

Tropical forest remnants as shelters of avian diversity within a tourism development matrix in Yucatan Peninsula, Mexico

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Abstract: Tropical forests have undergone extensive transformation because of increasing tourism development, in addition to historic clearing for agricultural and cattle grazing activities. Altogether, these activities have had an important effect on bird diversity, reducing the habitat available to many species. In this study, the role of tropical forest remnants located between different land use types was evaluated for species diversity, composition, and distribution of the bird community at Akumal region in Quintana Roo, Mexico. Point counts were used to quantify the avifauna by habitat, and Shannon’s and Simpson’s diversity index were used to determine bird diversity. Additionally, bird species were classified according to seasonality and trophic guild by type of habitat. A total of 160 species and 50 families was recorded, of which 100 species were permanent residents, 47 winter visitors and 11 transients. Mature tropical forest and tropical forest remnants had higher species richness than those of modified environments. This study supports the importance of tropical forest remnants as shelters for bird species in landscapes with tourism developments, and the relevance of these remnants to maintaining high bird diversity. *Rev. Biol. Trop.* 66(2): 000-000. Epub 2018 June 01.

Key words: avian community; conservation; species richness; fragmentation; Akumal; Quintana Roo.

Tourism development is an important driver of forest fragmentation in some countries in tropical areas, in addition to the historic clearing for cattle and agriculture (Bierregaard & Stouffer, 1997; Lambin, Geist, & Lepers, 2003). Construction of tourism developments and associated infrastructure (golf courses, residential zones, recreational parks, roads, etc.) result in fragmentation of forest habitats (Fahrig, 1997; Christ, Hillel, Matus, & Sweeting, 2003; White et al., 2012), leaving many different shapes and sizes of forest remnants. Further, selective extraction of native vegetation and introduction of exotic species to increase the value of tourism complexes (Chettri, Chandra, Sharma, & Jackson, 2005; Schlaepfer, Sax, & Olden, 2011), modify plant species composition, and forest structure and

complexity (vertical stratification and plant species composition). Altogether, these environmental modifications reduce the availability of habitats with suitable attributes (e.g., food resources and shelter) to forest-dependent wild fauna, including bird communities (McGarigal & McComb, 1995; Newsome, Moore, & Dowing, 2002; Buckley, 2004).

In addition, if the number of remnants increases, distance between them increases and the exposed edge becomes larger (Fahrig, 1997; Sodhi, 2002; Sekercioglu, 2007), resulting as plausible scenario a higher mortality of bird species by high nest predation as well lower food availability near to the edge of remnants with respect to their interior (e.g., Whyte, Didham, & Briskie, 2005; Newmark & Stanley, 2011). However, these effects depend

on the attributes of avian community such as: migratory status, feeding guilds, species richness, and abundance (Stouffer & Bierregaard, 1995; Bierregaard & Stouffer, 1997); as well as forest type and the local threats facing each of them. Nevertheless, some bird species are able to use forest remnants surrounded by secondary growth, in a matrix with pasture and crops and other land uses, with stable population sizes and even experiencing significant increases in their populations (Hughes, Daily, & Ehrlich, 2002; Sekercioglu, Loarie, Oviedo, Ehrlich, & Daily 2007). Thus, this biodiversity corresponds to species generalists or species associated with anthropogenic activities (Krauss et al., 2010). Forest-interior bird species (i.e., specialist species) abilities to use the matrix of modified habitats surrounding forest fragments may affect their vulnerability in fragmented landscapes i.e. species that avoid the matrix tend to decline or disappear in fragments, while those (i.e., generalist bird species) that tolerate or exploit the matrix often remain stable or increase. However, it is not known what happens in a tourism development where forest remnants are interspersed by residential buildings and tourism activities, which are increasing across the tropical forest in Latin American.

During the period 2000-2010, world tropical forest deforestation was 62 % (Keenan et al., 2015), resulting in 6.5 million hectares lost per year. However, in Mexico showed the largest deforestation rates, with 197 651 hectares lost from the 2001 to 2015 period (see details in <http://www.globalforestwatch.org/country/MEX>). Tropical forest originally covered about 8 % of the country, being considered a world “hotspot” because of its high biodiversity and endemism (Myers, Mittermeier, Mittermeier, Da Fonseca, & Kent, 2000). Unfortunately, this ecosystem has experienced high deforestation rates, particularly since the early 1970’s, because of conversion to pastures and crops, and the establishment of tourism development. Nonetheless, it is still possible to find considerable amount of tropical forest in the Yucatan Peninsula. However, these tropical forest area consist of forest remnants surrounded by

mosaics of agricultural land, tourism development and secondary growth. Therefore, it is very important to know the characteristics and extension of these remnants of tropical forest and evaluate if it possible to conserve bird diversity and richness compared to other areas with different land uses. In order to know if the tropical forest remnants are functioning as bird diversity shelters within a matrix dominated by tourism development in one of the most important tourism area in Mexico, our goal was to better understand differences in bird species richness among natural and modified habitats in Akumal region in Quintana Roo, Mexico. In addition, to investigate the role of the different habitat types in a matrix dominated by tourism development. This study aims to provide a general understanding of how bird communities are affected by tourism development. We expected to find a lower species richness and a distinctive bird species composition in modified environments compared with natural environments (mature tropical forest and tropical forest remnants).

MATERIALS AND METHODS

Study area: The present study was carried out in Akumal, an area with several tourism developments (covering approximately 143 km²) located in the Yucatan Peninsula between 20°30’ N - 87°12’ W & 20°10’ N - 87°26’ W (Fig. 1), at the municipality of Tulum in Quintana Roo State, Mexico. This site ranges in elevation from 0 to 20 masl, climate of warm subhumid type with abundant rainfalls in summer. Annual average temperature ranges from 25 to 28 °C, and annual precipitation between 1 300 and 1 500 mm. Dominant natural vegetation in the area is tropical semideciduous forest, tropical deciduous forest, and tropical flooded forest associated with secondary growth; as well as relicts of dunes coast vegetation and mangrove. Common tree species in the study area included *Brosimum alicastrum*, *Bursera simaruba*, *Manilkara zapota*, *Talisia olivaeformis*, *Metopium brownei*, *Caesalpinia gauderi*, *Thrinax radiata*, *Coccothrinax readi* and

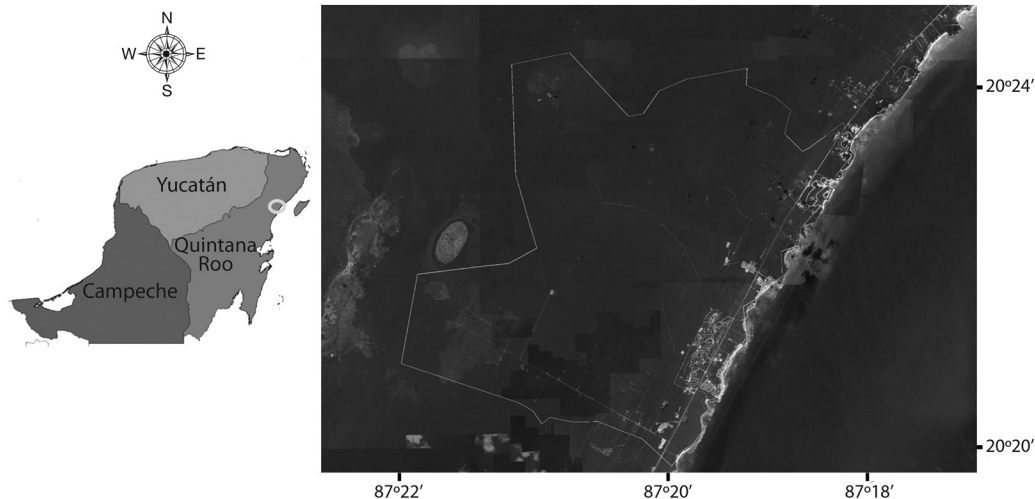


Fig. 1. Map show the location of study area in Yucatan Peninsula, Mexico. The location of study area is found in the eastern Yucatan Peninsula, and it's delimited by a square that it's shown in detail in the right panel.

Pseudophoenix sargentii. The mangrove relicts founded are dominated by *Rhizophora mangle* and *Laguncularia racemose*. From the tide line, where the sand accumulates and the soil is very unstable plants, are established *Sesuvium portulacastrum*, trailblazers like *Ambrosia hispida*, *Salicornia* and *Hymenocallis littoralis bigelavii*. This vegetation is the limit to stable dunes where there is a thicket forming shrub species complex as *Cocoloba uvifera*, *Ipomoea pes-caprae*, *Camavelia rosea*, *Sophora tomentosa*, and *Ernodea littoralis*, among others (Miranda, 1959; Rzedowski, 1978).

Habitat classification: Habitat classification was based on main vegetation cover, land uses, and the pattern of utilization by settlements as follow: (a) mature tropical forest: tropical semideciduous and tropical deciduous forest >2 ha with mature trees >10 years with canopy height 8 to 15 m and, diameters >20 cm; (b) tropical forest remnants: tropical semideciduous and tropical deciduous forest remnants <2 ha with mature trees <10 years, with canopy height 4 to 8 m and, diameters <20 cm within golf courses and residential zones; (c) modified environments by tourism developments, that include golf course and artificial water bodies

in golf course; hotels zones and residential with natural and introduced vegetation; (e) modified environments by urban developments, crops and livestock, that include urban zone with natural and introduced vegetation, cattle pastures and agricultural fields; (f) coast dunes, beach zone and small remnants mangrove.

Bird surveys: Point counts surveys were conducted along transects in the different habitat types (see above; Hutto, Pletschet, & Hendricks, 1986) from April 2009 to November 2010, for a total of 412 point counts in 96 days. Points were randomly selected to represent different types of natural vegetation and land uses in the area (107 km²). Distance between sampling points were at least 250 m to avoid double-counting of highly local species (Hutto et al., 1986; Ralph, Saber, & Droege, 1995). Observation time by point was 20 min, as proposed for tropical environments (Vielliard, 2000). Points were located in both edge and interior of the forest remnants. Sampling was conducted monthly mostly in the morning (06:00 to 11:30 h) and in the afternoon (15:30 to 20:00 h), additional to nocturnal observations. Birds were identified by sight and sound (mostly), excluding birds that overflew the

sampling points. Sampling was avoided on rainy days. Species richness was expressed as the total number of species recorded in each habitat, because effort was approximately equal at all habitats (21 days of sampling effort per habitat, with exception of coast dunes, beach zone and small remnants mangrove, which was 12 days). For species identification, Peterson and Chalif (1989), and Howell and Webb (1995) guides were used, and nomenclature and taxonomic status followed AOU (2017), as well as some supplements.

Bird attributes: Birds were categorized as resident or migratory species according to their presence during the study period and complemented with Howell and Webb (1995). Feeding habits were categorized according to which the species was feeding most frequently, which was complemented with literature sources (Peterson & Chalif, 1989; Howell & Webb, 1995) and field observations: omnivores, nectarivores, carnivores, frugivores, granivores, and insectivores (included aquatic invertebrates as well as bark insectivores, aerial insectivores, trunk insectivores, generalist insectivores, ground insectivores, and leaf insectivores). Habitat use preferences were categorized based on Blair (1996), and based on main cover vegetation of the land uses (see above).

Statistical analyses: Species richness was calculated as the cumulative number of species observed in the study area. EstimateS v.9 was used to compute species accumulation curves for the species detected by survey (number of sampling days) (Colwell, 2013). Species accumulation curves estimate the number of species expected in the study area and to compare qualitatively avian richness among habitat types, based on randomized re-sampling from all pooled samples. Asymptote from species accumulation curves was constructed by Michaelis-Menton species richness estimation function using EstimateS v.9 (Colwell & Coddington, 1994). This method estimates of total species richness based on successively larger numbers of samples from the data set. Non-parametric

estimator Jackknife 2 was selected based for having the slightest bias in the accuracy data (Walther & Moore, 2005; Hortal, Borges, & Gaspar, 2006). The Shannon diversity index (H') and Simpson's index (D) were obtained to estimate diversity among habitats (Krebs, 2000). Point Abundance Index (PAI) was calculated by dividing the number of detections for each species by the total number of point's sampled (Blondel, Ferry, & Frochot, 1970). To understand how community composition differs, and what species are present and how the habitats differ in the mix of species they have, we conducted a hybrid multidimensional scaling ordination (HMDS), using the Bray-Curtis dissimilarity index on untransformed species abundance. The hybrid MDS was introduced by Faith, Michin and Belbin (1987) and combines both the PCoA (principal coordinate analysis or classical MDS) and the non-metric MDS (NMDS). It has the advantage of assuming a linear relationship between the ecological distances obtained by the ordination and the dissimilarity measures where it is most often straight (the PCoA part), and only monotonicity where ecological distances (in the ordination space) are too high to be accurately measured (the NMDS part; Faith et al., 1987). Differences between natural environments and modified environments (see above) were tested using a permutation multivariate analysis of variance (PERMANOVA; Anderson, 2005). Data of the coast dunes, beach zone and mangrove were not included given the low number of sampling points made in those areas. All analyses were conducted using Minitab (see details <http://www.minitab.com/>).

RESULTS

We recorded a total of 1914 bird sightings during the study period, with a bird density of 54.3 individuals/observation-hour. A total of 160 species and 50 families was recorded, from which only five species are considered endemic, and 10 species were most frequently recorded (Appendix). Accumulation curves for sampling by census reached an asymptote

(Fig. 2A) in the value of 170 species. In this context, Jackknife's 2 estimator resulted in a value of 177 species, indicating that the probability of encountering more species increasing sampling effort is very low (Fig. 2B). From all detected bird species, 99 were permanent residents, 47 were winter visitors, 11 were transients, and three introduced (Appendix). The avian community in the study have a predominance of insectivore species (N= 97, see Appendix).

Bird community attributes by habitats:

A total of 96 species were found in mature

tropical forest, 92 in tropical forest remnants, 79 in modified environments by tourism developments and, 40 in modified environments by urban developments, crops and livestock (Appendix). Accumulation curves showed that the expected species richness present in mature tropical forest had the highest bird richness (Jackknife 2 = 114), followed by tropical forest remnants with expected species (Jackknife 2 = 110), modified environments by tourism developments (Jackknife 2 = 91), and (Jackknife 2 = 57; Fig. 2B). Only 17 species were exclusively found in mature tropical forest, three in tropical forest remnants, and the rest

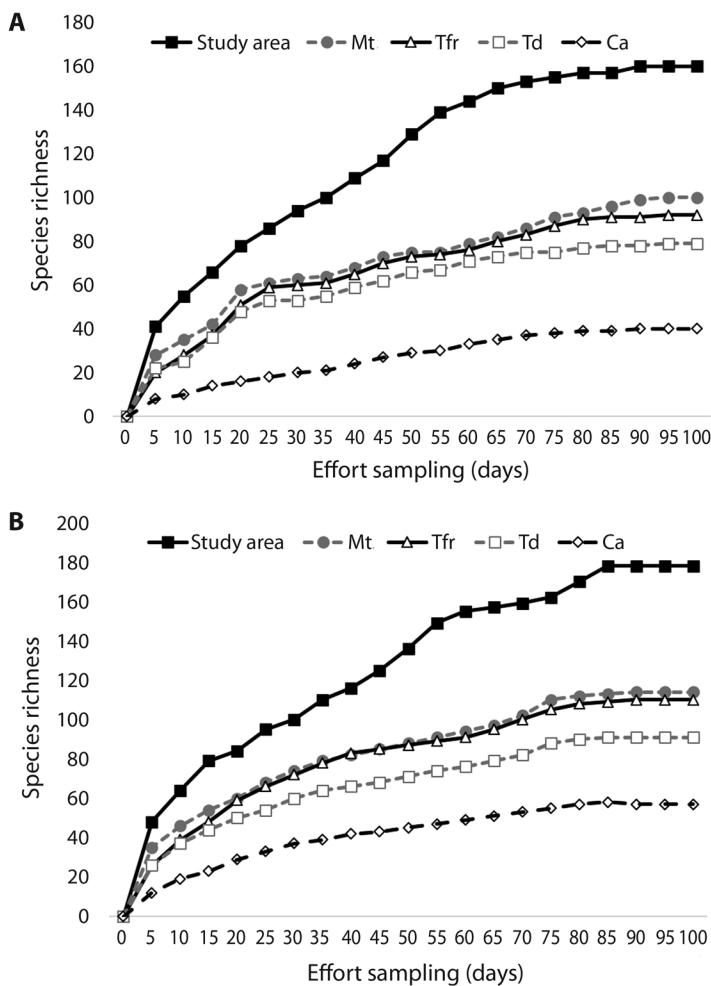


Fig. 2. Species accumulation curve for birds sampled by census in the study area. Observed species richness (a) and expected (b) in the study area and habitat type: Mature tropical forest (Mt), Tropical forest remnants (Tfr), Modified environments by tourism developments (Td), and Modified environments by urban developments, crops and livestock (Ca).

was shared, and four in modified environments by tourism developments and two in modified environments by urban development, crops and livestock, while the rest were found in two to four habitat types (Appendix). The species richness and diversity values were highest in mature tropical forest (96 species, $H' = 3.78 \pm 0.006$, $D = 0.93 \pm 0.010$) and tropical forest remnants (94 species, $H' = 3.32 \pm 0.008$, $D = 0.90 \pm 0.010$); while, modified environments by tourism developments (72 species, $H' = 2.89 \pm 0.014$, $D = 0.73 \pm 0.030$), and modified environments by urban developments, crops and livestock (40 species, $H' = 2.73 \pm 0.012$, $D = 0.69 \pm 0.029$) presented the lowest species richness and diversity values (Fig. 3). Bird species

richness and diversity values (H' , D) varied significantly among habitats (Fig. 3; $P < 0.001$), with few species detected in modified environments compared with mature tropical forest and tropical forest remnants. This was supported also by the HMDS ordination explained 55 % of the variation in species composition among habitats. Clear gradients in community composition were observed along both axes, with the centroids for mature tropical forest sites and tropical forest remnants having negative values on both axes and the centroids for modified environments (by tourism developments and by urban developments, crops and livestock) having positive values (Fig. 4). Mature tropical forest and tropical forest remnants sites were

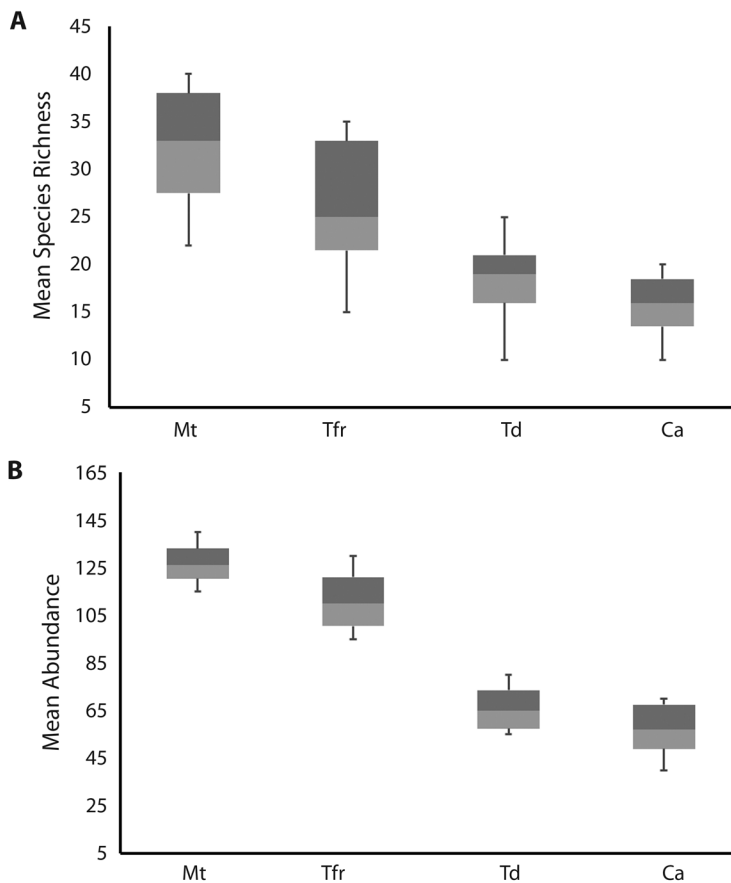


Fig. 3. Boxplots of mean species richness (a), mean abundance (b), (c) Shannon diversity index, and (d) Simpson's diversity index of bird species at Akumal region, Quintana Roo, Mexico: Mature tropical forest (Mt), Tropical forest remnants (Tfr), Modified environments by tourism developments (Td), and Modified environments by urban developments, crops and livestock (Ca). Lines represent minimum, first quartile, median, third quartile, and maximum.

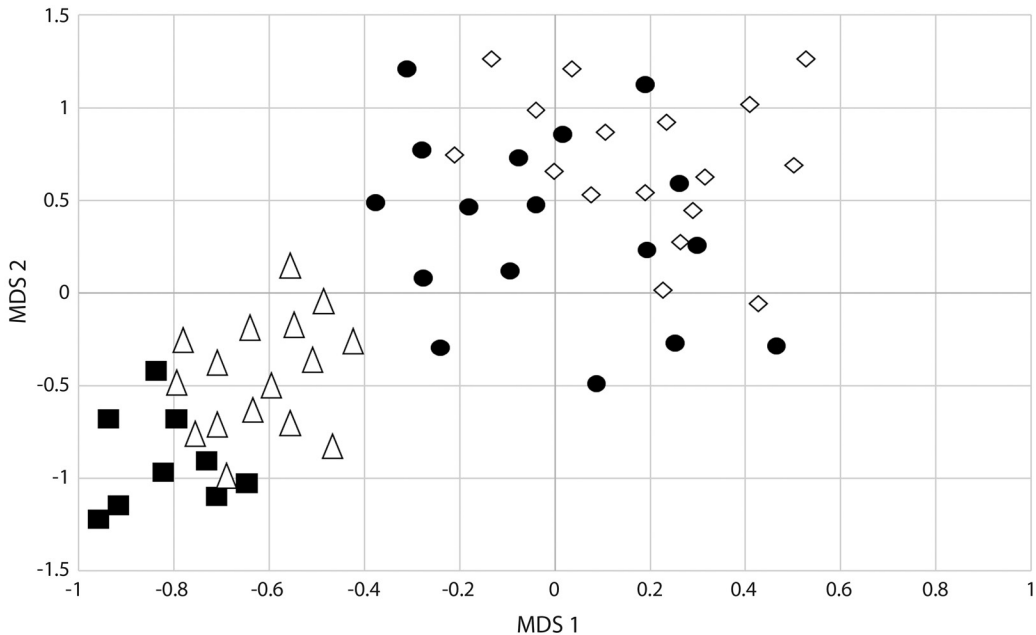


Fig. 4. Ordination plot of HMDS axes showing gradients in bird composition in mature tropical forest (■), tropical forest remnants (Δ), modified environments by tourism developments (●) and modified environments by urban developments, crops and livestock (◇).

clearly separated from modified environments, and grouping of same land-use sites was significant ($F_2 = 28.632$, $R^2 = 0.412$, $P < 0.05$) showing that bird richness differ significantly between the four analyzed habitats (Fig. 4). Similarly, with migratory status, the highest species richness of resident and migratory species was recorded in mature tropical forest (69 resident species and 26 migratory species) and tropical forest remnants (62 resident species and 35 migratory species) while modified environments by tourism developments (45 resident species, 26 migratory species, and one introduced species) and modified environments by urban developments, crops and livestock (30 resident species, eight migratory species, and two introduced species) recorded the lowest species richness; but no significant difference depending on migratory status, both migratory and resident species respond the same way. Insectivore species were better represented in the mature tropical forest, and tropical forest remnants (>16). Frugivores and nectarivores

species were slightly higher and abundant in mature tropical forest and, tropical forest remnants (with six species in each habitat). Carnivores (18), granivores (10) and omnivores (10) species were better represented in modified environments (particularly in cattle pastures and agricultural fields), and insectivore species were better represented in in mature tropical forest (65 species) and, tropical forest remnants (59; Appendix). Results in this study are consistent with respect to that modified environments (i.e., agricultural and livestock areas) had a higher proportion of carnivores and granivores species in comparison with tropical forest.

DISCUSSION

Our study revealed that mature and tropical forest remnants in Akumal region had higher bird species diversity that the modified environments, which is expected because modified environments lack suitable vegetative

remnants, shrubs and canopy cover that limits food density and diversity, nest placement, and predator avoidance. Above mentioned reveals the importance of tropical forest remnants for bird diversity conservation in a tourism area, as an important shelters to the bird community. According with our results, Bennet and Saunders (2010) mentioned that the forest remnants are very important in terms of shelter, feeding and nesting areas, particularly to birds that depend on native vegetation.

Bird species recorded accounted for 32 % of all species reported for the State of Quintana Roo by Correa and MacKinnon (2011), being the order Passeriformes the most representatives with 52 % (83 species) from the total recorded. Abundance index values (PAI) showed a large number of species with low PAI, as well as few species with intermediate to high PAI compared to the pattern observed in other surveys (Aleixo & Vielliard, 1995; Lyra-Neves, Martins, Mendes, Rodrigues, & Lacerda, 2004). Bird species richness in the study was similar to other tropical forest areas with a predominance of insectivore species (e.g., Estrada, Coates-Estrada, & Meritt, 1997; Blake & Loiselle, 2001). Omnivore species abundance can be directly related to the variety of available resources for change in land use and declining native resources like fruits. However, the presence of frugivore species, also some bark insectivore species indicate that the study area is relatively well conserved (Blake & Loiselle, 2015). Others signs of relative adequate habitat conditions included the occurrence of mixed-species flocks (Stotz, Fitzpatrick, Parker, & Moskovits, 1996), and trunk insectivores. Frequency and structure of mixed-species flocks also suggests habitat conditions at the study area were adequate for many common in tropical forest bird species according to Stotz et al. (1996). Most bird species recorded in this study were dependent on forest edge, these results suggest that the sensitivities of bird species to vegetation are associated with their dependence of food resources as availability of native fruit (Hasiu, Gomes, & Silva, 2007).

The differences in the species richness and diversity found in this study indicated that the mature tropical forest and tropical forest remnants present greater diversity and richness compared with modified environments. This accords with other studies in tropical environments, and indicates that the loss of original habitats directly influences the presence, abundance and persistence of species (Kattan, Álvarez-López, & Giraldo, 1994; Laurance & Bierregaard, 1997; Rocha, Virtanen, & Cabeza, 2015). The higher avian diversity found in tropical forest may be due to high numbers of individuals and mature vegetation that provide many different microhabitats, which promote varieties of bird species compared with habitats with different land covers (e.g., with human infrastructure or tourism development). However, others studies have found highest richness in modified environments than natural environments (Petit, Petit, Christian, & Powell, 1999; Martin, Viano, Ratsimisetra, Laloë, & Carrière, 2012), but this may be due to the environmental heterogeneity that can get to present the area.

Tropical forest remnants had a significant contribution to the bird species richness and diversity in the study area which is consistent with those reported by Estrada et al. (1997) in Los Tuxtlas region in Veracruz, Mexico. On the other hand, bird composition in terms of the feeding guilds is related to vegetation structure (Laurance & Bierregaard, 1997). Different groups of bird species were found that respond differently to the conversion of forest to modified environments. Not surprisingly, tropical forest assemblages were characterized by a high proportion of forest-associated species, whereas modified habitats were dominated by generalists and open habitat specialists. However, modified environments by urban developments, crops and livestock are very important to a lot of carnivores, granivores and insectivores species because of temporarily or permanently provide such resources depending on their phenology and seasonality (Loiselle & Blake, 1994).

In general, the tropical forest remnants that presents the study area appears to contribute to

the relatively high species richness, especially considering the number of species occurring in mature tropical forest. Results of this study showed evidence that tropical forest remnants are significantly important in tourism zones as an available habitat for birds. The continuing expansion of tourism complex, particularly large-scale, will likely result in the simplification and loss of bird diversity. That is particularly important in tourism zones from Quintana Roo because these remnants representing shelters, feeding or nesting areas for birds dependent from natural environments; as well as responsible for maintaining an important proportion of regional avian diversity. The importance of tropical forest remnants provides important habitats for many species of resident and migrant birds in Yucatan Peninsula. Our results confirm the great need for conservation (preserved areas), restoration with native vegetation, and ecological studies of tropical forests remnants, because represent the first step to take actions for conservation of regional avian diversity in the Yucatan Peninsula subjected to anthropogenic activities. An added potential value to this tourist area to attract other tourism type (as birdwatchers) as an alternative to preserve and promote ecological tourism. Furthermore, create incentives for protection and preservation on natural areas and, native biota, which allow preserve these tropical forest remnants.

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RESUMEN

Remanentes de bosque tropical como refugios de la diversidad de aves dentro de una matriz de desarrollo turístico en la Península de Yucatán, México. Los

bosques tropicales han sufrido una transformación extensa debido al aumento de los desarrollos turísticos, además de la compensación histórica de las actividades agrícolas y de pastoreo del ganado. En conjunto, estas actividades han tenido un efecto importante en la diversidad de aves, reduciendo el hábitat disponible para muchas especies. En este estudio, se evaluó el papel de los remanentes de bosque tropical para la diversidad de especies y composición de la comunidad de aves ubicados en diferentes tipos de uso de suelo en la región de Akumal en Quintana Roo, México. Se utilizaron puntos de conteo para caracterizar la avifauna por hábitat, y se utilizó el índice de diversidad de Shannon y Simpson para determinar la diversidad de aves. Además, las especies de aves se clasificaron según la estacionalidad y el gremio alimenticio. Se registraron 160 especies, distribuidas entre 50 familias; 100 especies fueron residentes permanentes, 47 visitantes de invierno y 11 transitorias. El bosque tropical maduro y remanentes de bosque tropical tuvieron una mayor riqueza de especies y valores de diversidad que los ambientes modificados. La composición de las especies de aves de los remanentes de bosque tropical fue similar a la del bosque tropical maduro, pero mayor que los ambientes modificados. Este estudio demuestra la importancia de los remanentes forestales tropicales como refugios y corredores biológicos en paisajes con desarrollos turísticos, y la relevancia de estos remanentes en el mantenimiento de una alta diversidad de aves.

Palabras clave: comunidad de aves; conservación; riqueza de especies; fragmentación; Akumal; Quintana Roo.

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APPENDIX

Bird species recorded were classified according to their migratory status and feeding habits in each habitat type in Akumal region, Quintana Roo, Mexico

Species	Migratory status	Feeding habits*	PAI	Habitat use preferences**
<i>Dendrocygna autumnalis</i>	Resident	I	0.9856	Td (Gc)
<i>Anas discors</i>	Winter visitor	I	0.6312	Td (Gc)
<i>Nomonyx dominicus</i>	Resident	I	0.9856	Td (Gc)
<i>Ortalis vetula</i>	Resident	Fr	1.8874	Td (Gc), Cbm
<i>Phoenicopterus ruber</i>	Resident	I	0.1322	Cbm
<i>Podilymbus podiceps</i>	Winter visitor	I	0.6312	Td (Gc), Cbm
<i>Columba livia</i>	Introduced	Om	2.2480	Ca (Us)
<i>Patagioenas flavirostris</i>	Resident	Fr	0.8523	Mt
<i>Streptopelia decaocto</i>	Introduced	Om	0.8523	Td (Rh), Ca (Us)
<i>Columbina passerina</i>	Resident	Gr	1.2340	Tfr , Td (Rh)
<i>Zenaida asiatica</i>	Resident	Gr	1.2340	Mt , Tfr , Td (Gc, Rh), Ca (Cp, Us)
<i>Zenaida aurita</i>	Resident	Gr	1.2003	Td (Rh), Ca (Cp, Us)
<i>Coccyzus minor</i>	Resident	Fr, I	0.0045	Mt , Tfr
<i>Chordeiles acutipennis</i>	Resident	I	0.0987	Mt , Tfr , Td (Gc)
<i>Nyctidromus albicollis</i>	Resident	I	0.0846	Mt
<i>Chaetura vauxi</i>	Resident	I	1.0084	Mt , Tfr , Td (Gc, Rh), Ca (Cp, Us)
<i>Anthracothorax prevostii</i>	Resident	Ne	0.0012	Mt
<i>Archilochus colubris</i>	Winter visitor	Ne	0.0458	Mt , Tfr
<i>Chlorostilbon canivetii</i>	Resident	Ne	0.0683	Mt , Tfr
<i>Amazilia yucatanensis</i>	Resident	Ne	0.0879	Mt , Tfr
<i>Amazilia rutila</i>	Resident	Ne	0.0879	Mt , Tfr , Td (Rh), Ca (Us)
<i>Gallinula chloropus</i>	Winter visitor	I	0.0875	Td (Gc), Cbm
<i>Fulica americana</i>	Winter visitor	I	0.0875	Td (Gc), Cbm
<i>Himantopus mexicanus</i>	Transient	I	0.0987	Td (Gc)
<i>Pluvialis squatarola</i>	Winter visitor	I	0.0784	Cbm
<i>Pluvialis dominica</i>	Transient	I	0.0012	Td (Gc), Cbm
<i>Charadrius semipalmatus</i>	Winter visitor	I	0.5489	Cbm
<i>Charadrius vociferus</i>	Winter visitor	I	0.6231	Td (Gc), Cbm
<i>Jacana spinosa</i>	Resident	I	0.0023	Td (Gc), Cbm
<i>Actitis macularius</i>	Winter visitor	I	0.0987	Td (Gc), Cbm
<i>Tringa solitaria</i>	Winter visitor	I	0.0846	Td (Gc), Cbm
<i>Arenaria interpres</i>	Winter visitor	I	0.0846	Cbm
<i>Calidris minutilla</i>	Winter visitor	I	0.0846	Cbm
<i>Calidris pusilla</i>	Transient	I	0.0784	Cbm
<i>Leucophaeus atricilla</i>	Winter visitor	Ca	0.0784	Cbm
<i>Hydroprogne caspia</i>	Winter visitor	Ca	0.0458	Cbm
<i>Chlidonias niger</i>	Transient	I, Ca	0.0030	Cbm
<i>Thalasseus elegans</i>	Winter visitor	Ca	0.0458	Cbm
<i>Thalasseus maximus</i>	Winter visitor	Ca	0.0458	Cbm
<i>Fregata magnificens</i>	Resident	Ca	0.6307	Td (Gc), Cbm
<i>Sula leucogaster</i>	Resident	Ca	0.5543	Td (Gc), Cbm
<i>Phalacrocorax brasilianus</i>	Resident	Ca	0.9936	Td (Gc), Cbm
<i>Anhinga anhinga</i>	Resident	Ca	0.9701	Td (Gc), Cbm
<i>Pelecanus occidentalis</i>	Resident	Ca	0.6111	Td (Gc), Cbm
<i>Ardea Herodias</i>	Winter visitor	Ca	0.0224	Td (Gc), Cbm

Species	Migratory status	Feeding habits*	PAI	Habitat use preferences**
<i>Ardea alba</i>	Resident	Ca	0.0458	Td (Gc), Cbm
<i>Egretta thula</i>	Resident	I, Ca	0.1322	Td (Gc), Cbm
<i>Egretta caerulea</i>	Winter visitor	I, Ca	0.1322	Td (Gc), Cbm
<i>Egretta tricolor</i>	Winter visitor	I, Ca	0.0112	Td (Gc), Cbm
<i>Bubulcus ibis</i>	Resident	I	0.7789	Ca (Cp)
<i>Butorides virescens</i>	Resident	I, Ca	0.0112	Td (Gc), Cbm
<i>Euducimus albus</i>	Resident	I	0.6803	Td (Gc), Cbm
<i>Coragyps atratus</i>	Resident	Ca	1.9635	Mt, Tfr, Td (Gc, Rh), Ca (Cp, Us)
<i>Cathartes aura</i>	Resident	Ca	1.9648	Mt, Tfr, Td (Gc, Rh), Ca (Cp, Us)
<i>Pandion haliaetus</i>	Winter visitor	Ca	0.0112	Cbm
<i>Buteogallus anthracinus</i>	Resident	Ca	0.0157	Tfr, Cbm
<i>Rupornis magnirostris</i>	Resident	Ca	0.1002	Mt, Tfr, Ca (Cp, Us)
<i>Buteo nitidus</i>	Resident	Ca	0.0875	Mt, Tfr, Ca (Cp)
<i>Tyto alba</i>	Resident	Ca	0.0045	Td (Rh), Ca (Cp, Us)
<i>Megascops guatemalae</i>	Resident	Ca	0.0012	Mt, Tfr
<i>Glaucidium brasilianum</i>	Resident	Ca	0.0012	Mt
<i>Trogon melanocephalus</i>	Resident	Fr	0.0085	Mt, Tfr
<i>Trogon caligatus</i>	Resident	Fr	0.0088	Mt,
<i>Momotus coeruliceps</i>	Resident	Om	0.0654	Mt
<i>Eumomota superciliosa</i>	Resident	Om	0.0879	Mt, Tfr
<i>Megaceryle alcyon</i>	Winter visitor	Ca	0.0085	Td (Gc), Cbm
<i>Chloroceryle americana</i>	Resident	Ca	0.0084	Td (Gc), Cbm
<i>Melanerpes pygmaeus</i>	Resident	I	0.0879	Mt, Tfr
<i>Melanerpes aurifrons</i>	Resident	I	0.6321	Mt, Tfr, Td (Rh), Ca (Us)
<i>Picoides scalaris</i>	Resident	I	0.6004	Tfr, Td (Rh), Ca (Us)
<i>Campophilus guatemalensis</i>	Resident	I	0.0081	Mt, Tfr
<i>Herpetotheres cachinans</i>	Resident	Ca	0.0879	Tfr, Ca (Cp)
<i>Falco sparverius</i>	Winter visitor	Ca	0.0701	Tfr, Ca (Cp)
<i>Falco columbarius</i>	Winter visitor	Ca	0.0556	Mt, Tfr, Td (Gc), Ca (Cp)
<i>Eupsittula nana</i>	Resident	Fr	0.7540	Mt, Tfr, Td (Rh), Ca (Cp, Us)
<i>Amazona xantholora</i>	Resident	Fr	0.6412	Mt
<i>Sittasomus griseicapillus</i>	Resident	I	0.0683	Mt
<i>Xiphorhynchus flavigaster</i>	Resident	I	0.0023	Mt
<i>Synallaxis erythrothorax</i>	Resident	I	0.0023	Mt
<i>Camptostoma imberbe</i>	Resident	I	0.0023	Mt, Tfr
<i>Myiopagis viridicata</i>	Resident	I	0.0245	Mt, Tfr
<i>Elaenia flavogaster</i>	Resident	I	0.0023	Mt, Tfr
<i>Oncostoma cinereigulare</i>	Resident	I	0.0245	Mt
<i>Todirostrum cinereum</i>	Resident	I	0.0023	Mt
<i>Rhynchocyclus brevirostris</i>	Resident	I	0.0023	Mt
<i>Contopus virens</i>	Transient	I	0.0245	Mt, Tfr
<i>Contopus cinereus</i>	Resident	I	0.0335	Mt, Tfr, Td (Rh), Ca (Cp)
<i>Attila spadiceus</i>	Resident	I	0.0335	Mt, Tfr
<i>Myiarchus yucatanensis</i>	Resident	I	0.0335	Tfr
<i>Myiarchus tuberculifer</i>	Resident	I	0.0278	Mt, Tfr, Td (Rh), Ca (Cp, Us)
<i>Myiarchus tyrannulus</i>	Resident	I	0.1150	Mt, Tfr, Td (Rh), Ca (Cp, Us)
<i>Pitangus sulphuratus</i>	Resident	Om	0.2369	Mt, Tfr, Td (Rh, Gc), Ca (Us)
<i>Myiozetetes similis</i>	Resident	I	0.4481	Mt, Tfr, Td (Rh), Ca (Us)
<i>Myiodynastes luteiventris</i>	Resident	I	0.1150	Mt, Tfr

Species	Migratory status	Feeding habits*	PAI	Habitat use preferences**
<i>Tyrannus melancholicus</i>	Resident	I	0.2369	Tfr, Td (Gc, Rh), Ca (Cp, Us)
<i>Tyrannus couchii</i>	Resident	I	0.2369	Mt, Tfr, Td (Gc), Ca (Cp)
<i>Tyrannus tyrannus</i>	Transient	I	0.1150	Mt, Tfr, Td (Rh), Ca (Cp)
<i>Tityra semifasciata</i>	Resident	Fr, I	0.2369	Mt, Tfr
<i>Pachyramphus aglaiae</i>	Resident	I	0.1123	Mt, Tfr
<i>Vireo pallens</i>	Resident	I	0.2369	Mt
<i>Vireo philadelphicus</i>	Winter visitor	I	0.2369	Mt, Tfr
<i>Vireo magister</i>	Resident	I	0.1123	Mt
<i>Psilorhinus morio</i>	Resident	Om	1.0523	Mt, Tfr, Td (Rh), Ca (Cp)
<i>Cyanocorax yucatanicus</i>	Resident	Om	1.1238	Mt, Tfr, Td (Rh)
<i>Stelgidopteryx serripennis</i>	Winter visitor	I	1.0523	Mt, Tfr, Td (Gc, Rh), Ca (Cp, Us)
<i>Riparia riparia</i>	Transient	I	1.0035	Td (Gc), Cbm
<i>Petrochelidon fulva</i>	Resident	I	1.0523	Td (Gc), Cbm, Ca (Cp)
<i>Hirundo rustica</i>	Transient	I	1.0035	Td (Rh, Gc), Ca (Cp, Us)
<i>Thryothorus maculipectus</i>	Resident	I	0.1123	Mt, Tfr
<i>Thryothorus ludovicianus</i>	Resident	I	0.1122	Mt, Tfr
<i>Uropsila leucogastra</i>	Resident	I	0.2369	Mt, Tfr
<i>Polioptila caerulea</i>	Resident	I	0.2035	Mt, Tfr, Td (Rh), Ca (Us)
<i>Catharus ustulatus</i>	Transient	I	0.1122	Mt, Tfr
<i>Turdus grayi</i>	Resident	Om	0.2369	Mt, Tfr, Td (Rh)
<i>Hylocichla mustelina</i>	Winter visitor	I	0.1122	Mt, Tfr
<i>Dumetella carolinensis</i>	Resident	I	0.2369	Mt, Tfr
<i>Melanoptila glabirostris</i>	Resident	I	0.1123	Mt, Tfr
<i>Mimus gilvus</i>	Resident	Fr, I	0.2369	Mt, Tfr, Td (Rh), Ca (Us)
<i>Arremonops rufivirgatus</i>	Resident	Gr	0.1123	Mt, Tfr
<i>Euphonia hirundinacea</i>	Resident	Fr	0.2369	Mt
<i>Dives dives</i>	Resident	Om	0.9856	Mt, Tfr, Td (Gc, Rh), Ca (Us)
<i>Quiscalus mexicanus</i>	Resident	Om	3.4522	Td (Gc, Rh), Ca (Us)
<i>Molothrus aeneus</i>	Resident	Gr	0.9856	Td (Gc, Rh), Ca (Us)
<i>Icterus prothemelas</i>	Resident	I	0.2369	Mt, Tfr
<i>Icterus cucullatus</i>	Resident	Om	0.2568	Mt, Tfr, Td (Rh)
<i>Icterus chrysater</i>	Resident	I	0.1148	Mt, Tfr
<i>Icterus auratus</i>	Resident	I	0.1148	Mt, Tfr
<i>Icterus galbula</i>	Winter visitor	Om	0.1148	Tfr, Td (Rh)
<i>Seiurus aurocapilla</i>	Winter visitor	I	0.1123	Mt, Tfr
<i>Helmitheros vermivorum</i>	Winter visitor	I	0.1123	Mt, Tfr
<i>Parkesia noveboracensis</i>	Winter visitor	I	1.0035	Mt, Tfr
<i>Mniotilta varia</i>	Winter visitor	I	0.1123	Mt, Tfr, Td (Rh)
<i>Protonotaria citrea</i>	Transient	I	0.0041	Mt, Tfr
<i>Oreothlypis peregrina</i>	Transient	I	0.0041	Mt, Tfr
<i>Oreothlypis ruficapilla</i>	Winter visitor	I	0.1148	Mt, Tfr, Td (Rh)
<i>Geothlypis poliocephala</i>	Resident	I	0.0245	Mt, Tfr
<i>Geothlypis trichas</i>	Winter visitor	I	0.0041	Tfr
<i>Setophaga citrina</i>	Winter visitor	I	0.0041	Mt, Tfr
<i>Setophaga ruticilla</i>	Winter visitor	I	0.0041	Mt, Tfr
<i>Setophaga americana</i>	Winter visitor	I	0.0041	Mt, Tfr
<i>Setophaga magnolia</i>	Winter visitor	I	0.1123	Mt, Tfr
<i>Setophaga petechia</i>	Winter visitor	I	0.1148	Mt, Tfr, Td (Rh)
<i>Setophaga caeruleascens</i>	Winter visitor	I	0.0041	Mt, Tfr

Species	Migratory status	Feeding habits*	PAI	Habitat use preferences**
<i>Setophaga virens</i>	Winter visitor	I	0.0041	Mt, Tfr
<i>Cardellina canadensis</i>	Winter visitor	I	0.0041	Mt, Tfr
<i>Cardellina pusilla</i>	Winter visitor	I	0.0245	Tfr, Td (Rh), Ca (Us)
<i>Icteria virens</i>	Winter visitor	I	0.0041	Mt, Tfr, Td (Rh)
<i>Thraupis abbas</i>	Resident	Fr, I	0.1148	Mt, Tfr
<i>Piranga roseogularis</i>	Resident	I	0.2035	Mt
<i>Piranga rubra</i>	Winter visitor	I	0.2369	Mt, Tfr
<i>Cardinalis cardinalis</i>	Resident	Gr	0.1148	Tfr
<i>Pheucticus ludovicianus</i>	Winter visitor	I, Gr	0.2035	Mt, Tfr, Td (Rh)
<i>Cyanocopsa parellina</i>	Resident	Gr	0.2369	Mt, Tfr, Td (Rh)
<i>Passerina caerulea</i>	Winter visitor	Gr	0.2568	Tfr, Td (Rh), Ca (Us, Cp)
<i>Passerina cyanea</i>	Winter visitor	Gr	0.1148	Tfr, Ca (Cp)
<i>Volatinia jacarina</i>	Resident	Gr	0.1123	Tfr, Ca (Cp)
<i>Cyanerpes cyaneus</i>	Resident	Ne	0.1123	Mt, Tfr
<i>Sporophila torqueola</i>	Resident	Gr	0.1148	Tfr, Ca (Cp)
<i>Saltator atriceps</i>	Resident	Gr	0.2035	Mt, Tfr
<i>Saltator coerulescens</i>	Resident	Gr	0.2369	Mt, Tfr