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Research Article

Bird diversity in different vegetation types in the Pacific coastal plain of Guatemala

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Abstract

Guatemala's Pacific coastal plain, although largely dominated by agricultural land, still contains patches of diverse vegetation that could be vital for supporting bird diversity. Despite the country's recognition for its rich avian biodiversity, updated data on species richness in this region are still lacking. Understanding the role of different vegetation types in maintaining bird diversity is essential for developing targeted conservation strategies that can both preserve and improve biodiversity in these fragmented landscapes. In this study, we compared species richness and the composition of bird communities across four distinct vegetation types along Guatemala's Pacific coastal plain and analyzed species turnover and replacement to understand how these habitats contribute to maintaining overall bird diversity at the study site. The avian community consisted predominantly of species adapted to open habitats, with generalist bird species prevailing and only a limited representation of species typical of the understory in subtropical wet forests. Additionally, the observed species turnover value suggests a moderate level of species replacement among different vegetation types at the study site. The moderate nestedness, wherein species-poor communities are subsets of more diverse ones, further implies a decline in overall biodiversity. These findings suggest that the homogenization of the avian community indicates that our study focused on isolated areas that remain in this transformed environment. Our findings argue that protecting and restoring seminatural patches, even modestly sized patches, can be critical for safeguarding biodiversity in human-dominated landscapes and highlight the importance of landscape-level conservation, which enables connectivity between habitat patches to support species with different ecological requirements.

Key words: Anthropogenic landscape, avifauna, replacement, riparian forest

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Introduction

Habitat influences the diversity of birds, particularly in transformed landscapes where diverse vegetation coexists (Gumede et al. 2022). The relationship between habitat and bird diversity involves the interaction of different vegetation types, structural complexity, and resource availability (Hall et al. 2022). Habitat conversion often decreases bird diversity because it imposes ecological filters and homogenizes habitat structure along environmental gradients (Püttker et al. 2014; Karp et al. 2017), leading to greater dissimilarity (β-diversity) among different cover types present in the landscape. Research has indicated that landscapes characterized by a mosaic of diverse habitats, such as those containing diverse tree covers, water bodies, and grasslands, can support bird species richness (Collina et al. 2021). Karjee et al. (2022), found that peri-urban landscapes with a mix of vegetation types were more productive and could support a greater variety of bird species compared to more homogeneous environments. Guilherme and Pereira (2013) agree on this, noting that bird diversity is significantly influenced by landscape-scale heterogeneity, as birds actively select habitats that facilitate their movement and foraging. Furthermore, the presence of specific vegetation types, such as riparian forest vegetation, has been shown to disproportionately affect bird communities, highlighting the importance of certain habitats in maintaining bird diversity (Hall et al. 2022). The findings support this notion, indicating that agricultural landscapes with diverse habitat types can support greater functional diversity among bird communities (Tscharntke et al. 2008).

Guatemala is recognized for its biological diversity, particularly its rich avifauna, with more than 750 bird species reported (Eisermann and Avendaño 2018). This biodiversity coexists with a predominantly agricultural economy, with key agricultural regions spread across the country. One of the most important agricultural zones is the Pacific coastal plain in southern Guatemala, which has been an agricultural hub for over a century (Higbee 1947; Blanco and Enríquez 2018). Although agricultural expansion has transformed much of the landscape, these regions still retain fragments of different habitats that support biodiversity. Notably, the Pacific coastal plain are home to several Important Bird Areas (IBAs), where critical ecosystems such as wetlands, swamps, and mangroves persist (GT025, GT026, GT027) (Eisermann and Avendaño 2009).

Despite its ecological importance, the Pacific coastal plain zone has become a highly degraded habitat, since a lot of decades ago. Between 2016 and 2020, natural vegetation cover was less than 15% in the departments of Escuintla, Santa Rosa, and Retalhuleu, while Suchitepéquez remained close to 27%, although this vegetation has remained during this period (INAB 2024). Most of the remaining land is dominated by agricultural systems, such as coffee, sugar cane, and rubber plantations (GCI 2018). The fragmented vegetation, a mix of trees, shrubs, herbs, and grasses at various successional stages, provides essential shelter and feeding areas for birds, highlighting its ecological value for avian diversity (Casas et al. 2016; Mayhew et al. 2019; Rajpar et al. 2024).

Although Guatemala is widely recognized for its high bird diversity (Eisermann and Avendaño 2018), there remains a significant gap in updated data on bird species richness in the Pacific coastal plain, especially concerning the role of different vegetation types in maintaining this diversity. Therefore, documenting bird biodiversity across the varied vegetation types of the Pacific coastal plain is crucial for developing effective conservation strategies that not only preserve but also enhance regional biodiversity. In this study, we compared the species richness and composition of bird communities across four distinct vegetation types along the Pacific coastal plain of Guatemala. We also aimed to analyze species turnover and replacement to gain a clearer understanding of how these vegetation types contribute to maintaining overall bird diversity at the study site. By examining the differences in bird species composition across these habitats, we aimed to shed light on the complementary roles that each vegetation type plays in supporting avian diversity on the Pacific coastal plain of Guatemala.

Methods

Study area

The study area encompasses four departments in Guatemala: Suchitepéquez, Escuintla, Retalhuleu and Santa Rosa (see Fig. 1). These regions lie within the expanse of the Pacific coastal plain of Guatemala, which lies at the base of the country's volcanic chain. The predominant ecological zone comprises warm subtropical wet forests and humid subtropical forests at different successional stages (IARNA 2018). This intricate ecological landscape has evolved over at least a century and is shaped by extensive and intensive agricultural and livestock activities (Paiz 2006). The selected forest segments, where the sampling points are located, are integrated into farms primarily engaged in sugarcane production. The climate of the area is characterized as warm, with temperatures ranging between 24 °C and 28.1 °C. The annual rainfall fluctuates between 1426 mm and 4071 mm. The altitudinal gradient spans from sea level to 1139 elevation, with an average elevation of 182 m (IARNA 2018).

Study design

Field work was conducted at the study site between 2018 and 2022. The initial phase involved the preselection of sampling points to represent various vegetation types within the study area. This process was facilitated via UTM Geo Map, Google Earth (Google Earth 2023), and QGIS 3.24.2 for data processing. Following preselection, the sampling points were evaluated onsite, considering factors such as accessibility, entry permits, and safety precautions. A total of 166 count points were established, each with a 30-meter radius of influence (see Fig. 1).

The selected points were then categorized into four distinct vegetation types: forest plantations, riparian forests, secondary forests, and natural riparian forests. The vegetation classification for each point was determined based on the conditions observed in satellite images, complemented by data on the prevailing tree species obtained through the establishment of 1200 m^2 vegetation plots at selected points. To ensure methodological coherence, proximate sampling points within a defined area (with distances between them less than 300 linear meters) and characterized by comparable vegetation types were strategically clustered. This clustering approach resulted in the formation of a total of 28 sampling units, with each unit comprising between 10 and 15 count points. This stratification resulted in the establishment of multiple replicates for each vegetation type as follows: seven replicates for riparian forest, seven replicates for secondary forest, five replicates for forest plantations, and nine replicates for riparian forest plantation.

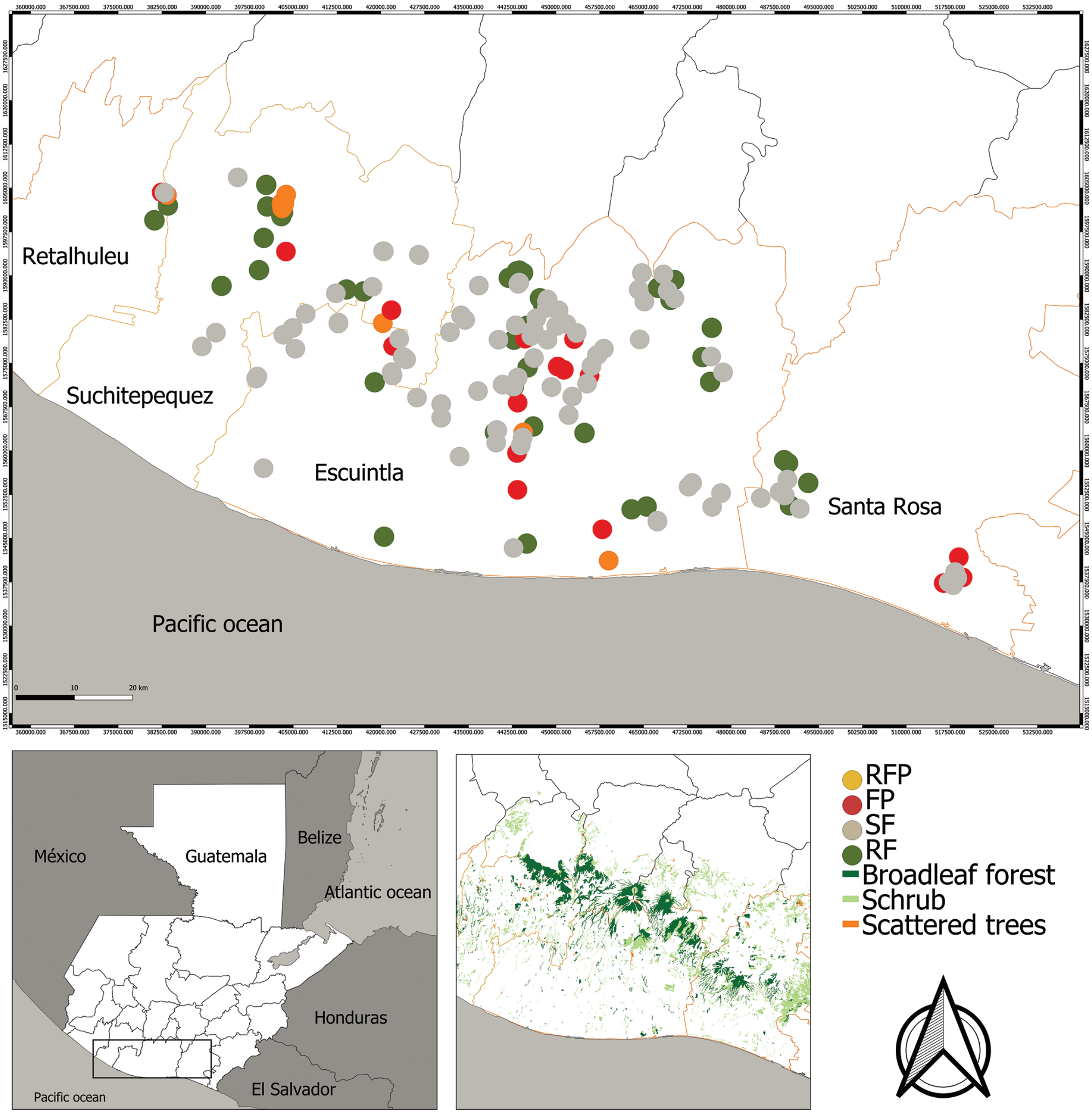

Figure 1. Study site location in Guatemala. Bird counting points. Vegetation types at bird counting points, where the RF are riparian forest, the SF is secondary forest, the FP are forest plantations and the RFP is riparian forest plantations. Source: own data and MAGA 2021.

Riparian forests are characterized by a predominant mix of native regenerated species located along or near riverbanks, including *Attalea cohune*, *Acacia hindsii*, *Brosimum costaricanum*, and *Terminalia oblonga*. The secondary forest sites were dominated by native species in various successional stages, with representative flora such as *Cecropia obtusifolia*, *Ceiba pentandra*, *Guazuma ulmifolia*, *Vatairea lundellii*, and *Sterculia apetala*, reflecting the characteristics of evergreen and semievergreen forests. Forest plantation areas primarily feature plantations of *Tectona grandis* and *Handroanthus donnell-smithii*, along with natural growth species such as *Simira salvadorensis*, *Triplaris melaenodendron*, and *Castilla elastica*. At the riparian forest plantation sites, the dominant vegetation included fruit trees such as *Mangifera indica* and *Manilkara sapota*, timber species such as *Gmelina arborea*, and ornamental species such as *Andira inermis*.

Bird survey

The bird data included visual and acoustic records (Sullivan et al. 2009) during constant-speed walks between adjacent sampling units from 6:00 to 8:00 am each sampling day.

Birds were categorized into functional groups, and information on their main diet and ecological niche was obtained through a literature review, encompassing works by Kissling et al. 2012 as well as the "Guide of the Birds of Mexico and Northern Central America" by Howell and Webb (2001), and the taxonomic names were corroborated (AOS 2024).

Functional traits of the avian community

We created a list of avian functional traits for each species recorded. These included avian families, primary diets (granivores, frugivores, nectarivores, insectivores, aquatic invertebrates, carnivores, scavengers and omnivores based on Kissling et al. (2012) and ecological niches (forest dependent, open forest, generalist, swamps). The traits we selected indicated the use of resources and habitat provisioning (Gumede et al. 2022), and we created a species-trait matrix of these traits. The threat levels of bird species were assessed based on the criteria outlined in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2024).

Data analysis

Richness estimates were computed for the entire study area via the Chao-Richness function within the iNEXT package (Hsieh et al. 2016) applied to the incidence matrix encompassing species occurrences across the four vegetation types defined.

Species richness ($q = 0$) and diversity of common ($q = 1$) and dominant species ($q = 2$) were compared through rarefaction and extrapolation curves facilitated by the ggiNEXT function from the iNEXT package (Hsieh et al. 2016). Notably, rarefaction curves are essential for equitable comparisons among communities with uneven sampling efforts (Gotelli and Colwell 2001; Chao et al. 2014), a circumstance present in our survey. This approach allows computation of expected species richness at a standardized sample size, enabling precise extrapolations as bootstrap samples augment the pool of previously identified species. Leveraging these curves, we applied a bootstrap procedure to establish 95% confidence intervals, facilitating the comparison of diversity orders (MacGregor-Fors and Payton 2013). Nonoverlapping confidence areas indicated significant differences in species richness between curves ($P < 0.05$).

To assess the components of beta diversity across various vegetation types, we calculated the species turnover and the nestedness-resultant fraction of Jaccard dissimilarity via the multiple-site dissimilarity approach implemented in the betapart package (Martín-Devasa et al. 2022). The turnover fraction quantifies species replacement among sites (JTU), whereas the nestedness fraction (JNE) elucidates how variations in species composition are associated with less diverse subsets within richer communities.

To visualize and examine differences in bird species composition between vegetation types, we produced a nonmetric multidimensional scaling (NMDS) ordination via the Bray–Curtis similarity index. Prior to this analysis, the raw data were standardized via the Hellinger correlation using the HellCor package (Geenens and Micheaux 2020). To assess differences in bird distribution across vegetation types, we applied Adonis2 analysis, followed by a post hoc test via the pairwiseAdonis function from the PairwiseAdonis package (Martinez 2020).

To identify species associated with each vegetation type as well as those acting as indicators of combinations of vegetation types, we applied indicator species analysis (ISA), which not only identifies species as potential indicators for specific vegetation groups but also highlights those that are more abundant and frequent in one group than others. Additionally, ISA enables the identification of species with varying niche breadths, such as those whose niches span multiple categories (De Cáceres and Legendre 2009; De Cáceres et al. 2010).

To assess differences in bird assemblage composition according to feeding guild composition, taxonomy group (family), and habitat specialization between different vegetation types, PERMANOVA was conducted with the command adonis2 from the vegan package (Oksanen et al. 2022). This analysis uses F values to compare among-group to within-group similarity and assesses significance via permutation (9999 times). To achieve this goal, we generated a database containing the total number of records for each bird species per vegetation type, summing the occurrences of each species across all the sampled sites (R Core Team 2023).

Results

Overview of bird richness and community composition

A total of 3168 individuals, belonging to 218 species across 48 bird families, were documented throughout the 661 hours of sampling (see Suppl. material 1). Notably, within this bird assemblage, three families emerged prominently: Tyrannidae (36 species), Icteridae (10 species), and Picidae (9 species). A subset of 17 species contributed more than 40% of the dataset. Among these (see Fig. 2), Altamira Oriole (*Icterus gularis*) (122 records), Golden-fronted Woodpecker (*Melanerpes aurifrons*) (111 records), Rufous-backed Wren (*Campylorhynchus rufinucha*) (103 records), Great Kiskadee (*Pitangus sulphuratus*) (100 records), White-throated Magpie-jay (*Calocitta formosa*) (99 records), and Cinnamon Hummingbird (*Amazilia rutila*) (91 records) presented the greatest number of records.

Among the 218 bird species recorded at our study sites, 159 were identified as residents (R), 58 as migrants (M), and 1 as a transcendent (see Suppl. material 1). One species, the Orange-fronted Parakeet (*Eupsittula canicularis*), listed as Vulnerable/NT on the IUCN Red List, was recorded 14 times in Secondary Forest, 10 times in Riparian Forest and once in Forest Plantation. Additionally, two species, the Chuck Will Widow (*Antrostomus carolinensis*) and the Eastern Meadowlark (*Sturnella magna*), were classified as Near Threatened. Both species were recorded only twice, with sightings exclusively in the Secondary Forest. The only bird species recorded at the study site classified as critically endangered was the Yellow-naped Parrot (*Amazona auropalliata*).

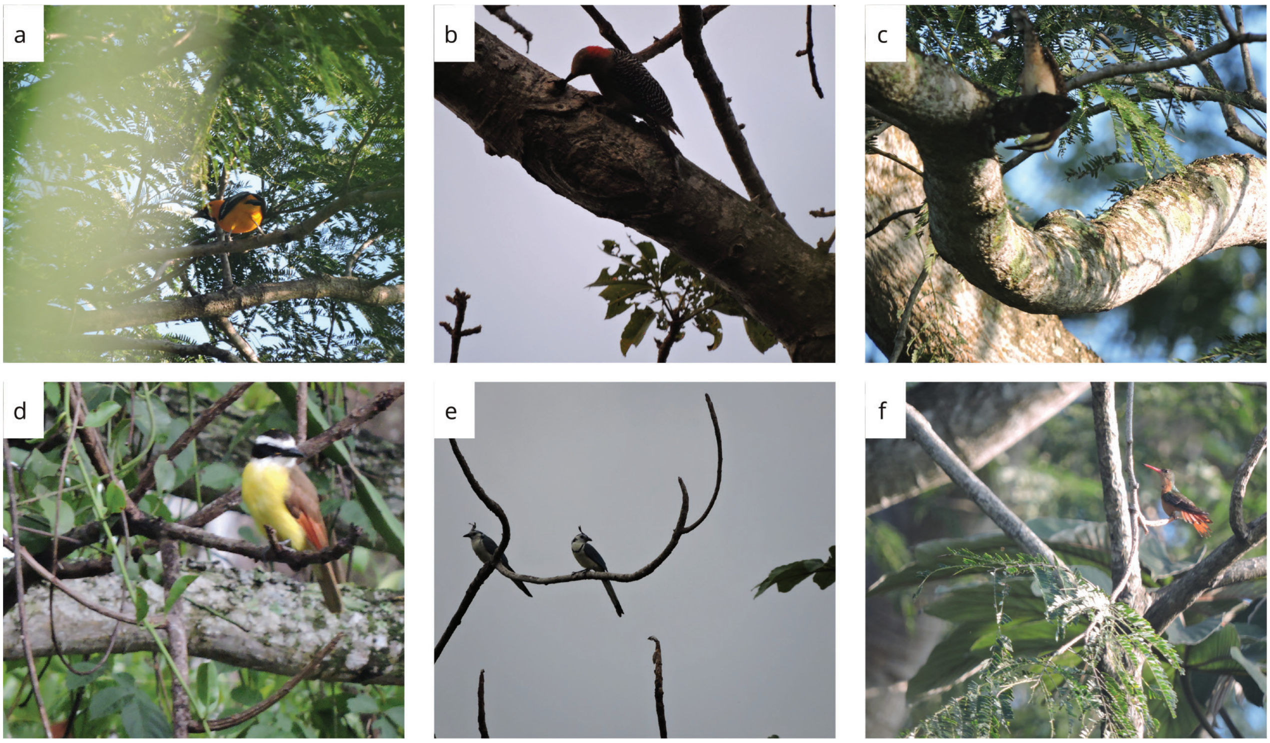

Figure 2. Most frequented birds recorded at vegetation type in the Pacific coastal plain of Guatemala (**a**) Altamira oriole (**b**) Golden-fronted Woodpecker (**c**) Rufous-backed Wren (**d**) Great Kiskadee (**e**) Magpie-jay (**f**) Cinnamon hummingbird

This species was recorded primarily in secondary forests (21 times), followed by riparian forests (8 times), forest plantations (2 times), and riparian forest plantations (1 time). Additionally, 27% of the species (58) were recorded across all habitats, primarily those species adapted to open environments classified as generalist species.

Furthermore, 78 species were observed only once during the sampling period. These include mainly forest-associated species, such as the Thicket Tinamou (*Crypturellus cinnamomeus*) seen in the riparian forest and the Collared Forest-Falcon (*Micrastur semitorquatus*) recorded in the secondary forest, among others. We also recorded 54 bird species typically associated with forested habitats, accounting for ~23% of the observed bird richness. Forest-dependent species accounted for 43% of all individuals across the whole community and more prevalent in both secondary forests (26%) and riparian forests (22%) than in forest plantations (20%) and riparian forest plantations (12%).

The Chao-1 index estimated a species richness of 272 (95% CI: 248.583–315.285) for the entire study site, with a standard error of 16.46, indicating variability in our estimates. The rarefaction curves of different vegetation types revealed a steady increase in species richness in relation to sample units, indicating that more species are expected to be discovered in these areas with greater sample effort.

The feeding guild assemblages indicate that insectivores were the most abundant feeding guild (58%), followed by carnivores (10%), aquatic invertebrate eaters (8%), frugivores (7%), omnivores (5%) and granivores and nectarivores (3%), and the least abundant group was scavengers (1%). The Altamira Oriole and Golden-fronted Woodpecker were the most abundant insectivores recorded, whereas White-throated Magpie-jay were the dominant omnivores recorded.

Nectivorous species included Cinnamon hummingbirds and Ruby-throated hummingbirds (*Archilochus colubris*), which were the most abundant. Carnivorous species included Roadside Hawks (*Rupornis magnirostris*) and Gray Hawks (*Buteo plagiatus*). The fructivorous species included orange-chinned parakeets (*Brotogeris jugularis*) and yellow-naped parrots. Granivore species were represented by a Blue–black Gassquit (*Volatinia jacarina*) and a Bluish-gray Saltator (*Saltator coerulescens*). The invertebrate eaters that feed on mollusks include Eastern Great Egret (*Ardea alba*) and Western Cattle Egret (*Bubulcus ibis*), which are the most abundant. The scavengers were represented by the Crested Caracara (*Caracara plancus*) and Turkey Vulture (*Cathartes aura*).

Among the different vegetation types, secondary forest presented greater observed and expected species richness, reaching approximately 200 expected species at approximately 90 sampling units (see Fig. 3 and Table 1), and riparian forest plantations presented the lowest observed and expected values (see Figs 3, 4, and Table 1). The interpolation analysis revealed no significant differences in the species richness or diversity of common (q = 1) or dominant species (q = 2) between these vegetation types (see Fig. 4).

Bird diversity across habitat types

The NMDS ordination clearly distinguishes the riparian forest plantation assemblage from the other vegetation types (see Fig. 5, stress value = 1). Furthermore, the analysis suggests that the bird communities in the riparian Forest and secondary forest are subsets of the more diverse forest plantation habitat (see Fig. 5). The adonis2 analysis confirmed that the bird composition in riparian forest plantations was significantly different from that in the other habitat types (with forest plantation: P = 0.002; with riparian forest: P = 0.001; with secondary forest: P = 0.01). The other vegetation types did not present significant differences in species composition (P > 0.05).

Our data indicates a moderate degree of species replacement among the different vegetation types (JTU = 0.401). The nestedness fraction (JNE = 0.261) indicates that a substantial portion of the variation in bird species composition can be attributed to species-poor subsets present within more diverse communities.

We identified 15 out of the 218 bird species as indicators associated exclusively with a single vegetation type, whereas the others were linked to combinations of vegetation types. In the forest plantations the American Redstart (*Setophaga ruticilla*) (0.421, P = 0.025) and the Blue-gray Gnatcatcher (*Polioptila caerulea*) (0.327, P = 0.035) were the main indicators. For the riparian forest, the Streaked Flycatcher (*Myiodynastes maculatus*) (0.337 P = 0.030) was the main indicators.

In the riparian forest plantations, the indicator species included the Great-tailed Grackle (*Quiscalus mexicanus*) (0.779, P = 0.005), the Inca Dove (*Columba inca*) (0.625, P = 0.010), Great Egret (*Ardea alba*) (0.613, P = 0.005), Cattle Egret (*Bubulcus ibis*) (0.475, P = 0.02), Little Blue Heron (*Egretta caerulea*) (0.422, P = 0.010), the Spotted Sandpiper (*Actitis macularius*) (0.397, P = 0.010) and Black Phoebe (*Sayornis nigricans*) (0.397, P = 0.015).

For the combination of forest plantation, riparian forest and riparian forest plantation, the Clay-colored Thrush (*Turdus grayi*) (0.703, P = 0.010) and the Blue-gray Tanager (*Thraupis episcopus*) (0.550, P = 0.015) were associated.

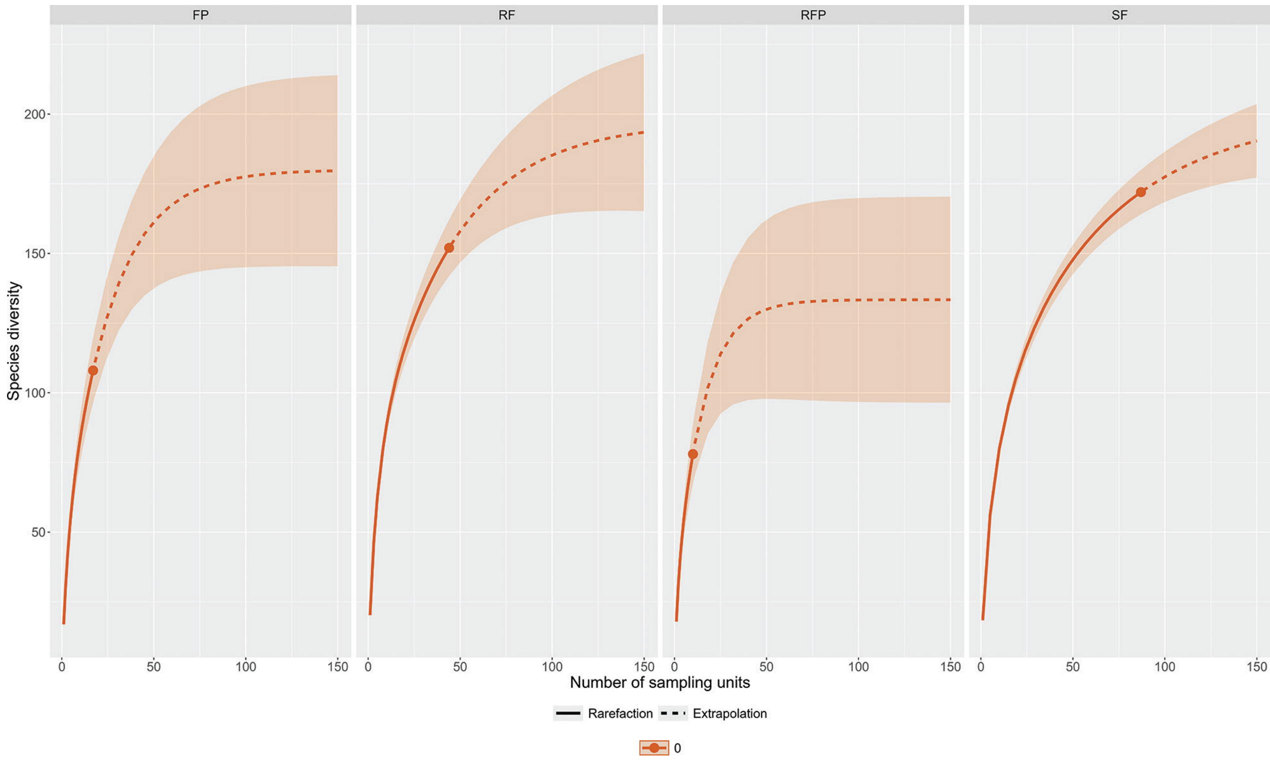

Figure 3. Rarefaction (solid line) and extrapolation (dashed line) curves with 95% confidence intervals of species richness (q = 0) at every vegetation type analyzed.

Table 1. Observed and expected species richness and diversity values of birds in each vegetation type in the Pacific coastal plain of Guatemala. In the case of species richness (diversity order = 0), the 95% CIs are shown in parentheses.

	Secondary Forest	Riparian Forest Plantation	Riparian Forest	Forest Plantation
Number of species	172	78	152	108
Number of registers	1698	201	977	731
Number of distinct bird families	43	31	39	34
Chao-1	200 ± 11.7 (185.26 233.884)	133 ± 24.45 (102.218 204.660)	197 ± 17.18 (173.866 244.745)	180 ± 27.99 (142.513 258.204)
Simpson (1-D)	0.984 ± 0.00 (0.984-0.985)	0.980 ± 0.02 (0.984-0.985)	0.985 ± 0.001 (0.985-0.987)	0.984 ± 0.001 (0.985-0.988)
Shannon (H)	4.480 ± 0.023 (4.51-4.57)	4.106 ± 0.099 (4.325-4.603)	4.530 ± 0.029 (4.600-4.682)	4.379 ± 0.070 (4.591-4.789)

Finally, for the combination of forest plantation, riparian forest and secondary forest, the indicator species were Turquoise-browed motmot (*Eumomota superciliosa*) (0.668, P = 0.025) and Tropical Kingbird (*Tyrannus melancholicus*) (0.621, P = 0.04).

Finally, the PERMANOVA revealed that the bird species distribution across the different vegetation types was significantly influenced by the avian family (F = 1.2268, P = 0.013), and the pairwise adonis analysis indicated that riparian forest plantations were the only vegetation type whose family composition significantly differed from that of the secondary forest. On the other hand, no significant effects were found for the primary diet (F = 1.1502, P = 0.293) or the ecological niche (F = 1.1323, P = 0.315).

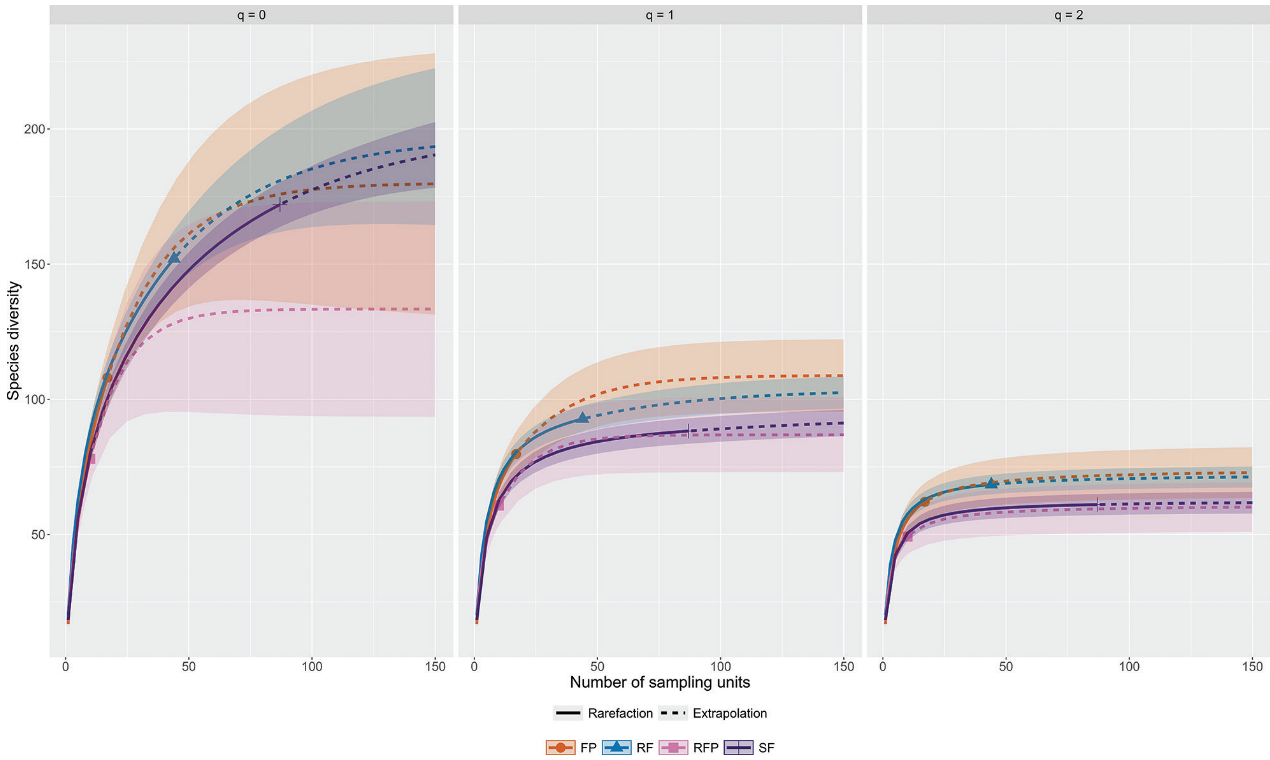

Figure 4. Interpolation analysis of rarefaction (solid line) and extrapolation (dashed line) curves with 95% confidence intervals comparing species richness (q = 0) and diversity of common (q = 1) and dominant species (q = 2) (q = 0) between vegetation types. FP = Forest Plantation; RF = Riparian Forest; RFP = Riparian Forest Plantations; and SF = Secondary Forest.

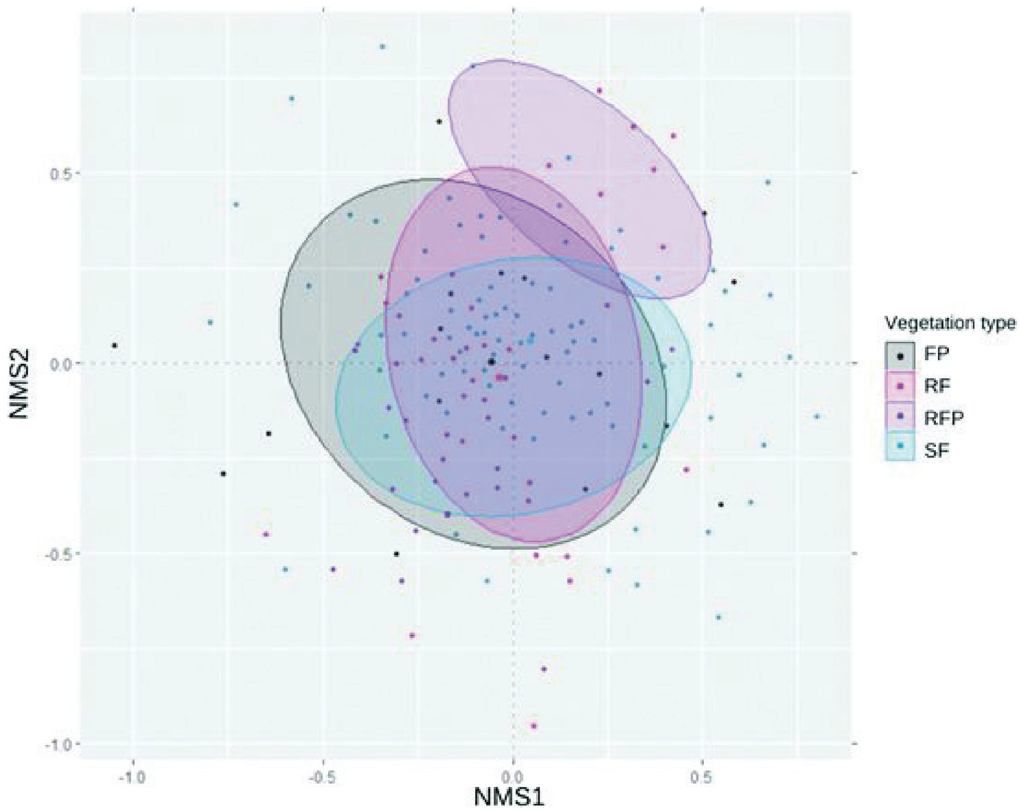

Figure 5. Nonmetric multidimensional scaling (NMDS) displays a distinctive grouping of our four study vegetation types (FP = Forest Plantation; RF = Riparian Forest; RFP = Riparian Forest Plantations; and SF = Secondary Forest) in the study area (stress = 0.095) on the basis of the presence and absence of avian species during the survey.

Discussion

Avian diversity and composition in the study site

Our results demonstrate that the various vegetation types along the Pacific coastal plain support substantial bird species richness. Approximately 36% of the country's total bird richness (Eisermann and Avendaño 2018) and 67% of the bird species richness found in Guatemala's tropical humid ecosystems (IARNA 2008) were observed within the sampled vegetation units. These findings highlight the importance of small habitat patches, such as tree plantations, secondary forests, and riparian forests, as critical hubs for avian diversity in this fragmented landscape (Griscom 1932; Eisermann and Avendaño 2018).

Although the avian community in the studied area is primarily composed of species adapted to open habitats, we recorded a significant number of bird species typically associated with forested environments, representing approximately 23% of the total species richness. Furthermore, the sampled vegetation patches support four bird species listed on the IUCN Red List (IUCN 2024) and provide habitats for several migratory species. These findings underscore the importance of these vegetation units for conserving the region's biodiversity. Similar studies across Mesoamerica and South America, including Mexico, Costa Rica, and Colombia, have highlighted the critical role of small vegetation patches, live fences, and riparian forests within agricultural and livestock areas in preserving tropical bird diversity (Arcos et al. 2008; Ramírez-Albores 2010; Arendt et al. 2012; Araya and Carvajal 2019). These parallels emphasize the broader significance of fragmented or seminatural habitats for maintaining avian diversity in human-dominated landscapes.

The avian species richness documented in our survey, consisting of 218 species, is comparable to findings from similar studies examining bird diversity across different vegetation types in agroecosystems of Central and South America. For example, a survey in Nicaraguan habitats (Vilchez et al. 2008) reported 165 species, with a predominance of species commonly associated with open and disturbed environments, such as the Blue-black Grassquit (*Volatinia jacarina*), Tropical Kingbird (*Tyrannus melancholicus*), Groove-billed Ani (*Crotophaga sulcirostris*), and Cinnamon Hummingbird (*Amazilia rutila*). Similarly, Sáenz et al. (2007) documented 154 species in Nicaragua, 111 in Costa Rica, and 170 in Colombia. These studies highlight the consistency of avian biodiversity patterns across vegetation types in the region, particularly the prevalence of certain species in response to specific habitat conditions.

The bird community composition in the study area was dominated by generalist species adapted to open areas such as Rufous-Backed Wren, Altamira Oriole, Great Kiskadee, White-throated Magpie-jay, and the Golden-fronted Woodpecker. In contrast, a few species typical of the understory area of subtropical wet forests (IARNA 2018), especially those that have special requirements for nesting and foraging, such as cedar waxwing (*Bombycilla cedrorum*) and the golden-crowned Warbler *Basileuterus culicivorus*, were recorded only once. These data suggest that their populations in the area are likely to be small. In this context, several bird species, such as Thicket Tinamou and large, frugivorous birds, such as Military Macaw (*Ara militaris*) and Red Macaw (*Ara macao*), are known to be locally extinct because of habitat loss (Pérez 1998).

In this context, it is likely that the bird community was altered by fragmentation and deforestation, with the consequent decline of some species and the loss of others (Castelletta et al. 2005; McCarthy 2012; Mariano-Neto and Santos 2023). For example, some species associated with forested areas, such as White-fronted Amazon (*Amazona albifrons*), Gartered trogon (*Trogon caligatus*), Barred Antshrike (*Thamnophilus doliatus*), Red-throated Ant-Tanager (*Habia fuscicauda*), and species of the Furnariidae family were detected in this mosaic landscape but with few records, and they were observed only in secondary and riparian forests. In addition, it is difficult to determine how much the bird community composition changed due to the conversion of the landscape to extensive agriculture decades ago, given that there are no previous studies on bird communities in this region of the country.

During this survey, we detected four species classified as threatened, with two belonging to the Psittacidae family. Notably, the Yellow-naped Parrot holds particular importance given its precarious conservation status. This species faces a severe threat from poaching activities, reflecting a heightened demand within local markets and nearby villages, as comprehensively documented by Herrera et al. (2020). Additionally, the conversion of forests into agricultural crops or grazing areas decades ago played a significant role in the decline in Yellow-naped parrot populations across their entire range. A study conducted in Central America revealed a small remaining population of 2361 individuals in the wild (Dupin et al. 2020), underscoring the importance of immediate conservation efforts. Our data underscore the persistent occurrence of this parrot species in the studied landscape, emphasizing its almost exclusive observation in natural riparian and secondary growth habitats. Consequently, the conservation of patches of these specific habitats, even those of relatively modest sizes, seems to be crucial for the sustained preservation of this species in the area.

The significant diversity observed in the study area may be influenced by the landscape composition, which retains certain seminatural components, such as riparian and secondary forests. The connectivity and accessibility of these habitats likely contribute to patterns of species richness. Furthermore, the scattered presence of tree species—such as *Enterolobium cyclocarpum*, *Bursera simaruba*, and *Ceiba pentandra*—provides foraging and perching opportunities during specific flight periods. Previous research on agricultural landscapes has indicated that preserving and promoting patches of vegetation can enhance biodiversity and ecosystem services without compromising productive areas (Rivera-Pedroza et al. 2019). Similarly, McDermott et al. (2015) found that increased canopy cover, tree density, basal area, and structural complexity are positively correlated with the presence of both resident and migratory bird species.

Bird diversity across habitat types

Our study site was predominantly characterized by generalist bird species. Additionally, the species turnover value reflects a moderate level of species replacement across different vegetation types. This suggests a limited ecological diversity and reduced resilience within the bird community, highlighting potential vulnerabilities in maintaining both species richness and functional diversity. In environments with low species turnover, communities are often dominated by a few generalist species capable of thriving under various conditions, while specialist species requiring specific habitats tend to decline or disappear (Smith et al. 2018). This pattern is frequently linked to habitat degradation and fragmentation, which erodes the ecological niches that support more diverse bird populations (Quintas et al. 2020). In addition, the moderate nestedness found in our bird community can further indicate a decline in overall biodiversity at the study site. This pattern suggests that the more diverse habitats support a wider range of species, while the less diverse habitats are left with only a few generalist species. The loss of specialist species, which are often more sensitive to habitat changes, can lead to a homogenization of the bird community. For instance, Bomfim et al. (2018) found that local extinctions of obligate frugivores due to habitat loss disrupted seed dispersal networks, highlighting the cascading effects of species loss on ecosystem functions.

The homogenization of bird composition due to the loss of specialist species is a concerning trend for conservation. As habitats become more uniform, the unique ecological roles played by specialist species are diminished, leading to a decline in overall ecosystem health and functionality (Latimer et al. 2022). This is particularly evident in agricultural landscapes, where intensive land use often favors generalist species at the expense of more sensitive species (Xie et al. 2019). For example, research by Vallejos et al. (2016) demonstrated that human-induced landscape changes led to a significant homogenization of Atlantic Forest bird assemblages, with a marked decrease in beta diversity following habitat. This indicates that as landscapes are modified, the unique species compositions that characterize diverse habitats are lost, resulting in a more uniform and less resilient bird community.

Our findings indicate that riparian forest plantations harbor distinct bird communities compared to other habitat types. The lower bird species richness in riparian forest plantations, along with the presence of species primarily associated with aquatic environments (e.g., herons, black phoebes, and sandpipers), suggests a specialized avifauna that is highly reliant on the availability of water bodies. In terms of conservation value, these results highlight the critical role riparian habitats play in supporting unique bird assemblages not found in other vegetation types, contributing significantly to overall biodiversity and ecosystem function (Bennett et al. 2014; Nimmo et al. 2015). However, the lower species richness in riparian forests compared to forest plantations suggests that conservation efforts should prioritize the restoration and protection of these habitats to enhance their ecological integrity and resilience (Bennett et al. 2014; Hall et al. 2022) and underscore the need of the integration of biodiversity considerations into agricultural policies (ICC and ASAZGUA 2022). Effective management strategies, such as selective logging and promoting natural regeneration, could improve riparian habitat quality and aid in the recovery of bird populations (Mendoza et al. 2014; Nimmo et al. 2015).

Additionally, our data indicates that generalist species such as the Clay-colored Thrush, Blue-gray Tanager, Turquoise-browed Motmot, and Tropical Kingbird inhabit a wide range of vegetation types at the study site, demonstrating that certain birds benefit from habitat heterogeneity by utilizing multiple environments to fulfill their life cycle needs. These species may thrive in the more heterogeneous landscapes created by the combination of different habitat types, which enhances resource availability and nesting opportunities (Collina et al. 2021; Kadir et al. 2021). This interdependence underscores the importance of taking a landscape-level conservation approach, ensuring that diverse habitat types remain and are accessible to bird populations.

The predominance of insectivorous birds across habitats indicates that they are exploiting similar resources, likely due to the availability of insect prey that is abundant in agricultural settings. This can result in reduced beta diversity as the species composition becomes more uniform across different habitat types (Karp et al. 2017). The findings align with previous studies that have shown how agricultural practices can lead to a decline in habitat-specific species and an increase in functional redundancy, where multiple species fulfill similar ecological roles (Diekötter and Crist 2013; Püttker et al. 2014). In this case, the insectivorous guild may be less sensitive to habitat changes, allowing them to persist across diverse vegetation types, thus masking the potential differences in species turnover that might occur under more natural conditions (Bhuiyan et al. 2019).

Conclusion

Our results demonstrate that the diverse vegetation types along the Pacific coastal plain support a significant richness of bird species. The results showed that the studied bird community reflects a moderate degree of species replacement between the different vegetation types, evidencing a more uniform bird community, with a predominance of generalist species. Riparian forest plantations are shown to host distinct bird communities compared to the other habitat types studied. Therefore, in terms of conservation value, these results highlight the critical role that riparian habitats play in supporting unique bird assemblages not found in other vegetation types, contributing significantly to overall biodiversity and ecosystem functioning. These findings highlight the importance of small habitat patches, such as secondary and riparian forests within agricultural areas, in preserving tropical bird diversity in this region of the country. Effective management efforts in agricultural areas, such as forest restoration and natural regeneration activities, could improve the quality of riparian and terrestrial habitat, and increase the ecological integrity and resilience of bird communities.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

Species table

Authors: Sofia Aguilar-Jocol, Marco Tax, Michelle Bustamante-Castillo

Data type: xlsx

Explanation note: Correspond an observed species table, the vegetation type where were observed.

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