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Planting Profiles' Impact on Bird Species Diversity in Taman Botani Negara, Shah Alam

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Abstract
The influence of planting profiles on avian diversity is poorly quantified in managed park landscapes. The study's objectives are to investigate the effects of vegetation structure, plant composition, and canopy complexity on bird species richness and diversity, besides their consequences for bird abundance, distribution patterns, and foraging guilds across selected zones of Taman Botani Negara Shah Alam (TBNSA). Vegetation profiling and standardized avifaunal point counts were applied, along with diversity indices and non-parametric statistics. The results revealed significant inter-zone differences ($H = 8.24$, $p < 0.05$); exhibiting canopy cover, vertical layering, and native plant proportion as strong predictors of diversity.

Keywords: Planting profile, bird species diversity, urban park.

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1.0 Introduction

Urban expansions in most tropical countries such as Malaysia, often lead to fragmentation of natural habitats, making the urban parks crucial refuges for wildlife, predominantly avian communities (Khiruddin et al., 2025). Birds are beneficial bioindicator of ecological integrity and habitat quality, due to their sensitivity to environmental and surrounding changes (García-Quintas et al., 2024). Understanding the influence of vegetation structure and composition on bird assemblages is thus essential in creating sustainable landscapes and managing urban biodiversity. Rapid urbanization has intensified the need for ecological evaluation of urban landscapes as it has particularly impacted avifauna, which are highly susceptible to ecological disturbances, often compelling many species to seek refuge and adapt to urban parks despite these environments not being their primary habitats (Cull et al., 2025). While general correlations between vegetation complexity and bird richness are well-established, there remains a research gap concerning species-specific and guild-specific preferences within structurally diverse tropical parks, which is currently underrepresented in ecological literature (Chiron et al., 2023) besides relatively few studies have explored the relationship between planting profiles and bird diversity in managed public landscapes such as TBNSA. Therefore, this study aims to examine the relationship between planting profile characteristics and bird species diversity across selected zones of TBNSA. Specifically, the objectives of this study are firstly to investigate how variations in vegetation structure, plant composition, and canopy complexity influence bird species richness and diversity indices; and secondly to determine the relationship between native versus ornamental plant compositions affect the bird abundance, distribution patterns, and foraging guilds. By providing empirical ecological evidence, this research contributes to improving biodiversity-sensitive landscape planning in Malaysia and supports broader global efforts to integrate ecological considerations into urban design and management.

2.0 Literature Review

Human activities and urban growth, and the decline in natural habitat and local species richness are undeniably correlated, making urban green spaces vital for biodiversity conservation nowadays (Aiman et al, 2022). The importance of urban green spaces for many bird species' survival is though undeniable (Cull et al., 2025), their efficiency in supporting their diversity is rather uneven as it is also profoundly influenced by factors like overall park design, habitat connectivity, and microclimatic conditions (Khiruddin et al., 2025). While larger-sized urban parks are normally claimed to better support high bird richness, landscape composition and vegetation's structural variety are essentially more significant in defining species diversity (Zhu et al., 2024). This therefore shaped the hypothesis that environmental heterogeneity collectively increases species diversity, especially within limited-size urban green spaces (Chiron et al., 2023), while still acknowledging that habitat and plant compositions are also major drivers (Zhu et al., 2024). In short, complex vegetative structures and diverse native plantings improved the functional quality of urban green spaces, making them more significant in supporting robust avian communities (Chiron et al., 2023; Khiruddin et al., 2025). Moreover, the incorporation of various vegetation types, such as trees, shrubs, and ground cover, forms a multi-layered habitat that accommodates a wider range of bird species with varying nesting and foraging requirements (Zhu et al., 2024). Hence, investigating the influence of various vegetation types, both native and exotic, within these urban parks is crucial in order to understand their impact on bird communities and perhaps in developing effective urban conservation strategies (Sulaiman et al., 2013).

3.0 Methodology

This study applied the mixed-methods ecological assessment, participating (i) vegetation structure profiling, (ii) standardized avifaunal surveys, (iii) geospatial mapping, and (iv) semi-structured interviews for expert validation, with the statistical approaches utilized for data interpretation.

3.1 Study Area and Zone Selection

Taman Botani Negara Shah Alam (TBNSA), located in Selangor, Malaysia, is recognized as a prominent urban park, forest reserve, and gazetted green area (Leeonis et al., 2024). It was designed to conserve diverse flora and fauna in the tropical climate of Malaysia, specifically Selangor (Khiruddin et al., 2025). TBNSA is ecologically relevant as a critical biodiversity hotspot within a rapidly urbanizing landscape (Zi et al., 2024), offering refuge and resources for numerous bird species (Bichi et al., 2024). The park is broadly zoned into thematic areas to showcase different planting profiles and offer wide-ranging ecological niches. These therefore, have made TBNSA an ideal site for studying the impact of vegetative heterogeneity on avian diversity, as these zones offer a unique opportunity to evaluate how specific planting profiles, ranging from manicured ornamental gardens and crop fields to a more naturalized landscape setting, influence avian species richness, abundance, and community composition (Wong et al., 2022). Four zones (Herbs Garden, Zingiberales Garden, Ornamental Garden, and Paddy Field) were selected for this study based on their distinct vegetation composition, vertical structure, and plant typology; a clear basis for comparative ecological analysis.

3.1 Sampling Design

Fig. 1: Location of the circular plots within the study area.
(Source: Google Earth / Author)

A stratified sampling design to include representative coverage of the diverse habitats within TBNSA was done, which involved defining the park into distinct strata based on initial assessments of vegetation type and density (Wilgenburg et al., 2024). Random plot selection was then conducted within each zone (Stafford et al., 2005). Geospatial data, including satellite imagery and existing botanical surveys, were used to outline these zones and the placement of survey plots (Khiruddin et al., 2025). Within each selected plot, a fixed circular sampling area with a 50m radius was established (Figure 1) (Latifi et al., 2023). This method accounts for variations in landscape parameters such as canopy cover and park configuration, which are known to significantly influence bird assemblages and diversity (Oropeza-Sánchez et al., 2024).

3.3 Vegetation Structure Analysis

3.3.1 Species Identification and Classification

Plant species within each sampling plot were identified to the lowest possible taxonomic level using standard field guides and botanical references (Waheed et al., 2024). The locations of these identified plant species were precisely georeferenced using GPS tools and subsequently mapped onto Google Earth to record their spatial distribution (Nowak et al., 2020). Subsequently, all identified species were classified based on their origin and growth form.

3.3.2 Vertical Structure Profiling

The vertical structure of vegetation within each plot was profiled through several quantitative metrics. Canopy height was recorded using direct observation-based assessment of vertical forest structure into distinct height classes, which are <2m, 2-5m, 5-10m, and >10m (Ferrara et al., 2023). Canopy cover was estimated using the line-intercept method, which quantifies the percentage of overhead coverage within each plot (Drezner & Drezner, 2021). Understory density was assessed using a 5-point visual scale, where each point represented a subjective assessment of density (1 = very sparse, 5 = very dense) across the understory layer (Ferrara et al., 2023). The number of distinct foliage layers, such as groundcover, shrub, and sub-canopy layers, was also recorded to characterize vertical complexity. All of these inventories were done by a Certified Arborist and Landscape Architect.

3.3.3 Spatial Referencing

The coordinates of each sampling plot were collected using smartphone-based Global Positioning System applications (Shaffril et al., 2021). The GPS data were then superimposed onto high-resolution satellite imagery obtained from Google Earth in order to enhance the interpretability of how varied planting profiles and habitat structures influence avian communities within TBNSA.

3.4 Avifaunal Survey

3.4.1 Point Count Method

Point count surveys were conducted within the defined 50m radius plots to assess bird occupancy and richness (Oropeza-Sánchez et al., 2024). A single visit was conducted for each sampling point within the month, primarily to capture a snapshot of avian activity, while the surveys were done between 8:00 AM to 11:00 AM (peak bird activity hours), to maximize detection and capture a representation of the plots' avian community (Latifi et al., 2023; Wilgenburg et al., 2024). Surveys were not conducted on days with adverse weather conditions such as rain or strong winds, as these factors may significantly reduce bird activity and detection rates (Oropeza-Sánchez et al., 2024).

3.4.2 Identification Tools

To ensure accuracy and provide regional verification, observations were cross-referenced with online avian databases like eBird, a recognized citizen science platform that provides data for broad-scale biodiversity patterns and species distributions. For acoustic identification of species, particularly those challenging to observe visually, sound recordings were processed and analyzed using BirdNET. Furthermore, digital cameras and binoculars were utilized to aid in visual identification.

3.5 Functional Guild Classification & Diversity Analysis

Each species recorded was categorized into specific functional guilds based on their primary dietary habits, which are insectivores, frugivores, granivores, nectarivores, and omnivores, to ensure consistency and ecological relevance in understanding resource partitioning (Bichi et al., 2024). Next, species richness was determined as the total number of bird species, while abundance was measured as the total number of individual birds for each species within the plots (Chiron et al., 2023). Further analyses, the Shannon–Wiener Diversity Index (H') was used to quantify species diversity, with both species richness and evenness being considered (Cull et al., 2025). Meanwhile, Simpson's Diversity Index (λ) was calculated to measure the probability that two individuals randomly selected from a sample will belong to different species, providing insight into community dominance in the four zones of TBNSA. Lastly, Pielou's Evenness (J') was figured to assess the relative abundance of different species, to know how evenly individuals are dispersed among the species in the four plots.

3.6 Statistical Analysis

The non-parametric Kruskal-Wallis H-test was applied to compare avian diversity metrics across the zones, as ecological count data often show abnormal distributional properties. Correlation analysis was then employed to assess the relationships between vegetation attributes, avian species richness, and abundance (Zhu et al., 2024).

3.7 Qualitative Interview

Semi-structured interviews were conducted with Mr. Syamsul Idris Saleh, a Conservation and Botanical Officer with 8 years of experience in managing the park's plant conservation works. This is to validate the data from field observations, including the plant and bird species found.

3.8 Mixed-Methods Integration

The quantitative ecological data - the avian diversity metrics (species richness, abundance, Shannon-Wiener, and Simpson's indices) and vegetation attributes were compared and systematically integrated with qualitative insights obtained from interviews with key TBNSA personnel. These diverse data sources offered an all-inclusive understanding of the complex interactions between TBNSA's planting profiles, vegetation management, and avian diversity.

4.0 Results and Discussion

Findings of the avifaunal survey and vegetation assessment across four planting profile zones in TBNSA are presented in five components as follows: (i) species richness and abundance, (ii) vegetation structure characteristics, (iii) diversity indices, (iv) functional guild composition, and (v) statistical analysis.

4.1 Species Richness and Abundance

The quantitative ecological data - the avian diversity metrics (species richness, abundance, Shannon-Wiener, and Simpson's indices) and vegetation attributes were compared and systematically integrated with qualitative insights obtained from interviews with key TBNSA personnel. These diverse data sources offered an all-inclusive understanding of the complex interactions between TBNSA's planting profiles, vegetation management, and avian diversity.

Table 1 Species richness and abundance matrix by zone

Species	Zone A	Zone B	Zone C	Zone D	Total Abundance
Acridotheres tristis	-	6	-	8	14
Aegithina tiphia	-	-	2	-	2
Ardea intermedia	-	-	-	3	3
Cridotheres javanicus	-	-	-	2	2
Dicaeum cruentatum	2	-	-	-	2
Dicaeum ignipectus	1	-	-	-	1
Dicaeum trigonostigma	1	-	-	-	1
Eurylaimus ochromalus	2	-	-	-	2
Gracula religiosa	4	2	-	-	6
Lanius cristasus	2	3	-	-	5
Lonchura maja	-	-	-	7	7
Oriolus chinensis	3	2	-	2	7
Orthotomus atrogularis	-	2	-	-	2
Orthotomus sutorius	-	-	2	-	2
Phylloscopus borealis	5	-	-	-	5
Picus puniceus	-	1	-	-	1
Poliolimnas cinereus	-	2	-	-	2
Pomatorhinus montanus	-	-	1	-	1
Pycnonotus plumosus	4	-	-	-	4
Pycnonotus simplex	-	-	2	-	2
Surniculus lugubris	-	-	1	-	1
Total Individual	24	18	8	22	72
Species Richness (S)	9	7	5	5	21

(Source: Author)

Zone A recorded the highest species richness with 9 species, followed by Zone B with 7 species, and then Zones C and D with 5 species each. Meanwhile, in terms of abundance, Zone A also led with 24 individuals. In contrast, Zone D exhibited high abundance (22 individuals) but low richness, dominated by a few open-field generalist species. These patterns strongly reflect the critical effect of habitat complexity and resource availability on avian communities. Kruskal-Wallis H test analyzing the findings in Table 4.1 produced a statistically noteworthy result with $H = 8.24$, $p < 0.05$, indicating that bird species richness and diversity among the four zones are not uniformly distributed. This means at least one of the zones supported a bird community composition significantly different from the others, which is discussed in section 4.2.

4.2 Vegetation Structure Characteristics

Vegetation profiling revealed clear differences in plant composition, canopy structure, and understory density across zones.

Table 2 Vegetation structural characteristics across zones

Vegetation Attribute	Zone A	Zone B	Zone C	Zone D
Dominant Species	*Cinnamomum iners* (Medang Teja)	*Zingiber officinale* (Halia Bara)	*Ehretia microphylla* (Fukien Tea Tree)	*Oryza sativa* L. (Paddy)
Average Canopy Height (m)	8	4	2	3
Canopy Cover (%)	60 (moderate-high)	56 (moderate)	20 (low)	10 (very low)
Vertical Stratification	Multi-layered	Dense understory and canopy	Sparse layers	Single-layer (Paddy)
Understory Density (%)	35	60	40	80
Native Plant Proportion (%)	90 (High)	65 (Moderate)	15 (Low - mostly ornamental)	10 (Low - crop)

(Source: Author)

Specifically, Zone A's multi-layered vertical stratification, high canopy cover, and high native plant proportion provide diverse ecological niches, sufficient nesting opportunities, varied foraging areas, and protection from predators, thereby supporting a broader range of bird species and higher abundance (Bichi et al., 2024). Conversely, Zone D's single-layer structure, low canopy cover, and low native plant proportion likely limit niche availability, favoring generalist species capable of thriving in less complex habitats (Aiman et al, 2022). Kruskal–Wallis H test's result in section 4.1 confirms that bird species richness and diversity are contrasting across the four planting zones, aligning with vegetation complexity gradients observed in TBNSA (Table 2).

4.3 Diversity Indices

Table 3 Diversity indices per zone

Zone	Species Richness (S)	Shannon–Wiener (*H'*)	Simpson (λ)	Pielou's Evenness (*J'*)
A	9	2.07	0.86	0.94
B	7	1.80	0.81	0.93
C	5	1.56	0.78	0.97
D	5	1.44	0.73	0.89

(Source: Author)

The indices declined gradually from Zone A (H' = 2.07) to Zone D (H' = 1.44). Zone A showed the highest diversity and evenness, suggesting that its complex canopy structure enabled adequate habitat resources across multiple species. Zone B, though a little lower in overall richness, still has moderate diversity (H' = 1.80) due to its high abundance of nectarivores and insectivores linked to flowering vegetation. Zones C and D displayed reduced variety and dominance of a few flexible species, particularly granivores and omnivores, consistent with their open and/or ornamental vegetation character. The results emphasized the importance of native multi-layered canopies. Zone A's high Simpson's diversity index (λ) confirms less dominance by any single species, as there is a low probability of randomly selecting two individuals of the same species (Khiruddin et al., 2025). On the other hand, the Simpson index is particularly sensitive to the most abundant species, thus supporting the finding on Zone D's low diversity as a result of a few dominant species like *Lonchura maja* and *Acridotheres tristis* (Aiman et al, 2022). This phenomenon, where a few species monopolize resources, significantly impacts the overall ecological resilience and functional integrity of the avian community within such simplified habitats (Khiruddin et al., 2025). Further, Pielou's Evenness (J') for Zone D is comparably lower than that of other zones, showing a less equal distribution of individuals among its species, a trait often seen in either disturbed or less complex ecosystems (Zhu et al., 2024).

4.4 Functional Guild Composition

Zone A shows a balanced mix of insectivore, frugivore, and nectarivore species. This is due to its many vertical layers, extensive canopy, and high native plant presence, which offer varied ecological niches and sufficient resources. This supports the previous studies that link these attributes to higher bird richness, particularly benefiting specialist species that need undisturbed interior spaces (Khiruddin et al., 2025; Oropeza-Sánchez et al., 2024), besides the native fruiting and flowering species in these complex vertical layers further attract fruit-eating and insect-eating birds. A high presence of nectarivores and insectivores is recorded in Zone B, attributed to a flowering understory. This matches Zone B's dense understory and canopy, which probably offer more nectar and insects, as plenty of flowers are key for nectar-eating birds; besides boosting insect numbers (Oropeza-Sánchez et al., 2024). Meanwhile, Zone C is dominated by generalist insectivores and bulbuls. Its sparse vegetation, less canopy cover, and fewer native plants likely favor generalist species that can adapt to simpler habitats. Lower canopy cover and many non-native species tend to support more generalist and disturbance-tolerant birds, but provide scarcer foraging and nesting opportunities for specialists (Khiruddin et al., 2025; Oropeza-Sánchez et al., 2024). This shows that varied habitats can negatively affect habitat specialists but benefit generalist species, which are well-adapted to living in altered environments (Zhu et al., 2024). Zone D displays a high proportion of granivores and open-field insectivores. Its single vertical layer, minimal canopy, and dense understory, typical of open fields, provide abundant seeds and easy foraging for these bird groups (Cull et al., 2025). The simple vertical structure and limited plant diversity in these zones typically result in less guild diversity (Bichi et al., 2025).

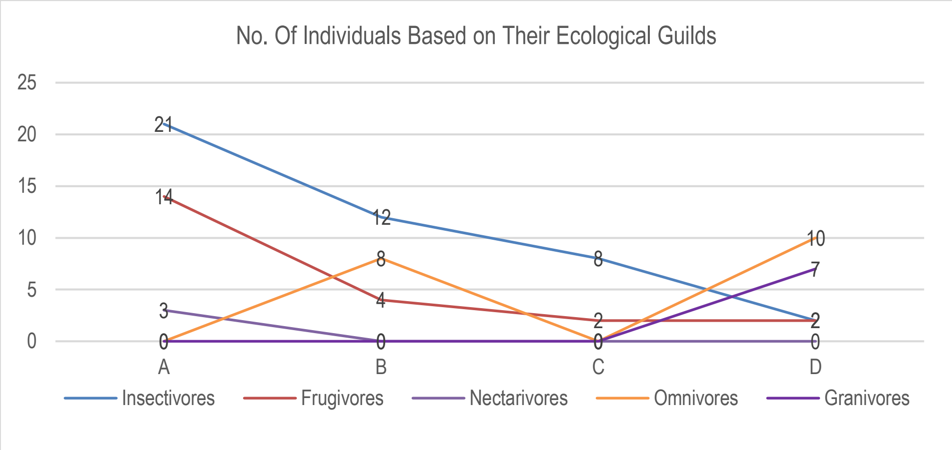

Figure 2 Functional guild composition across sampling zones
(Source: Author)

5.0 Conclusion

This study reaffirms that vegetation structure and composition are among the key determinants of avian diversity in tropical urban parks. The stratified vegetation profiling and avifaunal surveys across TBNSA's four planting zones revealed that zones with higher canopy cover, greater native plant representation, and multi-layered vegetation supported richer, more evenly distributed bird communities. In contrast, simplified or ornamental vegetation structures were associated with lower diversity and dominance by generalist species. Furthermore, statistical insights reveal the precise mechanisms by which canopy cover, vertical layering, and native-plant ratios positively influence species richness and diversity indices, thereby fulfilling a primary objective of this research: empirically establishing the ecological drivers of urban avian communities. Functionally, zones with higher vegetation complexity supported a broader representation of foraging guilds, underscoring the ecological value of structurally diverse habitats. Collectively, these findings highlight that biodiversity-sensitive planting design and management can substantially enhance ecological integrity within urban parks.

6.0 Limitations of The Study

Although this study achieved its aims and objectives, it had certain limitations. Firstly, bird surveys were conducted only during the day, over a single season, limiting the detection of crepuscular or nocturnal species. Besides that, the study was only focused on four planting zones, and other microhabitats in TBNSA might yield additional insights. Therefore, the way forward is for future research to adopt a multi-seasonal, multi-habitat, and long-term framework, enhanced by technological, analytical, and participatory innovations, to refine the understanding of how urban planting design shapes bird diversity. Implementing these recommendations would significantly improve the precision, scalability, and applicability of the findings, thereby advancing Malaysia's pursuit of sustainable and biodiversity-sensitive urban planning.

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Paper Contribution to the Related Field of Study

The results may be used to formulate a practical guide for urban planners, landscape architects, and park managers to integrate biodiversity goals into landscape design, reinforcing the role of parks such as TBNSA as critical refuges for urban wildlife within rapidly urbanizing cities. This study's intentions and outcomes also align with Malaysia's commitment to the United Nations' Sustainable Design Goals (SDGs), precisely SDG11, 13, and 15; and its National Policy on Biological Diversity.

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