Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

WNOFNS 15 (2017) 37-48 EISSN 2543-5426

Diversity of frugivorous and omnivorous birds in different stages of ecological succession in Amazon Rainforest fragments

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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. Thus, 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 was realized in fragments of the Amazon Rainforest, and the main objective was to analyze the behavior of frugivorous and omnivorous birds in three different stages of ecological succession. In forest environments where a vertical stratification of resources occurs, these species are distributed occupying a in a high diversity of trophic niches. The diversity and density of the frugivorous and omnivorous birds in the forest fragments in medium and advanced stage of ecological succession could be directly correlated not only with the structure of the forest, but also to the fact that these birds feed almost exclusively on abundant and easy to find food sources - shrub and tree fruit of certain vegetable species that are naturally abundant in the rainforest understory layer.

Keywords**:** birds, frugivory, ecological succession, Amazon Rainforest

1. 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.

The diversity of fauna is more directly correlated with the structure of the forest than the quantity of plant species in the natural environment [1]. Tropical forests possess a large variation of internal microclimates, taking advantage of both its horizontal and vertical structure. The increase in structural complexity of the vegetation on various vertical levels makes new forms of occupancy of the environment possible. The increase in the number of animal species is principally due to the increase of both the new food guilds and the number of species in the existing guilds [2].

The composition of the fauna is the product of an evolutionary process. Each animal species is dependent on certain characteristics of the vegetation and the biological interactions that determine where it will be able to exist [3]. The structure of the forest, the distance between trees, the different types of vegetation, as well as the special arrangement of the forest elements that constitute the landscape determine the patterns of movement of these animals and explain a large part of the spatial variation in the number and categories of tree visits. 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 [4, 5]. The increase in structural complexity of the vegetation on various vertical levels makes new forms of occupancy of the environment possible [6]. 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 [2].

The guild of the birds frugivorous is principally represented in the Amazon Forest, by species of the Cracidae, Psittacidae, Cotingidae, Trogonidae, and Pipridae. These species could be considered the principle seed dispersing agents in the Amazon Forest [7].

Omnivorous birds were an important guild in the Amazon Rainforest. The guild of the omnivores is composed of species which eat grains, fruit, seeds, and small arthropods, contributing considerably to the dispersion of seeds. Omnivores on the edges of the forest are the main representatives of this group, in Amazon Rainforest, especially for species of the following families: Tyrannidae, Icteridae, Ramphastidae, Vireonidae, Thraupidae, and Fringillidae [8]. The birds are considered the most important bioindicator of the ecosystems quality because they are sensible to the alterations of the environment. The main objective of this study was to analyze if the groups of birds of the both guilds frugivorous and omnivorous were affected by the forest fragmentation, analyzing the diversity of frugivorous and omnivorous birds in different stages of ecological succession in Amazon Rainforest fragments: initial, medium and advance stages.

2. MATERIALS AND METHODS

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 1,300 mm, 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 $m^2 \cdot ha^{-1}$ and densities ranging from 1,200 to 1,400 trees·ha^{-1}. A low species diversity was observed, H = 2.80 nats ind^{-1}. 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 $m^2 \cdot ha^{-1}$ and densities ranging from 900 to 1,100 trees·ha^{-1}. A high species diversity was observed, H = 3.68 nats ind^{-1}.

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 $m^2 \cdot ha^{-1}$ and densities ranging from 600 to 800 trees·ha^{-1}. A high species diversity was observed, H = 4.24 nats ind^{-1}.

The 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 being these the most important families to the fruits production to the fauna. The herbaceous stratum (generally until 0.80 meters tall) is predominated by ferns, terrestrial bromeliads and herbs as heliconias.

The method used to sample the avifauna specimens was the technique of observations per point-counts developed by Blondel *et al.* [9]. 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 is 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.

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 classification of the species in agreement with the respective ecological groups 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 frugivorous and omnivorous bird's species.

3. RESULTS AND DISCUSSION

Taking into account 240 hours of observations, it was possible to register a total of 105 frugivorous and omnivorous birds' species. Of these, a total of 47 birds' species was recorded in the forest fragments in the initial stage of ecological succession, and this site was characterized by low diversity. In this anthropic environment, birds' species who occupied the edge of the forest fragments were the most representative. Understory birds species have little importance, because the understory is inexpressive.

In the forest fragments in medium stage of ecological succession were registered 71 frugivorous and omnivorous birds' species. According to results, birds' species who occupied the edge of the forest fragments had the same representativeness that in the forest fragments in the initial stage of ecological succession, but understory frugivores had a good representativeness.

In the forest fragments in the advanced stage of ecological succession were registered a total of 85 frugivorous and omnivorous birds' species. This fact was already expected, since it is common in mature forests with great vertical heterogeneity [12, 13]. The increase in the number of frugivorous and omnivorous birds' species, from forest fragments in initial stages to the forest fragments in more advanced stages (from 47 to 85 birds species) is the result of the better vegetation structure in the more advanced stages. Studies realized by Bierregaard & Lovejoy [14] in similars forests in Amazon Rainforest also showed birds' communities much diversified. This fact is because the forest fragments in more advanced stages are the most important centers of colonization of forest species [7, 15].

The significant presence of the understory frugivorous birds in forest fragments in the medium and advanced stages of ecological succession is in reason of the vertical structure of these with three strata of the vegetation: herbaceous stratum, understorey and canopy stratum [16].

Of the plant species of the Amazon Rainforest, the majority of plant species very important as fruit producers, and are eaten by diversity of fauna species. The genus *Palicourea* (Rubiaceae family) comprehends dozens of shrub and small tree species distributed in the understory layer of the tropical rainforest. Their fruit are small berries and are fairly attractive due to their dark coloration. Among the frugivorous birds that feed on these species were members of the Pipridae family [17, 18]. Others genera of the Rubiaceae family in the understory layer of the tropical rainforest have species that produce fruit for fauna, such as *Alibertia, Bothriospora, Psychotria* and *Randia* [19].

Some species of the *Trichilia* genus (Meliaceae family), typical of understory layer of the tropical rainforest possess attributes evident to birds, such as coloration and accessibility of the fruit positioned closer to the extremities with long pedicels. The physical accessibility, determined by the structure of the fruit and their position on the branch, can determine in large part the birds' choice [20]. This could explain the large quantity of bird species that eat the fruit of these plants.

Species of the *Miconia* genus (Melastomataceae family), also typical of understory layer of the tropical rainforest and highly of great abundance in the present study in the forest fragments in the advanced stage of ecological succession, have small, rounded fruit consumed by birds [21]. Many small seeds are embedded in its sweet pulp, another characteristic of plants that belong to secondary formations that invest more in the number of seeds than nutritional reserves for the establishment of its descendants [22].

Snow [22] studied 19 shrub and tree species of the *Miconia* genus in the Amazon Rainforest. Each species produced fruit during a specific season of the year, and none bore fruit all year long. Nevertheless, fruiting season of all of the 19 species did cover the whole year. The author suggested that the various *Miconia* species compete among themselves for the services of animal seed dispersers like manakins (*Pipridae* family) and, to reduce the competition between them for dispensers, they segment the market for dispersers, offering fruit in different seasons of the year. In the present study, the manakins were registered only in medium and advanced stage of ecological succession in the forest fragments. A great diversity of bird species eats fruit from Melastomataceae species besides manakins, and in general these plants are recognized as one of the most important food sources of small frugivorous birds. In tropical forests, where manakins are one of the most numerous birds, they seem to be the most important dispersers of Melastomataceae species. However, the tanagers (Thraupidae family) are also important dispersers and, in medium high forests, substitute manakins as the most important dispersers of Melastomataceae species [23].

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**
Canopy frugivores	20	7	14	16
Canopy omnivores	5	1	5	5
Edge omnivores	46	32	32	32
Understory frugivores	34	7	20	32
Total	**105**	**47**	**71**	**85**

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**
CANOPY FRUGIVORES				
Cracidae				
Penelope superciliaris	Rusty-margined Guan		X	X
Penelope pileata	White-crested Guan			X

Ortalis motmot	Variable Chachalaca		X	
Ortalis superciliaris	Buff-browed Chachalaca	X	X	X
Psittacidae				
Ara chloropterus	Red-and-green Macaw			X
Guaruba guarouba	Golden Parakeet			X
Psittacara leucophthalmus	White-eyed Parakeet	X		
Aratinga solstitialis	Sun Parakeet	X	X	X
Eupsittula aurea	Peach-fronted Parakeet		X	
Pyrrhura perlata	Crimson-bellied Parakeet			X
Pyrrhura picta	Painted Parakeet			X
Forpus xanthopterygius	Blue-winged Parrotlet		X	X
Brotogeris versicolurus	White-winged Parakeet		X	
Brotogeris chiriri	Yellow-chevroned Parakeet	X	X	X
Brotogeris chrysoptera	Golden-winged Parakeet		X	X
Pionus menstruus	Blue-headed Parrot		X	X
Pionus maximiliani	Scaly-headed Parrot		X	X
Amazona farinosa	Mealy Parrot	X	X	X
Amazona amazonica	Orange-winged Parrot	X	X	X
Icteridae				
Psarocolius decumanus	Crested Oropendola	X	X	X
CANOPY OMNIVORES				
Ramphastidae				
Ramphastos tucanus	White-throated Toucan		X	X
Ramphastos vitellinus	Channel-billed Toucan		X	X
Pteroglossus inscriptus	Lettered Aracari		X	X
Pteroglossus bitorquatus	Red-necked Aracari		X	X
Pteroglossus aracari	Black-necked Aracari	X	X	X

EDGE OMNIVORES				
Tinamidae				
Crypturellus parvirostris	Small-billed Tinamou	X	X	X
Rhynchotus rufescens	Red-winged Tinamou			X
Odontophoridae				
Odontophorus gujanensis	Marbled Wood-Quail			X
Columbidae				
Patagioenas picazuro	Picazuro Pigeon		X	X
Tityridae				
Pachyramphus viridis	Green-backed Becard			X
Pachyramphus rufus	Cinereous Becard	X		
Pachyramphus polychopterus	White-winged Becard	X	X	X
Rhynchocyclidae				
Tolmomyias sulphurescens	Yellow-olive Flycatcher		X	X
Tolmomyias flaviventris	Yellow-breasted Flycatcher	X	X	X
Tyrannidae				
Camptostoma obsoletum	Southern Beardless-Tyrannulet	X	X	X
Elaenia flavogaster	Yellow-bellied Elaenia	X	X	X
Vireonidae				
Cyclarhis gujanensis	Rufous-browed Peppershrike	X	X	X
Vireo olivaceus	Red-eyed Vireo	X	X	X
Hylophilus thoracicus	Lemon-chested Greenlet	X	X	X
Turdidae				
Turdus nudigenis	Spectacled Thrush	X	X	X
Turdus amaurochalinus	Creamy-bellied Thrush	X	X	X
Mimidae				
Mimus saturninus	Chalk-browed Mockingbird	X		

Passerellidae				
Zonotrichia capensis	Rufous-collared Sparrow	X	X	
Icteridae				
Cacicus cela	Yellow-rumped Cacique	X	X	X
Icterus cayanensis	Epaulet Oriole		X	X
Icterus jamacaii	Campo Troupial	X	X	X
Gnorimopsar chopi	Chopi Blackbird	X	X	
Chrysomus ruficapillus	Chestnut-capped Blackbird	X		
Molothrus oryzivorus	Giant Cowbird	X		
Molothrus bonariensis	Shiny Cowbird	X		
Thraupidae				
Cissopis leverianus	Magpie Tanager	X	X	X
Schistochlamys melanopis	Black-faced Tanager	X	X	
Schistochlamys ruficapillus	Cinnamon Tanager		X	
Tangara episcopus	Blue-gray Tanager	X	X	X
Tangara sayaca	Sayaca Tanager		X	
Tangara palmarum	Palm Tanager	X	X	X
Tangara cayana	Burnished-buff Tanager	X		X
Nemosia pileata	Hooded Tanager	X		
Conirostrum speciosum	Chestnut-vented Conebill	X		
Lanio luctuosus	White-shouldered Tanager		X	
Tachyphonus rufus	White-lined Tanager	X	X	X
Ramphocelus carbo	Silver-beaked Tanager	X	X	X
Saltatricula atricollis	Black-throated Saltator	X		
Saltator maximus	Buff-throated Saltator	X	X	X
Saltator coerulescens	Grayish Saltator	X	X	X
Saltator similis	Green-winged Saltator		X	X

Saltator grossus	Slate-colored Grosbeak		X	X
Cardinalidae				
Caryothraustes canadensis	Yellow-green Grosbeak		X	X
Fringillidae				
Euphonia chlorotica	Purple-throated Euphonia	X	X	X
Euphonia violacea	Violaceous Euphonia			X
Euphonia cayennensis	Golden-sided Euphonia			X
UNDERSTORY FRUGIVORES				
Tinamidae				
Crypturellus soui	Little Tinamou	X	X	X
Crypturellus undulatus	Undulated Tinamou		X	
Crypturellus tataupa	Tataupa Tinamou		X	
Columbidae				
Patagioenas speciosa	Scaled Pigeon		X	X
Patagioenas cayennensis	Pale-vented Pigeon			X
Patagioenas plumbea	Plumbeous Pigeon	X	X	X
Patagioenas subvinacea	Ruddy Pigeon	X	X	X
Leptotila verreauxi	White-tipped Dove	X	X	X
Leptotila rufaxilla	Gray-fronted Dove	X	X	X
Geotrygon montana	Ruddy Quail-Dove			X
Trogonidae				
Trogon viridis	Green-backed Trogon		X	X
Trogon violaceus	Guianan Trogon			X
Pipridae				
Tyranneutes stolzmanni	Dwarf Tyrant-Manakin			X
Pipra fasciicauda	Band-tailed Manakin			X
Ceratopipra rubrocapilla	Red-headed Manakin		X	X

Manacus manacus	White-bearded Manakin		X	X
Chiroxiphia pareola	Blue-backed Manakin		X	X
Tityridae				
Schiffornis turdina	Thrush-like Schiffornis			X
Tityra inquisitor	Black-crowned Tityra			X
Tityra cayana	Black-tailed Tityra			X
Tityra semifasciata	Masked Tityra		X	X
Cotingidae				
Querula purpurata	Purple-throated Fruitcrow	X	X	X
Lipaugus vociferans	Screaming Piha		X	X
Pipritidae				
Piprites chloris	Wing-barred Piprites			X
Rhynchocyclidae				
Mionectes oleagineus	Ochre-bellied Flycatcher		X	X
Tyrannidae				
Lathrotriccus euleri	Euler's Flycatcher		X	X
Attila spadiceus	Bright-rumped Attila		X	X
Turdidae				
Turdus leucomelas	Pale-breasted Thrush	X	X	X
Turdus fumigatus	Cocoa Thrush			X
Thraupidae				
Hemithraupis guira	Guira Tanager		X	X
Lanio cristatus	Flame-crested Tanager			X
Cardinalidae				
Habia rubra	Scarlet-throated Ant-Tanager			X
Granatellus pelzelni	Rose-breasted Chat			X
Cyanoloxia rothschildii	Rothschild's Blue Grosbeak			X

4. 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. The diversity and density of the frugivorous and omnivorous birds in medium and advanced stage of ecological succession in the forest fragments could be directly correlated not only with the structure of the forest but also to the fact that these birds feed almost exclusively on abundant and easy to find food source: shrub and tree fruit of certain vegetable species abundant in rainforest understory layer.

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(Received 16 October 2017; accepted 30 October 2017)