EFFECTS OF HABITAT STRUCTURE AND INVASIVE ALIEN PLANT SPECIES ON BIRD ASSEMBLAGES IN JALTHAL FOREST, EASTERN NEPAL

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Nepal

April 2021

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All the sources have been specially acknowledged by reference to the author(s) and institution(s)

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RECOMMENDATION

This is to recommend that the proposal entitled **"EFFECTS OF HABITAT STRUCTURE AND INVASIVE ALIEN PLANT SPECIES ON BIRD ASSEMBLAGES IN JALTHAL FOREST, EASTERN NEPAL"** has been carried out by **Binod Bhattarai,** for the partial fulfillment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institution.

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LETTER OF APPROVAL

On the recommendation of supervisor Assistant Professor Dr. Bishnu Prasad Bhattarai, this thesis submitted by Binod Bhattarai entitled **"EFFECTS OF HABITAT STRUCTURE AND INVASIVE ALIEN PLANT SPECIES ON BIRD ASSEMBLAGES IN JALTHAL FOREST, EASTERN NEPAL"** is approved for the examination in partial fulfillment of the requirements for the Master's Degree of Science in Zoology with special paper Ecology and Environment.

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CERTIFICATE OF ACCEPTANCE

This Thesis work submitted by Binod Bhattarai, entitled "**EFFECTS OF HABITAT STRUCTURE AND INVASIVE ALIEN PLANT SPECIES ON BIRD ASSEMBLAGES IN JALTHAL FOREST, EASTERN NEPAL**" has been accepted as partial fulfillment for the requirements of Masters Degree of Science in Zoology with special paper Ecology and Environment.

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Binod Bhattarai

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LIST OF ABBREVIATIONS

CCA	Canonical Correspondance Analysis
DD	Data Deficient
GLM	General Linear Modeling
IAS	Invasive Alien Species
IAPS	Invasive Alien Plant Species
IPS	Invasive Plant Species
LC	Least Concern
MS	Migratory Status
NRLB	National Red list of Birds
NT	Near Threatened
RAC	Rank Abundance Curve
VU	Vulnerable

ABSTRACT

Invasive alien plant species (IAPS) are recognized to have an impact on faunal diversity and the global environment by changing the sort of native habitat in which they thrive. The Jalthal forest is one of the most invaded forests in eastern Tarai. Hence, this study aimed to find out the effects of IAPS cover on the occurrence of birds. By dividing the IAPS cover into three classes (Low, Medium, and High) outer one km strip of the forest was sampled. A total of 89 point count stations were deployed for the point count survey of birds. Generalized linear model (GLM) was done to understand the relation of the diversity and abundance of birds with environmental variables. Spearman's rank correlation was calculated to understand the relation of abundance and richness of different feeding guilds with the cover of IAPS. Canonical Correspondence Analysis (CCA) was done to understand the association of different feeding guilds with disturbance variables and habitat types. A total of 86 species of birds belonging to 13 orders and 41 families were recorded. The insectivorous birds had the highest species richness. Wooded grassland had the highest diversity of birds. Bird species richness and abundance decreased significantly when the distance to the nearest water source, IAPS cover, and shrub cover increased. The Sal (*Shorea robusta*) forest was found to be the most preferred habitat type, however, the preference of habitats by feeding guilds was conditional. Jalthal forest is Nepal's only forest of its kind, and it is heavily infested by IAPS, more research into biodiversity and the effects of IAPS on biodiversity is in this forest required.

1. INTRODUCTION

Background

Invasive alien species (IAS) refer to species introduced outside of their place of origin, which can successfully expand their new range and harm biodiversity, economy, and human health (Davis et al. 2001). Human livelihood and biodiversity now have come to be threatened by invasive alien species (Early et al. 2016). Invasive alien species are considered a major pressure on the current state of biodiversity globally (Butchart et al. 2010). Currently, biological invasions are regarded as part of global change, habitat destruction, and global warming. People's livelihoods hence are directly affected (Mooney and Cleland 2001, Vilà et al. 2011, Pyšek et al. 2012, Schirmel et al. 2016).

There is a severe concession on a conversation due to invasion (Jäger et al. 2009). Only a few introduced species become invasive, and their invasion can cause major damage to biodiversity as well as the human economy, despite the fact that the number of IAS has expanded dramatically since people began exploring the world (Mooney and Cleland 2001).

Mikania micrantha and *Chromolanea odorata*, both native to Central and South America, are among the world's worst IAPS. (Holms 1977 and Gautier 1992). In Nepal, *C. odorata* was first reported in 1956 and *M. micrantha* was first reported in 1963 (Shrestha and Shrestha 2021). IAPS is predominantly found in the Tarai, Siwalik, and Mid-hill regions of Nepal (Shrestha 2016), and most naturalized species are native to tropical and subtropical regions of the world (Bhattarai et al. 2014, Shrestha 2016). *C. odorata* and *M. micrantha* spread quickly and successfully due to their ability to proliferate via roots, stem segments, and easily spreadable seeds (Zachariades et al. 2009 and Day et al. 2016).

The invasion alters the behavior and identification of native species (Dufour et al. 2020). Invasive plant species have resulted in significant reductions in diversity, abundance, and animal fitness (Schirmel et al. 2016). Invasive plant species are likely to have a positive impact on avian diversity by providing new habitat and prey (Gan et al. 2009), or a detrimental impact by modifying acceptable habitat (Pearson 2009, Aravind et al. 2010, Kessler et al. 2017), and IAPS have a cascading effect on the food web (Gan et al. 2009). As a result, the animals' ability to thermoregulate or hydroregulate within their microenvironment is limited, as well as their ability to create barriers to critical behaviors like traveling, building nests, and finding refuge. The IAPS directly or indirectly affects food resources for wildlife communities (de Groot et al. 2007).

Various factors like the scale of invasion, density of invasion, region, range, stage, and taxa group affected of invasion can design the level of impacts of IPS on faunal communities (Kumschick et al. 2014). These matrices' dependencies make a surmise of the effects of IPS on resident biota. The invasion of a new area significantly brings several changes to habitat (Gan et al. 2009, Pearson 2009, Aravind et al. 2010, Kessler et al. 2017) usually there are negative effects (obvious or non-obvious) on fauna (Kessler et al. 2017).

Herbivore is directly affected by the change in plant composition, which reduces the quality of plant hosts, and changes in habitat, microhabitat, and soil properties which indirectly affect prey availability or abundance of predator and trophic interactions are ultimately altered (Pearson 2009). The invasion sometimes shows the positive effects on the ecosystem services to birds, but have more negative effects than its positive effects and this possibility of different effect on ecosystem services due to plant invasion is usually seen (Eviner et al. 2012).

Habitat structure

Habitat structure is extremely essential in shaping species diversity since it changes continuously during the succession (Blake 2007). Human disturbance (Wright 2010), climate change (Pearson and Dawson 2005, Miller et al. 2006, Jaffé et al. 2019, Marchini et al. 2019), and invasion all have an impact on both marine and terrestrial ecosystems (Dijkstra et al. 2017, Heringer et al. 2019). The structure of habitats changes as the vegetation composition changes, thus the vegetation of a location plays a significant influence in establishing the habitat structure of a location (Seymour and Dean 2009). Changes in vegetation structure, biodiversity, and ecological processes are all linked to changes in habitat structure (Blake 2007, Casas et al. 2016).

There is various perspective for the classification of habitat type. Jefferson et al. (2014) developed a method for classification of lowland grassland by acknowledging the dominant flora and its association. Bell et al. (2018) described the habitat type by observing the detailed vegetation type, tree canopy, and shrub canopy, presence of water resources, and land-use type.

In the case of invaded habitat (Flanders et al. 2006, Gan et al, 2009) used the presence of invasive plants to name the habitat type. Holland-Cleft et al (2011) mentioned that the complexity of habitat increases with the addition of exotic species, and they defined the habitat type by observing the IAPS presence in a particular area.

The type of forest and structure of habitat is related to the diversity and abundance of birds, and their assemblages (Wethered and Lawes 2005, Maron et al. 2011, Bergner et al. 2015). Different community of birds uses the different layer of vertical strata. According to Robinson and Holmes (1984), components of habitat structure such as foliage structure and its arrangements on twigs play a role to provide the availability of arthropods so that foliage gleaner birds are likely to use such habitats.

The vertical stratification of forest contains different layers of canopy which provide diverse habitat and microhabitat for birds (Whitehurst et al. 2013, Supriatna et al. 2018). Birds usually prefer habitats best suitable for their survival and they tend to differently use the levels of vertical strata (Yahner 1982). For example, small insectivorous gleaners like *Prinia flavicans* and *Parisoma subcaeruleum* prefer lower bushy canopy (Seymour and Dean 2009). Soerianegara and Indrawan (2005) and (Dinanti et al. 2018) defined five different vertical strata (top layer, upper canopy, middle canopy, understory, and ground story) in tropical rainforest's strata of Indonesia.

Jalthal forest is a peculiar forest since it is the only remaining patch of moist subtropical forest in the southeastern part of Nepal (GGN 2021). The forest is highly disturbed as it is encroached by local peoples for the collection of timber, firewood, fodder etc. This facilitates a good environment for the invasion of IAPS. This forest is managed by 22 Community Forest User's Group. The management should understand the effects of invasion on the biodiversity of the forest, which helps them to formulate effective management practices to protect this unique forest of Nepal. Birds are one of the major taxa to respond to an altered habitat. So, this study aims to find out the effect of invasion on the bird community on the very unique forest type of Nepal.

Objectives

General objective

The general objective of this study was to assess the effects of habitat structure and IAPS on bird assemblages in Jalthal Forest, Eastern Nepal.

Specific objectives

1. To understand bird community composition in the study area.
2. To investigate the effects of habitat structure on bird assemblages.
3. To assess the impacts of IAPS on bird diversity and abundance.

Rationale of the study

Jalthal forest is a peculiar, biologically significant type of forest of southern Jhapa, Nepal. This important forest is badly invaded by major IAPS species (*Mikania micrantha* and *Chromolaena odorata*). This is an isolated large patch of forest surrounded by human settlements and farmlands. The forest is highly encroached by local peoples, which facilitates a good environment for the invasion of IAPS.

The IAPS cover the feeding and breeding ground of the birds. Hence, this study is designed to find out the impacts of IAPS on the bird communities. This study is based on the theme that IAPS, directly and indirectly, affects the composition and diversity of birds. Sometimes the IAPS only might not be responsible for this impact. That is why this study also focuses on assessing the impacts of some important environmental variables on the diversity and abundance of the birds.

This study provides the basic status of birds and highlights the impacts of IAPS on the occurrence of birds that is very useful for the planners and conservationists to conserve the biodiversity of ecologically important Jalthal forest.

Limitation of the study

Due to the danger of wild elephants and wild boars, we were prohibited from entering the core of the forest, which is why sampling is carried out only on the one km-long outer strip.

2. LITERATURE REVIEW

Invasive species in Nepal

There are now 27 known invasive plant species in Nepal, with the addition of *Mimosa diplotricha*, a recently reported invasive plant (Sharma et al. 2020). However, there are 183 vascular IAPS present in natural habitats (Shrestha 2021) and 64 alien animals (Budha 2015). Four species namely, *Chromolaena odorata, Eichhornia crassipes, Lantana camara,* and *Mikenia micrantha* are of 100 worst IAPS in the world (Lowe et al. 2000).

Many studies have been conducted, and more are being conducted, to assess the effects of IAPS in Nepal. The studies are primarily concerned with assessing the effects on biodiversity, changes in edaphic composition (Timsina et al. 2011), local perceptions (Shrestha et al. 2019), and the cause of dispersion and distribution status of IAPS (Siwakoti et al. 2016). IAPS cause issues in both natural and anthropogenic landscapes. IAPS can outcompete native species in natural habitats, reducing their abundance and diversity. In an anthropogenic landscape, IAPS can reduce productivity, cost money to remove (Rai et al. 2012), and pose health risks to livestock (Shrestha 2016).

Effects of IAPS on abundance and diversity of birds

Various studies have reported that the IAPS has a conditional impact on bird abundance. Flanders et al. (2006) discussed the effects of IAPS in terms of exotic species' ability to change the habitat type of birds, provide innutritious foods, and disrupt functional relationships with birds and their habitats. Many studies have shown that vegetation structure has an effect on birds' selectivity for their habitats, resulting in different communities of birds using the habitat in different ways (Karr and Roth 1971, Yahner 1982, Robinson and Holmes 1984, Supriatna et al. 2018).

The thick layer produced by many invasive species, for example, *L. camara*, barricades insectivorous birds for easier movement, flight, and insect capturing efficiency (Aravind et al. 2010), and frugivores are negatively affected if native plant fruit production is compromised due to IAPS invasion (Mangachena and Geerts 2017), but positively affected if the invasive species provides nutritious and abundant fruits (Ramaswami et al. 2019).

The higher abundance of songbirds, water birds, and breeding birds on uninvaded habitat types can be due to dense vegetation of IAPS blocking the access of birds to the ground vegetation, they are unable to forage on the ground and hence they try to avoid such vegetation type (Gan et al. 2009).

However, the IAPS in many areas are supposed to create diverse habitat types, bird species select the most beneficial one. Hence in the invaded area, the abundance of particular species is high but as a whole abundance and diversity seem to be low (Flanders et al. 2006, Wilcox and Beck 2007, Gan et al. 2009, Aravind et al. 2010, Keller and Avery 2014).

The reduction of the species diversity in the invaded area is quite vivid (Wilcox and Beck 2007, Aravind et al. 2010, Holland-Clift et al. 2011, Keller and Avery 2014). However, there is no proof of species extinction due to IAPS (Jäger et al. 2009). Significant difference on the diversity and evenness in invaded and uninvaded habitats is usually reported (Holland-Clift et al. 2011, Mangachena and Geerts 2017). The impacts due to IAPS are not only in the native birds but migrants are also affected by the presence of IAPS, for example, the richness of Nearctic-Neotropical migrants was higher in uninvaded natural wooded habitats (Keller and Avery 2014). But, the presence of IAPS can be a positive effect on some conditions. Fruiting IAPS in the urban area can support a higher diversity of birds. Generalists and frugivorous guilds had positive effects due to the fruiting of IAPS (Gleditsch 2017). The diversity of birds may conditionally differ. Wilcox and Beck (2007) reported a higher richness of birds during winter in habitat invaded by Chinese Privet but not significant impacts on songbirds in the same condition.

The IAPS is widely acknowledged to have positive, conditionally positive, and negative effects on avian diversity. Because most urban birds rely on IAPS for food, shelter, and nesting the services provided by fruiting IAPS on urban habitat are unquestionable (Gleditsch 2017). IAPS in urban habitat at least provide nesting site (Sogge et al 2008). As a result, eradicating such invasive species is not thought to be a wiser choice in the fight against IAPS. The removal of regular fleshy fruit providing invasive species had an unintended and serious negative impact in South Carolina (Borgmann and Rodewald 2004), the Amazon (Moegenburg and Levey 2003, Wright 2010), and the Block Islands of the United States (Parrish 2000). But, this type of positive effect is contrarily seen in habitats other than urban areas.

An increase in the variety of birds on invaded territory by observed Ligustrum sinense during the winter was observed by (Wilcox and Beck 2007), which was conditional because the diversity of birds in invaded areas decreased significantly during the summer. Such an unexpected increase of avian diversity on invaded habitats during the winter season was discussed as facilitation of the benefits from fruiting berries of invasive *Ligustrum sinense*. However, birds tried to neglect the highly-dense invaded area so they concluded that the removal of invasive Chinese Privet would not negatively impact the population of birds.

And another possibility of avoidance of fruits of IAPS might be due to very small fruits of *Salix rubens* was unlikely to be eaten by some bird-like parrots and finches. Mangachena and Geerts (2017) discussed the lower diversity of birds on invaded habitat is due to loss and modification of resources, particularly food and nesting sites. It can be clarified by an example of the increased richness of insectivorous birds in habitats where the abundance of arthropods is high. If birds find a better nesting site, they are likely to use that habitat so often as in the case of urban areas (Gleditsch 2017). But most IAPS does not offer such habitats hence avian diversity is likely to be less. A similar explanation by (Wilcox and Beck 2007, Aravind et al. 2010, Holland-Clift et al. 2011) supports that the patterns of impacts by IAPS are conditional, if an IAPS offers good food, nesting place and creates suitable habitat, it is likely to increase avian diversity. But often IAPS are privileged not to offer such suitable conditions hence bird diversity is usually found decreasing in invaded areas.

The quantification of impacts of IAPS on abundance has been done in a different study. Most of all studies selected for this study used a point count survey of birds in a different type of habitat. The point count method is easier, less effort requiring, feasible in most of the habitat, and generates convincing results hence, mostly preferred (Nur 1999). But different modified point count methods were employed.

To count birds by audio-visually, the radius of fixed-point count stations is determined by the visibility factor of any habitat since the visibility can be blocked by large buildings and the fixed radius point count method is unlikely to work, (González-Oreja et al. 2018) used unlimited radius point count method and line transect for estimating species abundance of urban birds. But this is not necessarily required in forest habitats where sudden blockade of visibility is unlikely to occur hence, fixed radius point count survey methods were used in most studies (Flanders et al. 2006, Wilcox and Beck 2007, Aravind et al. 2010, Keller and Avery 2014, Mangachena and Geerts 2017). But the size of the point count station varied according to the type of habitats.

The methods of the avian survey can be different in different habitat types. In the tidal and intertidal zones, the fixed-point count survey method is not feasible hence trails used by fishermen were used by (Gan et al. 2009), and they used 100 meters' detection width. And in riparian habitats, (Holland-Clift et al. 2011) walked continuously on transects recording front encountered birds. However, 10 minutes in a point station is suggested sufficient for avian sampling by most studies, the time allocation for bird observation is differently defined. Some studies focused on rare species inclusion and hence they spent more time on a point count station.

Effects of habitat structure on bird assemblages

There can be different ways of classifying the habitat structure, usually in the case of avian use of forest the structure of a habitat can be defined in terms of vertical stratum (Yahner 1982, Robinson and Holmes 1984, Laiolo 2002, Casas et al. 2016, Dinanti et al. 2018). Birds use different types of habitats differently some habitats are preferred for nesting while some are preferred for foraging. There are so many studies about how birds use different types of habitats. Yahner (1982) studied how birds use vertical strata, different tree genera, and shrubs in farmsteads and shelterbelts where, three vertical strata were defined namely ground (0-0.36 meter), mid-story (0.6-7.6 meters), and canopy (>7.63meters), ground story supported the majority of birds and some species of tree were much preferred. Similarly, Robinson and Holmes (1984) took four different passerine bird species to quantify their foraging behavior on arthropods they also divided the vertical strata of the forest into three layers but, they named as canopy (15-27 meters), sub-canopy (2-14meters), and shrubs (<2 meters) and found a strong influence of floristic composition on foraging opportunity of birds though the structure of foliage was not affecting the behavior of passerine birds.

Height more than 8 meters was taken as canopy by (Laiolo 2002) where they observed the influence of canopy cover on trunk feeder birds, understory influence on shrub feeder, shrub nesters, and edge species. Classification of vertical strata can be greatly differing according to the type of forest and the average height of the trees. When the average height of the tree is less (Laiolo 2002) took height more than 8 meters as the canopy, but when there is the high average height of trees (Soerianegara and Indrawan 2005, Dinanti et al. 2018) classified strata as, the top layer (trees with 30 meters high with uneven canopy crown), upper canopy (trees with height more than 20 meters with even crown, trunks, and branch), middle canopy (height 4 to 20 meters), understory (layer of shrubs, 1 meter to 4 meters), Ground story (layer covering ground 0 to 1-meter height) in the tropical forest.

But the structure of habitat can be defined in terms of age of the forest stand (Bergner et al. 2015), successional stages (Casas et al. 2016), land use (Rocha et al. 2015), the complexity of vegetation (Seymour and Dean 2009), since IAPS are known for altering the structure of habitat after being successfully established (Pearson 2008, Aravind et al. 2010) there must be a relationship between the richness of bird assemblages and altered habitats.

Significant loss of biodiversity of Jalthal forest due to anthropogenic causes is mentioned by (Bhattarai 2017), but this research was not focused on the impacts of IPS. *Mikania micrantha* and *chromolanea odorata* are some of the worst IAPS in the world that also invaded all parts of the Jalthal forest. Hence, it is expected that the loss of biodiversity of the Jalthal forest is not only due to anthropogenic causes but also due to invasion by IAPS. Hence, this study aimed to find out the relation of IAPS with bird species to fulfill this research gap.

3. MATERIALS AND METHODS

Study area

The study was done in Sal forest of Jalthal (87^0 55' and 88^0 03'E longitudes and 26^0 27' and $26^0$32'N), Far East lowland of Nepal with tropical monsoon type climate. Jalthal Forest spreads in Haldibari Rural Municipality in North, Barhadasi Rural Municipality in the west, Kachankabal Rural Municipality in the south, and Bhadrapur Municipality in the east. The forest occupies an area of 63 sq. km. and altitude ranges from 62 m to 129 m elevations. The forest is divided into 22 Community Forests and the forest is managed by Community Forest User Groups (Neupane et al. 2017). The forest is all surrounded by human settlement and the patch has remained as an island.

This forest contains unique and diverse plant species of tropical and sub-tropical regions (IUFRO 2018). The major dominant plant species is Sal. A total of 57 tree species, 16 shrub species, 67 herb species, and 10 climber species is reported by (Bhattarai 2017), among them, Latahar (*Artocarpus chama*) is not found elsewhere in Nepal.

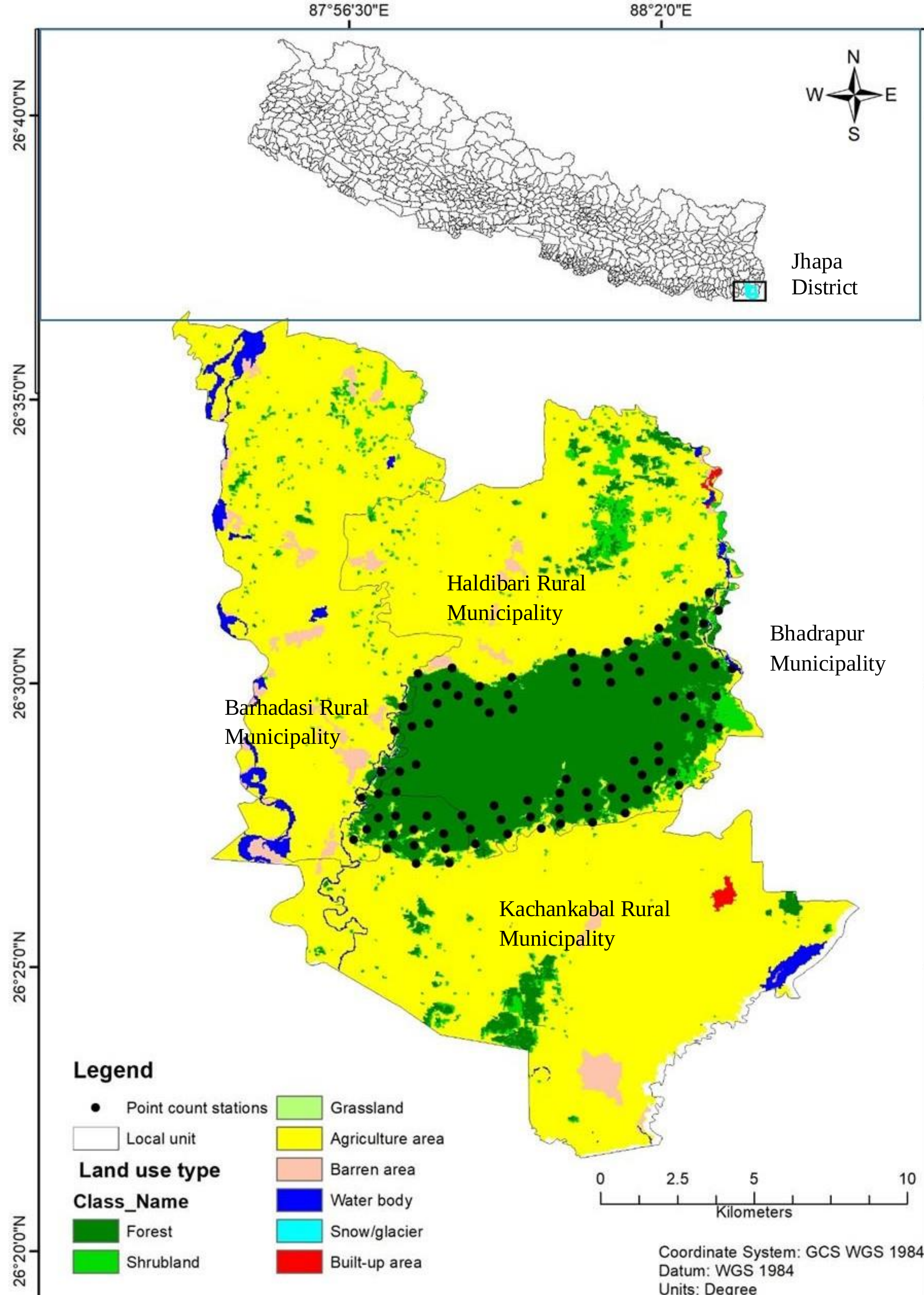

Figure 1. Map of study area showing point count stations.

Data collection

Bird survey

The field survey was carried out between January 17, 2020, and January 31, 2020. The single-point counting method was used (Laiolo 2002). By using Google Earth Pro, an area one kilometer long was intercepted from the forest's edge, and the first point count station was located at the forest's edge, resulting in a total of 28 transects. We walked straight inside the forest from the first point count station to find the second and third point count stations along a transect. The second point count station of a transect was 500 m inside the first point count station, and the third point count station was 500 m inside the second point count station. The two transects were separated by 1000 meters. Birds were counted along the transect from 7:00 a.m. to 11:00 a.m., and from 2:00 p.m. to 5:00 p.m., because birds are most active in the morning and evening. In each point count station birds were recorded for 20 minutes (Wilcox and Beck 2007). We counted all the birds seen within visibility range in dense forests, and all the birds seen within a 50-meter radius in open grasslands and shrublands. Crossings of the quadrate by high-flying birds were ignored. The birds were observed by using binoculars (Bushnell 20 X 50) and were identified by using a field guide (Grimmett et al. 2016). By photographing birds (Nikon D3400, 75-300mm) and comparing those with reference books (Grimmett et al. 2016) birds were identified up to species.

Vegetation sampling

Because of a very thick cover of *Mikania micrantha* over the bush of shrubs, and most areas were inaccessible, the tree canopy cover, shrub cover, and IAPS cover percentage were recorded by visual estimation in each 10m radius quadrate. Besides these large tree numbers, the number of fruiting trees, cavities present on trees were also noted. The disturbance indicators such as distance to nearest motorable road, presence of human trails, and distance to nearest water source were also observed and noted. The presence of cattle dung and nearby water resources, as well as the combination of dominant plant species, were all noted and later used in habitat classification. The Global Positioning System recorded the coordinates of each point count station.

Data analysis

Bird diversity was calculated by usin Shannon-Wiener index (Magurran 1988).

Shannon-Wiener index (H) = $\sum[(pi)\times\ln(pi)]$

Where, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log and Σ is the sum of the calculations.

Evenness (E) = H/Hmax (Where Hmax is maximum diversity possible).

Generalized linear model (GLM) was done to understand the relation of the diversity and abundance of birds with environmental variables. Spearman's rank correlation was calculated to understand the relation of abundance and richness of different feeding guilds with the cover of IAPS (Aravind et al. 2010). Canonical Correspondence Analysis (CCA) in Canoco v 4.5 was used to determine the relationship between different bird communities and habitat types, disturbance variables, and environmental variables (Ter Braak and Smilauer 2002). The habitats were classified as (Aravinda et al. 2015, Bergner et al. 2015). Because there were fewer than four point stations, pastureland, floodplains, and invaded scrub were excluded from the analysis. The types of habitats are described in detail below (Table 1). The forest's vertical strata were classified as (Rocha et al. 2015), and the Rank Abundance Curve (RAC) was created to show the relative abundance of bird species as by (Pandey et al. 2020).

All univariate and multivariate analyses were carried out using various statistical software, including PAST v 4.03, Canoco v 4.5 (Ter Braak and Smilauer 2002), and MS-Excel 2016, and the corresponding figures, graphs, and charts were created using MS-Excel 2016. To create the map of the study area, the coordinates of the point count station were imported into ArcMap 10.4.

Table 1. Details of habitat types.

S.N	Habitat type	Codes	Details of Habitat
1	Sal forest	sf	Dominant Sal tree and IAPS cover less than 25%
2	Sal *Mikania* forest	sm	Dominant Sal tree and *Mikania* Cover >25
3	Sal *Chromolanea*	sc	Dominant Sal tree With Chromolanea Cover >25
4	Invaded Scrub	is	Invaded(with any of IAPS) Shrubland with very few trees
5	Flood plain	fp	Side of Flowing Stream/River
6	Pastureland	pl	Regularly grazed area, presence of cattle dung
7	Mixed woodland	mw	Forest not dominated by any species
8	Wooded Grassland	wg	Open grassland with less than 25% shrub with trees number less than 5

4. RESULTS

Species composition and abundance

A total of 1373 individuals of birds from 13 orders, 41 families, and 86 species were identified. The most dominant order was Passeriformes having 21 families (Figure 2). And the most dominant families were Dicruruide and Sturnidae with five species each followed by Ardeidae, Picidae, Columbidae, Motacillidae, and Muscicapidae with four species each. There are 20 families with single species recorded (Appendix 1). The wooded grassland had the highest species richness (average 8.2 ± 0.83) followed by floodplains (average 7.4 ± 1.67) and the least species richness was found in Sal *Chromolanea* habitats (average 3.78 ± 1.67).

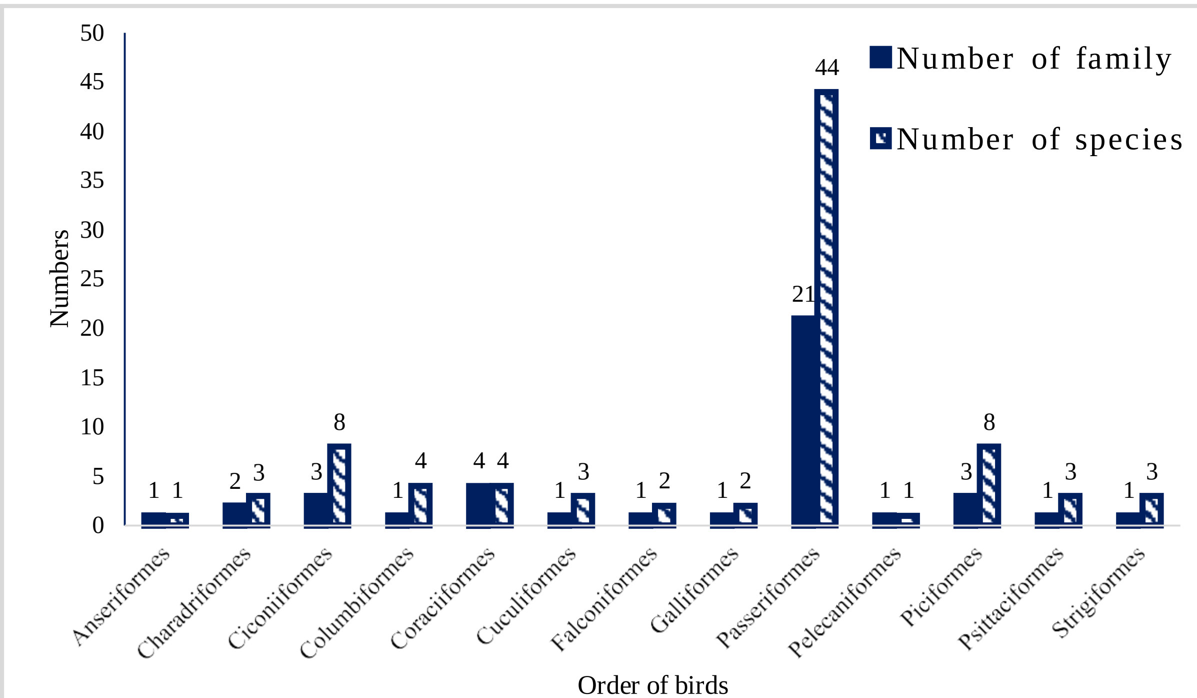

Figure 2. Numbers of families and species in each order

Among the recorded species, 74 were found to be resident species, 10 were winter visitors and one passage and summer visitor bird were recorded. Most of the species were insectivorous (32) and least were frugivorous (2) (Figure 3).

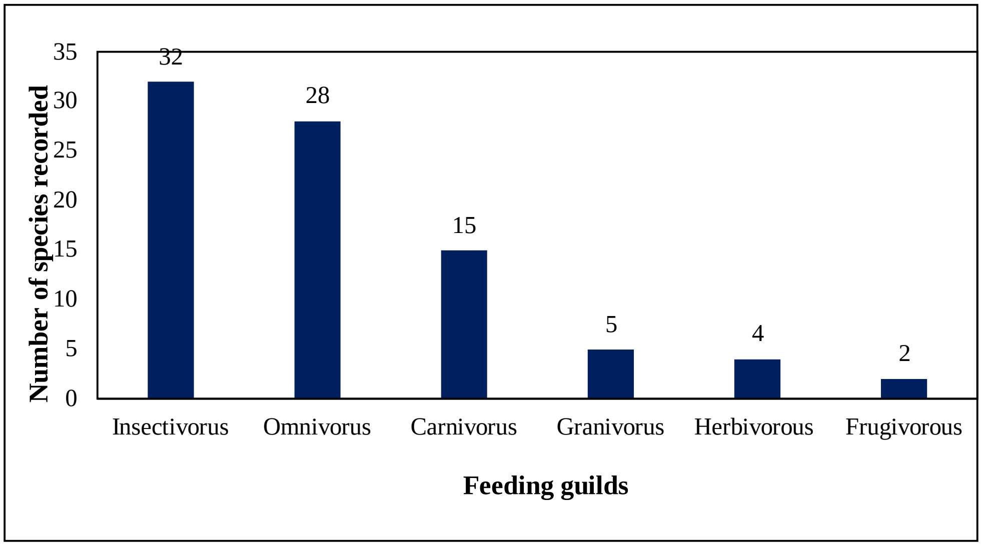

Figure 3. Number of species according to feeding guild

The rank abundance curve (RAC) was prepared by plotting the relative abundance of species in Y-axis with their natural logarithmic value of rank abundance on the X-axis. The RAC (Figure 4) showed a gradual decline of relative abundance of lower-ranked species.

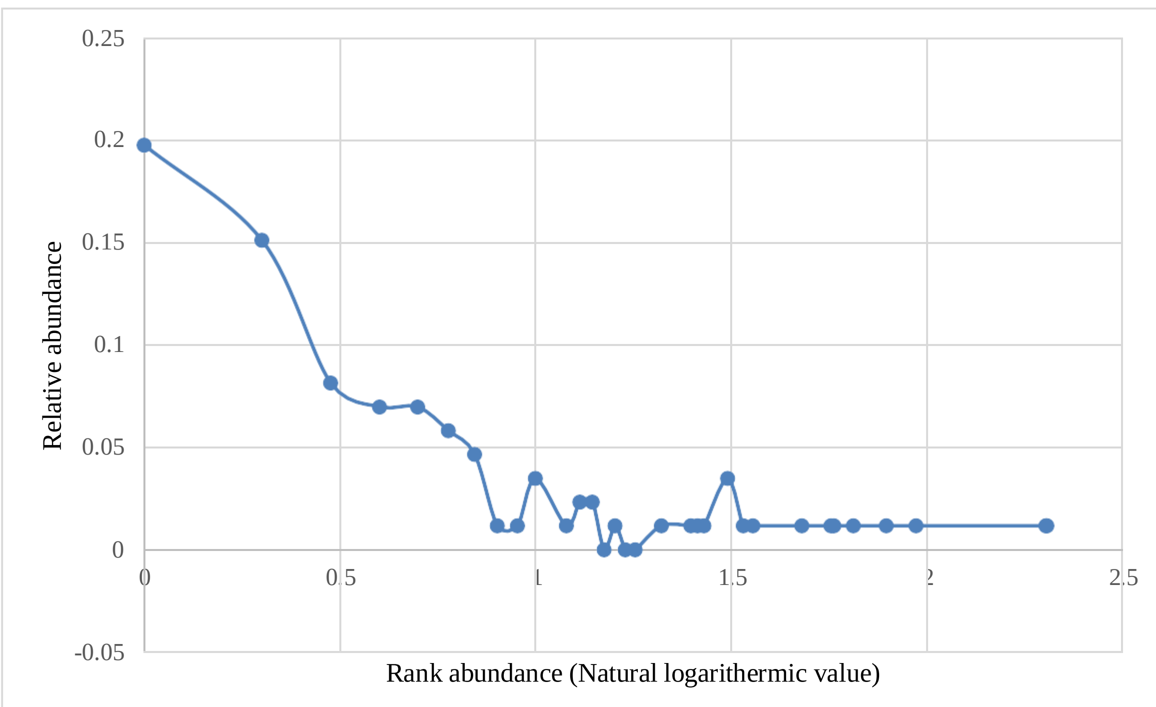

Figure 4. Rank abundance curve of bird species recorded.

Overall, the Jungle babbler had the highest relative abundance (14.75%), followed by Alexandrine parakeet (14.71%) and Red-vented bulbul (6.84%). Furthermore, the 17 species were only recorded once, and they had the lowest relative abundance (0.07283%).

Bird diversity

The highest Shannon H value was found in wooded grassland (1.99), followed by floodplains (1.78), and the lowest Shannon H value was found in mixed woodland (0.12). Mixed woodland had the highest evenness value, while floodplains had the lowest. The highest bird abundance was found in the Sal-Mikenia forest, with a mean of 47 birds per plot, while the lowest abundance was found in pastureland, with a mean of 10.5 birds (Table 2).

Table 2. Bird species richness and their diversity indices per habitat type.

Diversity measures	Habitat types								
	wg	**sm**	**sc**	**sf**	**mw**	**fp**	**is**	**pl**	**Total**
Abundance in each habitat	115.00	470.00	150.00	275.00	182.00	128.00	32.00	21.00	1373
Species richness per habitat	29.00	47.00	24.00	37.00	33.00	30.00	9.00	6.00	
Species richness per plot	5.80	1.56	1.71	1.76	3.30	6.00	4.50	3.00	
Shannon_H	1.99	1.40	1.18	1.41	0.12	1.78	1.52	1.35	
Evenness	0.91	0.92	0.96	0.94	1.50	0.83	0.96	0.97	

Relation of abundance and species richness with environmental variables

While increasing the distance to the nearest water source, the generalized linear model (GLM) revealed a significant decrease in abundance ($p<0.05$) and species richness ($p<0.05$) (Table 3). On the higher cover of IAPS, there was a significant decrease in abundance ($p<0.001$) and species richness ($p<0.001$).

The generalized linear model (GLM) showed a significant decrease in abundance ($p<0.05$) and species richness ($p<0.05$) while increasing the distance to the nearest water source (Table 3). There was a significant decrease in abundance ($p<0.001$) and species richness ($p<0.001$) on the higher cover of IAPS. Shrub cover was also found to have a significant decrease in abundance ($p<0.05$) and species richness ($p<0.001$) (Figure 5a and Figure 5b). Other environmental variables, however, did not show a significant difference in bird abundance and species richness (Table 3).

Table 3. The result summary of GLM between environment variables and diversity and species richness (Bold letters on italics indicate significant results).

Environmental variables	Abundance			Richness		
	Slope a	**Intercept b**	**p-value**	**Slope a**	**Intercept b**	**p-value**
Distance to nearest water source	-0.006	19.288	***0.012***	-0.001	6.437	***0.014***
Distance to nearest moterable road	-0.004	19.453	***0.034***	-0.0009	6.408	0.061
Cover of IAPS	-0.149	23.98	***P<0.001***	-0.054	8.488	***P<0.001***
Tree canopy cover	0.001	16.428	0.975	0.008	5.361	0.415
Shrub cover	-0.110	21.983	***0.002***	-0.052	8.325	***P<0.001***
Numbers of large trees	0.204	15.322	0.525	0.110	5.103	0.177
Human trail	-1.505	17.650	0.572	-0.992	6.500	0.142

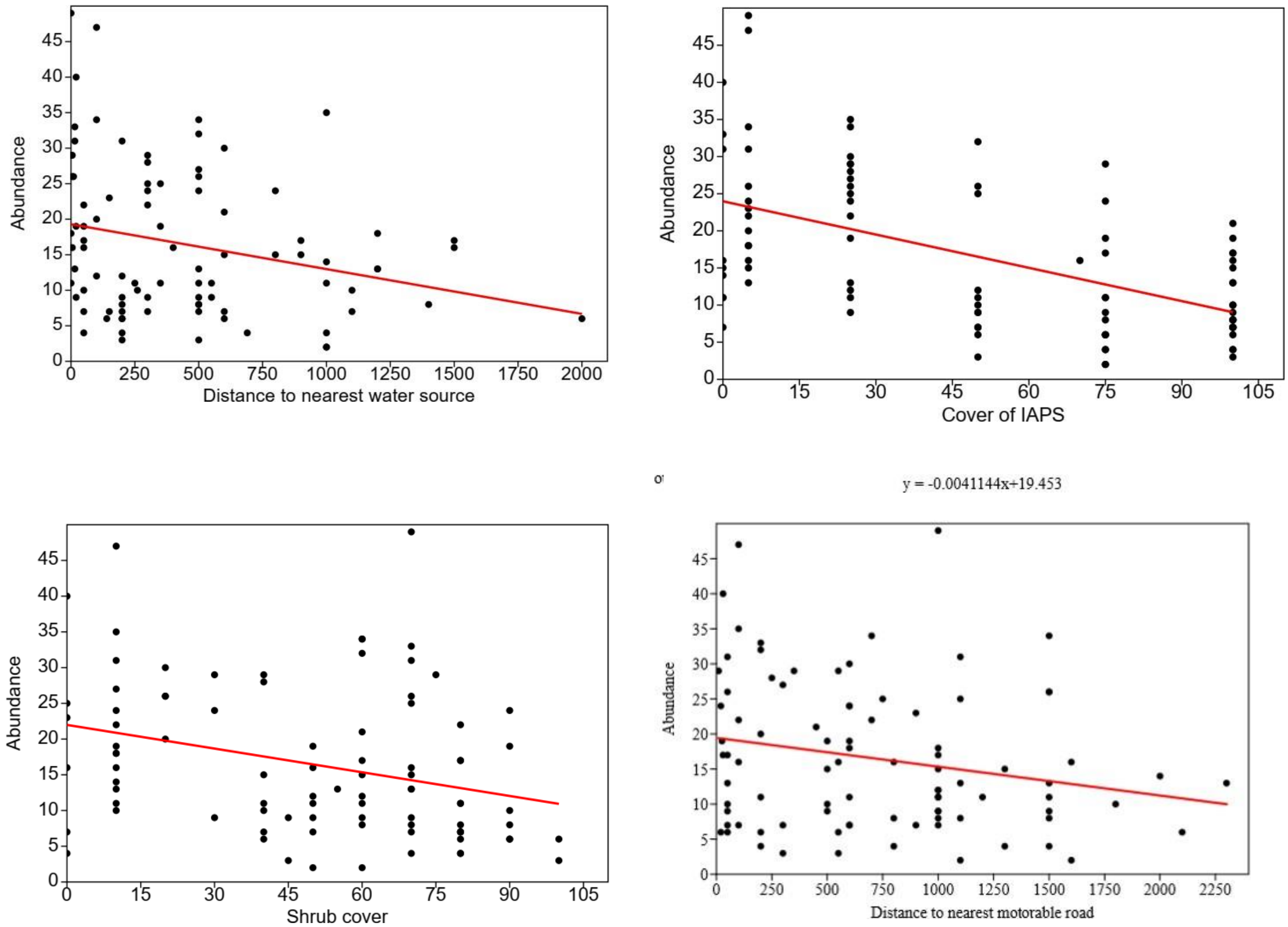

Figure 5a. Relationship between bird abundance and different environmental variables (Distance to the nearest water source, Cover of IAPS, Shrub cover and Distance to the nearest motorable road).

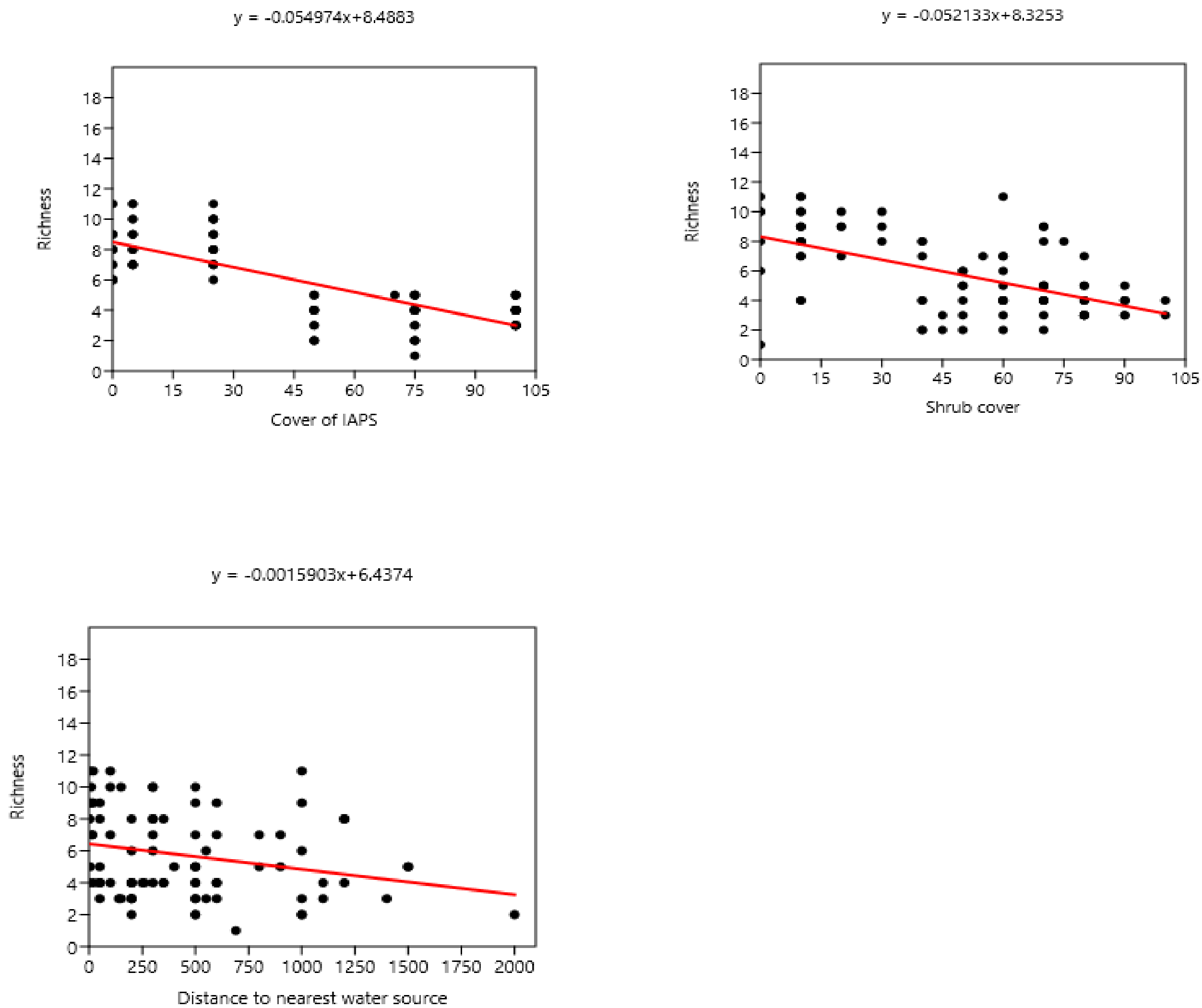

Figure 5b. Relationship between species richness of birds and different environmental variables (Cover of IAPS, Shrub cover, Distance to nearest water source).

Relation between the cover of invasive alien plant species and bird species

Ten most abundant species was taken to test if there is any significant difference between the abundance of different feeding guild in the different cover class of IAPS. There was a significant difference between the abundance of different feeding guilds in different cover classes (The chi-square value is 54.71 and the p-value is <0.00001). The abundance and richness of herbivorous species were most affected by the cover of IAPS (Spearman's rank correlation (r_s) = -0.366 and p<0.001 and Spearman's rank correlation (r_s) = -0.259 and p =

0.018). The abundance and species richness of every guild except omnivorous species were significantly higher in the lower cover of IAPS. However, the relation was moderate for all guilds (Table 4).

Table 4. The results of Spearman's rank correlation between the abundance and richness of different feeding guilds to the IAPS cover class.

Feeding Guilds	Abundance		Richness	
	r_s-value	p-value	r_s-value	p-value
Carnivorous	-0.273	***0.012***	-0.200	0.067
Herbivorous	-0.366	***0.0007***	-0.259	***0.018***
Insectivorous	-0.266	***0.015***	-0.237	***0.040***
Omnivorous	-0.032	0.773	-0.036	0.740
Carnivorous	-0.273	***0.012***	-0.200	0.067

Use of vertical strata of the forest by birds

The abundance of birds was highest (32%) in the top layer of vertical strata, followed by the middle (27%). The abundance of birds in the ground stratum was higher (22%) than in the lower stratum. The species richness was also highest in the middle strata (Figure 6).

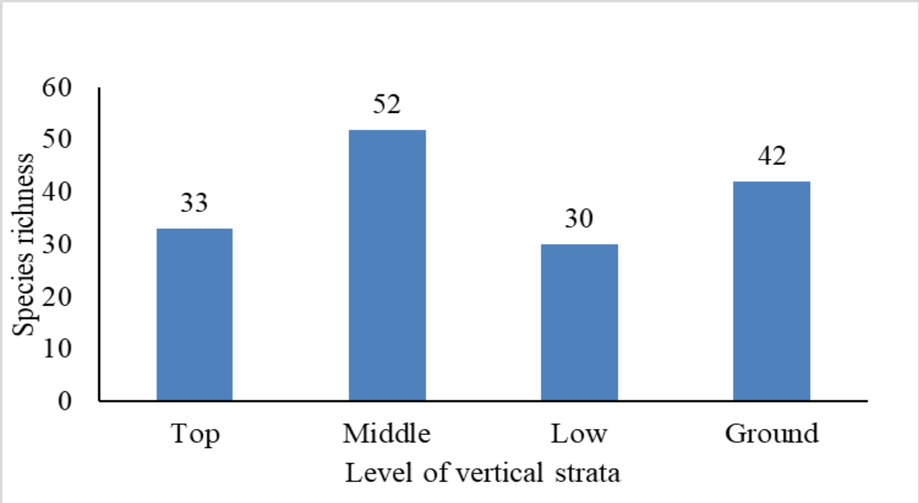

Figure 6. Species richness in each verticle strata.

Effects of habitat structure

The guilds association of bird species with the disturbance variables and habitat structure were tested by CCA. The Monte-Carlo permutation test of significance of all canonical axes showed no significant relationship of the insectivorous to the habitat type (Trace = 1.871, F-ratio = 1.320, P-value = 0.1080), and carnivorous (Trace = 1.128, F-ratio = 1.052, P-value = 0.322) but had significant relationship with herbivorous (Trace = 0.591, F-ratio= 1.663, P-value = 0.049) and omnivorous (Trace = 0.980, F-ratio = 1.400, P-value = 0.049) (Figure 7a).

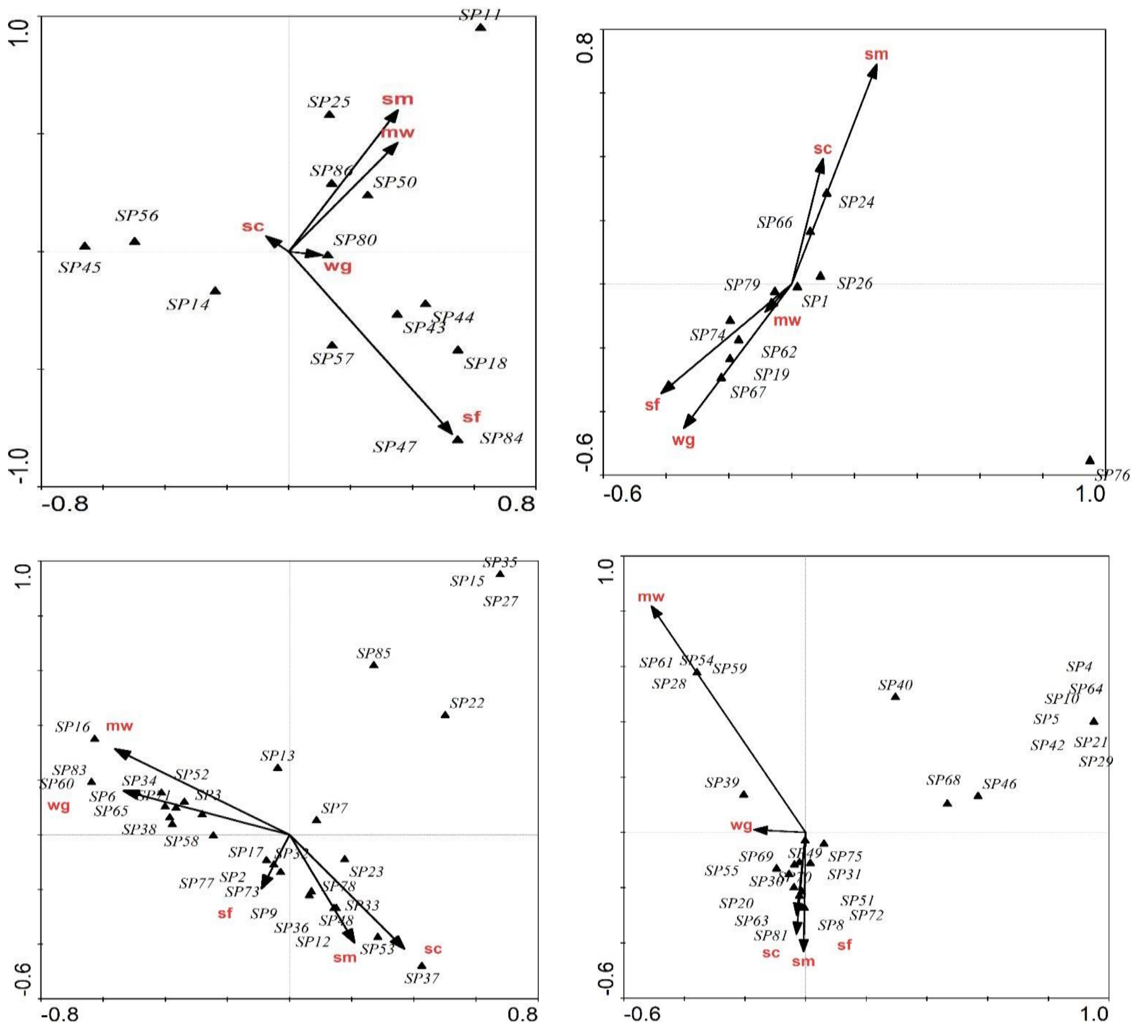

Figure 7a. CCA ordination diagram (biplot) showing the response of different feeding guilds response to habitat types of Jalthal forest. (mw: Mixed woodland, wg: Wooded grassland, sf: Sal forest, sm: Sal *Mikenia* forest, Sal *Chromolanea* forest). Codes used for bird species are

given in the appendix. The first two axes are displayed. The first axis and second axis account for 42% and 33% for carnivorous, 51.2% and 33.6% for herbivorous, 38.1% and 30.3% for omnivorous, 23.4% and 19.2% for insectivorous).

The Monte-Carlo permutation test of significance of all canonical axes revealed significant rejection of disturbance area by carnivorous birds (Trace = 1.385, F-ratio = 1.77, P-value = 0.006 with 499 permutations). Species like Crested serpent eagle (SP25) and black stork (SP11) preferred the invaded areas, but other species didn't prefer the areas invaded by IAPS Figure 7b. Similarly, herbivorous birds also showed a significant preference for habitats with less disturbance (Monte-Carlo permutation test of significance of all axis, Trace = 0.579, F-ratio = 2.064, P-value = 0.02 with 499 permutations). Insectivorous birds also didn't prefer the invaded habitats (Trace = 1.051, F-ratio = 1.470, P-value = 0.024 with 499 permutations) however, some species are found to be associated with dw and IAPS. Omnivorous birds also had significant Monte-Carlo permutation test of all axis (Trace = 1.018, F-ratio = 1.852, P-value = 0.006 with 499 permutations) Figure 7b.

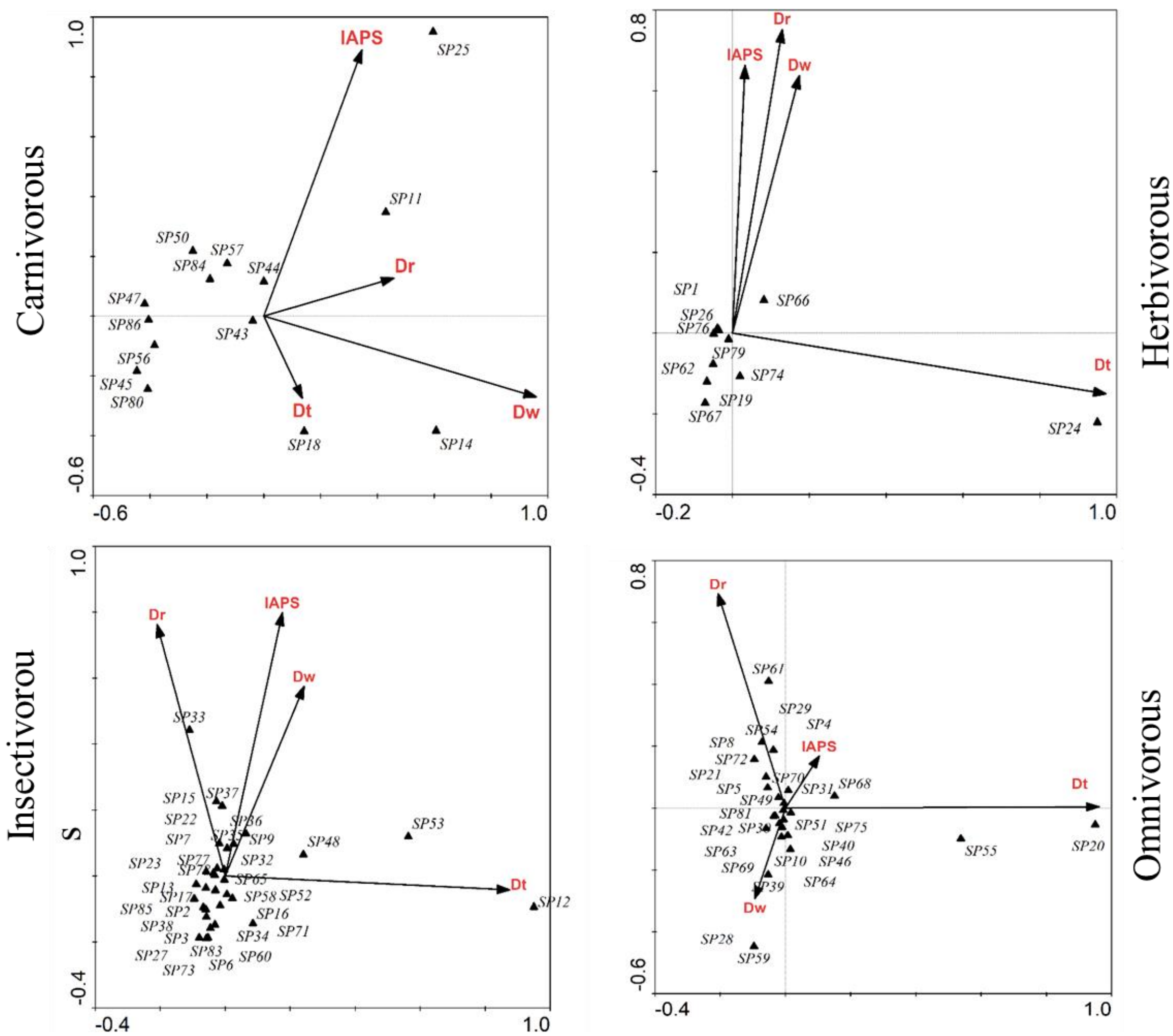

Figure 7b. CCA ordination diagram (biplot) showing the response of different feeding guilds response to disturbance variables of Jalthal forest. (IAPS: cover % of invasive alien plant species, Dr: Distance to the nearest motorable road, Dw: Distance to the nearest water source, Dt: Dead trees). Codes used for bird species are given in the appendix. The first two axes are displayed. The first axis and second axis account for 43.4 % and 30% for carnivorous, 51.2% and 33.6% for herbivorous, 24% and 19.2% for insectivorous, 37% and 28% for omnivorous).

5. DISCUSSION

Bird diversity

Jalthal is one of the very unique forest types of Nepal. In this study single-season point, count survey method was used to explore the diversity of birds. Insectivorous birds were found to be the most species-rich birds in the Jalthal forest and frugivorous were the least. For the eastern part of Nepal, this result is consistent to (Chettri et al. 2018). The least abundance of frugivorous may be due to no availability of fruiting trees in the forest due to off-season and the majority of the forest is sal forest which is privileged not to offer many fruiting trees.

Higher diversity of birds is usually seen in mixed type of habitats because mixed type of habitat can provide different types of habitats for differently inhabiting bird species, and higher value of diversity indices in grassland has been reported by (Tu et al. 2020). Which was consistent with our results but it was contrary to the results of (Pandey et al. 2020), where they found the highest diversity in agriculture and settlements. Mean abundance of birds were found highest in floodplain habitats (fp) which is because the bird species like Little Cormorant and Lesser Whistling Ducks usually live in large groups around the water source. The Jungle Babbler was the most dominant bird because it is a generalist bird species that can forage in any type of habitat and can be found in groups of 4-16 (Anthal and Sahi 2013).

Effects of Habitat structure

The number of birds was highest in the forest's middle strata. This result agrees with (Robinson and Holmes 1984, Dinanti et al 2018), but not with the ground level. The presence of more species in ground strata in the Jalthal forest may be due to the abundance of water and food. Low diversity in the lower and upper strata may be due to a scarcity of food.

Carnivorous birds typically avoided invaded areas, but species such as the Crested Serpent Eagle and Black Stork preferred invaded areas if they were close to water sources. Carnivorous birds have a higher chance of finding food when they are near a source of water. This type of conditional preference of invaded habitats by carnivorous birds was also reported by (Holland-Cleft et al. 2011, Mangachena and Greets 2016). Similarly, herbivorous, omnivorous, and insectivorous birds attempted to avoid IAPS-invaded habitats near roads and away from water resources.

Similarly, herbivorous, omnivorous, and insectivorous birds also tried to avoid the habitats that are invaded by IAPS, near to the road and far from the water resources. IAPS cover restricts access to the ground, particularly for ground foraging birds (songbirds, waterbirds, and breeding birds), causing them to avoid invaded habitats (Gan et al. 2009). IAPS reduces the number of foliar arthropods, and thus the number of insectivorous birds (Gleditsch 2017).

Insectivorous, omnivorous, carnivorous, and herbivorous bird feeding guilds were associated with Sal forest, Sal Mikania forest, Sal Chromolanea forest, mixed woodland, and wooded grassland. Sal forest habitat was preferred by birds over other types of habitat. The availability of resource supplements could explain such preference. Insectivorous birds can supplement their diet with invertebrates found in various forest strata (MacArthur and MacArthur 1961, Orians and Wittenberger 1991). During the study, the most species-rich feeding guild was insectivorous.

Effects of IAPS

Cover of IAPS and shrub cover showed a strong association with the richness and abundance of birds. Altered habitat changes the floristics of the native habitat (Aravind et al. 2010, Flanders et al. 2006, Holland-Clift et al. 2011, Keller and Avery 2014, Mangachena and Geerts 2017). IAPS has also reduced the availability of fruiting trees and insects, which is the primary cause of food scarcity for birds, particularly insectivorous, granivorous, and frugivorous birds (Schirmel et al. 2016). The richness and abundance of omnivorous birds were found to be comparable in invaded and non-invaded habitats.

Omnivorous birds can use a variety of habitats because they can easily adapt to changing environments. Holland-Clift et al. (2011) also discussed higher species richness of birds in native habitats in terms of food availability, i.e., arthropods (most likely prey of insectivores, carnivores, and omnivores), which was also supported by (Almeida-Neto et al. 2011).

Mangachena and Geerts (2017) also discussed the lower diversity of birds on invaded habitats due to loss and modification of resources, particularly food and nesting sites. If birds find a better nesting site, they are likely to use that habitat so often as in the case of urban areas (Gleditsch 2017).

Effects of the environmental variable

Increasing the distance to the nearest water source showed a significant decrease in species richness and abundance of bird species, this result is consistent with (Tilghman 1987, Pandey et al. 2020). The disturbances from moving vehicles, horns, and human movements usually put a negative effect on the diversity and abundance of birds that’s why decreasing the distance to the road birds' diversity and abundance decrease (Alexander et al. 2019, da Silva and Silva 2020, Leveau et al. 2020). Contrarily, in this study, the birds' diversity and abundance increased with the decreasing distance to the road. Such a result may be due to the association of habitat on the edge of the forest. The forest is surrounded by a motorable road in most areas and there is farmland surrounding the forest, which provides a heterogeneous habitat and is utilized by many species of birds (Moges et al. 2017, Callaghan et al. 2019). Other environmental variables did not show a significant difference between the diversity and abundance of birds.

6. CONCLUSION AND RECOMMENDATION

This study shows the negative impacts of IAPS on the bird assemblages by decreasing the species richness and abundance while increasing the cover of IAPS. Variables like the cover of IAPS, shrub cover, and distance to nearest water source had significant negative impacts on species richness and abundance of birds, but the abundance of birds was found to be decreasing while increasing the distance to the nearest motorable road. Sal forest was the most preferred habitat type by the birds.

Because of the frequent threat of wild elephants and wild boars, our study was limited to the forest's outskirts. In the core of the forest, the intensity of the invasion usually decreases. As a result, a more detailed study that includes the core area could increase bird diversity and provide a more precise estimate of the effects of habitat structure and IAPS on birds. Jalthal forest supports a large number of migratory birds because it is the largest forest in eastern Jhapa and has abundant water sources. As a result, this study suggests more research on the seasonal diversity of birds, as well as similar research in other parts of Nepal's lowlands.

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Appendix 1. Details of bird species recorded.

SN	Order	Family	Common name	Scientific name	Feeding guild	Code	MS	NRLB	IUCN
1	Anseriformes	Anatidae	Lesser whistling duck	*Dendrocygna javanica*	Omnivorous	SP54	R	LC	LC
2	Charadriformes	Charadriidae	Red wattled lapwig	*Vanellus indicus*	Insectivorous	SP71	R	LC	LC
			River lapwig	*Vanellus duvaucelii*	Insectivorous	SP73	R	LC	LC
		Scolopacidae	Common sand piper	*Actitis hypoleucos*	Omnivorous	SP21	W	LC	LC
3	Ciconiiformes	Ardeidae	Cattle egret	*Bubulcus ibis*	Carnivorous	SP14	R	LC	LC
			Indian pond heron	*Ardeola grayii*	Carnivorous	SP43	R	LC	LC
			Intermediate egret	*Mesophoyx intermedia*	Carnivorous	SP45	R	LC	LC
			Little egret	*Egretta garzetta*	Carnivorous	SP57	R	LC	LC
		Ciconiidae	Black Stork	*Ciconia nigra*	Carnivorous	SP11	W	VU	LC
			Lesser adjutant	*Leptoptilos javanicus*	Carnivorous	SP50	R	VU	VU
			Asian Wolly neck	*Ciconia episcopus*	Carnivorous	SP86	R	NT	NT
		Threskiornithidae	Red naped ibis	*Pseudibis papillosa*	Omnivorous	SP69	R	LC	LC
4	Columbiformes	Columbidae	Eurassian collard dove	*Streptopelia decaocto*	Granivorous	SP26	R	LC	LC
			Oriental turtle dove	*Streptopelia orientalis*	Granivorous	SP62	R	LC	LC
			Spotted dove	*Stigmatopelia chinensis*	Granivorous	SP79	R	LC	LC
			Red collard dove	*Streptopelia tranquebarica*	Granivorous	SP27	R	LC	LC
5	Coraciiformes	Bucerotidae	Oriental pied hornbill	*Anthracoceros albirostris*	Omnivorous	SP61	R	NT	LC
		Coraciidae	Indian roller	*Coracias benghalensis*	Carnivorous	SP44	R	LC	LC
		Meropidae	Green bee eater	*Merops orientalis*	Insectivorous	SP34	R	LC	LC
		Upupidae	Common hoopee	*Upupa epops*	Insectivorous	SP16	R	LC	LC

6	Cuculiformes	Cuculidae	Common Hwak cuckoo	*Hierococcyx varius*	Insectivorous	SP17	R	LC	LC
			Greater coucal	*Centropus sinensis*	Omnivorous	SP31	R	LC	LC
			Lesser coucal	*Centropus bengalensis*	Omnivorous	SP51	R	LC	LC
7	Falconiformes	Accipitridae	Black kite	*Milvus migrans*	Omnivorous	SP10	R	LC	LC
			Creasted Serpent Eagle	*Spilornis cheela*	Carnivorous	SP25	R	LC	LC
8	Galliformes	Phasianidae	Indian peacock	*Pavo cristatus*	Omnivorous	SP42	R	NT	LC
			Red jungle fowl	*Gallus gallus*	Omnivorous	SP68	R	LC	LC
9	Passeriformes	Aegithinidae	Common lora	*Aegithina tiphia*	Frugivorous	SP19	R	LC	LC
			Common kingfisher	*Alcedo atthis*	Carnivorous	SP18	R	LC	LC
			White throated kingfisher	*Halcyon smyrnensis*	Carnivorous	SP84	R	LC	LC
		Campephagidae	Black headed cuckooshrike	*Coracina melanoptera*	Omnivorous	SP8	S	LC	LC
			Large cuckooshrike	*Coracina macei*	Insectivorous	SP48	R	LC	LC
			Scarlet minivet	*Pericrocotus flammeus*	Insectivorous	SP77	R	LC	LC
		Cisticolidae	Common tailorbird	*Orthotomus sutorius*	Insectivorous	SP23	R	LC	LC
		Corvidae	Eastern jungle crow	*Corvus levaillanti*	Omnivorous	SP40	R	-	LC
			Rufous treepie	*Dendrocitta vagabunda*	Omnivorous	SP75	R	LC	LC
		Dicruruide	Ashy Drongo	*Dicrurus leucophaeus*	Insectivorous	SP2	W	LC	LC
			Black drongo	*Dicrurus macrocercus*	Insectivorous	SP7	R	LC	LC
			Greater racket tailed drongo	*Dicrurus paradiseus*	Insectivorous	SP33	R	LC	LC
			Lesser Racket tailed drongo	*Dicrurus remifer*	Insectivorous	SP53	R	LC	LC
			Spangled drongo	*Dicrurus hottentottus*	Insectivorous	SP78	R	LC	LC
		Estrildidae	Scaly breasted muniya	*Lonchura punctulata*	Granivorous	SP76	R	LC	LC
		Hirundinidae	Barn swallow	*Hirundo rustica*	Insectivorous	SP6	R	LC	LC
		Laniidae	Brown shrike	*Lanius cristatus*	Insectivorous	SP13	W	LC	LC
			Grey backed shrike	*Lanius tephronotus*	Insectivorous	SP35	W	LC	LC

			Long tailed shrike	*Lanius schach*	Insectivorous	SP58	R	LC	LC
		Leiothrichidae	Jungle babbler	*Turdoides striata*	Omnivorous	SP49	R	LC	LC
		Motacillidae	Olive backed pipit	*Anthus hodgsoni*	Omnivorous	SP59	W	LC	LC
			Paddyfield pipit	*Anthus rufulus*	Omnivorous	SP64	R	LC	LC
			White brrowed wagtail	*Motacilla maderaspatensis*	Insectivorous	SP82	R	LC	LC
			White wagtail	*Motacilla alba*	Insectivorous	SP85	W	LC	LC
		Muscicapidae	Asian brown flycatcher	*Muscicapa dauurica*	Insectivorous	SP3	P	LC	LC
			Common stonechat	*Saxicola torquatus*	Insectivorous	SP22	W	LC	LC
			Oriental magpie robin	*Copsychus saularis*	Insectivorous	SP60	R	LC	LC
			Pied bushchat	*Saxicola caprata*	Insectivorous	SP65	R	LC	LC
		Muscicapidae	Verditer flycatcher	*Eumyias thalassinus*	Omnivorous	SP81	W	LC	LC
		Nectariniidae	Purple sunbird	*Nectarinia asiatica*	Nectarivorous	SP67	R	LC	LC
		Oriolidae	Black hooded oriole	*Oriolus xanthornus*	Insectivorous	SP9	R	LC	LC
		Paridae	Great tit	*Parus major*	Omnivorous	SP30	R	LC	LC
			House sparrow	*Passer domesticus*	Omnivorous	SP39	R	LC	LC
		Passeridae	Eurassian tree sparrow	*Passer montanus*	Omnivorous	SP28	R	LC	LC
		Pycnonotidae	Red vented bulbul	*Pycnonotus cafer*	Omnivorous	SP70	R	LC	LC
			Red whiskered bulbul	*Pycnonotus jocosus*	Omnivorous	SP72	R	LC	LC
		Rhipiduridae	White throated fantail	*Rhipidura albicollis*	Insectivorous	SP83	R	LC	LC
		Stenostiridae	Grey headed canary flycatcher	*Culicicapa ceylonensis*	Insectivorous	SP37	W	LC	LC
		Sturnidae	Asian pied starling	*Sturnus contra*	Omnivorous	SP4	R	LC	LC
			Bank myna	*Acridotheres ginginianus*	Omnivorous	SP5	R	LC	LC
			Chestnut tailed starling	*Sturnus malabarica*	Insectivorous	SP15	R	LC	LC
			Common myna	*Acridotheres tristis*	Omnivorous	SP20	R	LC	LC

			Jungle myna	*Acridotheres fuscus*	Omnivorous	SP46	R	LC	LC
		Zosteropidae	Oriental White eye	*Zosterops palpebrosus*	Omnivorous	SP63	R	LC	LC
10	Pelecaniformes	Phalacrocoracidae	Little cormorant	*Phalacrocorax niger*	Carnivorous	SP56	R	LC	LC
11	Piciformes	Dendrocopos	Fulvous breasted woodpecker	*Dendrocopos macei*	Omnivorous	SP29	R	LC	LC
		Megalaimidae	Blue throated barbet	*Megalaima asiatica*	Insectivorous	SP12	R	LC	LC
			Coppersmith barbet	*Megalaima haemacephala*	Frugivorous	SP24	R	LC	LC
			Lineated barbet	*Megalaima lineata*	Omnivorous	SP55	R	LC	LC
		Picidae	Greater goldenback woodpecker	*Chrysocolaptes lucidus*	Insectivorous	SP32	R	LC	LC
			Grey capped pigmy woodpecker	*Dendrocopos canicapillus*	Insectivorous	SP36	R	LC	LC
			Himalayan Goldenback woodpecker	*Dinopium shorii*	Insectivorous	SP38	R	-	-
			Lesser goldenback woodpecker	*Dinopium benghalense*	Insectivorous	SP52	R	LC	LC
12	Psittaciformes	Psittaculidae	Alexandrine parakeet	*Psittacula eupatria*	Herbivorous	SP1	R	NT	NT
			Plum headed parakeet	*Psittacula cyanocephala*	Herbivorous	SP66	R	LC	LC
			Rose ringed parakeet	*Psittacula krameri*	Herbivorous	SP74	R	LC	LC
13	Strigiformes	Strigidae	Spotted owlet	*Athene brama*	Carnivorous	SP80	R	LC	LC
			Jungle owlet	*Glaucidium radiatum*	Carnivorous	SP47	R	LC	LC
			Indian eagle owl		Carnivorous	SP41	R	-	-