sturnia malabarica* | O | SV | | | | | | | + | |
| 114 | Common Myna | *Acridotheres tristis* | O | R | + | + | | | | + | | + |
| 115 | Jungle Myna | *Acridotheres fuscus* | O | R | | | | | | + | + | + |
| | **Family Nectariniidae** | | | | | | | | | | | |
| 116 | Crimson Sunbird | *Aethopyga siparaja* | N | SV | | | | | | | | + |
| | **Family Motacillidae** | | | | | | | | | | | |
| 117 | Grey Wagtail | *Motacilla cinerea* | I | SV | + | | + | | | + | | + |
| 118 | White Wagtail | *Motacilla alba* | I | WV | | | + | + | | | | |
| 119 | Paddyfield Pipit | *Anthus rufulus* | I | R | | + | | | | | | |
| 120 | Long-billed Pipit | *Anthus similis* | I | R | | + | | | | | | |
| | **Family Fringillidae** | | | | | | | | | | | |
| 121 | Common Rosefinch | *Carpodacus erythrinus* | G | WV | | | | + | | | | |
| 122 | Yellow-breasted Greenfinch | *Chloris spinoides* | G | SV | | + | | | | | | |
| | **Family Passeridae** | | | | | | | | | | | |
| 123 | House Sparrow | *Passer domesticus* | G | R | | + | + | | | | | + |
| 124 | Russet Sparrow | *Passer cinnamomeus* | G | WV | + | | | + | | + | + | |
| | **Family Estrildidae** | | | | | | | | | | | |
| 125 | Indian Silverbill | *Euodice malabarica* | G | SV | | | | | | + | | |

Note. Feeding guilds: I — insectivores; C — carnivores; O — omnivores; G — granivores; F — frugivores; N — nectarivores. Resident/migratory status: R — residents; SV — summer visitors; WV — winter visitors; PM — passage migrant.

**References**

Ahmed, A., Dey, M. 2014. A checklist of the winter bird community in different habitat types of Rosekandy tea estate of Assam, India. *Journal of Threatened Taxa*, **6** (2), 5478–5484.

Ali, S., Ripley, S. D. 1983. *Compact handbook of the birds of India and Pakistan*. Oxford University Press, Bombay.

Aratrakorn, S., Thunhikorn, S., Donald, P. F. 2006. Changes in bird communities following conversion of lowland forest to oil palm and rubber plantations in southern Thailand. *Bird Conservation International*, **16** (1), 71–82.

Barlow, J., Mestrec, L. A. M., Gardner, T. A., Peres, C. A. 2007. The value of primary, secondary and plantation forests for Amazonian birds. *Biological Conservation*, **136**, 212–231.

Bellanthudawa, B. K. A., Nawalage, N. M. S. K., Subanky, S., Panagoda, P. A. B. G., Weerasinghe, H. W. G. A. S., Tharaka, L. K. D. N., … Abeywickrama, M. S. J. 2019. Composition and diversity variation of avifauna, along different vegetative habitat types in a human-modified area, University of Kelaniya, Sri Lanka. *International Journal of Zoology*, 2019, Article ID 9727609.

Buck, L. E., Gavin, T. A., Lee, D. R., Uphoff, N. T., Behr, D. C., Drinkwater, L. E., … Werner, F. R. 2004. *Ecoagriculture: A review and assessment of its scientific foundations*. Ithaca, Cornell University, USA.

Chamberlain, D. E., Wilson, J. D., Fuller, R. J. 1999. A comparison of bird populations on organic and conventional farm systems in southern Britain. *Biological Conservation*, **88**, 307–320.

Chandel, S., Kumar, V., Sharma, B. P., Patiyal, R. 2014. Bird diversity of Dhauladhar Nature Park-Gopalpur, district Kangra, Himachal Pradesh. *International Journal of Plant, Animal and Environmental Sciences*, **4** (2), 236–244.

Chazdon, R. L., Peres, C. A., Dent, D., Sheil, D., Lugo, A. E., Lamb, D., … Miller, S. 2009. The potential for species conservation in tropical secondary forests. *Conservation Biology*, **23**, 1406–1417.

Chetana, H. C., Ganesh, T. 2012. Importance of shade trees (*Grevillea robusta*) in the dispersal of forest tree species in managed tea plantations of southern Western Ghats, India. *Journal of Tropical Ecology*, **28** (2), 187–197. https://doi.org/10.1017/S0266467411000721

Datta, T. 2011. Human interference and avifaunal diversity of two wetlands of Jalpaiguri. *Journal of Threatened Taxa*, **3** (12), 2253–2262.

Ding, Z., Liang, J., Hu, Y., Zhou, Z., Sun, H., Liu, L., … Si, X. 2019. Different responses of avian feeding guilds to spatial and environmental factors across an elevation gradient in the central Himalaya. *Ecology and Evolution*, **9** (7), 4116–4128. https://doi.org/10.1002/ece3.5040

Griffith, D. M. 2000. Agroforestry: A refuge for tropical biodiversity after fire. *Conservation Biology*, **14**, 325–326.

Grimmett, R., Inskipp, T. 2003. *Birds of Northern India*. Om Books International.

Harvey, C. A., Villalobos, J. A. G. 2007. Agroforestry systems conserve species-rich but modified assemblages of tropical birds and bats. *Biodiversity and Conservation*, **16**, 2257–2292.

Hossain, A., Aditya, G. 2016. Avian diversity in agricultural landscape: records from Burdwan, West Bengal, India. *Proceedings of the Zoological Society*, **69** (1), 38–51. https://doi.org/10.1007/s12595-014-0118-3

Javed, S., Kaul, R. 2002. *Field methods for bird surveys*. Bombay Natural History Society, India.

Kleijn, D., Baquero, R. A., Clough, Y., Díaz, M., Esteban, J., Fernández, F., … Yela, J. L. 2006. Mixed biodiversity benefits of agri-environment schemes in five European countries. *Ecology Letters*, **9** (3), 243–254. https://doi.org/10.1111/j.1461-0248.2005.00869.x

Kottawa-Arachchi, J. D., Gamage, R. N. 2015. Avifaunal diversity and bird community responses to man-made habitats in St. Coombs Tea Estate, Sri Lanka. *Journal of Threatened Taxa*, **7**, 6878–6890. https://doi.org/10.11609/JoTT.o3483.6878-90

Kumar, A. 2018. Avifauna of North West Himalaya. *In*: Sivaperuman, C., Venkataraman, K., eds. *Indian Hotspots*, 151–194. Springer Nature Singapore Pte Ltd.

Maas, B., Tscharntke, T., Saleh, T., Putra, D. D., Clough, Y. 2015. Avian species identity drives predation success in tropical cacao agroforestry. *Journal of Applied Ecology*. https://doi.org/10.1111/1365-2664.12409

Mahabal, A., Sharma, T. R. 1992. Distribution patterns of Himalayan, birds of Kangra Valley (Himachal Pradesh). *Himalayan Journal of Environment and Zoology*, **6** (2), 85–96.

MEA. 2005. *Millennium Ecosystem Assessment: Ecosystems and Human Well-being*. Synthesis, Island Press.

Morelli, F. 2015. Indicator species for avian biodiversity hotspots: Combination of specialists and generalists is necessary in less natural environments. *Journal for Nature Conservation*, **27**, 54–62.

Mukhopadhyay, S., Mazumdar, S. 2019. Habitat-wise composition and foraging guilds of avian community in a suburban landscape of lower Gangetic plains, West Bengal, India. *Biologia*, **74** (8), 1001–1010. https://doi.org/10.2478/s11756-019-00226-x

Narwade, S. S., Jathar, G. A., Rahmani, A. R. 2006. Bibliography of the birds of North India. *Buceros*, **11** (1), 1–144. https://doi.org/10.13140/2.1.2121.5529

Niemi, G. J., McDonald, M. E. 2004. Application of ecological indicators. *Annual Review of Ecology, Evolution and Systematics*, **35** (1), 89–111.

O'Connell, T. J., Jackson, L. E., Brooks, R. P. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. *Ecological Applications*, **10** (6), 1706–1721.

Panda, B. P., Das, A. K., K, J. S., Mahapatra, B., Dash, A. K., Pradhan, A., Parida, S. 2021. Habitat heterogeneity and seasonal variations influencing avian community structure in wetlands. *Journal of Asia-Pacific Biodiversity*, **14** (1), 23–32. https://doi.org/10.1016/j.japb.2020.10.001

Poggio, S. L., Chaneton, E. J., Ghersa, C. M. 2010. Landscape complexity differentially affects alpha, beta, and gamma diversities of plants occurring in fencerows and crop fields. *Biological Conservation*, **143** (11), 2477–2486. https://doi.org/10.1016/j.biocon.2010.06.014

Raman, T. R. S. 2006. Effects of habitat structure and adjacent habitats on birds in tropical rainforest fragments and shaded plantations in the Western Ghats, India. *Biodiversity and Conservation*, **15**, 1577–1607.

Roy, U. S., Pal, A., Banerjee, P., Mukhopadhyay, S. K. 2011. Comparison of avifaunal diversity in and around Neora Valley National Park, West Bengal, India. *Journal of Threatened Taxa*, **3** (10), 2136–2142.

Scharlemann, J. P. W., Green, R. E., Balmford, A. 2004. Land-use trends in Endemic Bird Areas: global expansion of agriculture in areas of high conservation value. *Global Change Biology*, **10**, 2046–2051.

Sekercioglu, C. H. 2006. Increasing awareness of avian ecological function. *Trends in Ecology and Evolution*, **21** (8), 464–471.

Sharief, A., Paliwal, S., Sidhu, A. K., Kubendran, T. 2018. Studies on bird diversity of pong dam wildlife sanctuary, Kangra, Himachal Pradesh, India. *Journal of Entomology and Zoology Studies*, **6** (4), 904–912.

Sidhu, S., Raman, T. R. S., Goodale, E. 2010. Effects of plantations and homegardens on tropical forest bird communities and mixed-species bird flocks in the southern Western Ghats. *Journal of the Bombay Natural History Society*, **107** (2), 91–108.

Singh, A. P. 2011. Birds of the upper catchment of Ravi River, Chamba district, Himachal Pradesh, India. *Indian BIRDS*, **7** (4), 97–103.

Singh, J., Thakur, M. L., Banyal, H. S. 2014. Avifauna of Prashar Lake and its surrounding area in Mandi district (Himachal Pradesh), India. *Asian Journal of Biological Sciences*, **7** (2), 47–56. https://doi.org/10.3923/ajbs.2014.47.56

Singh, V., Banyal, H. S. 2013. Avian fauna of Khajjiar Lake, District Chamba, Himachal Pradesh, India. *Proceedings of the Zoological Society*, **66** (2), 130–136. https://doi.org/10.1007/s12595-012-0049-9

Sohil, A., Sharma, N. 2020. Assessing the bird guild patterns in heterogeneous land use types around Jammu, Jammu and Kashmir, India. *Ecological Processes*, **9** (1), 49. https://doi.org/10.1186/s13717-020-00250-9

Ulman, Y., Sharma, M., Kumar, A. 2016. Agroforestry systems as habitat for avian Species : Assessing its role in conservation. *Proceedings of the Zoological Society*, 1–16. https://doi.org/10.1007/s12595-016-0198-3

Vickery, J. A., Bradbury, R. B., Henderson, I. G., Eaton, M. A., Grice, P. V. 2004. The role of agri-environment schemes and farm management practices in reversing the declinev of farmland birds in England. *Biological Conservation*, **119**, 19–39.

Received 15 August 2021
Accepted