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Original Article

Patterns of Bird Diversity Across Forest Habitats in a Tropical Conservation Forest, University of Phayao, Northern Thailand

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Abstract:
Tropical forest landscapes are experiencing increasing pressure from urban expansion, resulting in the loss and fragmentation of wildlife habitats. Birds are widely recognized as effective ecological indicators because their diversity and distribution respond rapidly to environmental changes and habitat structure. However, biodiversity information from small conservation forests embedded within developing landscapes remains limited, particularly in Southeast Asia. This study examined patterns of bird diversity across forest and wetland habitats within a tropical university conservation forest in Northern Thailand. Bird surveys were conducted using line transect methods across three habitat types, including dry dipterocarp forest, mixed deciduous forest, and reservoir-associated wetlands. A total of 57 bird species belonging to 30 families were recorded, comprising resident, migratory, and partially migratory species. Species diversity varied among habitats, with the highest Shannon diversity index observed in wetland-associated forest areas. Bird occurrence showed clear seasonal patterns and was influenced by environmental factors, particularly light intensity and rainfall, which affected bird activity and detectability. The presence of heterogeneous habitats, including forest vegetation and aquatic environments, contributed significantly to supporting diverse bird communities within the conservation area. Our findings highlight the ecological importance of small conservation forests within institutional landscapes as refugia for avian biodiversity. These results provide baseline information for biodiversity conservation planning and emphasize the role of habitat heterogeneity in maintaining bird diversity in rapidly changing tropical environments.
Keywords: Bird diversity, Conservation Forest, University of Phayao, Northern Thailand.

Introduction

Tropical forest ecosystems are among the most biologically diverse environments on Earth, supporting a large proportion of global terrestrial biodiversity. Birds play a crucial role in these ecosystems by contributing to key ecological functions, such as seed dispersal, pollination, and the regulation of insect populations. Because bird communities respond rapidly to changes in habitat structure, resource availability, and environmental conditions, they are widely recognized as effective ecological indicators of ecosystem health and biodiversity status. Therefore, understanding patterns of bird diversity and distribution is essential for evaluating ecosystem integrity and guiding conservation strategies in tropical landscapes (Lim et al., 2025; Matuoka et al., 2020; Moore et al., 2008).

Habitat heterogeneity is one of the primary drivers of avian diversity. Landscapes that contain a mosaic of habitat types, such as forests, wetlands, and riparian zones, typically support more diverse bird communities due to the availability of varied food resources, nesting sites, and microhabitats. In tropical regions, forest–wetland interfaces are particularly important because they provide both terrestrial and aquatic

ecological resources that sustain a wide range of bird species. Several studies have demonstrated that the structural complexity of vegetation, canopy cover, and proximity to water bodies can strongly influence bird species richness and community composition (Barros et al., 2019; Cooper et al., 2020; O'Dea & Whittaker, 2006).

Bird diversity across forest habitats is influenced by a complex interplay of ecological factors, such as vegetation structure, resource availability, and microclimatic conditions. Forests provide varied niches that support a wide range of bird species, from canopy dwellers to ground foragers, each adapted to specific habitat features. The heterogeneity within forest ecosystems—such as differences in tree species composition, age classes, and the presence of understory vegetation—enhances habitat complexity, thereby promoting higher bird species richness and abundance. Additionally, forest fragmentation and human-induced disturbances can significantly alter bird community composition by affecting habitat connectivity and resource distribution. Understanding bird diversity patterns in forest habitats is crucial for biodiversity conservation and ecosystem management, as birds often serve as indicators of forest health and ecological integrity (Kang et al., 2015; Laube et al., 2007; Rurangwa et al., 2021).

Despite the ecological importance of habitat diversity, many tropical forest landscapes are increasingly affected by land-use changes, urban expansion, and infrastructure development. These processes often lead to habitat fragmentation and biodiversity loss. In rapidly developing regions, small forest patches and conservation areas embedded within human-dominated landscapes may play a critical role as refugia for biodiversity. University-based conservation forests, which are commonly preserved for research, education, and environmental protection, represent unique ecological landscapes in which relatively undisturbed habitats coexist with the surrounding urban or semi-urban environments. However, biodiversity information from such institutional conservation areas remains limited, particularly in Southeast Asia (Singh et al., 2021; Thammanu et al., 2020; Wolseley & Aguirre-Hudson, 1997).

Northern Thailand has a variety of forest ecosystems, including dry dipterocarp and mixed deciduous forests, which support diverse bird communities. Within this region, conservation forests associated with academic institutions may provide important habitats for both resident and migratory bird species. These areas often include heterogeneous habitat types, such as forest stands, wetlands, reservoirs, and riparian vegetation, creating suitable environments for a wide range of avian guilds. Nevertheless, systematic studies examining patterns of bird diversity across these habitat types are still scarce (Litteral & Shochat, 2017; Reid et al., 2014).

The University of Phayao conservation forest represents a tropical landscape composed of dry dipterocarp forest, mixed deciduous forest, and wetland habitats associated with reservoir systems. These habitat types provide opportunities to investigate how environmental heterogeneity influences bird communities in conservation forests embedded within developing landscapes. Understanding the diversity and distribution of bird species in such areas can provide important baseline information for biodiversity conservation and habitat management.

Therefore, the objectives of this study were as follows:(1) to assess bird species diversity in forest and wetland habitats within a tropical university conservation forest,(2) to compare bird community composition among different habitat types, and(3) to examine environmental factors influencing bird occurrence and distribution.

The findings of this study contribute to a better understanding of avian diversity patterns in heterogeneous tropical landscapes and highlight

the ecological importance of small conservation forests in maintaining biodiversity in rapidly changing environments.

2. Materials and Methods

2.1 Study Area

This study was conducted in the plant genetic conservation forest of the University of Phayao, located in Mae Ka Subdistrict, Mueang Phayao District, Northern Thailand. The university area covers approximately 9.16 Km^3, including forest reserve areas and public land. The study site included approximately 600 acres of conservation forest located near the Huai Tub Chang reservoir (Fig 1).

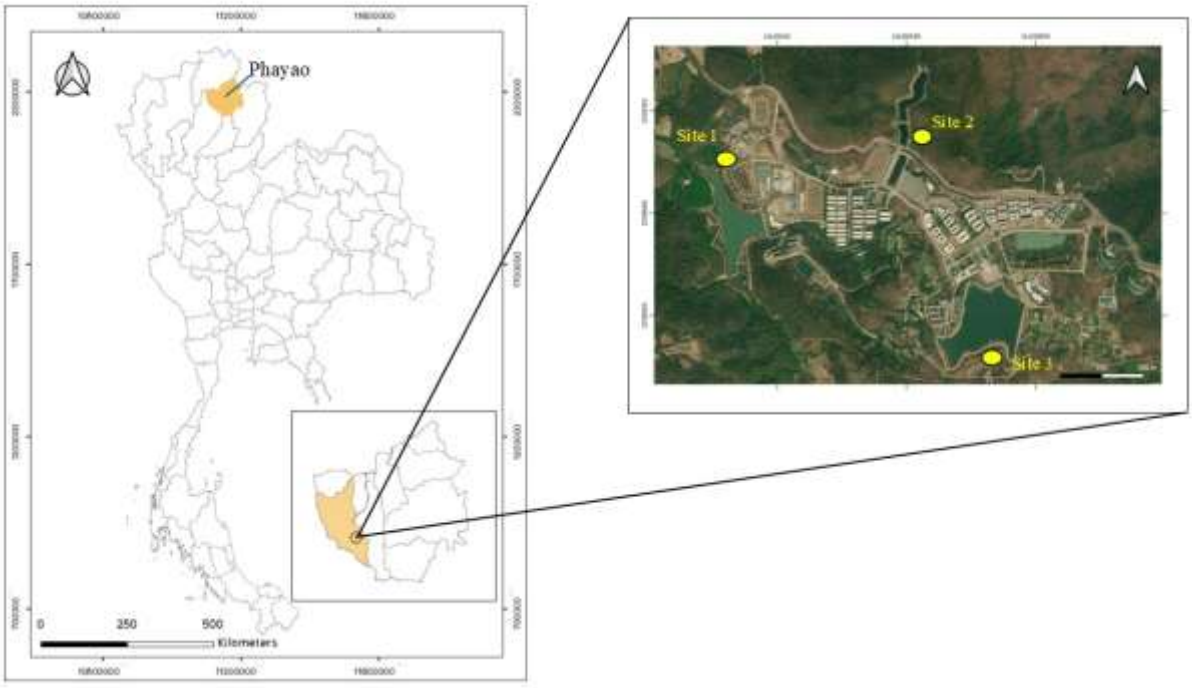

Fig. 1. Research area overview

The forest ecosystem primarily comprises dry dipterocarp, mixed deciduous, and dry evergreen forests, with adjacent wetland habitats associated with reservoirs and streams. These heterogeneous habitats provide diverse ecological niches that support a variety of bird species.

The region experiences a tropical monsoon climate, with a rainy season from May to October and a dry season from November to April. Seasonal variations in rainfall and environmental conditions influence vegetation structure and bird activity within the study area.

2.2 Bird Survey

Bird surveys were conducted using the line transect method, following the approach described by Henroid (1998). Nine transects were established within the study area, with three transects in each forest type. Each transect was 200 m in length, resulting in a total survey distance of 1,800 m.Field surveys were conducted between March 2014 and February 2015, covering both the rainy and dry seasons.Bird observations were conducted during peak bird activity periods.Morning: 06:00–09:00 h Afternoon: 15:00–18:00 h Each transect was surveyed for approximately 30 min. Observers walked slowly along the transect and recorded all birds detected visually or acoustically.For each observation, the following data were recorded: species identification,number of

individuals,feeding behavior ,vocalizations (if species identification was uncertain) Bird species were classified into feeding guilds, as follows: insectivores, frugivores, carnivores,nectarivores and granivores

2.3 Vegetation Survey

Vegetation surveys were conducted along the bird transects to assess habitat structure and plant species composition. Sampling plots were established at 50 m intervals along each transect (0, 50, 100, 150, and 200 m), resulting in five plots per transect and a total of 45 plots.

2.4 Bird community structure

Bird community structure was analyzed to quantify species richness

Species richness was calculated using Margalef's richness index. bird diversity was calculated using the Shannon–Wiener diversity index. Species evenness was calculated using Pielou's evenness index. Community similarity between habitats was calculated using the Sørensen similarity index, as follows:

Bird Density Estimation

Bird density was estimated using distance sampling analysis with the software Distance 6.0 to estimate detection probability and species density across habitats.

Bird density was estimated using the distance sampling approach based on line transect data. Perpendicular distances from the transect line to each detected bird or bird group were recorded during field surveys and used to model the detection function. Density estimation was conducted using Distance 6.0 software, which accounts for imperfect detectability and provides more reliable estimates of bird density across habitats.

The general formula used for density estimation was:

$$D = \frac{n}{2L\widehat{P_a}}$$

where

D= estimated bird density (individuals per unit area),

n= number of detected individuals,

L= total transect length, and

$\widehat{P_a}$= estimated probability of detection within the surveyed area.

When birds were detected in groups, density was adjusted using mean cluster size. Density estimates were calculated separately for each study site to compare bird abundance among habitat types.

3. Results

3.1 Bird Survey

A total of 57 bird species belonging to 30 families were recorded during the study period at the three study sites. Most of the species were resident birds, whereas several species were identified as migratory or partially migratory (Table 1).

Table 1. Bird species recorded in the study area, including scientific names, IUCN conservation status, and migratory status.

Common Name	Scientific Name	IUCN	Migratory Status
Yellow-legged Buttonquail	*Turnix tanki*	LC	R
Lineated Barbet	*Megalaima lineata*	LC	R
Common Kingfisher	*Alcedo atthis*	LC	R/WM
Stork-billed Kingfisher	*Pelargopsis capensis*	LC	R
Indian Roller	*Coracias benghalensis*	LC	R
Greater Coucal	*Centropus sinensis*	LC	R

Common Name	Scientific Name	IUCN	Migratory Status
Lesser Coucal	*Centropus bengalensis*	LC	R
Chestnut-winged Cuckoo	*Clamator coromandus*	LC	PM
Green-billed Malkoha	*Phaenicophaeus tristis*	LC	R
House Swift	*Apus affinis*	LC	R
Barn Swallow	*Hirundo rustica*	LC	WM
Cook's Swift	*Apus acuticauda*	LC	R
Dusky Crag Martin	*Ptyonoprogne concolor*	LC	R
Asian Barred Owlet	*Glaucidium cuculoides*	LC	R
Spotted Dove	*Spilopelia chinensis*	LC	R
Red Collared Dove	*Streptopelia tranquebarica*	LC	R
Black Kite	*Milvus migrans*	LC	WM
Brahminy Kite	*Haliastur indus*	LC	R
Peregrine Falcon	*Falco peregrinus*	LC	WM
Northern Goshawk	*Accipiter gentilis*	LC	WM
Sparrowhawk sp.	*Accipiter sp.*	NE	R/WM
Little Grebe	*Tachybaptus ruficollis*	LC	R
Chinese Pond Heron	*Ardeola bacchus*	LC	WM
Black Bittern	*Dupetor flavicollis*	LC	R
Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	R
Asian Openbill	*Anastomus oscitans*	LC	R
Golden-fronted Leafbird	*Chloropsis aurifrons*	LC	R
Black Drongo	*Dicrurus macrocercus*	LC	R
Greater Racket-tailed Drongo	*Dicrurus paradiseus*	LC	R
Ashy Woodswallow	*Artamus fuscus*	LC	R
Common Iora	*Aegithina tiphia*	LC	R
Eurasian Jay	*Garrulus glandarius*	LC	R/WM
Pin-striped Tit-Babbler	*Macronus gularis*	LC	R
Oriental Magpie-Robin	*Copsychus saularis*	LC	R
Brown Shrike	*Lanius cristatus*	LC	WM
Sooty-headed Bulbul	*Pycnonotus aurigaster*	LC	R
Zitting Cisticola	*Cisticola juncidis*	LC	R
Oriental White-eye	*Zosterops palpebrosus*	LC	R
Olive-backed Sunbird	*Cinnyris jugularis*	LC	R
Fire-breasted Flowerpecker	*Dicaeum ignipectum*	LC	R
Scaly-breasted Munia	*Lonchura punctulata*	LC	R
Chestnut Munia	*Lonchura atricapilla*	LC	R
Common Tailorbird	*Orthotomus sutorius*	LC	R
Dark-necked Tailorbird	*Orthotomus atrogularis*	LC	R
Brown Prinia	*Prinia polychroa*	LC	R
Puff-throated Babbler	*Pellorneum ruficeps*	LC	R
Yellow-bellied Warbler	*Abroscopus superciliaris*	LC	R

Common Name	Scientific Name	IUCN	Migratory Status
Grey-cheeked Warbler	*Seicercus poliogenys*	LC	WM
Asian Stubtail	*Urosphena squameiceps*	LC	WM
White Wagtail	*Motacilla alba*	LC	WM
Forest Wagtail	*Dendronanthus indicus*	LC	WM
Paddyfield Pipit	*Anthus rufulus*	LC	R
Bar-winged Flycatcher-shrike	*Hemipus picatus*	LC	R
Oriental Reed Warbler	*Acrocephalus orientalis*	LC	WM
Black-browed Reed Warbler	*Acrocephalus bistrigiceps*	LC	WM
White-breasted Waterhen	*Amaurornis phoenicurus*	LC	R

Note: LC = Least Concern; NE = Not Evaluated; R = Resident; WM = Winter migrant; PM = Passage migrant; R/WM = Resident and winter migrant.

Species richness varied among the study sites. Site 1, located near the reservoir area with a heterogeneous vegetation structure, recorded the highest number of bird species (44 species). Sites 2 and 3 recorded 34 and 30 species, respectively.

Several species were commonly observed at the study sites. In the reservoir-associated habitat (Site 1), dominant species included Asian pied starling (*Gracupica contra*), Zebra dove (*Geopelia striata*), and Plain prinia (*Prinia inornata*), which were frequently recorded during early morning surveys.

In the mixed forest habitat (Site 2), the commonly observed species included the black drongo (*Dicrurus macrocercus*), common tailorbird (*Orthotomus sutorius*), and streak-eared bulbul (*Pycnonotus blanfordi*).

In the dry dipterocarp forest habitat (Site 3), the dominant species included the Indochinese roller (*Coracias affinis*), red-whiskered bulbul (*Pycnonotus jocosus*), and greater coucal (*Centropus sinensis*).

Bird activity was highest during the morning survey period (06:00–09:00 h), when feeding and vocalization behaviors were frequently observed. Seasonal variations also influenced species occurrence, with higher species detections during the dry season than during the rainy season.

3.2 Vegetation Survey

Vegetation surveys identified several dominant plant species that characterized the forest structure within the study area. The forest ecosystem was primarily composed of dry dipterocarp and mixed deciduous forest vegetation.

The dominant tree species recorded in the study area, namely, *Shorea obtusa*, *Dipterocarpus tuberculatus*, *Xylia xylocarpa*, and *Lagerstroemia calyculata*, are typical species of dry dipterocarp forest ecosystems in northern Thailand.

The vegetation structure consisted of multiple layers, including canopy trees, understory shrubs, and herbaceous plants. An importance value index (IVI) analysis indicated that dipterocarp species were the most dominant components of the forest community.

Wetland areas near the reservoir were characterized by riparian vegetation, such as Bambusa species, Phragmites species, and various aquatic plants, which provided important feeding and nesting habitats for bird species.

3.3 Bird Community Analysis

Species richness and diversity indices varied among the three study sites. Site 1 exhibited the highest species richness ($S \approx 42$), followed by Site 2 ($S \approx 35$) and Site 3 ($S \approx 33$).

The Shannon diversity index (H′) showed a similar trend, with Site 1 having the highest diversity (H′ ≈ 2.45), followed by Site 2 (H′ ≈ 2.30) and Site 3 (H′ ≈ 2.10).

The evenness of bird occurrence varied among the three study sites. Site 1 exhibited the lowest evenness value (0.32), followed by Site 2 (0.41), while Site 3 showed the highest evenness (0.55). These results indicate that bird communities at Site 3 were more evenly distributed among species, whereas Site 1 was characterized by a higher dominance of a few species.

Despite having lower species richness and diversity, Site 3 exhibited higher evenness (as previously reported), suggesting a more balanced distribution of individuals among species, whereas Site 1 was dominated by a few highly abundant species.

The bird species recorded during the survey were classified into feeding guilds based on their primary feeding behavior. The bird community consisted of five main feeding groups:insectivores, frugivores, carnivores, nectarivore and sgranivores

Insectivorous birds were the most dominant group, representing the largest proportion of species recorded. Typical insectivorous species included plain prinia (*Prinia inornata*), common tailorbirds (*Orthotomus sutorius*), and black drongos (*Dicrurus macrocercus*), which were frequently observed foraging among shrubs and tree branches.

Frugivorous birds, such as streak-eared bulbul (*Pycnonotus blanfordi*) and red-whiskered bulbul (*Pycnonotus jocosus*), were commonly observed feeding on the fruits of forest plants.

Carnivorous species, including the greater coucal (*Centropus sinensis*), occasionally prey on small vertebrates and insects in dense vegetation.

Granivorous birds, such as the zebra dove (*Geopelia striata*), are frequently observed feeding on seeds in open areas and forest edges.

Nectarivorous birds, including sunbirds, occasionally feed on flowering plants.

The dominance of insectivorous birds suggests that the forest habitats in the study area support a rich insect community, providing abundant food resources for insectivorous bird species.

3.4 Bird Density Estimation

Bird density estimates were calculated using distance sampling analysis. The results indicated variations in bird density among the three study sites.

Bird density estimates varied among the three study sites, reflecting differences in habitat structure and resource availability. The highest bird density was recorded at Site 2, where a total of 878 individuals were observed, followed by Site 1 with 768 individuals, and Site 3 with 452 individuals

These results indicate that bird abundance was greatest in habitats associated with more open vegetation and wetland influence, while the lowest density was observed in the more structurally complex habitat at Site 3. The higher density at Site 2 may be related to the dominance of several highly abundant species, whereas Site 3 supported fewer individuals despite showing a more even distribution of species

The higher bird density observed near the reservoir suggests that habitat heterogeneity and water availability play important roles in supporting bird communities. The combination of forest vegetation and wetland habitats likely increases resource availability and habitat suitability for multiple bird species.

Discussion

In the present study, we recorded a total of 57 bird species belonging to 30 families, including 40 resident species, nine migratory species, six partially migratory species, one rarely observed migratory species, and one passage migrant.

These findings indicate that conservation forest and reservoir habitats within the University of Phayao support relatively high avian diversity compared with similar landscapes in northern Thailand. The diversity of species recorded reflects the complex ecological dynamics present in these habitats, which offer a variety of niches and resources essential for sustaining different bird populations.

The predominance of resident species (40 species) suggests that the conservation forest and reservoir provide stable and suitable conditions year-round, such as adequate food availability, nesting sites, and shelter. The presence of nine migratory species further highlights the importance of these habitats as critical stopover or wintering sites, facilitating seasonal movements and contributing to regional biodiversity connectivity. Partially migratory species, which exhibit flexible movement patterns depending on environmental conditions, further emphasize the adaptive capacity of the habitat to support birds with varying ecological requirements.

(Blount et al., 2021; Dolman & Sutherland, 1995; Guo et al., 2024)

Moreover, the detection of a rarely observed migratory species and a passage migrant underscores the conservation area's role as a refuge for less common or transient bird populations, which may be vulnerable to habitat loss elsewhere. This diversity in migratory behavior and species composition points to the ecological significance of the University of Phayao's habitats not only for local avifauna but also for broader migratory networks across northern Thailand and beyond.(Altamirano et al., 2020; Somveille et al., 2013; Yong et al., 2021)

Compared to similar landscapes in the region, the relatively high avian diversity observed suggests that these habitats maintain essential ecological functions, such as providing food resources, breeding grounds, and safe resting areas. These functions are crucial for maintaining bird populations and supporting their life cycles, including breeding, foraging, and migration. The findings also imply that habitat quality and conservation management practices at the University of Phayao contribute positively to sustaining avian biodiversity.(Kavana et al., 2024)

These results have important implications for conservation strategies in the region. Protecting and managing these forest and reservoir habitats can help preserve avian diversity, maintain ecological balance, and support migratory corridors vital for bird species survival. Additionally, the study highlights the potential for further research into habitat preferences, species interactions, and the effects of environmental changes such as climate variability and human disturbance on bird communities in this area. Such research can inform adaptive management approaches to enhance habitat resilience and biodiversity conservation.

(Brüniche-Olsen et al., 2021) Overall, the recorded avian diversity within the University of Phayao's conservation forest and reservoir habitats underscores their ecological value and reinforces the need for continued conservation efforts to safeguard these critical ecosystems.

The diversity of bird species observed in this study is comparable to that reported in previous studies conducted in forest ecosystems and mixed landscapes in Thailand. For example, earlier research reported 92 bird species belonging to 13 orders and 39 families in a similar ecological survey using transect methods. Another study recorded 177 bird species from 35 families, including both resident and migratory birds, demonstrating that tropical forest ecosystems in Thailand support high bird diversity.

The diversity indices calculated in this study also indicated moderate levels of bird diversity among the three habitats. The highest Shannon diversity index was recorded for the reservoir habitat (Site

1), suggesting that habitats associated with water bodies and heterogeneous vegetation structures may provide favorable conditions for bird communities.

Habitat structure and vegetation composition appear to play important roles in determining bird diversity and distribution. The study area is characterized by dry dipterocarp forest, mixed deciduous forest, and wetland-associated vegetation, which create diverse ecological niches for bird species.(Atikah et al., 2021; Sukri et al., 2011)

Several dominant tree species recorded during the vegetation survey, including Dipterocarpus tuberculatus, Shorea obtusa, and Xylia xylocarpa, are typical components of the dry dipterocarp forest ecosystems in northern Thailand. These tree species provide food resources, nesting sites, and perching locations for several bird species.Previous studies have suggested that plant diversity and vegetation structure strongly influence bird communities. Urban parks and forest fragments that contain a mixture of tree species capable of producing fruits, seeds, or nectar can support a wide range of bird species by providing essential food resources and breeding habitats(Atikah et al., 2021).(King & Rappole, 2001)

Environmental factors, such as rainfall correlations between bird abundance and environmental variables, indicated that bird occurrence tended to decrease during periods of heavy rainfall.(Zuckerberg et al., 2018)

Rainfall can reduce bird activity because heavy rain interferes with flight behavior and foraging activities. Similarly, low light intensity can affect birds that rely on visual cues for feeding and movement. These findings are consistent with previous ecological studies, which indicate that climatic factors play an important role in shaping bird distribution patterns.(De La Fuente et al., 2023)

Several studies have reported that the number of bird species observed in tropical ecosystems is often inversely related to rainfall. During periods of heavy rainfall, birds tend to reduce their foraging activity, resulting in fewer observations. Conversely, clear weather conditions generally increase bird activity and detectability.

Seasonal migration also contributes to variations in bird diversity in tropical ecosystems. During the cooler season, migratory birds from temperate and northern regions move southward to tropical areas with more favorable environmental conditions and food resources.(Thammanu et al., 2020)

This seasonal influx of migratory birds can increase the number of bird species observed in tropical habitats during certain periods of the year. Previous studies have reported that migratory birds begin arriving in tropical regions around September, resulting in increased species richness during the cooler months.(Coppack et al., 2003; Studds & Marra, 2007; Weiwei et al., 2012)

The results of this study highlight the ecological importance of conservation forests located within university landscapes. Although such areas are often relatively small compared with protected national parks, they can function as important refugia for wildlife biodiversity.

The presence of heterogeneous habitats, including forest vegetation, wetlands, and reservoir systems, can increase habitat complexity and support diverse bird communities. Similar findings have been reported in ecological studies, showing that habitat diversity and vegetation complexity are key factors influencing avian biodiversity.

These results suggest that maintaining forest structure, protecting water resources, and conserving vegetation diversity are essential strategies for supporting bird diversity in rapidly developing landscapes.

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Disclosure of AI usage

During the preparation of this work the author(s) used Paperpal in order to check language and search for citation. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published work.

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