Asian Journal of Conservation Biology, July 2026. Vol. 15 No. 1, pp. 75–82 AJCB: FP0283/87736
ISSN 2278-7666 ©TCRP Foundation 2026 https://doi.org/10.53562/ajcb.87736

Research Article

Avian Species Survey Across Urban Habitat Types in Malolos City, Bulacan, Philippines

Mary Ylane S. Lee*[,1,2], Marlyn Rose M. Sacdalan[1,2], Judith Clarisse J.Tan[1]

[1]*College of Science, Bulacan State University, Philippines*

[2]*Saint Louis University, Baguio, Philippines*

(Received: September 29, 2025; Revised: March 05, 2026; Accepted: June26, 2026)

ABSTRACT

This study examined bird diversity across four habitat types in Malolos City, Bulacan: agricultural zones, wetlands/ near coastal areas, urban parks/institutional sites, and remnant woodlots. Standardized point counts were conducted in 16 plots (four per habitat), and diversity was evaluated using species richness, Shannon–Wiener (H′), Pielou's evenness (J′), rarefaction, and species accumulation curves. A total of 32 species were recorded. Remnant woodlots supported the highest richness (26 species) and showed the steepest rarefaction trend, while agricultural areas supported moderate richness (10 species). Wetlands and urban parks had lower but comparable richness (8 species each). Overall diversity was moderate (H′ = 1.240), with high evenness (J′ = 0.894). Results emphasize the ecological importance of remnant woodlots as key biodiversity reservoirs and the complementary role of agricultural and wetland habitats. Conservation strategies should focus on protecting woodlots, enhancing farmland and riparian vegetation, and promoting habitat heterogeneity in urban planning to sustain avian communities.

Key words: bird diversity; urban ecology; remnant woodlots; agricultural habitats; wetlands; urban parks; Malolos City

INTRODUCTION

Major cities have been a hotbed of biodiversity focused research in recent decades, but there have been relatively few studies conducted on bird assemblages occurring in the urban landscapes. Thus, there is a gap in knowledge that still exists with regards to structure and composition of bird species assemblages in towns and cities. Understanding how avian communities are related to characteristics of urban habitats could be key to promote biodiversity conservation. Knowledge on the drivers of urban bird assemblages should be taken into consideration as rapid population growth is being experienced and undergoing intensive expansion of residential development. Therefore, design, planning and management for more biodiverse cities require understanding relationships between biodiversity and different types of urbanization (Camacho-Cervantes *et al*., 2018). Although transferring results from landscape-scale urban biodiversity research into policy may be challenging, biodiversity conservation and enhancement is still important in a rapidly urbanizing world.

The City of Malolos, Bulacan, located in Central Luzon is continuously undergoing infrastructure expansion and land conversion and habitat degradation and displacement of bird species are inevitable (WBCP, 2020). Notably, recent citizen science initiatives and birdwatching efforts have recorded important avian sightings within Malolos. The Wild Bird Club of the Philippines (WBCP) has documented over 20,000 migratory waterbirds across 41 species in coastal and wetland areas during the 2025 Asian Waterbird Census, including threatened species such as the Black-faced Spoonbill (*Platalea minor*) and Great Knot (*Calidris tenuirostris*). Additionally, the Pamarawan mudflat, a known hotspot in Malolos, has yielded 69 bird species on the global birding platform eBird, with records spanning multiple years and including both residents and passage migrants. Inland observations have also identified species commonly adapted to urban environments, such as the Philippine Coucal (*Centropus viridis*), Yellow-vented Bulbul (*Pycnonotus goiavier*), and Pied Fantail (*Rhipidura nigritorquis*), along with endemics like the Philippine Pygmy Woodpecker (*Yungipicus maculatus*).

Despite these initial records, there remains no comprehensive, site-specific ecological inventory of bird species in the City of Malolos. Most avian studies in Bulacan have focused on natural ecosystems such as dipterocarp forests (Basicolan *et al*., 1992), karst landscapes (Duco *et al*., 2020), and watershed areas (Pabio *et al*., 2020). Urban biodiversity, particularly avifauna associated with varied urban and peri-urban habitats, has received minimal scientific attention.

Although bird taxonomy is relatively stable and field identification resources are widely available (Kennedy *et al*., 2000; Eglington *et al*., 2012), the lack of localized ecological data limits conservation and monitoring efforts. Birds are valuable ecological indicators, capable of reflecting habitat quality, fragmentation, and anthropogenic pressures.

Given the expectation of continued urban growth in Malolos, this study aims to assess bird species diversity across selected habitat types in the city, including wetlands, agricultural zones, urban parks, and

*Corresponding Author's E-mail:maryylane.lee@bulsu.edu.ph

remnant woodlots. It seeks to examine the structure and composition of avian assemblages and relate them to habitat characteristics and landscape context. The findings will contribute baseline data for urban biodiversity monitoring, support local conservation planning, and inform policy development for sustainable urban development.

METHODS

Research Sites.

The surveyed sites represent a range of habitats across agricultural, wetland, urban, and residential landscapes in Malolos City, Bulacan (Table 1; Figure 1). The agricultural zone at 14.8608° N, 120.8411° E consists of seasonal crop fields dominated by rice (*Oryza sativa*) in the wet season and alternative crops such as corn (*Zea mays*) or vegetables in the dry season. Irrigation dikes are lined with scattered *Leucaena leucocephala* and *Gliricidia sepium*, and the area forms part of a larger contiguous farmland block extending over several hectares. This intensively cultivated landscape has minimal canopy cover, favoring ground- and edge-feeding birds such as egrets, doves, and sparrows (Haribon Foundation, 2015).

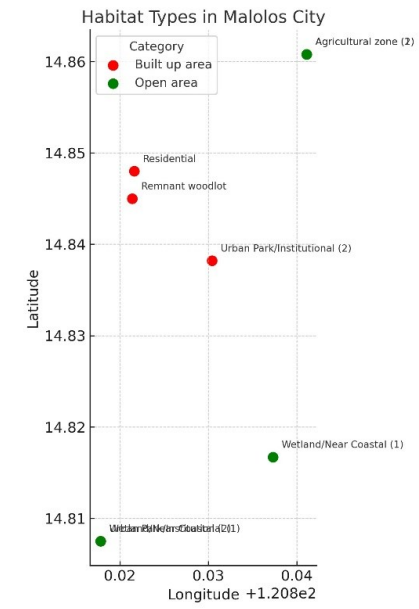
The wetland or near coastal site at 14.8167° N, 120.8373° E features emergent vegetation like reeds (*Phragmites karka*), sedges (*Cyperus* spp.), and aquatic plants including *Eichhornia crassipes* and *Nymphaea* spp., with seasonal mudflats and possible connections to tidal creeks. Covering roughly 1–5 hectares, it supports fishing, small-scale aquaculture, and serves as an important feeding habitat for herons and migratory waterbirds (DENR-BMB, 2019). Another wetland or near coastal site at 14°48'27" N, 120°49'4" E is characterized by brackish-water vegetation with mangrove associates (*Avicennia marina*, *Sonneratia alba*) interspersed with salt-tolerant grasses. This narrow coastal fringe with adjoining mudflats functions as a coastal protection zone and artisanal fishing area, and may also include salt pond operations, supporting both resident and migratory waterbirds (Primavera *et al*., 2012).

The urban park or institutional site at the same coordinates contains managed ornamental trees (*Delonix regia*, *Samanea saman*), shrubs, and turf grass (*Axonopus compressus*), generally occupying less than 5 hectares. This landscaped green space attracts urban-adapted species like the Eurasian Tree Sparrow and Yellow-vented Bulbul (Ong *et al*., 2002). The remnant woodlot at 14.8450° N, 120.8214° E includes mixed secondary-growth trees such as *Acacia auriculiformis*, *Mangifera indica*, and *Ficus septica* with patchy understory vegetation. Likely smaller than 2 hectares and fragmented by surrounding farmland and housing, it functions as a transitional habitat for woodland and edge species (Jensen *et al*., 2017). Finally, the residential area at 14.8480° N, 120.8216° E has sparse vegetation consisting mostly of ornamental and fruit trees (mango, banana) along with potted plants. This densely built-up environment with small gardens is primarily occupied by urban generalist birds, notably the Eurasian Tree Sparrow (*Passer montanus*) (Bautista *et al*., 2016).

Bird Survey. A bird survey was conducted to provide an ecological snapshot of urban bird assemblages in Malolos City. The survey spanned six months during the dry (summer) season in the Philippines, a period generally characterized by higher avian detectability and activity (Bibby *et al*., 2000).

The point count method was employed, with fixed-radius plots established using a GPS unit. Thirty point count stations with a 50 m radius were distributed across selected habitats—16 in open fields and 14 in built-up areas. Each plot was visited four times for 10 minutes, totaling 150 observation sessions. Observations were evenly distributed across four daily time periods: early morning (06:30–08:30), late morning (09:00–11:00), late afternoon (15:00–17:00), and early evening

Table 1. Habitat Types and its coordinates

	Habitat types	Category	Coordinates	Plots
1	Agricultural zone	Open area	14.8608° N, 120.8411° E	
2	Agriculture zone	Open area	14.5134° N 120.4952° E	
3	Wetland/ Near Coastal	Open area	14.8167° N, 120.8373° E,	
4	Wetland/ Near Coastal	Open area	14°48'27"N, 120°49'4"E	
5	Urban Park/ Institutional	Built up area	14.8566° N, 120.8146° E	
6	Urban Park/ Institutional	Built up area	14.8585° N, 120.8147° E	
7	Remnant woodlot with Agriculture zone and residential	Built up area	14.8450° N, 120.8214° E	
8	Residential;	Built up area	14.8465° N, 120.8174° E	

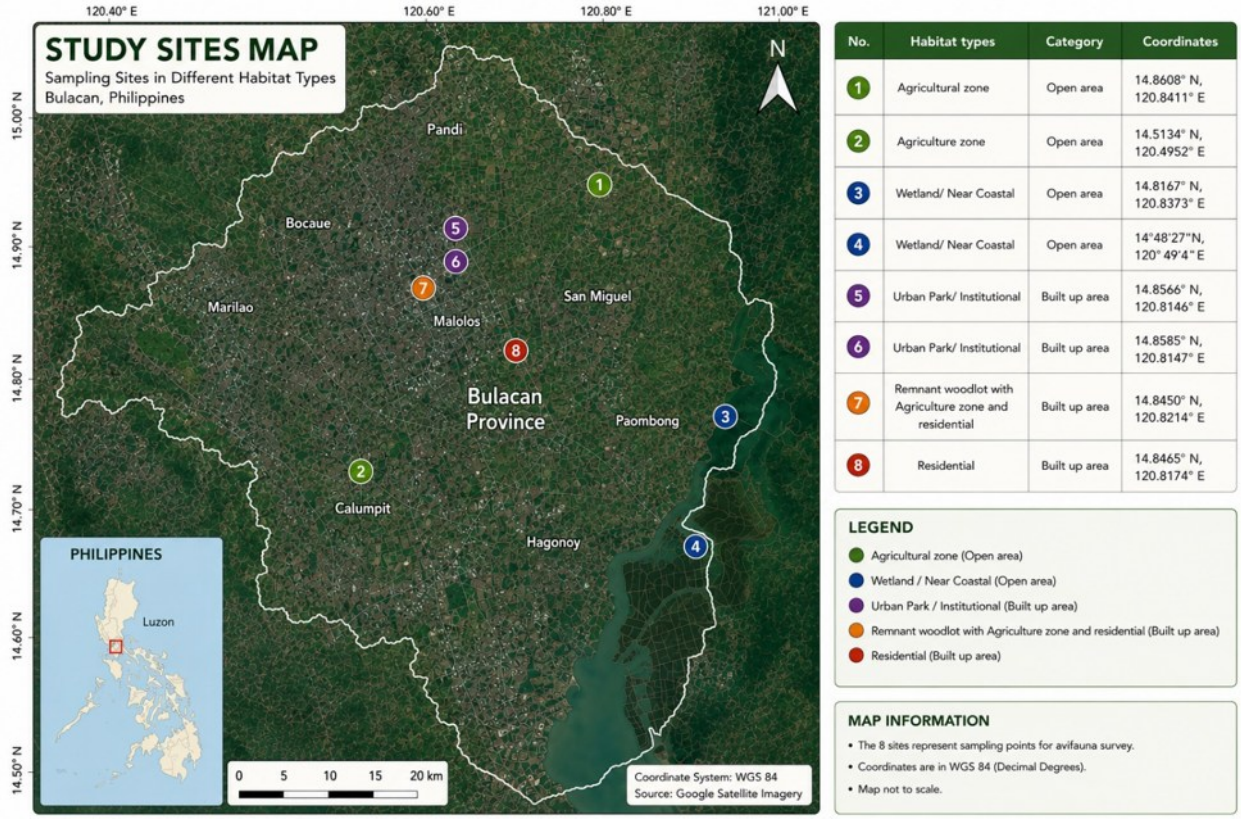


Figure 1. Map showing the eight avian sampling sites representing four habitat types in Bulacan, Philippines. The study sites include agricultural zones, wetland, urban park, and residential areas. Sampling locations are presented using the WGS 84 geographic coordinate system to illustrate the spatial distribution of the survey sites across the

(17:30–18:30). Surveys were suspended during adverse weather conditions such as rain or strong wind to avoid biases in bird detectability (Gatesire *et al*., 2014).

Birds were identified using 8 × 42 binoculars and regional field guides (Kennedy *et al*., 2000). Observed species were classified taxonomically (order and family) and by habitat preference based on their occurrence. For each observation, the following data were recorded: plot number, habitat type, arrival and departure times, species common and scientific names, number of individuals, weather conditions, vegetation cover, and disturbances (e.g., human activity or vehicular noise).

Birds observed outside plot boundaries were documented only if they had not been previously recorded within the study area. These incidental sightings contributed to a cumulative bird checklist for Malolos City but were excluded from statistical analyses. Unidentified species were photographed and documented with field notes for later identification by a bird expert.

Data Analysis.

Species diversity of bird populations was assessed using the Shannon–Wiener diversity index (Shannon, 1948), which accounts for both species richness and the relative abundance of individuals. Additionally, Pielou's Evenness index (Pielou, 1966) was applied to evaluate the uniformity in the distribution of individuals across species, providing insights into community structure and species dominance within the surveyed habitats.

RESULTS AND DISCUSSIONS

Species Composition and Taxonomic Diversity

A total of 32 species from multiple families are represented, including insectivores, carnivores, frugivores, granivores, and nectarivores. Families such as Ardeidae (herons and egrets), Columbidae (pigeons and doves), and Hirundinidae (swallows) are well-represented, indicating both wetland-associated and open-area species. The presence of resident, migratory, and endemic species suggests that the survey area supports a wide range of habitat types—from agricultural fields and wetlands to built-up and wooded zones.

Feeding Guild Patterns, Endemicity and Residency

Insectivores represented the largest proportion of recorded species (Figure 2A; Table 2), followed by carnivores and granivores, with fewer frugivores and a single nectarivore. This diverse avian community highlights the relationship between local habitats and resident populations,
stressing the significance of community involvement in conservation efforts. The dominance of insectivores suggests that the surveyed habitats, comprising agricultural fields, remnant woodlots, urban parks, and wetlands, support diverse invertebrate populations that provide ample foraging opportunities. Carnivores were primarily wading birds and terns associated with wetland and coastal zones, indicating the presence of aquatic prey and the continued ecological function of these habitats. Local people, particularly fishermen and

recreational users of wetland areas, are often directly impacted by the health and sustainability of these habitats.

Granivores were common in open areas and residential zones where seeds are abundant, particularly in sites with agricultural activity. These birds birds thrive in open spaces and residential areas rich in seeds, particularly near agricultural zones, where they contribute to seed dispersion and plant health.

The presence of frugivores (*Dicaeum australe*, *Pycnonotus goiavier*) and the nectarivore (*Cinnyris jugularis*) reflects the availability of fruit-bearing and flowering plants, particularly in mixed vegetation habitats and residential gardens. This denotes the success of fruit -bearing and flowering vegetation in mixed habitats and gardens, reflecting community engagement in urban gardening and sustainable practices.

These feeding patterns align with earlier findings that habitat heterogeneity fosters a more balanced distribution of feeding guilds, allowing for the coexistence of species with varying dietary requirements (Bibby *et al*., 2000; Sekercioglu *et al*., 2002). The presence of multiple trophic levels, ranging from insectivores to carnivores, also points to a relatively intact local food web.

The majority of recorded species are native residents, with significant numbers of migratory and endemic birds present (Figure 2.B). Migratory birds such as *Hirundo rustica*, *Lanius cristatus*, and *Chlidonias leucopterus* highlight the site's importance as a seasonal stopover in the East Asian–Australasian Flyway which also draws the attention of birdwatchers and ecotourists, thereby fostering local economic initiatives. . Additionally, the presence of Philippine endemics (*Collocalia marginata*, *Dicaeum australe*, *Yungipicus maculatus*, *Rhipidura nigritorquis*) enhances the conservation relevance as these birds are unique to the Philippines and may be particularly vulnerable to environmental changes, motivating local conservation groups and policymakers to act. While introduced species were observed, they made up a minor part of the overall community, indicating that, despite their universal presence in urban areas, natural and semi-natural environments remain predominant in the surveyed locales, which is crucial for maintaining both ecological integrity and cultural heritage. Their presence, while common in urban and peri-urban areas, can sometimes indicate habitat disturbance; however, the relatively low proportion suggests that natural and semi-natural habitats still dominate the surveyed areas.

Species Accumulation Patterns

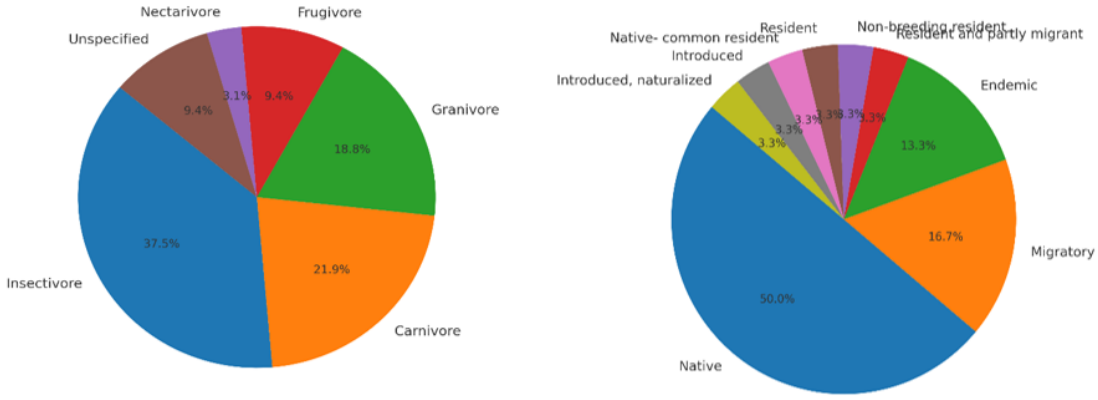
The species accumulation revealed clear differences in species contributions . The agricultural zone accounted for 10 species, while the addition of wetlands raised the cumulative richness to 12 species. Urban parks further increased the cumulative total to 17 species, reflecting the importance of semi-natural green spaces for sustaining bird diversity. Finally, the remnant woodlot contributed the greatest increase, bringing the total richness to 32 species (Figure 3).

This pattern underscores the significance of structurally complex habitats (Deng *et al*., 2015)., such as woodlots embedded within agricultural and residential landscapes, in supporting the highest levels of avian diversity. Open agricultural and wetland habitats supported fewer unique species, but they play complementary roles by providing feeding grounds for granivores, insectivores, and carnivorous waterbirds. Urban parks acted as biodiversity refuges for both resident and generalist species, while the remnant woodlot provided niches for endemic and forest-associated birds.

These results are consistent with ecological theory, which emphasizes that structurally diverse and heterogeneous landscapes support higher species richness due to greater habitat complexity and niche availability (Magurran, 2013; Tews *et al*., 2004). The combined evidence suggests that maintaining a mosaic of agricultural, wetland, urban green spaces, and remnant forest patches is crucial for sustaining bird communities in rapidly urbanizing areas like Malolos City.

Biodiversity Indices

Values of biodiversity indices indicate a moderate but well-balanced distribution of species richness across habitat types. The relatively high evenness value suggests that, although the remnant woodlot with agriculture and residential areas supported the greatest number of species (n = 26), the other habitats—agricultural zones, wetlands near coastal areas, and urban parks—also contributed substantially to overall diversity. This distribution pattern, when interpreted alongside the



(A) (B)

Figure 2. (A) Feeding guild composition of recorded bird species in the study area, showing dominance of insectivores, followed by carnivores and granivores, with smaller proportions of frugivores, nectarivores, and unspecified feeders. (B) Endemicity and residency status of recorded bird species, highlighting the predominance of native species, presence of migratory and endemic birds, and a small fraction of introduced species.

Table 2. Bird Species recorded.

	Family	Scientific name	Common name	Feeding guild	Endemicity
1	Acanthizidae	*Gerygone sulphurea*	Golden-bellied Gerygone	Insectivore	Native
2	Alcedinidae	*Halcyon smyrnensis*	White-throated kingfisher	Carnivore/ Insectivore	Resident and partly migrant
3	Apodidae	*Collocalia marginata*	Grey-rumped Swiftlet	Insectivore	Endemic
4		*Ardea alba*	Great Egret	Carnivore	Native
5		*Ardea intermedia*	Intermediate Egret	Carnivore	Non- breeding resident
6		*Ardea purpurea*	Purple Heron	Carnivore	Native
7		*Egretta garzetta*	Little Egret	Carnivore	Native
8		*Nycticorax nycticorax*	Black-crowned Night Heron	Carnivore	Native
9	Ardeidae	*Bubulcus coromandus*	Eastern Cattle Egret	Carnivore/ Insectivore	Migratory
10	Artamidae	*Artamus leucorynchus*	White-Breasted Wood-swallow	Insectivore	Native
11	Campephagidae	*Lalage nigra*	Pied Triller	Insectivore	Native
12	Columbdiae	*Columba livia*	Rock Dove	Granivore	Introduced, naturalized
13		*Streptopelia tranquebarica*	Red Collared Dove	Granivore	Native
14	Columbidae	*Geopelia striata*	Zebra Dove	Granivore	Native
15	Dicaeidae	*Dicaeum australe*	Red-keeled Flowerpecker	Frugivore	Endemic
16	Estrildidae	*Lonchura atricapilla*	Chestnut Munia	Granivore	Native
17		*Lonchura punctulata*	Scaly-breasted Munia	Granivore	Native
18	Hirundinidae	*Cecropis striolata*	Striated swallow	Insectivore	Migratory
19		*Hirundo rustica*	Barn Swallow	Insectivore	Migratory
20		*Hirundo tahitica*	Pacific Swallow	Insectivore	Native
21	Laniidae	*Lanius cristatus*	Brown Shrike	Insectivore	Migratory
22	Laridae	*Chlidonias hybrida*	Whiskered Tern	Carnivore	Native
23		*Chlidonias leucopterus*	White-winged tern	Insectivore	Native
24	Locustellidae	*Cinclorhampus timoriensis*	Tawny grassbird	Insectivore	Resident
25	Meropidae	*Merops philippinus*	Blue-tailed Bee-Eater	Insectivore	Native- common resident
26	Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbird	Nectarivore	Native
27	Passeridae	*Passer montanus*	Eurasian Tree Sparrow	Granivore	Introduced
28	Picidae	*Yungipicus maculatus*	Philippine Pygmy Woodpecker	Insectivore	Endemic
29	Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	Frugivore	Native
30	Rallidae	*Amauromis phoenicurus*	White-breasted waterhen	Omnivore	Native
31	Rhipiduridae	*Rhipidura nigritorquis*	Philippine Pied Fantail	Insectivore	Endemic
32	Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	Frugivore	Native

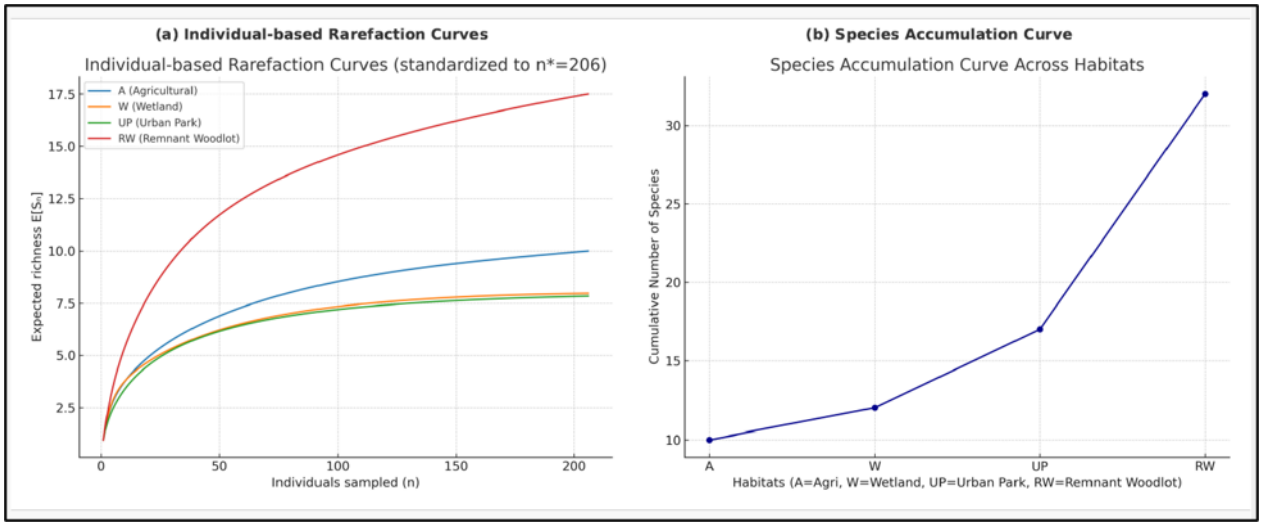


Figure 3. Diversity patterns of bird communities across habitats in Malolos City. (a) Individual-based rarefaction curves standardized to n* = 206 individuals. The Remnant Woodlot (RW) shows the highest expected species richness, followed by Agricultural (A), Wetland (W), and Urban Park (UP) habitats. (b) Species accumulation curve across habitats, showing cumulative species richness increases with the addition of each habitat type, with remnant woodlots contributing the greatest number of species.

species accumulation curves, indicates that no single habitat type monopolizes the bird assemblage, and that maintaining a mosaic of open areas, built-up green spaces, and semi-natural habitats is essential for sustaining the observed diversity (Hoffmann & Solymos, 2019).

Biodiversity indices not only illuminate the intricate relationships among species but also underscore the critical importance of human involvement in fostering these interconnected systems (Hoffmann & Solymos, 2019). The moderate yet balanced distribution of species richness among various habitat types is indicative of a healthy ecological framework, where each environment contributes uniquely to the overall ecosystem stability. The high evenness value, exemplified by the remnant woodlot adjacent to agricultural and residential areas—which boasts the largest number of species (n = 26)—highlights how human-altered landscapes can support diverse biological communities (Figure 4). Notably, agricultural zones, coastal wetlands, and urban parks also play indispensable roles in nurturing and sustaining biodiversity. These habitats, often overlooked, provide essential resources and refuges for various species, reinforcing the notion that urban planning and agricultural practices can be designed to accommodate ecological needs. The analysis of species accumulation curves further demonstrates that no single habitat type can claim dominance in supporting the bird population, indicating a need for a collaborative approach among stakeholders. Therefore, it is imperative for local communities, environmental organizations, and policymakers to work together to preserve a mosaic of open spaces, including developed green areas and semi-natural habitats. This collaborative effort will not only maintain but also enhance the observed diversity, benefiting both flora and fauna while enriching the human experience through improved ecological health and aesthetic values in the environment.

The analysis underscores the significance of various habitats for different avian feeding guilds. Wetland and coastal areas play a vital role in supporting carnivorous water birds and migratory species. Agricultural landscapes and open fields are beneficial for granivorous birds and some insectivores, while remnant woodlots and urban parks serve as essential habitats for endemic, forest-adapted insectivores and frugivores. The diverse array of feeding guilds, along with the presence of endemic and migratory species, emphasizes the importance of preserving habitat diversity in urbanizing environments.

CONCLUSION

Our findings show that bird diversity in Malolos City is strongly shaped by habitat type, with remnant woodlots sustaining the highest species richness, followed by agricultural areas, while wetlands/near coastal zones and urban parks supported comparatively fewer species. Rarefaction and accumulation curves confirm the importance of woodlots as biodiversity reservoirs, while diversity indices ($H' = 1.240$; $J' = 0.894$) indicate moderate diversity with relatively balanced species distribution across habitats. These results underscore the critical role of remnant woodlots in maintaining avian communities within an increasingly urbanized matrix.

From a management perspective, conservation strategies should prioritize the protection and rehabilitation of remnant woodlots, as they provide essential refuge for species richness. At the same time, agricultural and wetland habitats should be enhanced through agroforestry, riparian buffers, and integrated land-use practices to complement biodiversity support. Finally, urban planning must incorporate habitat heterogeneity, such as urban parks with native vegetation, to sustain bird communities and ecosystem services in rapidly developing landscapes.

REFERENCES

Anderle, M., & Tscharntke, T. (2023). Habitat heterogeneity promotes bird diversity in agricultural landscapes. *Agriculture, Ecosystems & Environment*, 356, 108201. https://doi.org/10.1016/j.agee.2023.108201

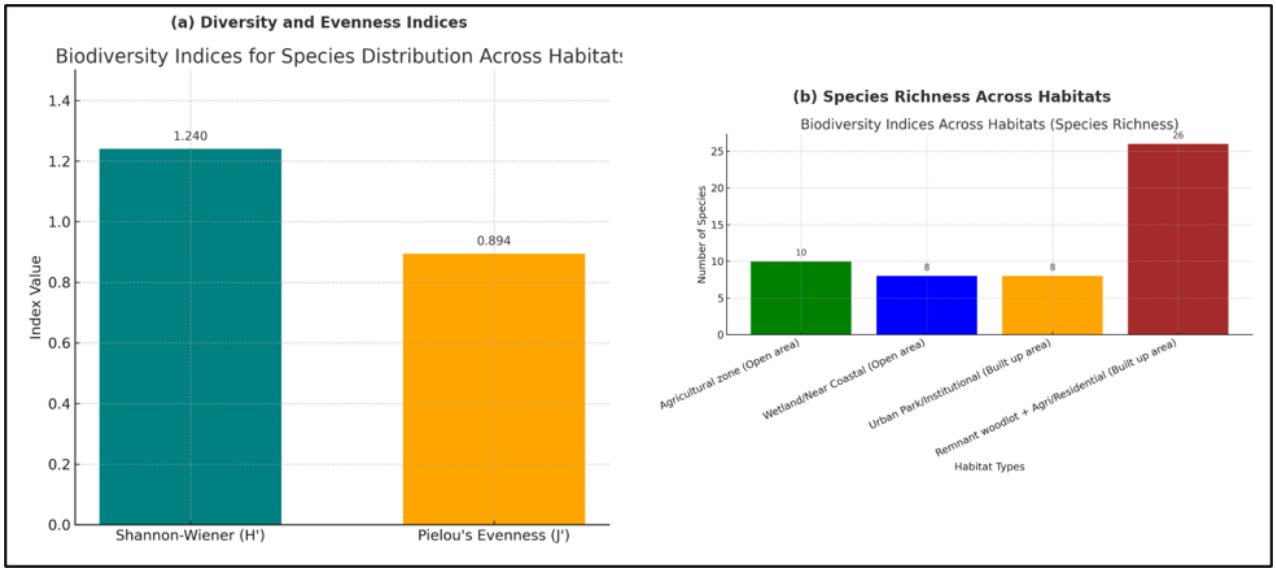


Figure 4. Biodiversity indices across habitats in Malolos City. (a) Shannon–Wiener diversity (H′ = 1.240) and Pielou's evenness (J′ = 0.894) indices indicate moderate diversity and relatively even species distribution. (b) Species richness per habitat type, showing highest richness in remnant woodlots with adjacent agricultural/residential areas (26 species), followed by agricultural zones (10 species), wetlands/near coastal (8 species), and urban park/ institutional sites (8 species).

Bautista, L. M., *et al*. (2016). Urban bird communities in Philippine cities. *Philippine Journal of Science*, 145(3), 237–250

Bibby, C. J., Burgess, N. D., Hill, D. A., & Mustoe, S. H. (2000). *Bird Census Techniques* (2nd ed.). Academic Press.

Callaghan, C. T., *et al*. (2018). Effects of local and landscape habitat attributes on bird biodiversity in urban greenspaces. *Ecology and Society*, 23(4), 40. https://doi.org/10.5751/ES-10428-230440

Callaghan, C. T., Gahbauer, M. A., Major, R. E., & Martin, P. A. (2019). Heterogeneous urban green areas are hotspots for bird diversity. *Landscape Ecology*, 34(5), 1231–1246. https://doi.org/10.1007/s10980-019-00848-0

Camacho-Cervantes, M., Schondube, J. E., Castillo, A., & MacGregor-Fors, I. (2018). How do urban green areas affect bird diversity? *Urban Ecosystems, 21*(1), 141–150. https://doi.org/10.1007/s11252-017-0709-8

Clarke, K. R., & Warwick, R. M. (2001). *Change in marine communities: An approach to statistical analysis and interpretation* (2nd ed.). PRIMER-E.

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

Deng, C., Liu, X., Chao, A., & Chiu, C. H. (2015). Applications of species accumulation curves in large -scale biodiversity assessment. *Ecology and Evolution*, 5(19), 4252–4265. https://doi.org/10.1002/ece3.1608

DENR-BMB. (2019). *Wetland conservation and management in the Philippines*. Department of Environment and Natural Resources – Biodiversity Management Bureau.

Fairbairn, A. J., Katholnigg, S., Leichtle, T., Merkens, L., Schroll, L., Weisser, W. W., & Meyer, S. T. (2025). NDVI and vegetation volume as predictors of urban bird diversity. *Scientific Reports*, 15, 96098. https://doi.org/10.1038/s41598-025-96098-0

Gatesire, T., Nsabimana, D., Nyiramana, A., Uwimana, A., & Seburanga, J. L. (2014). Bird species richness and abundance in relation to land use and vegetation structure in Rwanda. *The Scientific World Journal*, 2014, Article ID 157824. https://doi.org/10.1155/2014/157824

Gotelli, N. J., & Colwell, R. K. (2001). Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters, 4*(4), 379–391. https://doi.org/10.1046/j.1461-0248.2001.00230.

Gatesire, T., Nsabimana, D., Nyiramana, A., Uwimana, A., & Seburanga, J. L. (2014). Bird species richness and abundance in relation to land use and vegetation structure in Rwanda. *The Scientific World Journal*, 2014, Article ID 157824. https://doi.org/10.1155/2014/157824

Haribon Foundation. (2015). *Biodiversity and agricultural landscapes in the Philippines*.

Hoffmann, S. L., & Solymos, P. (2019). Optimizing sampling effort and information content of Shannon diversity. *Methods in Ecology and Evolution*, 10(2), 309–318. https://doi.org/10.1111/2041-210X.13110

Jensen, A. E., *et al*. (2017). Avian diversity in peri-urban woodlots. *Urban Ecosystems*, 20(5), 1065–1077.

Kennedy, R. S., Gonzales, P. C., Dickinson, E. C., Miranda Jr, H. C., & Fisher, T. H. (2000). *A Guide to the Birds of the Philippines*. Oxford University Press.

Koleff, P., Gaston, K. J., & Lennon, J. J. (2003). Measuring beta diversity for presence–absence data. *Journal of Animal Ecology, 72*(3), 367–382. https://doi.org/10.1046/j.1365-2656.2003.00710.x

Legendre, P., & Legendre, L. (2012). *Numerical ecology* (3rd ed.). Elsevier.

Lu, X., *et al*. (2024). Landscape patterns and bird richness: a global meta-analysis. *Landscape Ecology*, 39(10), 1205–1221. https://doi.org/10.1007/s10980-024-01933-w

Magurran, A. E. (2013). *Measuring biological diversity*. Wiley-Blackwell.

Ong, P. S., Afuang, L. E., & Rosell-Ambal, R. G. (Eds.). (2002). *Philippine biodiversity conservation priorities: A second iteration of the national biodiversity strategy and action*

Ong, P. S., *et al*. (2002). *Philippine biodiversity conservation priorities*. Department of Environment and Natural Resources.

Primavera, J. H., *et al*. (2012). The role of mangroves in coastal protection and biodiversity conservation. *Ocean & Coastal Management*, 80, 35–45.