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ASSESSMENT OF STOMACH CONTENTS OF SOME AMAZONIAN BIRDS

Paulo Ricardo Siqueira[1,3], Marcelo Ferreira de Vasconcelos[2], Raissa M. M. Gonçalves[1], & Lemuel Olívio Leite[1]

[1]Pós-graduação em Ciências Biológicas, Universidade Estadual de Montes Claros, Montes Claros, Minas Gerais, Brazil.

[2]Museu de Ciências Naturais, Pontifícia Universidade Católica de Minas Gerais, Avenida Dom José Gaspar, 290, Coração Eucarístico, 30535-901, Belo Horizonte, MG, Brazil.

[3]Current address: Universidade Estadual de Montes Claros. Laboratório de Ornitologia, Avenida Ruy Braga s/n, Vila Mauriceia, 39401-089, Montes Claros, Minas Gerais, Brazil. Telephone: + 55 38 3229-8191. *E-mail:* paulozoologo@gmail.com

Resumo. – Avaliação dos conteúdos estomacais de algumas espécies de aves amazônicas. - Estudos sobre a dieta das aves fornecem informações sobre a biologia e ecologia das espécies, como por exemplo, predação e a competição. Mesmo apresentando grande importância, poucos estudos sobre dieta têm sido desenvolvidos na região Neotropical, principalmente na Amazônia. A floresta amazônica brasileira apresenta uma elevada biodiversidade de aves, com aproximadamente 1300 espécies residentes. No entanto, a ecologia trófica da avifauna dessa floresta ainda é pouco estudada. O presente trabalho tem como objetivo avaliar a composição da dieta de algumas espécies de aves da Amazônia. As aves foram coletadas no município de Aripuanã, na região nordeste estado do Mato Grosso, Brasil. O método utilizado para acessar a dieta das espécies foi o do conteúdo estomacal de espécimes coletados. Analisamos o conteúdo estomacal de 59 indivíduos representantes de 40 espécies. Um total de 573 itens alimentares foi identificado, os quais foram organizados em 16 grupos. Desses grupos alimentares, a ordem Hymenoptera apresentou a maior abundância. Já em relação à frequência, os himenópteros e os coleópteros foram os mais representativos. Nossos resultados incluem informações sobre a dieta de espécies endêmicas da Amazônia, sendo muitas dessas informações desconhecidas na literatura. Essas informações são importantes para posteriores estudos sobre a biologia e ecologia das espécies de aves amazônicas.

Abstract. – Studies on avian diet provide important information about biology and ecological relationships of species, for instance, predation and competition. Despite the importance, studies about trophic ecology in the Neotropical region are still scarce, especially in the Amazonian region. The Brazilian Amazon hosts a high diversity of birds, with about 1300 resident species. However, trophic ecology of the regional avifauna is still poorly studied. This paper aims to describe the composition of the diet of some Amazonian bird species. Bird specimens were collected in the Aripuanã municipality, northern Mato Grosso state, Brazil. The analysis of the stomach contents of the collected birds was the method used to assess diets of birds. We analysed the stomach contents of 59 birds of 40 species. A total of 573 food items were identified and could be assigned to 16 different classes. Hymenoptera was the most abundant class. Hymenoptera and Coleoptera classes were the most frequent. Our results provide information on the diet of endemic Amazonian species, of which there is a lack of information in the literature. These facts are therefore important for future studies on the biology and ecology of these birds.

Key words: Amazonian rainforest, bird diet, endemism, food items, rare birds.

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INTRODUCTION

The diet of an organism is a result of its physiological, morphological, and behavioral adaptations in coherence with environmental processes (Schoeman & Jacobs 2011). The analysis of diets allows us to understand many ecological aspects, such as predation and competition (Wiens & Rotenberry 1979, Naoki 2007). Despite of the importance, studies on diet are still scarce (e.g., Poulin *et al.* 2001, Durães & Marini 2005, Lima *et al.* 2010, Manhães *et al.* 2010), especially in the Amazonian region (e.g., Mestre 2002, Mestre *et al.* 2010).

The Amazon rainforest hosts one of the highest levels of biodiversity in the world. Regarding birds, a number of 1300 species occurs only in the Brazilian Amazon, representing about 70% of the total of birds registered in the country (Mittermeier *et al.* 2003, Marini & Garcia 2005, CBRO 2014). The endemism in this region is also high, where about 20% of birds are endemic (Mittermeier *et al.* 2003, Marini & Garcia 2005). As far as avialbale, studies on the diet of Amazonian birds usually contain information on a small number of species (e.g., Roth 1984, Mestre 2002, Aguiar & Coltro-Jr 2008, Aguiar & Naiff 2009, Mestre *et al.* 2010, Omena-Jr. & Santos 2010). The single work presenting a good amount of data on the diet of Amazonian birds was published by Schubart *et al.* (1965), when the authors analyzed around 340 stomach contents from museum specimens.

Several methods are used to sample the diet of birds. These methods are: focal observation (e.g., Pineschi 1990, Galetti *et al.* 2000, Traveset *et al.* 2001, Mikich 2002, Manhães 2003); fecal analysis (e.g., Manhães *et al.* 2010, Omena-Jr. & Santos 2010); induced regurgitation by the use of emetic tartar (e.g., Poulin *et al.* 1994, Mestre 2002, Durães & Marini 2003, Lopes *et al.* 2005, Mestre *et al.* 2010); and analysis of stomach contents of collected specimens (e.g., Moojen *et al.* 1941, Moojen 1942, Hempel 1949, Schubart *et al.* 1965, Lima *et al.* 2010). Among them, the latter seems to be more effective because it allows greater precision in relation to the quantity and quality of the taxa in the samples (Rosenberg & Cooper 1990). The same does not happen with the other methods cited, mainly regarding insectivorous birds, because the aforementioned methods don't allow the total assessment of all stomach contents since the items are more digested (fecal analysis), ingested items are not precisely observed (focal observation), and there may be failure on obtaining the diet of all species (induced regurgitation). These facts may cause overestimation and underestimation of some items on diets (Rosenberg & Cooper 1990, Remsen *et al.* 1993).

Thus, the aim of this study was to evaluate the diet composition of some Amazonian species, emphasizing the diet of endemic species without previous dietary records.

METHODS

Samples of stomach contents were obtained from voucher-specimens (preserved in alcohol 70%) deposited at the Ornithological Collection of the Department of Zoology of the Federal University of Minas Gerais (DZUFMG), Belo Horizonte, Minas Gerais, Brazil. Birds specimens were collected in an Amazonian forest fragment at the Aripuanã municipality (10°09'S, 59°26'W), northern Mato Grosso state, Brazil, in October 2004 (dry season) and March 2005 (wet season). Carcasses of the birds specimens were sent to the Laboratory of Ornithology at State University of Montes Claros (LO-Unimontes), where food items were removed from their stomachs and identified with the aid of a stereoscopic microscope.

Arthropods found in the samples were identified to the lowest possible taxonomic level with specialized literature (Borror *et al.* 1989, Gullan & Cranston 2007) and by comparison with the collection of arthropods of the LO-Unimontes. The development stage of insects (adult or larvae) was identified whenever possible. Insects stage of development was identified based on morphological differences presented by larvae and adults. Due to the fragmented state of samples, we considered a minimum number of items per category, for example, a pair of similar elytra was considered an individual of Coleoptera, vertebrate specimens found were classified as subphylum level (Vertebrata), vegetal matter was separated into seeds or other plant material (due to the difficulty in identifying fragments of fruits and flowers), and seeds were separated into different morphospecies.

RESULTS

Stomach contents of 59 birds, belonging to 40 species and 19 families, were analyzed and the results are presented in the Appendix 1. We found 573 food items, of which 68.4% were invertebrates (of which 92.7% were Insecta), 31.4% vegetal matter, and 0.2% vertebrates. We were able to assign the food items to 16 different classes. The classes Hymenoptera (22%) (specially composed by Formicidae) and Coleoptera (22%) were the two most frequent classes presented in the samples (Fig. 1). The less frequent classes, each one presenting only one specimen, were Chilopoda, Vertebrata (Subclass Actinopterygii), Lepidoptera, and Diptera. Hymenoptera was the most abundant class (33%), followed by seeds (30%) and Coleoptera (17%) (Fig. 1). Together, those accounted for 80% of the total abundance (Appendix 1).

The 16 classes identified were different in relation to the percentage values of abundance and frequency. The classes Hymenoptera and Seeds showed the highest percentage values of abundance (Fig. 1). For all other classes, the frequency showed higher percentage values than abundance (Fig. 1). Seeds presented the highest ratio between percentage of abundance and percentage of frequency. This class abundance was almost three times higher than frequency.

We identified seven morphospecies of seeds that are represented in Appendix 1 and Fig. 2. Regarding the size of morphospecies, we found in *Attila phoenicurus* stomach the largest seed (morphospecies 6) with 7.2 mm length (Fig. 2, Appendix 1). Furthermore, in *H. punctulatus* and *B. chrysoptera*, we found the smallest morphospecies, the morphospecies 2, with 0.85 mm length (Fig. 2, Appendix 1).

DISCUSSION

High importance of Hymenoptera and Coleoptera in the diet of Amazonian birds could be explained by the high species richness and abundance, respectively, in the tropical region (Janzen & Schoener 1968, Wilson 1987, Nadkarni & Longino 1990, Stork & Grimbacher 2006). The predominance of insects in the diet of birds was also observed by other authors (e.g., Poulin *et al.* 1994, Durães & Marini 2003, Moorman *et al.* 2007). The social behavior of Formicidae (Hymenoptera) species can contribute to the abundance of this taxon in the diet of birds, since these insects usually live in colonies and are also often found in high concentrations (Haemig 1994, Manhães *et al.* 2010).

Some species, such as *Aratinga weddellii*, *Lepidothrix nattereri*, and *Heterocercus linteatus*, previously considered frugivorous (Silva 1996), showed consumption of invertebrates

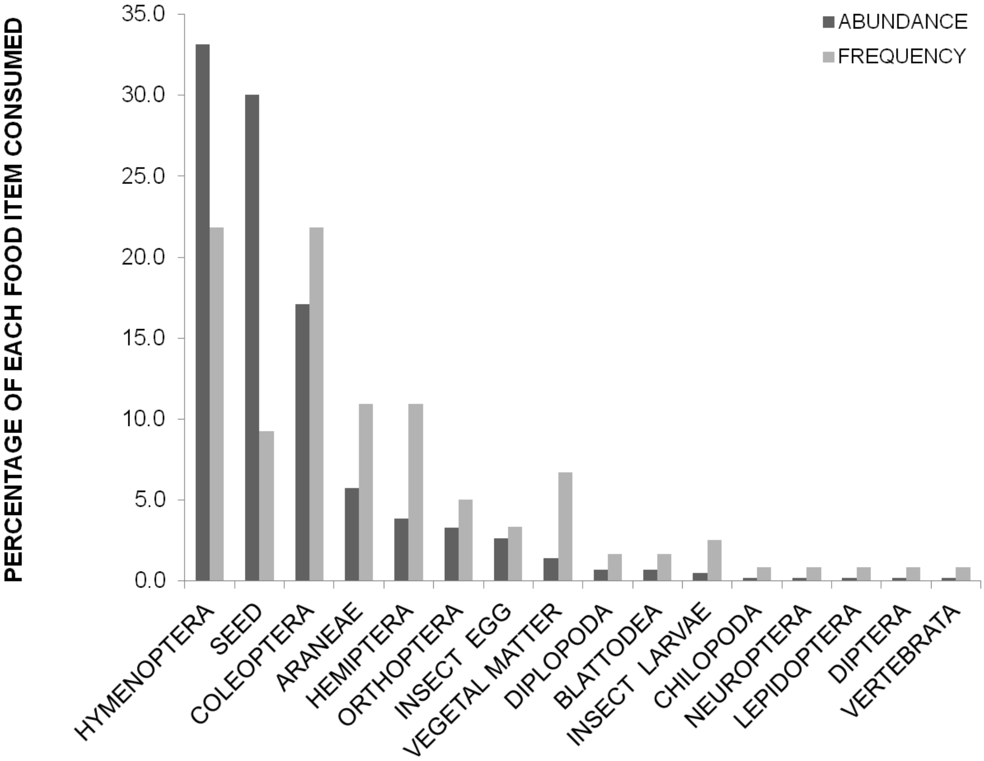

FIG. 1. Frequency and relative abundance of each food class in the 59 samples of individuals from an Amazonian rainforest fragment in northern Mato Grosso, Brazil.

(Appendix 1). The presence of insects in the diet may be related to the fact that fruits are nitrogen-poor. Therefore, arthropods could be a complementary item in the diet (Bell 1990, Lopes *et al.* 2003, Valerra *et al.* 2005). The presence of insects in the diet of frugivorous birds can also be related to seasonality. Insects become an alternative resource when fruits are scarce, especially during dry season, as fruits show an irregular distribution throughout the year (Peres 1994, Lima 2008).

We are also reporting the consumption of vegetal matter for some birds described as insectivorous (e.g., Silva 1996, Terborgh *et al.* 1990, Henriques 2003): *Hylophylax punctulatus*, *Formicarius colma*, and *Synallaxis rutilans* (see Appendix 1). Consumption of vegetal matter by insectivorous birds was observed in several other studies (Schubart *et al.* 1965, Wetmore 1972; Lopes *et al.* 2003, 2005). This consumption has been suggested due to the decrease of food supply of such birds during periods of shortage of food (Sick 1997). The increase of the consumption of fruits may provide more options for energy supplies during times of resource scarcity (Sick 1997, Lopes *et al.* 2003).

In the following, we present relevant comments that contribute to a better knowledge on the diet of some species endemic and/or typical of the Amazonian region, since many

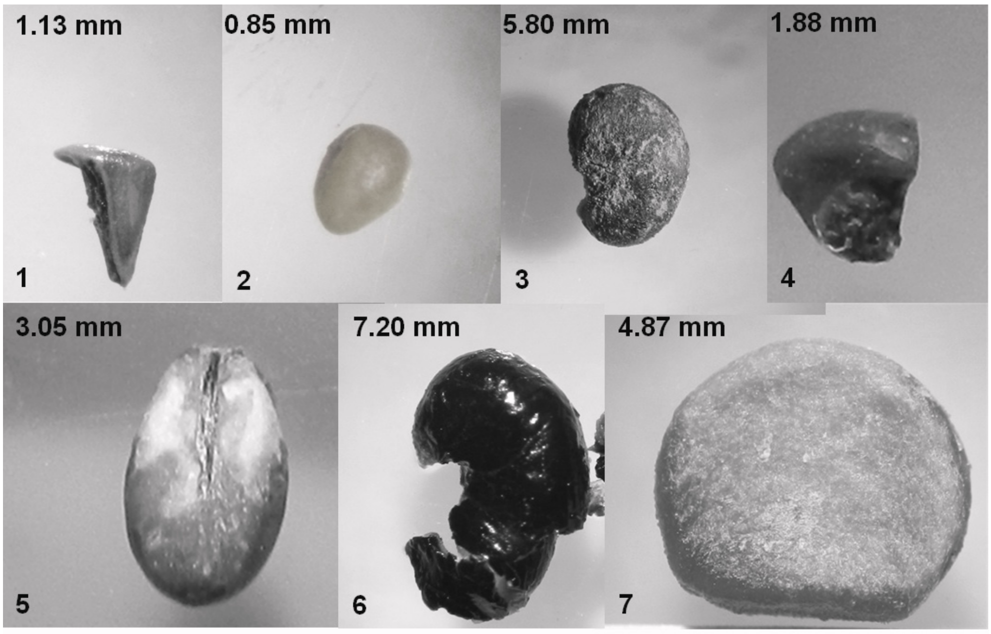

FIG. 2. Seed morphospecies found in the diet of Amazon birds. Upper numbers indicate average group seed size, lower ones the morphospecies of the determined seed.

of these dietary records differ from those found in the literature.

Aratinga weddellii. The stomach content of a single individual analyzed presented Hymenoptera (Formicidae) and Coleoptera, as well as seeds and other vegetal matter (fruit). Roth (1984) and Silva (1996) defined this species as frugivorous but, as recorded here, the species also feeds on insects. Sazima (1989), Faria (2007), and Costa (2006) also observed insects as items of other species of Psittacidae. Thus, *A. weddelli* can be considered omnivorous.

Isleria hauxwelli. In the three stomach content analyzed, only arthropods were identified, especially beetles and spiders. Differently, Rosenberg (1993), in Peruvian Amazonian, mentioned that *I. hauxwelli* feeds especially on order Orthoptera.

Phlegopsis nigromaculata. The diet of this obligate ant-following bird species was based on the analysis of two individuals, and consisting mainly of spiders and ants. Schubart *et al.* (1965) and Chesser (1995), studying the diet of Bolivian birds, reported a greater presence of spiders and orthopterans as food items. However, we were unable to find any orthopterans. A fact to be noted was the presence of army ants (genus *Labidus*) in the diet of this species. This consumption was possibly occasional, as this bird species usually avoids the consumption of these army ants (Willis & Oniki 1978).

Synallaxis rutilans. The diet of the birds was composed especially by seeds and ants. Schubart *et al.* (1965) reported only arthropods in the diet of this species, in which ants and beetles were the most consumed items. *S. rutilans* was considered as insectivorous by Silva

(1996) and Henriques *et al.* (2003). However, our results suggest that this species can be considered as omnivore.

Lepidothrix nattereri. The two analyzed specimens of this species, endemic to the Madeira – Tapajós interfluvium, presented a diet composed only by insects, especially from the Coleoptera, Hemiptera and Hymenoptera (family Formicidae). Schubart *et al.* (1965) also found only arthropods composing the diet of this species, belonging to the order Araneae and Coleoptera. However, *L. nattereri* was considered as frugivorous by Silva (1996). Thus, this species can be probably considered as omnivore, with diet composed of insects and fruits.

*Heterocercus linteatu*s. Three individuals analyzed of this species consumed arthropods (spiders and ants) and fruits (seeds and pulps). *Heterocercus linteatus* was considered by Silva (1996) as frugivorous. Therefore, this species can be considered as omnivorous.

We conclude that quantitative studies of diet can provide more reliable data about species feeding, resulting in a more accurate classification of species into feeding guilds. Therefore, these studies are recommended to avoid erroneous classifications. Another important contribution of this study is the increase of knowledge about Amazonian species diet, because the above presented diet records are the first in the literature for the concerning 12 species (see Appendix 1), providing a useful basis for future studies on avian biology and ecology, respectively.

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APPENDIX 1.

Food items, with their abundance, consumed by 40 species this study. Sampling season: D = dry season; W = wet season. * = species with first dietary record in the Brazilian Amazonian rainforest. ^{e} = endemic species Amazon rainforest. MS (morphospecies) = type of seeds consumed. The number after "Morphospecies" shows different type of seeds. Numbers in parentheses after sampling season (D and W) indicate how many stomach were evaluated. Abbreviations refer to each food items are: Araneae (Ara.), Orthoptera (Ort.), Blattaria (Blat.), Neuroptera (Neu.) Hemiptera (Hem.), Coleoptera (Col.), Hymenoptera (Hym.), Diptera (Dip.), Lepidoptera (Lep.), Insect eggs (Iegg.), Insect Larvae (Ilarv.), Diplopoda (Dipl.), Chilopoda (Chi.), Vertebrata (Subclass Actinopterygii) (Vet), Seeds (Seed.), Vegetal matters (Vmet.). Numbers following of abbreviations correspond to the total of items found in each stomach.

Order Charadriiformes: Family Scolopacidae
Actitis macularius: D (1) = Ara. 1

Order Columbiformes: Family Columbidae
Geotrygon montana: W(1) = Vmet. 1

Order Psittaciformes: Family Psittacidae
Aratinga weddellii *: D(1) = Col. 17, Hym. 17, Seed.29 (MS.1),Vmet. 1
Brotogeris chrysoptera *: D(1) = Seed.30 (MS.2), V.mat. 1

Order Cuculiformes: Family Cuculidae
Crotophaga major: D(1) = Ara.1, Ort.9, Blat.2, Hem.2, Col.2, Lep.2, Dip.2, Hym.2, Ieeg.2, Seed. 2 (MS.3)

Order Apodiformes: Family Trochilidae
Phaethornis malaris [e] *: W(2) = Ara.3
Thalurania furcata: D(1) = Ara.1, Col.2, Hym.7

Order Coraciiformes: Family Alcedinidae
Chloroceryle aenea: D(1) = Ara.1, Hem.1, Col.1, Hym.9, Vet.1

Order Galbuliformes: Family Bucconidae
Malacoptila rufa: D(1) = Col.2
Monasa nigrifrons: D(2) = Ara.2, Ort.5, Hem.2, Col.5, Hym.5
Chelidoptera tenebrosa: D(1) = Hem.1, Col.1, Hym.16

Order Passeriformes: Family Thamnophilidae
Thamnophilus amazonicus *: W(1) = Col.2, Hem.1
Thamnomanes saturninus [e] *: W(1) = Col.1, Hym.3
Pygiptila stellaris [e] : W(1) = Col.5, Ilarv.1
Isleria hauxwelli [e] : D, W (3) = Ara.4, Ort.1, Hem.1, Col.10, Hym.2, Iegg.2
Myrmoborus myotherinus [e] *: D(1) = Hem.1, Col.6
Rhegmatorhina hoffmannsi [e] *: D(2) = Col.3, Hym.10
Hylophylax naevius [e]: W(1) = Hem.1, Col.8, Hym.2
Hylophylax punctulatus [e] *: D(2) = Ara.2, Hem.1, Col.5, Hym.4, Seed.1 (MS.2)
Phlegopsis nigromaculata [e]: W(2) = Ara.7, Ort.1, Blat.2, Hem.1, Col.5, Hym.4

Family Formicariidae
Formicarius colma: D(1) = Ara.1, Hym.6, Iegg.1, Seed.12 (MS.1)
Formicarius analis: W(3) = Col.3, Hym.27, Ilarv.1

Family Dendrocolaptidae
Dendrocincla fuliginosa: D(2) = Col.6, Hym.3
Glyphorynchus spirurus: D(3) = Chi.1, Hem.1, Col.6, Hym.24, Iegg.4
Xiphorhynchus elegans [e]*: W(1) = Col.1, Hym.4

Family Furnariidae
Synallaxis rutilans [e]: W(2) = Ara.1, Ort.1, Hym.6, Seed.27 (MS.5)

Family Rhychocyclidae
Tolmomyias flaviventris: D(1) = Col.4

Family Platyrhinchidae
Platyrinchus platyrhynchos [c]: D(1) = Hym.2

Family Tyrannidae
Attila phoenicurus *: D(1) = Hym.2, Seed.1 (MS.6)

Family Pipridae
Lepidothrix nattereri [c]: D,W(2) = Hem.6, Neu.1, Col.9, Hym.7
Manacus manacus: D(1) = Dipl.3, Col.1, Vmet.1
Heterocercus linteatus [c]: D(3) = Ara.1, Hym.1, Vmet.1

Family Tityridae
Schiffornis turdinus [c]: D(1) = Col.1, Ilarv.1

Family Turdidae
Turdus hauxwelli [c]*: D(1) = Dipl.1, Hym.1, Seed.2 (MS.4)
Turdus albicollis *: D(1) = Seed.1 (MS.7), Vmet.1

Family Thraupidae
Lanio cristatus: W(1) = Ort.2, Col.1, Vmet.1
Arremon taciturnus: D,W(4) = Hem.1, Col.11, Hym.10
Saltator maximus: D(1) = Col.1, Seed.1 (MS.1)

Family Cardinalidae
Cyanoloxia rothschildii [c]: W(1) = Vmet.1

Family Icteridae
Cacicus cela: D(1) = Ara.8, Hem.3, Hym.2, Seed.66 (MS.1)