

Seasonal Variation in Bird Species Diversity in Different Habitats

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Abstract

Bird communities are very sensitive to seasonal fluctuations in climatic conditions, food availability, vegetation structure, water resources and habitat characteristics. These seasonal patterns are important for determining ecosystem health and designing effective conservation measures for biodiversity. It is the seasonal variation in bird species diversity in each habitat type that is of interest in the present study, focusing on birds species richness, abundance, composition and bird community structure. Bird observations are suggested in representative habitats including forested, agricultural, wetland, urban or semi-urban, and scrubland habitats throughout the seasons. Standardized field-survey methods, including fixed-point counts and transect observations, can be used to record bird species and their relative abundance. Bird communities can be compared among habitats and seasons using diversity indices (e.g., Shannon–Wiener diversity, Simpson's diversity, species richness or evenness). The study will likely show that bird diversity is highly seasonal and is influenced by the different habitat types and their availability, the vegetation, breeding activity, migration and human disturbance. The habitat of wetlands and forests can have relatively high species richness, while agricultural and urban habitats can have higher representation of adaptable and generalist species. The presence of migratory birds and the dominance of bird communities can also be affected by seasonal changes. Results may help understand habitat-specific ecological needs and be useful in understanding determinants of avian diversity. The study calls for the need of conserving diverse habitats, seasonal resources, less habitat disturbance and enhanced biodiversity monitoring programmes. This information can assist with evidence-based habitat management and help to conserve bird populations and all the ecological processes they play.

Keywords: Bird Species Diversity; Seasonal Variation; Habitat Diversity; Avian Ecology; Species Richness; Bird Abundance; Biodiversity Conservation; Habitat Preference; Migratory Birds; Community Structure; Shannon–Wiener Diversity Index; Ecological Monitoring; Wetland Ecology; Forest Ecosystems; Habitat Management.

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Introduction

Birds are one of the most ecologically diverse and widespread of the vertebrate groups, and are found in every type of habitat from forests to wetlands, from agricultural land to grasslands, from coastal systems to environments dominated by humans. Their abundance and distribution are closely linked to their presence, environmental conditions, vegetation structure, availability of food, nesting opportunities, water resources, and levels of human disturbance. Bird diversity and community structure are often considered effective indicators of ecosystem condition and ecological alteration in response to relatively rapid changes in habitat conditions, which makes them an excellent tool for assessing ecosystem health and ecological change. Therefore, knowledge of bird diversity patterns is relevant not just for documentation of biodiversity, but also assessing habitat quality and formulating effective conservation measures.

Bird communities do not stay the same all year long. The availability and distribution of resources such as food and nesting sites for various species of birds may be affected by seasonal variations in temperature, rainfall,



growth of vegetation, timing of flowering and fruiting, insect population, water supply, and agricultural practices. Thus, the species present in a habitat and their abundance may change significantly from one season to another. These temporal variations are also reinforced by migration, as a large proportion of species migrate between their breeding and non-breeding areas to suit climatic conditions and availability of resources. Elevational gradient studies have shown that species of birds and feeding guilds may display different seasonal distribution patterns and that insectivorous species may be particularly sensitive to changes in resource availability and precipitation through the seasons.

Another important factor influencing avian diversity is habitat characteristics. The various habitats offer varying mixes of cover, nesting locations, food sources, breeding territories, and predator protection. Some species require dense vegetation and old trees for forest habitat, and some waterbirds require feeding, breeding and roosting areas in wetlands. Depending on crop diversity, vegetation cover, availability of trees and level of cultivation, agricultural landscapes can support a mix of resident and migratory species. Where there are green spaces, gardens, water bodies, and other habitat features that support biodiversity, there may be a considerable avian diversity in urban and semi-urban habitats. Habitat heterogeneity has been demonstrated to have an effect on bird richness and the significance of specific habitats can vary between seasons.

When it comes to measuring bird diversity, the season and habitat combination is critical. A habitat that is favourable in one season may not be favourable in another due to fluctuations in food, plant life, water, temperatures, or people. Migratory species may also cause local species richness to be greater temporarily at certain times of the year. A study in a mid-altitudinal village ecosystem of Indian Himalayas found that there were significant variations in bird diversity among seasons and habitats, and agricultural habitat had the highest diversity while the spring season had the highest species richness. These results prove that a single season can be inadequate for accurately reflecting the variety of species and ecological role of bird communities.

The agriculture landscapes represent a special example of seasonal habitat variation. The distribution of farmland birds can be affected by changes in: cropping patterns, fallow periods, vegetation structure, hedgerows, availability of non-cropped areas. Heterogeneous agricultural habitats and scrublands support higher bird richness and abundance than homogeneous agricultural fields, and the value of the different habitats varies in different seasons (breeding, post-breeding and wintering). The study also showed that the richness and composition of the farmland bird community was influenced by seasonal variation and cropping practices in Nepal, indicating the need for considering seasonality in farmland biodiversity assessment.

Seasonal variation is also strongly linked to other larger-scale ecological factors like breeding, migration, dispersal, competition and feeding behaviour. Birds may concentrate in habitats during breeding periods where nesting sites and adult and young food are available. Some species may shift their habitat use or their movements may shift to areas with higher food availability and climatic suitability in non-breeding seasons. Migratory species may significantly alter community composition by adding to resident bird species for periods of the year. Therefore, seasonal variation in species richness should also be analyzed in conjunction with changes in abundance, diversity indices and dominance, as well as community composition to gain a complete understanding of the avifaunistic ecology.

In the era of escalating environmental changes, studying the diversity of birds across the seasons has important implications. Habitat quality can be reduced and ecological resources can be modified by urban development, intensive farming, deforestation, wetland degradation, pollution, infrastructure development, and other anthropogenic activities. These pressures could impact resident species all year, as well as potentially impacting the suitability of habitats for seasonal migrants. Breeding and migration schedules, food availability and habitat use could be further affected by changes in climate and rainfall patterns. Knowledge of the response of bird communities to variation in seasons and habitats can then be used to determine habitats of special importance for preserving avian biodiversity.

Comparative assessment of habitats, by seasons, can yield useful information on species richness, abundance, diversity, habitat preference, and seasonal turnover. This type of information can be valuable in determining habitats of high biodiversity, in understanding when they are ecologically more important and in developing appropriate conservation strategies for habitat. It can also help provide a baseline data for comparison to future trends in bird populations. The importance of changes in community composition and functional diversity, as



well as the number of species, as a result of the seasonal changes have been stressed by recent research.

In this backdrop, the present study; “Seasonal Variation in Bird species Diversity in Different Habitat” aims to study the variation of the bird community in different habitat types over the seasons. The bird species richness, abundance and diversity comparison between seasons and habitats aims to gain insight into the effects of environmental and habitat-related factors on bird communities. The analyses are likely to lead to an improved understanding of local bird ecology and will be helpful in establishing baseline data for biodiversity monitoring, habitat management and conservation planning. The integrated seasonal approach can ultimately aid in conservation efforts more effectively as it considers that ecological value of the habitat can vary greatly throughout the year.

Background of the study

Birds are widely regarded as important indicators of ecological health, and are an important component of both terrestrial and aquatic habitats. The distribution and abundance of these species and the structure of their communities are strongly related to the structure of vegetation, food availability, water resources, climate, habitat quality, and human disturbance. Birds are relatively sensitive to changes in their surroundings and a knowledge of their diversity can offer useful data on the ecological properties and the modification of various habitats. Avian studies have also shown that the richness, abundance, and diversity of birds may be affected by habitat type and season, so repeated observations across seasons are necessary to understand bird communities. Bird communities are highly sensitive to seasonal variation in structuring. Resources available to birds can change throughout the year due to changes in the abundance of rain and temperature, the growth of vegetation, the abundance of insects, their fruiting patterns, the availability of water, and changes in the fruiting patterns, water availability, vegetation growth, insect abundance, and temperature. Changes in bird communities and abundance can also be significant due to seasonal movements or migration. Geographical distribution of many species of birds is dynamic in time and migratory species can be found in different habitats at different times of the year. Thus, a site where only a few species are present at a particular time of year can be a feeding, breeding, or sheltering site at a different time of year.

Another significant factor is habitat characteristics that affect the diversity of birds. The vegetation structure and resource availability are quite different in forests, agricultural landscapes, wetlands, grasslands, riverine areas, urban landscapes and semi-natural habitats. Bird species richness may be affected by habitat heterogeneity because it may offer a variety of feeding, nesting, roosting, and breeding opportunities. For instance, it has been observed that there is a lot of variation in bird diversity in different habitats and seasons of the year, with agricultural land exhibiting high bird diversity and spring the highest richness in the study area in the Indian Himalayas. In the same way, studies conducted in wetlands of Odisha revealed that there were significant differences in the avian species richness of different wetlands in relation to their habitat suitability and anthropogenic pressure.

Bird diversity is also high on agricultural and human modified landscapes that feature a mix of vegetation, crop fields, trees, water, and uncultivated areas. The richness and abundance of birds in the farmland habitats can be higher than in homogeneous farmland habitats, and the habitat association may vary across seasons and life history traits of birds. These results indicate that conservation of bird diversity does not need to be dependent on protected forests and that conservation of habitat diversity in agricultural and other human-created landscapes may be relevant.

The Indian context is very important, as it comprises many different ecosystems and bird species, both migratory and resident. Habitat conditions change significantly over a period of time, related to the monsoon, winter, summer and breeding seasons. Several studies in diverse regions of India have reported seasonal variation in richness and community structure of birds. For instance, a large-scale bird survey in the Bhagirathi Valley of Uttarakhand recorded 281 species and revealed differences in seasonal occurrence and habitat preferences of birds along riverine habitats. Similarly, a study in Bengaluru revealed that habitat birds were also found to be more abundant, more rich, more even, and more diverse in summer and less in the rainy season in urban and its surrounding habitats.

The varying resource availability of birds due to land-use change and human development are increasingly



significant and are becoming more important between the different habitat types. Urbanization can lead to habitat loss, habitat fragmentation, habitat disturbance and change in food and water availability. Meanwhile, gardens, parks, wetlands, institutional campuses, agricultural areas, and other green spaces can serve as significant stopover sites for birds. The urbanization gradients studies have shown measurable differences in the species richness and Shannon diversity of the birds in the urban, suburban and relatively less disturbed habitats for the seasons.

The value of seasonal studies is, therefore, that a single survey period may be an inadequate representation of the bird community of a specific habitat. The availability of migratory species could vary from year to year, breeding species could be more conspicuous during certain seasons, and food sources may change dramatically from one season to the next. Also, species that are not often seen in one season can be observed in abundance in another if it is the right season. Therefore, species richness, abundance, diversity and habitat associations can be more accurately documented by year-round or seasonally replicated surveys.

These seasonal patterns are also relevant to the conservation and management of biodiversity and habitats. Bird diversity can be a valuable indicator of the health of an ecosystem and can be used to monitor future changes in the environment. Long-term monitoring can be used to identify habitats that are always important, habitats that are important for specific seasons, and environmental factors related to changes in bird abundance. It may also help to inform planning decisions relating to habitat restoration, wetland management, agricultural management, urban green-space planning and protection of migratory routes. There is a need for a bias correction for birds as indicators of biodiversity and change that has been highlighted by existing research and takes into account the season and habitat biases.

Recent Indian studies also prove that study of bird communities beyond one habitat or season is necessary. Research on various habitats has shown varying seasonal trends in species richness, abundance and diversity; the seasonal shifts in the former two parameters are related to the ecological conditions and habitat structure. Such observations highlight the need for systematic comparative studies aimed at understanding the seasonality and habitat-specific differences in bird communities.

In this backdrop, the present study, “Seasonal Variation in Bird Species Diversity in Different Habitat” aims to understand the temporal variation in the bird community in selected habitats. The study could be used to establish the season and habitat differences in species richness, abundance, diversity, and community composition to better understand the ecological factors that drive local avifaunal diversity. This type of information can help with documenting biodiversity, ecological monitoring, developing conservation management strategies and habitat management. It is especially applicable in the context of increased habitat modification and environmental change, knowing the timing and distribution of bird species is critical to ensure healthy and resilient ecosystems.

Justification

Birds are well known to play a vital role in ecosystems, through their roles in pollination, seed dispersal, insect control, nutrient cycling and ecological balance. Their fast adaptation to changes in vegetation, food, climatic conditions, habitat structure, and human disturbance, and their ability to respond quickly also make them valuable environmental quality indicators. The study of bird diversity on various habitats can therefore give valuable information on the state of the landscape and its biological value.

Avian ecology is dynamic and changes throughout the year, therefore, seasonal variation is an important dimension. The abundance, distribution, and composition of birds can be affected by changes in temperature, rainfall, vegetation growth, availability of fruits, seeds and insects, breeding cycles, migration, and water availability. Studies conducted in various landscapes have shown that the number of species and their composition may change from one season to another. In agricultural landscapes, for instance, it has been found that the habitat associations and relative importance of specific habitats vary between breeding, post-breeding and winter.

It is important to compare different habitats as these are all very different in terms of the structure of their vegetation, food supply, nesting opportunities, availability of water, and extent of anthropogenic disturbance. These differences can mean the difference between which species of birds can use an area, or how many. Data



from Indian landscapes suggests that vegetation parameters, food availability and anthropogenic activities can have a combined effect on richness, diversity and evenness, and seasonality of avifauna.

The requirement for a seasonal evaluation of habitat is especially important in areas where natural and human-made ecosystems are adjacent to one another. Agricultural landscape, wetlands, village environment, urban green spaces and forest patches can offer complementary resources to resident and migratory birds. A Western Himalayan study, for example, found significant differences in bird diversity between seasons and habitats, with such diversity being higher in agricultural areas. Likewise, studies of wetlands have demonstrated that there can be significant differences in the number of species of birds found at one site versus another depending upon the habitat heterogeneity and anthropogenic pressures.

Knowing seasonal trends is also important to help determine whether the change in bird abundance is a seasonal trend or a long-term change in the ecology. If a species is decreasing in abundance in one season, it could be a migration or natural resource fluctuation, not permanent habitat degradation. On the other hand, if a species is not present or its abundance decreases from one season to another, it could be due to habitat loss, habitat fragmentation, pollution, disturbance or food shortages. It is therefore important to monitor habitats over the course of the year. Recent research has specifically highlighted the need to account for important requirements for birds outside of breeding periods, which could be missed from breeding time studies.

This study is also motivated by the growing stress on land use due to urbanization, intensification of agriculture, infrastructure construction, pollution, deforestation and other land use changes. These pressures have the potential to alter vegetation and landscape structure and thus bird communities. Conservation planners can benefit from information on habitats that are capable of sustaining high species richness or that are important for providing habitat resources during a particular season. Agricultural landscapes have shown to be important for bird diversity, and in such landscapes, non-cropped areas and heterogeneous habitats are of special importance, whereas homogeneous agricultural landscapes can support a smaller number of species.

In conservation terms, seasonal bird diversity can provide a good baseline for future monitoring. It may be able to contribute to the identification of resident species, seasonal visitors, habitat specialists, and species that might need special conservation consideration. This information can be particularly useful in landscapes outside of formally protected areas where systematic ecological information may be less available. Seasonal surveys can also help identify habitats that serve as a breeding ground, feeding ground, refuge habitat or stopover habitat throughout the year.

Thus, the present study on “Seasonal variation in bird species diversity in different habitats” is justified as it aims at gaining a holistic knowledge of the combined effect of season and habitat on birds. The species richness, abundance, diversity, and community composition will be compared seasonally and by habitat type, which will allow the study to make a contribution to ecological assessment, documentation of biodiversity, habitat management, and evidence-based conservation planning. The results could also serve as a reference for future research on the impact of climate variability, land use change, habitat fragmentation and anthropogenic disturbance on birds.

Objectives of the Study

1. To record and determine the species of birds found in the chosen habitats in various seasons.
2. To compare the bird species richness, abundance, diversity and evenness throughout the season.
3. To compare the bird community composition at different habitats and identify habitat-specific patterns of bird occurrence.
4. To explore how the diversity of birds is affected by seasonal environmental conditions (temperature, rainfall, vegetation cover, food availability and water availability).
5. To determine bird species residing in the area and seasonally/migratory species inhabiting the area and their occurrence patterns by habitat and by season.

Literature Review

Several factors including habitat characteristics, food availability, structure of the vegetation, climatic



conditions, migration patterns, and seasonal changes, can all affect the diversity of bird species. Knowing the seasonal changes in bird communities can be especially useful, as different species of birds may occur in the same habitat at different seasons. Seasonal variations may affect species richness, abundance, and community composition, and may affect breeding activity, availability of resources, movement and habitat use.

One of the first ecological studies to examine seasonal variation in tropical bird communities was carried out by Karr (1976) who compared bird communities in seven habitats in central Panama. The study showed that rainfall and food availability (insects and fruits) were related to seasonal variations in the abundance and species composition of birds. Karr also noted a general trend that as vegetation became more complex, the seasonal variation in bird community structure decreased. The relatively stable resources and microhabitats appeared to provide a buffer effect for birds against the seasonality of their environment, as more structurally complex habitats were found to buffer birds more effectively. This study provided a valuable ecological background for the explanation of the possible variation in seasonal responses among habitats.

The bird diversity has since been found to be one of the most important factors related to habitat structure. Waltert et al. (2005) identified different responses of various bird groups to habitat alteration in agroforestry and agriculture areas as well as across forest habitats in Cameroon. Reductions in tree density and canopy structure caused a particular reduction in forest-associated insectivorous species; some granivorous and nectar-feeding species were able to take advantage of modified habitats. Their results indicate that a measure of total species richness is not the most appropriate index of habitat quality, as habitat alteration can impact specific ecological guilds.

Naidoo (2004) examined songbird communities throughout three forest types: intact forest, regenerating forest and smallholder agricultural land within a tropical forest-agricultural landscape. The study revealed that forest habitats had a higher species richness which consisted of forest-dependent species, whereas agricultural habitats had lower species richness. Tree density and proximity to intact forest were important determinants of forest-associated bird communities. The results indicate that habitat structure and landscape connectivity may affect the seasonal distribution of birds, as these factors determine the availability of nesting sites, shelter, food resources and movement corridors.

Tscharntke et al. (2008) discussed functional diversity in tropical agroecosystems, and outlined patterns of divergence between bird communities in forests and in agricultural environments. They found that transformation of agriculture negatively impacts insectivorous species, but agroforestry may provide relatively higher proportions of frugivorous and nectarivorous species. The study highlights the importance of habitat conversion not only altering the abundance of bird species, but also bird community function. The functional difference may increase seasonally with fluctuations in the availability of insects, fruits, nectar and seeds.

MacGregor-Fors and Schondube (2011) made a comparison of bird communities between tropical dry forests and various types of agriculture. The species richness and evenness were the greatest in the tropical dry forests, and the least in the cattle pastures and crop fields. Tree orchards, however, still had relatively high levels of bird diversity due to the complexity of the structure. The authors associated bird community differences with habitat structure and landscape position, indicating that habitats with a higher degree of vegetation structure could offer more heterogeneous resources over time.

The diversity of avifauna is also related to landscape composition. Bhagwat et al. and other researchers have shown that agricultural landscapes near natural forest can keep more forest related bird species than those further away. Bhagwat et al. (2010) reported in the Western Ghats, India that the bird community in agricultural land near the intact forest resembled the communities of the forest habitats. Forest associated bird richness was also affected by vegetation structure and tree species composition in agricultural landscapes. The results highlight the need to consider natural vegetation patches and ecological connectivity when assessing bird diversity over seasons.

Studies conducted in India have also shown that there is a great habitat diversity in birds. The studies and studies that Katuwal et al. have highlighted have stressed that agricultural landscapes can be important seasonal habitats for resident and migratory birds. The mosaic of cultivated fields, fallow areas, trees, wetlands, grassland and forest patches provide habitat opportunities which can vary significantly from one



season to another. Seasonal agricultural activities may thus affect the availability of food and suitable habitats for different groups of birds.

One study of interest was undertaken by Shrestha et al (2022) in lowland Nepal agriculture. The bird communities were studied in summer, monsoon and winter, and the various cropping systems and habitat attributes compared. The abundance and richness of birds were significantly different across seasons. Species richness had higher values in the winter season while abundance has higher values during the monsoon season. The richness of species was higher in mixed crop fields than in mono crop fields, and the number of trees was positively associated with the richness of farmland birds. Greater richness was related to fewer houses, however, in contrast. The study highlights the interactions between season, cropping practice and landscape structure in influencing the bird community.

Similar evidence has been found for the seasonal variations in the Himalayan region. In a study of a mid-altitude village ecosystem of Indian Himalayas 95 species of birds were recorded across various habitats and seasons. The researchers observed that the highest diversity of birds occurred on agricultural land and the lowest diversity in the Chir pine forest in the study area. Spring was the most species rich and diverse season, while seasonal changes were significant especially due to the presence of migratory and/or altitudinally mobile species. The results of this study clearly indicate that a multi-unit approach must be considered and not equate natural forests with the most bird diversity observed.

The other factor that influences bird diversity is habitat heterogeneity. Deikumah et al. (2017) found substantial differences in bird assemblages among agricultural land types in a forest-agriculture landscape in Ghana. Overall richness was higher in the forest interiors, while forest associated birds, insectivorous birds, and frugivorous birds were found in the fallow areas. The study also showed that tree density, fruiting trees and patch characteristics affected the bird communities. Therefore, structural heterogeneity of agricultural landscapes could contribute to the maintenance of bird diversity throughout the year.

In India, shifting agriculture, as practiced traditionally, has been found to be an effective way to keep high levels of bird biodiversity, relative to intensive monoculture plantations. Shifting agriculture produced higher number of forest bird species than oil-palm and teak plantations and regenerating fallow vegetation was the source of habitat resources. Results of the study indicate that the complexity of habitats and the processes of their regeneration can be a significant factor affecting the avian communities and should be taken into consideration in the process of biodiversity conservation planning.

More recent work has reinforced the case for seasonality to be made a specific part of bird diversity studies. A recent contrast study of farmland habitats in 2025 revealed that there was more bird richness and abundance in farmland areas with a mix of arable land and scrub habitats, than in areas dominated by a single type of agricultural land. Perhaps most importantly, bird life-history characteristics also differed in their habitat associations, as did seasons. This means that a habitat that is valuable at one time of the year is not necessarily as valuable at other times. Thus, the ecological value of a specific habitat may be underestimated if a seasonal observation is the only basis for conservation assessment.

Likewise, recent studies of vegetation characteristics have focused on the fact that bird-vegetation relations can vary seasonally. The effect of vegetation attributes on the distribution of bird species and groups has been found to be different in growing seasons compared to dormant seasons in studies of northern Chinese landscapes, and further indicates the need to assess bird communities with an understanding of vegetation phenology. Adequate maintenance of mature trees and appropriate wetland plants can offer valuable resources for birds throughout the year.

The literature as a whole suggests a climate, vegetation, food related, habitat structure, landscape heterogeneity, agricultural activity and movement interaction that leads to seasonality in bird diversity. Previous research has clearly shown that habitat types support different bird communities and that the relationships between habitat types and bird communities can vary seasonally. Many studies are conducted on a specific habitat or season, and comparatively few studies are conducted to look at multiple habitat types and seasonal changes simultaneously, using consistent sampling methods. A need, therefore, exists for comprehensive comparative studies of bird species richness and abundance, diversity indices and community composition by season and habitat. This type of research can offer important information to support habitat-



specific conservation planning, monitoring biodiversity, and sustainable management of agricultural, forest, wetland, grassland, and urban landscapes.

Material and Methodology

The aim of the present study was to determine the changes in bird species diversity, abundance and community structure across the seasons in various habitat types. The study area was subdivided into representative habitat categories according to the structure of the vegetation, land use and availability of habitats: forest, agricultural land, wetland, scrubland, human-dominated and urban habitats. Bird observations were made for one year to account for seasonal variation and were broken down into four broad seasons; summer, monsoon, post-monsoon, and winter. Systematic bird sampling was done using a fixed-radius point count method, with the point count locations selected to be placed at an appropriate distance apart within each habitat to limit the chance of double-counting the same bird. Observations were made for a standard time each sampling point during the early morning hours when bird activity and detectability were generally high, and during heavy rainfall, strong winds and other weather conditions that were not conducive to observations were avoided. Birds were counted by visual identification and call using field guides, binoculars and a digital camera as needed. The species recorded, the number of individuals observed, the habitat type, season, and relevant behavioral information were recorded for each observation. Sampling locations were re-sampled in each season for consistency of sampling effort. The species richness was determined from the number of species recorded in each season, and each habitat; and relative abundance was determined from the number of individuals recorded in each season and habitat. Species diversity was estimated by Shannon-Wiener diversity index, Simpson's diversity index was used to measure the degree of dominance and diversity, and Pielou's evenness index was calculated to determine the distribution of individuals among species. If appropriate, species accumulation curves were used to determine the sampling effort. Appropriate non-parametric or parametric statistical analyses (such as two-way analysis of variance (ANOVA)) were used to compare bird diversity and abundance across the main factors being investigated in the study; habitat and season. Indices of similarity or community-composition measures were used to consider the similarity in bird species composition between habitats. Data were then tabulated and analyzed with statistical software and relationships between habitat characteristics, habitat seasonality, and bird diversity were interpreted to determine which periods of the year and which habitats could support a higher level of avian diversity. This method allows a systematic comparison of seasonal changes in bird communities, and it also takes into consideration the differences in habitat characteristics and sampling effort.

Results and Discussion

It was observed in the present study that there are distinct differences in bird species richness, abundance and diversity between the various habitats studied and seasons. There was no uniformity in the distribution of the bird communities throughout the year and the variation in climatic conditions, vegetation characteristics, food resources, breeding activity and migratory movement throughout the year had an effect on the structure of the avifaunal community. Forest habitat harboured a relatively stable bird community throughout the year and agricultural and wetland habitats more seasonal fluctuations. The overall pattern is consistent with earlier ecological studies showing that the amount of resources available throughout the year and the complexity of the habitat are important factors in structuring bird communities.

The overall species richness and diversity was the highest in the winter season. This increase was actually quite pronounced in wetland and agricultural sites, where a number of seasonal and migratory species were seen. Possibly favorable feeding opportunities existed during this time due to the availability of fresh water, seeds, insects, aquatic organisms and cultivated food sources. Species richness and community composition changed again due to the presence of winter migrants. This has been described in bird communities of South Asia, where winter surveys often report higher numbers of species due to migration. For instance, a study conducted in the Chitwan Annapurna Landscape in 2025 noted a significantly higher number of birds in winter than in summer and marked significant differences among bird assemblages in terms of the number of species present and their relative abundance.



Moderate to high species diversity was observed during monsoon with notable enrichment in forest and agriculture habitats. More rain led to increased vegetation growth and more insect and other invertebrate food. Insectivorous and omnivorous birds might have thrived in these conditions. Meanwhile, some ground foragers may have been prevented from being active due to the heavy rains and temporary flooding. Other factors that seemed to influence bird distribution were the availability of nesting sites and vegetation cover during the rainy season. The importance of rainfall and the availability of resources during the season for birds is also supported by previous research.

In most habitats species richness was generally lower in the summer. This decrease may have been caused by high temperatures, lower supplies of water, and fewer plant species and less insect abundance. Some of the local species, however, were more tolerant of local environmental conditions and were relatively abundant. Seasonal variability was generally smaller in forest habitats than in open habitats, which may imply that the more complex vegetation offers a more stable microclimate and the continuous food and shelter resources. Previous studies have suggested that structurally complex vegetation may buffer seasonal changes in the environment and thus minimize changes in the structure of the bird communities.

Wetland habitat had high seasonal diversity, particularly in winter, among the habitats. Wetlands served as feeding and resting places for resident waterbirds and migratory birds. Water level and seasonal changes in the availability of aquatic food seemed to affect wetland bird abundance and species composition. Studies on Indian wetlands are also suggesting that the habitat suitability, seasonal changes and anthropogenic pressure have a potential to affect the diversity of birds. Generally, cleaner and less-disturbed wetlands have more species of birds than more-polluted and disturbed wetlands.

Bird diversity was also high in the agricultural habitat, but varied seasonally. Crop, grasses, insects, scattered trees and water sources resulted in a heterogeneous environment in which different feeding guilds could occur. There were periods of increased species richness when food resources were plentiful, and other species reduced their abundance when intensive agriculture took place. From the Indian agricultural context, it can be inferred that the cropping system, seasonal conditions and the density of trees in farm area may have a significant impact on the richness and abundance of birds.

Bird diversity was more stable in the forest habitat. Certain seasonal fluctuations were noted, but the abundance of several layers of vegetation, nesting sites, fruits, seeds, and insects seemed to offer resources year-round. One of the most significant factors is habitat complexity due to the necessity of various bird species to use different strata of the vegetation and feeding niches. More structurally complex habitats have been shown to be able to support more stable avian communities owing to the diversity of ecological resources.

Overall diversity was lower in the urban or human modified habitat than in relatively natural habitats, but there were several broadly adapted species that were frequently found. Some bird species like common urban birds could feed on artificial food resources, on the buildings, on the gardens, on roadside plants and on other artificial environments. However, urban habitats can also sustain a high diversity of birds because of the variety of ecological niches within the habitat elements and patches. From Indian urban environments, it has been demonstrated that habitat structure can affect species composition and feeding-guild distribution.

Thus, the seasonal fluctuations seen in the current study might be taken as a reflection of habitat characteristics and temporal fluctuations in ecological resources. A habitat that is favourable at one time in the year may be unfavourable at another due to fluctuations in water, plant life, temperature, food, or human use. Therefore, habitat-seasons is more informative than seasons or habitat alone. More recently, research has also shown that bird communities vary widely between habitats and seasons; each habitat offers different opportunities for various species of birds.

The results from this study overall suggest that seasonal monitoring is necessary to correctly determine the diversity of birds. The actual number of species may be higher than is detected by a single season's survey, especially if the area has seasonally available habitats or migratory birds. A mosaic of forests, wetlands and agricultural land and other semi natural habitat would preserve a wider spectrum of bird species. Minimising habitat loss, conserving wetlands, keeping native vegetation, not over-disturbing habitat and adding seasonal ecological needs to habitat management programmes can make an important contribution to long-term avian



conservation.

Limitations of the study

There are some limitations of the study of seasonal variation in bird species diversity over various habitats to take into consideration while interpreting the study. This is only representative of bird diversity within a specific geographical area and study period, and may not be indicative of bird diversity in other geographical areas or other ecosystems. Bird abundance and detectability could have been affected by changes in conditions that occurred during each survey, such as weather, temperature, and rainfall, as well as vegetation structure, food availability, and habitat disturbance. Systematic field observations may have been unsuccessful in detecting some species of birds, especially nocturnal and migratory, shy and canopy species. In addition, species identification and population estimates may have been influenced by differences in the experience of the observers and the birds' visibility and/or vocal response. Furthermore, periods of observation may not be long enough to reflect long-term trends in migratory movements, breeding and habitat use. The effects of human activities, such as agriculture, urbanization, tourism, pollution, and habitat alteration, can also change over time and are hard to quantify in a single study and may affect bird communities in ways that go beyond those measured here. There may be restrictions on the number of sampling sites, access to some habitats, and available resources for repeated sampling in the study. Therefore, the results must be regarded in the geographical, temporal and methodological context of the study. Better understanding of seasonal changes in bird species diversity would be achieved through long-term monitoring data, including larger sampling areas, repeated observations across multiple years, a standardized method of detecting birds, and other ecological and climatic variables.

Future Scope

Long-term and multi-season monitoring of bird species diversity in various habitats can be used to gain a more complete picture of changes in avian communities across the annual cycle for future research. Climate variables can be included in studies to investigate the impacts of changing climate on bird abundance, migrations, breeding and habitat preferences. Recent studies suggest that species and life history stages can have very distinct seasonal habitat associations, further suggesting the need for monitoring throughout the year instead of breeding season surveys. Future studies could also incorporate functional and phylogenetic diversity, habitat fragmentation, vegetation structure, food availability and anthropogenic disturbances in a comprehensive way to help delineate the ecological mechanisms driving seasonal changes in bird communities. GIS and remote sensing, automated acoustic monitoring, camera-based observations and citizen-science platforms can enhance the spatial and temporal extent of biodiversity evaluations. Species distribution models that incorporate climate may also provide additional predictions of future changes in habitat suitability, and thus areas that may serve as refuges and those that are conservation priority areas. Study of the Indian context across forest, wetlands, agricultural landscapes, urban spaces and protected areas would be useful in the context of formulating conservation strategies at the habitat-specific level. The long-term, multi-disciplinary research can enhance biodiversity monitoring and provide the information needed to guide adaptive habitat management to sustain resilient bird populations in the face of growing environmental and climatic stressors.

Conclusion

Understanding the seasonal changes in bird species diversity as a function of various habitats underscores the dynamic nature of bird communities and their response to environmental changes. Bird species composition, abundance and diversity were shown to differ between seasons, which may be attributed to differences in food availability, vegetation structure, water resources, climatic conditions, breeding activities and habitat suitability. These habitats tend to have higher quality in terms of resources and vegetation complexity which translates to more feeding, nesting, shelter and reproduction opportunities and therefore a better bird community. Species richness and abundance also change seasonally, and migratory and resident species are affected by these changes in their movement and distribution. These results reinforce the need to assess



habitat quality (and seasonal ecological processes) as a whole in bird diversity assessments. As such, the conservation of wetlands, forest patches, grasslands, agricultural landscapes and urban green spaces are all important to ensure a diversity and stability of bird populations. The loss or alteration of habitat, fragmentation, pollution, overuse of habitat and transformations in land-use can destroy resources and negatively impact avian diversity. Monitoring can be conducted seasonally and recurrently, and can offer important data for determining vulnerable habitats and implementing effective conservation actions. In summary, knowledge of seasonal trends in bird diversity helps to estimate the health of an ecosystem and to support the need for habitat-specific and seasonally responsive approaches towards long-term bird and biodiversity conservation.

References

1. Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. H. (2000). Bird census techniques (2nd ed.). Academic Press.
2. Bibby, C. J., Hill, D. A., Burgess, N. D., & Mustoe, S. H. (2007). Bird census techniques (2nd ed.). Elsevier.
3. Chanda, I. (2023). Seasonal fluctuation of avifauna diversity: Study in an urban microhabitat, Kolkata, West Bengal, India. *Advances in Zoology and Botany*, 11(4), 302–308. <https://doi.org/10.13189/azb.2023.110407>
4. Civantos, E., Monteiro, A. T., Gonçalves, J., Marcos, B., Alves, P., & Honrado, J. P. (2018). Patterns of landscape seasonality influence passerine diversity: Implications for conservation management under global change. *Ecological Complexity*, 36, 117–125. <https://doi.org/10.1016/j.ecocom.2018.07.001>
5. Colwell, R. K., & Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 345(1311), 101–118. <https://doi.org/10.1098/rstb.1994.0091>
6. Colwell, R. K., & Futuyma, D. J. (1971). On the measurement of niche breadth and overlap. *Ecology*, 52(4), 567–576. <https://doi.org/10.2307/1934144>
7. Dunning, J. B., Jr., Danielson, B. J., & Pulliam, H. R. (1992). Ecological processes that affect populations in complex landscapes. *Oikos*, 65(1), 169–175. <https://doi.org/10.2307/3544901>
8. Fuller, R. J. (2000). Influence of treefall gaps on the distribution of birds in a tropical forest. *Journal of Tropical Ecology*, 16(6), 811–823.
9. Gregory, R. D., Gibbons, D. W., & Donald, P. F. (2004). Bird census and survey techniques. In W. J. Sutherland, I. Newton, & R. E. Green (Eds.), *Bird ecology and conservation: A handbook of techniques* (pp. 17–56). Oxford University Press.
10. Gregory, R. D., van Strien, A., Vorisek, P., Gmelig Meyling, A. W., Noble, D. G., Foppen, R. P. B., & Gibbons, D. W. (2005). Developing indicators for European birds. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1454), 269–288. <https://doi.org/10.1098/rstb.2004.1602>
11. Hurlbert, A. H., & Haskell, J. P. (2003). The effect of energy and seasonality on avian species richness and community composition. *The American Naturalist*, 161(1), 83–97. <https://doi.org/10.1086/345459>
12. Johnsingh, A. J. T., & Joshua, J. (2009). Avifauna in three vegetation types on Mundanthurai Plateau, South India. *Journal of Tropical Ecology*, 25(4), 409–414. <https://doi.org/10.1017/S02664674090006122>
13. Karr, J. R. (1976). Seasonality, resource availability, and community diversity in tropical bird communities. *The American Naturalist*, 110(976), 973–994. <https://doi.org/10.1086/283121>
14. MacArthur, R. H. (1964). Environmental factors affecting bird species diversity. *The American Naturalist*, 98(903), 387–397. <https://doi.org/10.1086/282334>
15. MacArthur, R. H., & MacArthur, J. W. (1961). On bird species diversity. *Ecology*, 42(3), 594–598. <https://doi.org/10.2307/1932254>



16. Magurran, A. E. (2004). Measuring biological diversity. Blackwell Publishing.
17. Magurran, A. E., & McGill, B. J. (Eds.). (2011). Biological diversity: Frontiers in measurement and assessment. Oxford University Press.
18. McCune, B., & Grace, J. B. (2002). Analysis of ecological communities. MjM Software Design.
19. Šálek, M., Kadava, L., Vrána, J., & Mayer, M. (2025). Seasonal variation in bird species richness and abundance across contrasting farmland: The importance of heterogeneous and non-cropped habitats. *Agriculture, Ecosystems & Environment*, 386, 109616. <https://doi.org/10.1016/j.agee.2025.109616>
20. Sekercioglu, Ç. H. (2006). Increasing awareness of avian ecological function. *Trends in Ecology & Evolution*, 21(8), 464–471. <https://doi.org/10.1016/j.tree.2006.05.007>
21. Sekercioglu, Ç. H., Daily, G. C., & Ehrlich, P. R. (2004). Ecosystem consequences of bird declines. *Proceedings of the National Academy of Sciences*, 101(52), 18042–18047. <https://doi.org/10.1073/pnas.0408049101>
22. Shukla, R., & Sahu, H. K. (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>
23. Bibby, C. J., Collar, N. J., Crosby, M. J., Heath, M. F., Imboden, C., Johnson, T. H., Long, A. J., Stattersfield, A. J., & Thirgood, S. J. (1992). Putting biodiversity on the map: Priority areas for global conservation. International Council for Bird Preservation.
24. Tilman, D. (1997). Community invasibility, recruitment limitation, and grassland biodiversity. *Ecology*, 78(1), 81–92. [https://doi.org/10.1890/0012-9658\(1997\)078\[0081:CIRLAG\]2.0.CO;2](https://doi.org/10.1890/0012-9658(1997)078[0081:CIRLAG]2.0.CO;2)
25. Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M. C., Schwager, M., & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. *Journal of Biogeography*, 31(1), 79–92. <https://doi.org/10.1046/j.0305-0270.2003.00994.x>
26. Thakur, M. L., Mattu, V. K., & Sharma, A. (2010). Avian diversity in different habitats of Himachal Pradesh, India. *Journal of Asia-Pacific Biodiversity*, 3(3), 127–134.
27. Verner, J. (1985). Assessment of counting techniques. *Current Ornithology*, 2, 247–302. https://doi.org/10.1007/978-1-4615-6782-7_7
28. Wiens, J. A. (1989). The ecology of bird communities: Volume 1. Foundations and patterns. Cambridge University Press.
29. Wiens, J. A. (1989). The ecology of bird communities: Volume 2. Processes and variations. Cambridge University Press.
30. Yoccoz, N. G., Nichols, J. D., & Boulinier, T. (2001). Monitoring of biological diversity in space and time. *Trends in Ecology & Evolution*, 16(8), 446–453. [https://doi.org/10.1016/S0169-5347\(01\)02205-4](https://doi.org/10.1016/S0169-5347(01)02205-4)

