

Diversity and trophic structure of bird's community in Amazon Rainforest fragments in different stages of ecological succession

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Abstract

The diversity of birds is directly correlated with the structure of the forest. Any interfering with the vegetation produces direct effects on the avifauna through the increase, decrease, or alternation of two key attributes: food and shelter. So, the composition of life in the forest is altered as changes occur in vegetation that directly interferes with the population structure of the avifauna, be those changes natural or anthropic. This study realized in Amazon Rainforest was to analyze the groups of birds that were affected by the forest fragmentation in different stages of ecological succession and the results show alterations in the diversity and density of bird's species, principally among specialist species.

Key words : Birds, ecological succession, Amazon Rainforest

INTRODUCTION

The Amazon Rainforest is one of the principal Brazilian biome and is formed by dense tropical forests and associated ecosystems, and represents over half of the planet's remaining rainforests, and comprises the largest and most biodiverse tract of tropical rainforest in the world^[1].

Among the many factors thought to contribute to the high bird species richness in the Neotropics is the high diversity of habitat and microhabitat types, some of which are unique to tropical regions^[2,3]. The increase in structural complexity of the vegetation on various vertical levels makes new forms of occupancy of the environment possible^[4]. The increase in the number of bird species is principally due to the increase of both the new food guilds and the number of species in the existing guilds^[5].

The birds are considered the most important bioindicators of the quality of ecosystems because they are sensible to the alterations of the environment. The birds were group together according to their alimentary diet and to their forest layers, classifying those species that present feeding and similar biotope in distinct ecological groups (guilds)^[6].

The main objective of this study was to analyze the groups of birds that were affected by the forest fragmentation, using birds as ecological indicator in three sites: forest fragments in three different stages of ecological succession: initial, medium and advance stages.

MATERIAL AND METHODS

Study site

The study was carried out in Amazon Rainforest areas, situated in Southwest State of the Maranhão, Brazil, located at latitude 05°03'S to 05°15'S and longitude 47°33'W to 47°41'W, along the seasons of 1997. The climate of the region is the Aw type according to Köppen's classification. The annual average rainfall is over 1,300mm, concentrated in the summer. The annual medium temperature ranges is 26°C.

Three different natural environments were studied: a) Forest fragments in initial stage of ecological succession; b) Forest fragments in medium stage of ecological succession; c) Forest fragments in advanced stage of ecological succession. The vegetal community of these fragments is part of a forest subjected to human interference.

The forest fragments in initial stage of ecological succession have only one stratum with trees varying in average height between two and six meters. The total area covered with early growth was circa 12,000 hectares. The estimated basal area was 2.81 m².ha⁻¹ and densities ranging from 1,200 to 1,400 trees.ha⁻¹. A low species diversity was observed, H = 2.80 nats ind⁻¹.

The most important arboreal species in density and relative frequency were *Rollinia exsucca*, *Allophylus peruvianensis*, *Attalea maripa*, *Margaritaria nobilis*, *Cassia fastuosa*, *Sapium marmieri*, *Pouteria macrophylla*, *Miconia cuspidata*, *Cecropia obtusa*, *Apuleia leiocarpa*, *Inga heterophylla*, *Apeiba albiflora* and *Vismia guianensis*. Other species were important in the floristic composition of this successional stage as *Astronium gracile*, *Spondias lutea*, *Bauhinia macrostachya*, *Duguetia echinophora*, *Guateria poeppigiana*, *Oxandra reticulata*, *Protium tenuifolium*, *Mabea fistulifera*, *Himatanthus articulatus*, *Astrocaryum gynacanthum*, *Virola surinamensis* and *Guazuma ulmifolia*.

In the forest fragments in medium stage of secondary regeneration are recognizable three vertical strata of the vegetation: herbaceous stratum, understorey and canopy stratum. The canopy stratum is composed of the crowns of large sized trees, with sparse trees varying in average height between 8 and 18 meters. The total area covered in this stage of ecological succession was circa 8,000 hectares. The estimated basal area was 2.78 m².ha⁻¹ and densities ranging from 900 to 1,100 trees.ha⁻¹. A high species diversity was observed, H = 3.68 nats ind⁻¹.

The most important arboreal species in density and relative frequency were *Apeiba albiflora*, *Margaritaria nobilis*, *Rollinia exsucca*, *Helicostylis tomentosa*, *Dialium guianensis*, *Oxandra*

reticulata, *Hymenaea parvifolia*, *Sapium marmieri*, *Tabebuia serratifolia*, *Protium tenuifolium*, *Zanthoxylum rhoifolium*, *Sapindus saponaria* and *Cassia fastuosa*. Other species were important in the floristic composition of this successional stage as *Astronium lecoinei*, *Guateria poeppigiana*, *Astronium gracile*, *Cecropia obtusa*, *Duguetia echinophora*, *Himatanthus articulatus*, *Astrocaryum gynacanthum*, *Acrocomia aculeata*, *Astrocaryum vulgare*, *Lecythis usitata*, *Bagassa guianensis*, *Jacaranda copaia*, *Protium heptaphyllum*, *Mezilaurus itauba*, *Couratari guianensis*, *Hymenaea courbaril*, *Inga heterophylla*, *Inga racemiflora*, *Platypodium elegans*, *Poecilanthe effusa*, *Miconia cuspidata*, *Brosimum guianensis*, *Guapira opposita*, *Pouteria ramiflora* and *Simarouba amara*.

In the forest fragments in advanced stage of secondary regeneration are recognizable three vertical strata of the vegetation: herbaceous stratum, understorey and canopy stratum. The canopy stratum is composed of the crowns of large sized trees, with sparse trees varying in average height between 10 and 30 meters. The total area covered in this stage of ecological succession was circa 12,000 hectares. The estimated basal area was 39.83 m².ha⁻¹ and densities ranging from 600 to 800 trees.ha⁻¹. A high species diversity was observed, H = 4.24 nats ind⁻¹.

The most important arboreal species in density and relative frequency were *Rinorea passourea*, *Poecilanthe effusa*, *Metrodorea flavida*, *Chrysophyllum sparsiflorum*, *Pouteria macrophylla*, *Guapira opposita*, *Couratari guianensis*, *Siparuna guianensis*, *Croton matourensis*, *Neoraputia magnifica*, *Miconia cuspidata*, *Eugenia biflora*, *Parkia paraensis*, *Swartzia flaemingii*, *Jacaranda copaia*, *Protium tenuifolium*, *Trichilia salitunus* and *Pouteria hispida*. Other species were important in the floristic composition of this successional stage as *Cenostigma tocaninum*, *Astronium gracile*, *Astronium lecoinei*, *Duguetia echinophora*, *Guateria poeppigiana*, *Onychopetalum amazonicum*, *Rollinia exsucca*, *Aspidosperma desmathum*, *Pithecellobium latifolium*, *Astrocaryum gynacanthum*, *Protium heptaphyllum*, *Trattinickia burserifolia*, *Terminalia argentea*, *Phyllanthus nobilis*, *Parkia paraensis*, *Hymenaea courbaril*, *Nectandra rubra*, *Bowdichia nitida*, *Dipteryx odorata*, *Bagassa guianensis*, *Brosimum guianensis*, *Pouteria ramiflora*, *Theobroma speciosum* and *Vitex triflora*.

The understorey is characterized by the dominance of shrubs between 0.80 and 5 meters tall and the outstanding species in this stratum are of the families Melastomataceae, Rubiaceae, Fabaceae, Euphorbiaceae and Myrtaceae. The herbaceous stratum (generally until 0.80 meters tall) is predominated by ferns, terrestrial bromeliads and herbs as heliconias. The trees shelter a higher diversity of epiphytic plants such as bromeliads, orchids, aroids and cacti, mosses, lichens and vines. This dendricola vegetation is an outcome of saturated atmosphere of humidity. The marsh vegetation appears on poorly drained soil forming low terrains.

METHODS

Bird surveys

The method used to sample the avifauna specimens was the technique of observations per point-counts developed by Blondel *et al.* [7]. The location of the points used for this census was randomly chosen and was representative of the whole areas: for each sample, the point was sorted independently among previously determined points covering the whole areas. The points were marked at least 200 meters apart to avoid over-

representation of species with long-range voices.

The observations were realized in the first hours after the dawn and during the twilight. The samplings were accomplished in 38 days in two seasons: summer and winter of 1997 (in a total of 240 hours distributed in 720 samples). The duration of each point census as 20 minutes. The birds' identification was visual and mainly through the bird vocalization. The birds that overflying the areas without to perch on tree was not analyzed, because their dependence to the places were unlikely.

The bibliographical material used to the avifauna identification was Schauensee & Phelps [8] and Sick [9]. To the scientific nomenclature and taxonomic order was used the new systematic list of CBRO [10]. To determine if the samples were enough, were plotted the accumulated number of species against the total number of hours of observation. Since the curve reached a plateau, it was possible to conclude that the samples were enough for the registration of most species existent in each site.

The birds species recorded in the census were assigned in distinct ecological groups (guilds). The classification of the species in agreement with the respective guilds was based on that proposed for Amazon Rainforest bird communities by Willis [11]. This study was limited to trace the similar relationships of feeding habitats and preferred foraging strata in the vegetation for the following found guilds: aerial insectivores, canopy frugivores, canopy omnivores, carnivores, detritivores, edge insectivores, edge omnivores, edge seed-eater, nectar and insect eaters, riparian carnivores, swamp omnivores, trunk and twig insectivores, understorey frugivores, and understorey insectivores.

To characterize the bird community in the sites was calculated the Shannon-Weaver diversity index (H') [12], where H' max is the maximum diversity possible in the sample.

RESULTS

Taking into account 240 hours of observations, it was possible to register a total of 338 species of birds distributed in 62 families and 24 orders (Tables 1 and 2). The most representative order in number of species was Passeriformes, with 174 species distributed in 28 families.

A total of 165 bird species was recorded in the forest fragments in initial stage of ecological succession, and this site was characterized by low diversity. The Shannon-Weaver diversity index H' presented a value of 2.72. In this anthropic environment, edge omnivores and edge insectivores, respectively with 32 and 26 species were the most representative guilds. Understorey frugivores' species have little importance, because the understorey is inexpressive.

In the forest fragments in medium stage of ecological succession were registered a total of 193 species of birds and the Shannon-Weaver diversity index H' presented a value of 3.44. According to results, understorey insectivores and edge omnivores were the most representative's guilds respectively with 40 and 32 species. Other representative guilds were edge insectivores and understorey frugivores, respectively with 23 and 20 species. The number of forest species of birds registered in this site (n = 91) in comparison with com edge species (n = 64), show that the source of colonization is also responsible for the differences.

In the forest fragments in advanced stage of ecological succession were registered a total of 219 species of birds and the Shannon-Weaver diversity index H' presented a high value of 3.89, suggesting high equitability. According to results,

Table 1: Number of bird species in different guilds and in different natural environments.

Guilds	Number of species	Environments/Number of species		
		Initial stage	Medium stage	Advanced stage
Aerial insectivores	7	3	1	5
Canopy frugivores	20	7	14	16
Canopy omnivores	5	1	5	5
Carnivores	25	14	11	16
Detritivores	3	2	2	3
Edge insectivores	34	26	23	18
Edge omnivores	46	32	32	32
Edge seed-eater	14	11	9	5
Nectar and insect eaters	16	7	11	7
Riparian carnivores	19	12	8	2
Swamp omnivores	11	10	5	0
Trunk and twig insectivores	25	7	12	21
Understory frugivores	34	7	20	32
Understory insectivores	79	25	40	57
Total	338	165	193	219

Table 2: List of the bird species in different natural environments grouped into trophic guilds.

GUILDS/Family/Taxon names	English name	Environments		
		Initial stage	Medium stage	Advanced stage
AERIAL INSECTIVORES				
Apodidae				
<i>Chaetura brachyura</i>	Band-rumped Swift			X
<i>Tachornis squamata</i>	Fork-tailed Palm-Swift			X
<i>Panyptila cayennensis</i>	Lesser Swallow-tailed Swift			X
Hirundinidae				
<i>Stelgidopteryx ruficollis</i>	Southern Rough-winged Swallow	X	X	X
<i>Progne tapera</i>	Brown-chested Martin	X		
<i>Progne chalybea</i>	Gray-breasted Martin			X
<i>Tachycineta albiventer</i>	White-winged Swallow	X		
CANOPY FRUGIVORES				
Cracidae				
<i>Penelope superciliaris</i>	Rusty-margined Guan		X	X
<i>Penelope pileata</i>	White-crested Guan			X
<i>Ortalis motmot</i>	Variable Chachalaca		X	
<i>Ortalis superciliaris</i>	Buff-browed Chachalaca	X	X	X
Psittacidae				
<i>Ara chloropterus</i>	Red-and-green Macaw			X
<i>Guaruba guarouba</i>	Golden Parakeet			X
<i>Psittacara leucophthalmus</i>	White-eyed Parakeet	X		
<i>Aratinga solstitialis</i>	Sun Parakeet	X	X	X
<i>Eupsittula aurea</i>	Peach-fronted Parakeet		X	
<i>Pyrrhura perlata</i>	Crimson-bellied Parakeet			X
<i>Pyrrhura picta</i>	Painted Parakeet			X
<i>Forpus xanthopterygius</i>	Blue-winged Parrotlet		X	X
<i>Brotogeris versicolurus</i>	White-winged Parakeet		X	

<i>Forpus xanthopterygius</i>	Blue-winged Parrotlet		X	X
<i>Brotogeris versicolurus</i>	White-winged Parakeet		X	
<i>Brotogeris chiriri</i>	Yellow-chevroned Parakeet	X	X	X
<i>Brotogeris chrysoptera</i>	Golden-winged Parakeet		X	X
<i>Pionus menstruus</i>	Blue-headed Parrot		X	X
<i>Pionus maximiliani</i>	Scaly-headed Parrot		X	X
<i>Amazona farinosa</i>	Mealy Parrot	X	X	X
<i>Amazona amazonica</i>	Orange-winged Parrot	X	X	X
Icteridae				
<i>Psarocolius decumanus</i>	Crested Oropendola	X	X	X
CANOPY OMNIVORES				
Ramphastidae				
<i>Ramphastos tucanus</i>	White-throated Toucan		X	X
<i>Ramphastos vitellinus</i>	Channel-billed Toucan		X	X
<i>Pteroglossus inscriptus</i>	Lettered Aracari		X	X
<i>Pteroglossus bitorquatus</i>	Red-necked Aracari		X	X
<i>Pteroglossus aracari</i>	Black-necked Aracari	X	X	X
CARNIVORES				
Accipitridae				
<i>Leptodon cayanensis</i>	Gray-headed Kite			X
<i>Elanoides forficatus</i>	Swallow-tailed Kite			X
<i>Gampsonyx swainsonii</i>	Pearl Kite		X	
<i>Elanus leucurus</i>	White-tailed Kite			X
<i>Ictinia plumbea</i>	Plumbeous Kite	X	X	X
<i>Rostrhamus sociabilis</i>	Snail Kite			X
<i>Geranospiza caerulescens</i>	Crane Hawk	X		
<i>Heterospizias meridionalis</i>	Savanna Hawk	X	X	
<i>Urubitinga urubitinga</i>	Great Black Hawk		X	X
<i>Rupornis magnirostris</i>	Roadside Hawk	X	X	X
<i>Geranoaetus albicaudatus</i>	White-tailed Hawk			X
<i>Leucopternis kuhli</i>	White-browed Hawk			X
<i>Buteo nitidus</i>	Gray-lined Hawk	X	X	X
<i>Buteo brachyurus</i>	Short-tailed Hawk	X	X	
Tytonidae				
<i>Tyto furcata</i>	American Barn Owl			X
Strigidae				
<i>Megascops choliba</i>	Tropical Screech-Owl	X	X	X
<i>Bubo virginianus</i>	Great Horned Owl			X
<i>Glaucidium brasilianum</i>	Ferruginous Pygmy-Owl	X		
<i>Athene cucularia</i>	Burrowing Owl	X	X	
Falconidae				
<i>Daptrius ater</i>	Black Caracara	X	X	
<i>Ibycter americanus</i>	Red-throated Caracara			X
<i>Caracara plancus</i>	Southern Caracara	X		
<i>Milvago chimachima</i>	Yellow-headed Caracara	X		
<i>Herpetotheres cachinnans</i>	Laughing Falcon	X	X	X
<i>Falco rufigularis</i>	Bat Falcon	X		X
DETRITIVORES				
Cathartidae				
<i>Cathartes aura</i>	Turkey Vulture	X	X	X

<i>Cathartes burrovianus</i>	Lesser Yellow-headed Vulture			X
<i>Coragyps atratus</i>	Black Vulture	X	X	X
EDGE INSECTIVORES				
Ardeidae				
<i>Bubulcus ibis</i>	Cattle Egret	X		
Cuculidae				
<i>Crotophaga major</i>	Greater Ani	X	X	X
<i>Crotophaga ani</i>	Smooth-billed Ani	X	X	X
<i>Guira guira</i>	Guira Cuckoo	X		
Nyctibiidae				
<i>Nyctibius griseus</i>	Common Potoo		X	X
Caprimulgidae				
<i>Nyctidromus albicollis</i>	Common Pauraque	X	X	X
<i>Hydropsalis parvula</i>	Little Nightjar	X		
<i>Nannochordeiles pusillus</i>	Least Nighthawk		X	
<i>Podager nacunda</i>	Nacunda Nighthawk	X		
<i>Chordeiles rupestris</i>	Sand-colored Nighthawk	X		
<i>Chordeiles acutipennis</i>	Lesser Nighthawk	X		
Momotidae				
<i>Momotus momota</i>	Amazonian Motmot		X	X
Galbulidae				
<i>Galbula ruficauda</i>	Rufous-tailed Jacamar	X	X	X
Bucconidae				
<i>Nystalus striolatus</i>	Natterer's Striolated Puffbird	X	X	X
<i>Nystalus chacuru</i>	White-eared Puffbird	X		
<i>Monasa nigrifrons</i>	Black-fronted Nunbird	X	X	X
<i>Chelidoptera tenebrosa</i>	Swallow-winged Puffbird		X	X
Furnariidae				
<i>Furnarius leucopus</i>	Pale-legged Hornero	X		
Tyrannidae				
<i>Legatus leucophaeus</i>	Piratic Flycatcher		X	
<i>Myiarchus swainsoni</i>	Swainson's Flycatcher		X	X
<i>Myiarchus ferox</i>	Short-crested Flycatcher	X	X	X
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher	X	X	
<i>Pitangus sulphuratus</i>	Great Kiskadee	X	X	X
<i>Philohydor lictor</i>	Lesser Kiskadee	X	X	
<i>Myiodynastes maculatus</i>	Streaked Flycatcher	X	X	X
<i>Megarynchus pitangua</i>	Boat-billed Flycatcher	X	X	X
<i>Myiozetetes cayanensis</i>	Rusty-margined Flycatcher	X	X	X
<i>Myiozetetes similis</i>	Social Flycatcher	X		
<i>Tyrannus melancholicus</i>	Tropical Kingbird	X	X	X
<i>Empidonomus varius</i>	Variegated Flycatcher	X	X	X
<i>Colonia colonus</i>	Long-tailed Tyrant		X	X
<i>Fluvicola nengeta</i>	Masked Water-Tyrant	X		
<i>Knipolegus poecilocercus</i>	Amazonian Black-Tyrant		X	
Icteridae				
<i>Sturnella militaris</i>	Red-breasted Meadowlark	X		

EDGE OMNIVORES				
Tinamidae				
<i>Crypturellus parvirostris</i>	Small-billed Tinamou	X	X	X
<i>Rhynchotus rufescens</i>	Red-winged Tinamou			X
Odontophoridae				
<i>Odontophorus gujanensis</i>	Marbled Wood-Quail			X
Columbidae				
<i>Patagioenas picazuro</i>	Picazuro Pigeon		X	X
Tityridae				
<i>Pachyramphus viridis</i>	Green-backed Becard			X
<i>Pachyramphus rufus</i>	Cinereous Becard	X		
<i>Pachyramphus polychopterus</i>	White-winged Becard	X	X	X
Rhynchoyclidae				
<i>Tolmomyias sulphurescens</i>	Yellow-olive Flycatcher		X	X
<i>Tolmomyias flaviventris</i>	Yellow-breasted Flycatcher	X	X	X
Tyrannidae				
<i>Camptostoma obsoletum</i>	Southern Beardless-Tyrannulet	X	X	X
<i>Elaenia flavogaster</i>	Yellow-bellied Elaenia	X	X	X
Vireonidae				
<i>Cyclarhis gujanensis</i>	Rufous-browed Peppershrike	X	X	X
<i>Vireo olivaceus</i>	Red-eyed Vireo	X	X	X
<i>Hylophilus thoracicus</i>	Lemon-chested Greenlet	X	X	X
Turdidae				
<i>Turdus nudigenis</i>	Spectacled Thrush	X	X	X
<i>Turdus amaurochalinus</i>	Creamy-bellied Thrush	X	X	X
Mimidae				
<i>Mimus saturninus</i>	Chalk-browed Mockingbird	X		
Passerellidae				
<i>Zonotrichia capensis</i>	Rufous-collared Sparrow	X	X	
Icteridae				
<i>Cacicus cela</i>	Yellow-rumped Cacique	X	X	X
<i>Icterus cayanensis</i>	Epaulet Oriole		X	X
<i>Icterus jamaicaii</i>	Campo Troupial	X	X	X
<i>Gnorimopsar chopi</i>	Chopi Blackbird	X	X	
<i>Chrysomus ruficapillus</i>	Chestnut-capped Blackbird	X		
<i>Molothrus oryzivorus</i>	Giant Cowbird	X		
<i>Molothrus bonariensis</i>	Shiny Cowbird	X		
Thraupidae				
<i>Cissopis leverianus</i>	Magpie Tanager	X	X	X
<i>Schistochlamys melanopis</i>	Black-faced Tanager	X	X	
<i>Schistochlamys ruficapillus</i>	Cinnamon Tanager		X	
<i>Tangara episcopus</i>	Blue-gray Tanager	X	X	X
<i>Tangara sayaca</i>	Sayaca Tanager		X	
<i>Tangara palmarum</i>	Palm Tanager	X	X	X
<i>Tangara cayana</i>	Burnished-buff Tanager	X		X
<i>Nemosia pileata</i>	Hooded Tanager	X		
<i>Conirostrum speciosum</i>	Chestnut-vented Conebill	X		
<i>Lanio luctuosus</i>	White-shouldered Tanager		X	
<i>Tachyphonus rufus</i>	White-lined Tanager	X	X	X
<i>Ramphocelus carbo</i>	Silver-beaked Tanager	X	X	X
<i>Saltatricula atricollis</i>	Black-throated Saltator	X		

<i>Saltator maximus</i>	Buff-throated Saltator	X	X	X
<i>Saltator coerulescens</i>	Grayish Saltator	X	X	X
<i>Saltator similis</i>	Green-winged Saltator		X	X
<i>Saltator grossus</i>	Slate-colored Grosbeak		X	X
Cardinalidae				
<i>Caryothraustes canadensis</i>	Yellow-green Grosbeak		X	X
Fringillidae				
<i>Euphonia chlorotica</i>	Purple-throated Euphonia	X	X	X
<i>Euphonia violacea</i>	Violaceous Euphonia			X
<i>Euphonia cayennensis</i>	Golden-sided Euphonia			X
EDGE SEED-EATER				
Columbidae				
<i>Columbina talpacoti</i>	Ruddy Ground-Dove	X	X	X
<i>Columbina squammata</i>	Scaled Dove	X	X	X
<i>Columbina picui</i>	Picui Ground-Dove	X		
<i>Claravis pretiosa</i>	Blue Ground-Dove	X		
<i>Zenaida auriculata</i>	Eared Dove	X	X	
Passerellidae				
<i>Ammodramus humeralis</i>	Grassland Sparrow	X		
<i>Arremon taciturnus</i>	Pectoral Sparrow		X	
Thraupidae				
<i>Volatinia jacarina</i>	Blue-black Grassquit	X	X	X
<i>Tiaris fuliginosus</i>	Sooty Grassquit			X
<i>Sporophila lineola</i>	Lined Seedeater	X	X	
<i>Sporophila americana</i>	Wing-barred Seedeater		X	
<i>Sporophila nigricollis</i>	Yellow-bellied Seedeater	X	X	X
<i>Sporophila caerulescens</i>	Double-collared Seedeater	X	X	
<i>Sporophila angolensis</i>	Chestnut-bellied Seed-Finch	X		
Nectar and insect eaters				
Trochilidae				
<i>Glaucis hirsutus</i>	Rufous-breasted Hermit	X	X	X
<i>Phaethornis ruber</i>	Reddish Hermit	X	X	X
<i>Phaethornis superciliosus</i>	Long-tailed Hermit		X	
<i>Campylopterus largipennis</i>	Gray-breasted Sabrewing		X	X
<i>Eupetomena macroura</i>	Swallow-tailed Hummingbird		X	
<i>Anthracothorax nigricollis</i>	Black-throated Mango		X	
<i>Topaza pella</i>	Crimson Topaz	X		
<i>Chrysolampis mosquitus</i>	Ruby-topaz Hummingbird		X	
<i>Lophornis chalybeus</i>	Festive Coquette	X		
<i>Chlorestes notata</i>	Blue-chinned Sapphire		X	
<i>Thalurania furcata</i>	Fork-tailed Woodnymph		X	X
<i>Hylocharis cyanus</i>	White-chinned Sapphire	X		X
<i>Amazilia versicolor</i>	Versicolored Emerald	X		
<i>Heliothryx auritus</i>	Black-eared Fairy			X
<i>Heliomaster longirostris</i>	Long-billed Starthroat		X	X
Thraupidae				
<i>Coereba flaveola</i>	Bananaquit	X	X	
RIPARIAN CARNIVORES				
Ciconiidae				
<i>Ciconia maguari</i>	Maguari Stork	X		

Anhingidae				
<i>Anhinga anhinga</i>	Anhinga		X	
Ardeidae				
<i>Tigrisoma lineatum</i>	Rufescent Tiger-Heron		X	
<i>Agamia agami</i>	Agami Heron		X	
<i>Botaurus pinnatus</i>	Pinnated Bittern		X	
<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	X		
<i>Butorides striata</i>	Striated Heron	X		
<i>Ardeacocoi</i>	Cocoi Heron	X		
<i>Ardea alba</i>	Great Egret	X		
<i>Pilherodius pileatus</i>	Capped Heron	X		
<i>Egretta thula</i>	Snowy Egret	X		
Phalacrocoracidae				
<i>Nannopterum brasilianus</i>	Neotropic Cormorant	X		
Sternidae				
<i>Phaetusa simplex</i>	Large-billed Tern	X		
Rynchopidae				
<i>Rynchops niger</i>	Black Skimmer	X		
Alcedinidae				
<i>Megaceryle torquata</i>	Ringed Kingfisher	X	X	X
<i>Chloroceryle amazona</i>	Amazon Kingfisher	X	X	
<i>Chloroceryle aenea</i>	American Pygmy Kingfisher			X
<i>Chloroceryle americana</i>	Green Kingfisher		X	
<i>Chloroceryle inda</i>	Green-and-rufous Kingfisher		X	
SWAMP OMNIVORES				
Anhimidae				
<i>Anhima cornuta</i>	Horned Screamer	X	X	
Anatidae				
<i>Dendrocygna autumnalis</i>	Black-bellied Whistling-Duck	X		
Rallidae				
<i>Aramides ypecaha</i>	Giant Wood-Rail	X		
<i>Aramides cajaneus</i>	Gray-necked Wood-Rail		X	
<i>Laterallus viridis</i>	Russet-crowned Crake	X	X	
<i>Mustelirallus albicollis</i>	Ash-throated Crake	X	X	
<i>Gallinula galeata</i>	Common Gallinule	X		
Charadriidae				
<i>Vanellus cayanus</i>	Pied Lapwing	X		
<i>Vanellus chilensis</i>	Southern Lapwing	X		
Jacanidae				
<i>Jacana jacana</i>	Wattled Jacana	X	X	
Opisthocomidae				
<i>Opisthocomus hoazin</i>	Hoatzin	X		
TRUNK AND TWIG INSECTIVORES				
Picidae				
<i>Picumnus exilis</i>	Bahia Piculet		X	
<i>Picumnus pygmaeus</i>	Spotted Piculet			X
<i>Picumnus cirratus</i>	White-barred Piculet	X		
<i>Melanerpes candidus</i>	White Woodpecker	X	X	
<i>Melanerpes cruentatus</i>	Yellow-tufted Woodpecker		X	X
<i>Veniliornis passerinus</i>	Little Woodpecker	X	X	X
<i>Piculus flavigula</i>	Yellow-throated Woodpecker		X	X

<i>Colaptes melanochloros</i>	Green-barred Woodpecker	X	X	
<i>Celeus flavescens</i>	Blond-crested Woodpecker		X	X
<i>Celeus elegans</i>	Chestnut Woodpecker			X
<i>Dryocopus lineatus</i>	Lineated Woodpecker	X	X	X
<i>Campephilus rubricollis</i>	Red-necked Woodpecker		X	X
Dendrocolaptidae				
<i>Dendrocincla fuliginosa</i>	Plain-brown Woodcreeper		X	X
<i>Dendrocincla merula</i>	White-chinned Woodcreeper			X
<i>Sittasomus griseicapillus</i>	Olivaceous Woodcreeper			X
<i>Glyphorhynchus spirurus</i>	Wedge-billed Woodcreeper			X
<i>Xiphorhynchus spixii</i>	Spix's Woodcreeper			X
<i>Xiphorhynchus guttatus</i>	Buff-throated Woodcreeper	X		X
<i>Dendroplex picus</i>	Straight-billed Woodcreeper	X	X	X
<i>Lepidocolaptes albolineatus</i>	Guianan Woodcreeper			X
<i>Dendrocolaptes certhia</i>	Amazonian Barred Woodcreeper			X
<i>Dendrocolaptes picumnus</i>	Black-banded Woodcreeper			X
<i>Dendrocolaptes platyrostris</i>	Planalto Woodcreeper			X
<i>Xiphocolaptes falcirrostris</i>	Moustached Woodcreeper			X
Xenopidae				
<i>Xenops minutus</i>	Plain Xenops		X	X
UNDERSTORY FRUGIVORES				
Tinamidae				
<i>Crypturellus soui</i>	Little Tinamou	X	X	X
<i>Crypturellus undulatus</i>	Undulated Tinamou		X	
<i>Crypturellus tataupa</i>	Tataupa Tinamou		X	
Columbidae				
<i>Patagioenas speciosa</i>	Scaled Pigeon		X	X
<i>Patagioenas cayennensis</i>	Pale-vented Pigeon			X
<i>Patagioenas plumbea</i>	Plumbeous Pigeon	X	X	X
<i>Patagioenas subvinacea</i>	Ruddy Pigeon	X	X	X
<i>Leptotila verreauxi</i>	White-tipped Dove	X	X	X
<i>Leptotila rufaxilla</i>	Gray-fronted Dove	X	X	X
<i>Geotrygon montana</i>	Ruddy Quail-Dove			X
Trogonidae				
<i>Trogon viridis</i>	Green-backed Trogon		X	X
<i>Trogon violaceus</i>	Guianan Trogon			X
Pipridae				
<i>Tyrannetes stolzmanni</i>	Dwarf Tyrant-Manakin			X
<i>Pipra fasciicauda</i>	Band-tailed Manakin			X
<i>Ceratopipra rubrocapilla</i>	Red-headed Manakin		X	X
<i>Manacus manacus</i>	White-bearded Manakin		X	X
<i>Chiroxiphia pareola</i>	Blue-backed Manakin		X	X
Tityridae				
<i>Schiffornis turdina</i>	Thrush-like Schiffornis			X
<i>Tityra inquisitor</i>	Black-crowned Tityra			X
<i>Tityra cayana</i>	Black-tailed Tityra			X
<i>Tityra semifasciata</i>	Masked Tityra		X	X
Cotingidae				
<i>Querula purpurata</i>	Purple-throated Fruitcrow	X	X	X
<i>Lipaugus vociferans</i>	Screaming Piha		X	X

Pipritidae				
<i>Piprites chloris</i>	Wing-barred Piprites			X
Rhynchoyclidae				
<i>Mionectes oleagineus</i>	Ochre-bellied Flycatcher		X	X
Tyrannidae				
<i>Lathrotriccus euleri</i>	Euler's Flycatcher		X	X
<i>Attila spadiceus</i>	Bright-rumped Attila		X	X
Turdidae				
<i>Turdus leucomelas</i>	Pale-breasted Thrush	X	X	X
<i>Turdus fumigatus</i>	Cocoa Thrush			X
Thraupidae				
<i>Hemithraupis guira</i>	Guira Tanager		X	X
<i>Lanio cristatus</i>	Flame-crested Tanager			X
Cardinalidae				
<i>Habia rubra</i>	Scarlet-throated Ant-Tanager			X
<i>Granatellus pelzelni</i>	Rose-breasted Chat			X
<i>Cyanoloxia rothschildii</i>	Rothschild's Blue Grosbeak			X
UNDERSTORY INSECTIVORES				
Cuculidae				
<i>Coccyua minuta</i>	Little Cuckoo	X	X	X
<i>Coccyzus euleri</i>	Pearly-breasted Cuckoo		X	
<i>Piaya cayana</i>	Squirrel Cuckoo	X	X	X
<i>Tapera naevia</i>	Striped Cuckoo	X	X	X
Nyctibiidae				
<i>Nyctibius aethereus</i>	Long-tailed Potoo			X
Galbulidae				
<i>Brachygalba lugubris</i>	Brown Jacamar	X		X
<i>Galbula albirostris</i>	Yellow-billed Jacamar		X	X
<i>Galbula cyanicollis</i>	Blue-cheeked Jacamar			X
Bucconidae				
<i>Notharchus macrorhynchos</i>	Guianan Puffbird			X
<i>Notharchus tectus</i>	Pied Puffbird			X
<i>Bucco tamatia</i>	Spotted Puffbird			X
<i>Malacoptila striata</i>	Crescent-chested Puffbird			X
<i>Malacoptila rufa</i>	Rufous-necked Puffbird			X
<i>Monasa morphoeus</i>	White-fronted Nunbird			X
Thamnophilidae				
<i>Myrmotherula axillaris</i>	White-flanked Antwren		X	X
<i>Myrmotherula menetriesii</i>	Gray Antwren			X
<i>Formicivora grisea</i>	White-fringed Antwren	X	X	X
<i>Formicivora rufa</i>	Rusty-backed Antwren			X
<i>Isleria hauxwelli</i>	Plain-throated Antwren			X
<i>Thamnomanes caesius</i>	Cinereous Antshrike		X	X
<i>Dysithamnus mentalis</i>	Plain Antwren	X	X	X
<i>Sakesphorus luctuosus</i>	Glossy Antshrike		X	
<i>Thamnophilus doliatus</i>	Barred Antshrike	X		
<i>Thamnophilus palliatus</i>	Chestnut-backed Antshrike	X	X	X
<i>Thamnophilus punctatus</i>	Northern Slaty-Antshrike	X	X	X
<i>Thamnophilus aethiops</i>	White-shouldered Antshrike		X	X
<i>Thamnophilus amazonicus</i>	Amazonian Antshrike		X	X
<i>Taraba major</i>	Great Antshrike	X	X	X

<i>Hypocnemoides maculicauda</i>	Band-tailed Antbird			X
<i>Sclateria naevia</i>	Silvered Antbird		X	X
<i>Pyriglena leuconota</i>	White-backed Fire-eye		X	X
<i>Cercomacra cinerascens</i>	Gray Ant			X
<i>Cercomacroides nigrescens</i>	Blackish Antbird			X
<i>Cercomacroides laeta</i>	Willis's Antbird		X	X
<i>Cercomacroides tyrannina</i>	Dusky Antbird			X
<i>Willisornis poecilinotus</i>	Common Scale-backed Antbird			X
Conopophagidae				
<i>Conopophaga aurita</i>	Chestnut-belted Gnateater		X	
<i>Conopophaga roberti</i>	Hooded Gnateater		X	
<i>Conopophaga melanogaster</i>	Black-bellied Gnateater		X	X
Formicariidae				
<i>Formicarius analis</i>	Black-faced Antthrush	X		X
Scleruridae				
<i>Sclerurus macconnelli</i>	Tawny-throated Leafhopper			X
Furnariidae				
<i>Automolus rufipileatus</i>	Chestnut-crowned Foliage-gleaner			X
<i>Automolus infuscatus</i>	Olive-backed Foliage-gleaner			X
<i>Anabacerthia ruficaudata</i>	Rufous-tailed Foliage-gleaner		X	X
<i>Philydor erythrocerum</i>	Rufous-rumped Foliage-gleaner			X
<i>Mazaria propinqua</i>	White-bellied Spinetail			X
<i>Certhiaxis cinnamomeus</i>	Yellow-chinned Spinetail	X		
<i>Synallaxis ruficapilla</i>	Rufous-capped Spinetail		X	
<i>Synallaxis frontalis</i>	Sooty-fronted Spinetail	X	X	
<i>Synallaxis albescens</i>	Pale-breasted Spinetail	X		
<i>Synallaxis gujanensis</i>	Plain-crowned Spinetail	X		
<i>Cranioleuca vulpina</i>	Rusty-backed Spinetail	X		
Onychorhynchidae				
<i>Onychorhynchus coronatus</i>	Royal Flycatcher			X
<i>Terenotriccus erythrurus</i>	Ruddy-tailed Flycatcher			X
<i>Myiobius atricaudus</i>	Black-tailed Flycatcher		X	X
Platyrinchidae				
<i>Platyrinchus saturatus</i>	Cinnamon-crested Spadebill			X
<i>Platyrinchus mystaceus</i>	White-throated Spadebill			X
Rhynchocyclidae				
<i>Leptopogon amaurocephalus</i>	Sepia-capped Flycatcher			X
<i>Rhynchocyclus olivaceus</i>	Olivaceous Flatbill			X
<i>Todirostrum maculatum</i>	Spotted Tody-Flycatcher	X	X	X
<i>Todirostrum cinereum</i>	Common Tody-Flycatcher	X	X	X
<i>Poecilotriccus fumifrons</i>	Smoky-fronted Tody-Flycatcher	X	X	X
<i>Hemitriccus striaticollis</i>	Stripe-necked Tody-Tyrant	X		
<i>Hemitriccus margaritaceiventer</i>	Pearly-vented Tody-tyrant		X	
<i>Lophotriccus galeatus</i>	Helmeted Pygmy-Tyrant			X
Tyrannidae				
<i>Euscarthmus meloryphus</i>	Tawny-crowned Pygmy-Tyrant		X	
<i>Myiopagis gaimardii</i>	Forest Elaenia		X	
<i>Myiophobus fasciatus</i>	Bran-colored Flycatcher		X	
Troglodytidae				
<i>Microcerculus marginatus</i>	Scaly-breasted Wren			X
<i>Troglodytes musculus</i>	Southern House Wren	X	X	X

understory insectivores and understory frugivores were the most representative's guilds respectively with 57 and 32 species.

DISCUSSION

This study demonstrated that variations in habitat features among structural stages influence patterns of species abundance and composition of bird, according by Casas et al.^[13] and Modena et al.^[14] that observed in their bird studies realized in tropical forest that species composition differed significantly between the initial and advanced stages. This fact was already expected, since it is common in mature forests with great structural heterogeneity^[15,16].

The increase in the number of forest species of birds, from forest fragments in initial stages to the forest fragments in more advanced stages (from 48 to 131 birds species) is the result of the better vegetation structure in the more advanced stages. Studies realized by Bierregaard & Lovejoy^[17] in similar forests in Amazon Rainforest also showed birds' communities much diversified, mainly insectivorous. This fact is because the forest fragments in more advanced stages are the most important centers of colonization of forest species^[18,19].

Understory insectivores' species have little importance in the forest fragments in initial stage of ecological succession (n=25 species) but had a great diversity of species (n=57) in the fragments in advanced stage of ecological succession. Most small insectivores depend on forested habitats^[20] and are relatively sensitive to environmental disturbance^[21] and specialized insectivorous birds are more closely associated forest^[22].

Among the 15 species of hummingbirds observed visiting the flowers, six of these species, were registered in the forest fragments in initial stages, however, the other nine species of hummingbirds were only observed in the forest fragments in more advanced stage of ecological succession. This fact also happened for the guilds understory insectivores, understory omnivores, trunk and twig insectivores, canopy omnivores, and canopy frugivores. The significant presence of these guilds is in reason of the vertical structure of these forest fragments in medium and advanced stages of ecological succession, with three strata of the vegetation: herbaceous stratum, understorey and canopy stratum^[23]. This study showed that trophic structure of understory birds differed along the gradient of forest succession, and some trophic categories of understory birds would be more associated with the stage of forest succession than others. This result is according to the study by Modena et al.^[14] in forest tropical.

Others examples of good environmental quality are the occurrence of mixed flocks of birds and bird species follow army-ant swarms, and these examples were registered only in forest fragments in medium and advanced stages of ecological succession. Mixed flocks are groups of species that forage while move around through the understory, middle growth and through the canopies. These groups are very important in the diagnosis of the environmental quantity, because they reflect the coevolution adaptive of outlying species in relation to nuclear species^[24, 25]. Mixed-species flocking birds may increase foraging efficiency and protection from predation. Probably both factors interplay and confer advantages to the species^[26].

CONCLUSIONS

The integrity and complexity of a forest are the factors that influence the composition, abundance and probably the functions

of the assembly of different bird's species. In that way, in forest environments, where a vertical stratification of resources occurs, these species are distributed occupying a high diversity of trophic niches. They occupy different heights of the forest and a great diversity of bird species distributed among different trophic guilds, which means ecosystems relatively balanced and of great biological value.

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