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Diet of some passerines in south coast of Espírito Santo State, Brazil

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ABSTRACT

Studies about diet of birds in Atlantic Forest are scarce. In this study, we characterized the diet of Passeriformes from the south coast of Espírito Santo State, Brazil, classifying them into trophic guilds. From 26 species a total of 94 samples were obtained by regurgitation using tartar emetic method. The 855 items found were separated into two different categories: Insects (includes other terrestrial arthropods, such as spiders and opiliones) and Fruits/Seeds. The most frequent food item was Coleopterans, and the most abundant was Hymenoptera.

Key-Words: Atlantic Forest; Emetic tartar; Restinga; Trophic guilds.

INTRODUCTION

Knowledge on the diet of birds may be important for answering ecological and conservation questions (Durães & Marini, 2005). Studies of diet may also elucidate natural history of the species and guide conservation strategies (Lopes *et al.,* 2005). Although these studies are rare in Atlantic Forest (*e.g.,* Durães & Marini, 2005; Lopes *et al.,* 2005), they are essential for a better understanding on the ecology of the species (Poulin *et al.,* 1994). Studies of diet provide important data about evolution, ecology and conservation of species (Durães & Marini, 2005). Separating the diet into food categories (*e.g.,* insects and fruits), and the species into trophic guilds allows determining the habitat of a species based on the location of food consumed (Brändle *et al.,* 2002). This information can help conserving the habitat of species (Gomes *et al.,* 2008) as showed by Motta-Junior (1990), who studied the trophic structure of birds and concluded that degraded areas might represent a difference between birds' populations.

Interspecific competition is the concurrency between individuals of different species, but with similar ecological preference/niche/food. In these cases, competition for resources might result in the elimination of the less skillful species (Wasserman, 1996). This type of competition probably affects population dynamics, and can influence species distribution and their evolution (Begon *et al.,* 2007). On the other hand, if two species have different preferences, it is possible the coexistence without or small competition

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(Wasserman, 1996). Knowledge in diet is essential to development of hypothesis to elucidate the evolution of the coexistence between species, but studies about diet of birds is still scarce and there are few survey study of bird diet in Atlantic Forest (*e.g.,* Durães & Marini, 2005; Lopes *et al.,* 2005; Telino-Júnior *et al.,* 2005; Lima *et al.,* 2010).

In this study we describe the diet of passerines in restinga separating them into food categories, since this kind of study is scarce in restinga.

MATERIALS AND METHODS

Study Area

We sampled three different phytophysiognomy of Atlantic forest: the non-flooded restinga (sand-coastal plain) region of Parque Estadual Paulo César Vinha (PEPCV) (20°38'S; 40°26'W) located in Guarapari municipality; the Arboreal Restinga and the mangrove in municipality of Anchieta (20°45'S; 40°35'W). All areas are located in the south coast of Espírito Santo State, Brazil. The areas of arboreal restinga and mangrove were located in private properties with disturbed areas and cattle invasion. Those areas also had noise and atmospheric pollution derived from iron ore facilities nearby. Some samples of arboreal restinga were obtained next to lagoons and to the riparian forest of Benevente River. According to the Köppen classification, the regional climate is monsoon (Alvares *et al.,* 2013) with hot and rainy summers and dry winters, a mean annual temperature of 23.3°C, a mean annual rainfall of 1,307 mm, and a mean annual relative humidity of 80% (Fabris, 1995).

Bird Sampling

We made surveys between October 2010 and September 2011. Birds were captured using mist nets (12 m in length, 2.5 m in height, 16 and 19 mm mesh size). Captures occurred between 05h30min am and 11h00min am (when birds are usually most active). Individuals trapped were marked with metallic rings from CEMAVE/ICMBIO (Authorization number 3138/4), weighed with Pesola® spring scales and identified using field guides with taxonomic recommendations of Brazilian Committee of Ornithological Records CBRO (2015) (Piacentini *et al.,* 2015).

We forced birds to regurgitate with the administration of 1% antimony potassium tartarate solution (emetic tartar) at the dosage of 0.8 ml per 100 g of body mass, method tested and suggested by Durães & Marini (2005). The solution was given through a thin flexible tube attached to a syringe of 1 ml, introduced until the end of the esophagus. After the introduction of the liquid, the bird was kept in a dark ventilated box, lined with paper to avoid material loss. Regurgitations were stored in 70% alcohol for posterior analysis and samples were examined under a stereoscopic microscope. Food items were identified, counted and grouped into categories according to Durães & Marini (2005): Insects (includes other terrestrial arthropods, such as spiders, opiliones, and others) and vegetable (seeds, fruits and plant material). We consider samples containing only liquid, and samples from individuals that did not regurgitate or died during the emetic procedure.

All data were collected according the ethics committee (Number 74/2009) and SISBIO (Number 20216-1) permissions.

Data Analysis

In this study, we classified species using the Index of Alimentary importance (IAi) that considers the frequency of occurrence of consumed items. The index (IAi) corrects the importance of items occurring frequently, but at low abundance or items occurring rarely but at high abundance among the diet sample (Durães & Marini, 2005). It shows the importance of each alimentary category allowing the inclusion of each bird species in trophic guilds. It is expressed by the equation:

$$\mathrm{IAi} = \left(\frac{\mathrm{ROi} \times \overline{\mathrm{RAi}}}{\sum_{i=1}^{n} (\mathrm{ROi} \times \overline{\mathrm{RAi}})} \right)$$

Where IAi = Index of Alimentary importance, ROi = relative occurrence of the item "i" (where RO is the number of samples where category "i" occurs relative to n), RAi = relative abundance of the item "i" (where RA is the number of diet items belonging of category "i" relative to the total number of diet items in the sample).

Before the analysis, we grouped the 13 seed morphotypes into one category called Seeds, and the 17 arthropods taxa into a category called Insects. We calculated the mean relative abundance and the relative occurrence of alimentary categories in order to obtain the IAi (see details in Durães & Marini, 2005). For species with small or inadequate samples (< 5 samples), we calculated the Relative Abundance as percentage.

TABLE 1: Classification of the species from restinga and mangrove areas in south coast of Espírito Santo State, Brazil, into throphic guilds using the food importance index (IAi). RO = Relative Occurrence, RA_{mean} = Mean Relative Abundance, FRU_{INS} = Predominantly Frugivore, INS = Insectivorous, FRU = Frugivorous, OMN = Omnivorous

Species	N	Arthropods			Seeds + fruits			Trophic Guilds
		RO	RA_{mean}	IAi (%)	RO	RA_{mean}	IAi (%)	
Formicivora rufa	6	1.00	0.88	97.8	0.17	3.38	2.2	INS
Formicivora grisea	3	1.00	1.00	100.0	0.00	0.00	0.0	INS
Thamnophilus ambiguus	4	1.00	0.93	98.3	0.25	1.48	1.7	INS
Elaenia chiriquensis	9	0.67	0.60	71.5	0.44	8.77	28.5	OMN
Elaenia flavogaster	4	0.50	0.50	50.0	0.50	0.50	50.0	OMN
Tyrannus melancholicus	4	1.00	0.83	95.2	0.25	1.13	4.8	INS
Camptostoma obsoletum	2	1.00	1.00	100.0	0.00	0.00	0.0	INS
Hylophilus thoracicus	2	1.00	0.88	93.3	0.50	1.66	6.7	INS
Troglodytes musculus	2	1.00	1.00	100.0	0.00	0.00	0.0	INS
Turdus leucomelas	4	0.75	0.46	45.80	0.75	0.30	54.2	OMN
Turdus amaurochalinus	3	0.33	0.05	1.7	1.00	0.36	98.3	FRU
Tangara sayaca	3	0.33	0.08	6.6	0.67	0.36	93.4	FRU
Hemithraupis flavicollis	2	0.50	0.50	50.0	0.50	0.50	50.0	OMN
Ramphocelus bresilius	6	0.33	0.30	14.2	0.83	1.98	85.0	FRU_{INS}
Coryphospingus pileatus	5	0.80	0.70	38.1	0.40	1.37	61.9	OMN
Amodrammus humeralis	2	1.00	1.00	100.0	0.00	0.00	0.0	INS
Zonotrichia capensis	9	0.80	0.74	92.5	0.30	12.31	7.5	INS
Sporophila caerulescens	2	0.50	0.50	50.0	0.50	0.50	50.0	OMN
Sporophila bouvreuil	2	0.50	0.50	50.0	0.00	0.00	0.0	OMN
Volatinia jacarina	10	0.60	0.24	19.1	0.80	3.71	80.9	FRU_{INS}
Coereba flaveola	2	0.50	0.50	50.0	0.00	0.00	0.0	OMN
Geothlypis aequinoctialis	6	1.00	1.00	100.0	0.00	0.00	0.0	INS

The trophic guilds were based on the following criteria: 1 = Insectivore, those with diet exclusively composed by insects (includes other terrestrial arthropods, such as spiders and opiliones) ($AI_{insects} \geq 90\%$); 2 = Omnivore, those with a mixed diet composed by significant proportions of insects, seeds and fruits ($AI_{insects}$ and $AI_{fruits+seeds} \geq 20\%$ either); 3 = Frugivore, those with diet composed exclusively by fruits and seeds ($AI_{fruits+seeds} \geq 90\%$); 4 = Predominantly Frugivore, those with most part of the diet composed by fruits and seeds and occasionally by insects ($20\% \geq AI_{insects} \geq 10\%$); 5 = Predominantly Insectivore, those with most part of the diet composed by insects and occasionally by seed and fruits ($20\% \geq AI_{fruits+seeds} \geq 10\%$). This criterion was adapted from Durães & Marini (2005) and Lopes *et al.* (2016).

We verify the correlation between Relative Abundance (RA) and Relative Occurrence (RO) data of insects, seeds and fruits. We calculated Relative Abundance and Relative Occurrence for each food item found in the samples and thereafter food items were ranked. We used Pearson correlation to assess the correlation between occurrence and abundance of samples of insects. All analyses were performed according to Zar (1999) using the BioEstat 5.0 (Ayres & Ayres-Jr., 2007) considering $\alpha < 0.05$ as the significance level.

RESULTS

From the total birds that regurgitated, we obtained 94 samples of 26 species from 8 families, and 855 food items separated into 28 taxons (see Appendix). To estimate IAi, we selected the 22 species with more than one regurgitated sample. From these species, we classified 10 as insectivorous, two as frugivorous, two as predominantly frugivorous and eight as omnivores (Table 1).

Most samples of Insects presented a significant correlation between occurrence and abundance ($r = 0.932$; $p < 0.001$), and samples of Seeds + Fruits presented a non-significant correlation between RO and RA ($r = -0.116$; $p = 0.682$). In the food rank, the more frequent item was Coleoptera (RO = 37.1%), followed by Hymenoptera non-Formicidae (RO = 34.3%) and Hymenoptera – Formicidae (RO = 24.8%). The most abundant item was Hymenoptera non-Formicidae (Table 2).

Representative samples, with items in good state of conservation, were obtained from most of the individuals. From 124 attempts, only six individuals (4.8%) did not regurgitate. From 110 samples obtained, only four (3.6%) were empty or in an advanced state of fragmentation that did not allow

TABLE 2: Rank of Relative Occurrence and Abundance (%) of food items in decreasing order from restinga and mangrove areas in south coast of Espírito Santo State, Brazil. The numbers in parentheses represent relative abundance ranks

Food Items	Relative Occurrence	Relative Abundance (Rank)
Coleoptera	37.1	12.4 (2)
Hymenoptera non-Formicidae	34.3	23.9 (1)
Formicidae	24.8	11.3 (5)
Fruits	10.5	1.4 (11)
Seed_8	5.7	13.1 (4)
Seed_5	4.8	15.5 (3)
Seed_1	4.8	4.5 (6)
Orthoptera	4.8	1.6 (10)
Aranae	4.8	1.2 (12)
Lepidoptera Larva	4.8	1.2 (13)
Seed_9	3.8	3.0 (7)
Seed_6	3.8	2.3 (8)
Hemiptera	3.8	0.7 (14)
Coleoptera Larva	3.8	0.5 (17)
Seed_11	2.9	1.7 (9)
Seed_12	2.9	0.6 (15)
Odonata	2.9	0.5 (18)
Plant parts	2.9	0.3 (21)
Seed_2	1.9	0.6 (16)
Seed_3	1.9	0.5 (19)
Seed_4	1.0	0.2 (22)
Coleoptera (Curculionidae)	1.0	0.1 (23)
Coleoptera (Cerambicidae)	1.0	0.1 (24)
Collembola	1.0	0.1 (25)
Blattodea	1.0	0.1 (26)
Diptera	1.0	0.1 (27)
Thysanoptera	1.0	0.1 (28)
Seed_7	1.0	0.1 (29)
Seed_10	1.0	0.1 (30)
Seed_13	1.0	0.1 (31)
Opiliones	1.0	0.5 (20)

identification of food items. The mortality rate of the birds was 7.1%.

DISCUSSION

We observed a prevalence of insectivorous species (52.6%). Considering that Tyrannidae was the most abundant family – most exclusively composed by insectivorous species (Sick, 1997) – this result was expected. Other studies in Atlantic Forest (Durães & Marini, 2005) and Cerrado (Piratelli & Pereira, 2002) found similar results. Gomes *et al.* (2008) showed a prevalence of frugivorous species in a restinga area of Rio de Janeiro, but this result was obtained through direct observation method and fecal analysis. All of three representatives of the Thamnophilidae family found in the study area were classified as insectivorous. This family is described as insectivorous (Sick, 1997) and has many army-ant-follow species. Our results corroborate other studies performed in Atlantic Forest (Gomes *et al.,* 2001; Piratelli & Pereira, 2002; Lopes *et al.* 2005).

Two species presented a different trophic guild in our classification when compared with literature. *Zonotrichia capensis* and *Ammodramus humeralis* are classified as granivorous (Sick, 1997), and in our study they are classified as insectivorous. Insects are an important food resource for frugivorous during breeding (Sick, 1997), which may explain this inconsistence, although our data was not sufficient to confirm this factor.

We observed a high correlation in samples containing insects, which may indicate that the food items were abundant and frequent in the same proportion. Samples containing seeds and fruits did not have a significant correlation, which indicates the presence of some abundant but uncommon items and vice versa. Hymenopterans and Coleopterans occupied top positions on the rank of occurrence and abundance, corroborating several studies (Gomes *et al.,* 2001; Durães & Marini, 2005; Lopes *et al.,* 2005). This fact can be explained by the difficulty of digestion of these items due to their chitinous skeleton. Other factor that may affect this rank is the availability of these items in the study area. However, to confirm this hypothesis it is necessary to evaluate richness and abundance of insects in the study area to obtain the estimated amount and diversity of insects available to the birds.

The mortality rate found in this study (7.1%) is lower than rates found by Durães & Marini (2005) (10%), but higher than the ones found by Poulin *et al.* (1994) (2%) and Lopes *et al.* (2005) (2.3%). The lower mortality rate can be attributed to the concentration used in this study (1%), less than the concentration of 1.2% used by Durães & Marini (2005). Poulin *et al.* (1994) recommend reducing concentration to 1% in order to decrease the mortality rate in individuals.

RESUMO

Estudos sobre a dieta de aves em Mata Atlântica são raros. Neste estudo, caracterizou-se a dieta de Passeriformes na costa sul do estado do Espírito Santo, Brasil, classificando-os em guildas tróficas. Um total de 94 amostras foram obtidas de 26 espécies utilizando o método do tártaro emético. Os 855 itens encontrados foram separados

em duas categorias: Insetos (inclui outros artrópodes terrestres como aranhas e opiliões) e Frutos/Sementes. O item mais frequente foi Coleoptera e o mais abundante foi Hymenoptera.

Palavras-Chave: Guildas tróficas; Mata Atlântica; Restinga; Tártaro emético.

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