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ARTICLE

Stomach contents of Brazilian non-passerine birds

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ABSTRACT: We report on the stomach contents of 70 individuals belonging to 36 species and 12 families of non-passerine birds of the Ornithological Collection Marcelo Bagno, University of Brasilia, Brazil. The stomachs, mostly collected during the rainy season and in the Cerrado area, were opened and their food items sorted to the nearest taxonomic level. Virtually all stomachs contained food items consistent with the literature. *Galbula ruficauda*, however, had plant material in its stomach, although it is considered insectivorous. It is interesting to mention that species considered omnivorous, such as *Rhynchotus rufescens*, *Nothura maculosa* and *Ramphastos toco*, contained only animal material in their stomachs. *Columbina talpacoti, Leptotila verreauxi* and *Leptotila rufaxilla*, which can supplement their diet with arthropods, ate only vegetable material, reinforcing items of animal origin as unusual in their diet. *Geotrygon montana, C. talpacoti, L. verreauxi, N. maculosa, Aratinga aurea* and *Aratinga cactorum* had stones in their stomachs, which can help to macerate food items. This study covers non-passerines poorly sampled in the literature and can assist in improving the knowledge about the diet of these species.

KEY-WORDS: arthropod, Cerrado, diet, feeding, food item, seed.

Diet study is an important research line that may help to understand ecological, evolutionary and conservation questions about birds (Durães & Marini 2005). Field observations, even though easier to get for some species, may provide erroneous data (Hempel 1949), a problem that is avoided with the examination of stomach contents. However, there is very limited data about diet based on stomach contents of large birds, most of them non-Passeriformes. Classic studies, such as Moojen *et al.* (1941), Hempel (1949), and Schubart *et al.* (1965), describe the diet of only 36% of Brazilian non-passerine birds. The difficulty to capture large-bodied species with usually low population densities complicates the study of their stomach contents. Therefore there is still a poor knowledge to be supplemented on Brazilian non-passerine diet. In this study we describe the stomach contents from 36 species of non-passerine birds from a bird collection from central Brazil.

MATERIAL AND METHODS

Stomachs (N = 70) from 36 species of non-passerine birds were collected between 1987 and 2012, although mostly in the years of 1988 and 1989 (67.5%). The samples are from the Cerrado region, specifically from the states of Bahia, Goiás, Minas Gerais, Mato Grosso, Rondônia, Tocantins and the Federal District (Table 1).

The stomachs, preserved in alcohol 70%, were cut open and had the contents identified by Y. B. and M. R. F. The contents were examined under a stereomicroscope and analyzed in relation to the food type (animal or vegetal material). Seeds were separated in morphotypes, counted and measured to the nearest 0.1 mm. Arthropod fragments were identified to the nearest taxonomic level as possible and grouped, when possible, in families or orders (insects) and classes (other arthropods). Other animal fragments (vertebrates) were identified to the nearest taxonomic level as possible. All stomachs studied are from Coleção Ornitológica Marcelo Bagno (COMB/ML) - Universidade de Brasília, Brasília, DF, Brazil. Species names, collection date and locality are listed in the Appendix. Bird taxonomy follows Remsen *et al.* (2013).

RESULTS AND DISCUSSION

The 70 stomachs examined contained food items. Below we briefly describe and discuss the diet of each species. Detailed results are presented in the Appendix.

Tinamidae

Species of Tinamidae are considered omnivore, feeding on seeds, leaves, dry fruits, small arthropods and mollusks (Sick 1997). *Crypturellus undulatus* (N = 1) and

C. parvirostris (N = 1) ingested arthropods and vegetal material, which is consistent with an omnivore diet. The stomach of *Rhynchotus rufescens* (N = 1) analyzed contained two insect orders. No vegetal material was found, even though it may also be consumed besides arthropods (Sick 1997). The stomachs of *Nothura maculosa* (N = 3) contained four insect orders and stones, which may have been ingested accidentally or to help digestion (Beaune *et al*. 2009). Although no vegetal material was found, this species is known to feed on seeds, leaves, dry fruits, small arthropods and mollusks (Sick 1997).

Ardeidae

Nycticorax nycticorax (N = 1) contained insect fragments in its stomach, even though it is known that the species can feed on a variety of food items, as fish, aquatic insects, arthropods, mollusks and vertebrates such as frogs, lizards, and dead fledglings found on the ground (Sick 1997).

Accipitridae

The *Geranospiza caerulescens* (N = 1) stomach was composed by one insect order. *Rupornis magnirostris* (N = 3) stomachs contained seven insect genera, a lizard and an arachnid. The *R. magnirostris* (N = 1) sample from the wet season had a higher insect diversity, probably because insects are more abundant at this time of the year (Pinheiro *et al.* 2003). *Geranospiza caerulescens* and *R. magnirostris* are carnivores, feeding on arthropods and small vertebrates such as lizards, snakes, frogs, birds, bats and rodents (Mader 1981, Sick 1997, Sutter *et al*. 2001, Ramos *et al.* 2011, Camacho *et al.* 2012).

Falconidae

The stomachs of *Milvago chimachima* (N = 2) were composed of Coleoptera insects and arachnids. No other animal or vegetal material was found even though they are known to feed also on small vertebrates and carrion

TABLE 1. Collection sites of stomach samples analyzed in this study.

Code	Locality	Municipality	State
FAA	Fazenda Alegre	Correntina	Bahia
FIG	Fazenda Integrada	Correntina	Bahia
SMV	Santa Maria da Vitória	Santa Maria da Vitória	Bahia
AED	E.E. Águas Emendadas	Brasília	Distrito Federal
ASA	Asa Norte	Brasília	Distrito Federal
COU	Centro Olímpico-UnB	Brasília	Distrito Federal
DFE	DF 190, Km 14.1	Brasília	Distrito Federal
FAL	Fazenda Água Limpa	Brasília	Distrito Federal
FMB	Fazenda Mocambinho	Brasília	Distrito Federal
SHI	SHIS QI 23	Brasília	Distrito Federal
FDD	Fazenda do Delfino	São João da Aliança	Goiás
EFL	EFLEX	Silvânia	Goiás
FML	Fazenda Monalisa	Catalão	Goiás
FGA	Fazenda Graúna	Guarda-Mor	Minas Gerais
IBI	Ibiá	Ibiá	Minas Gerais
FAG	Fazenda Acangaú	Paracatu	Minas Gerais
FRT	Fazenda Rosato	Paracatu	Minas Gerais
FSB	Fazenda Sulbrasil	Paracatu	Minas Gerais
UHE	UHE Manso	Chapada dos Guimarães	Mato Grosso
BRE	BR 364, Km 180	Pimenta Bueno	Rondônia
FNI	Fazenda Nova Iguaçu	Dianópolis	Tocantins

(Sick 1997, Olmos *et al*. 2006). The insect orders found in the *Falco sparverius* (N = 1) stomach were the most common items reported for its diet in the Cerrado region (Cabral *et al*. 2006). However, this species also feeds on small vertebrates such as lizards, birds, rodents and bats (Sick 1997, Cabral *et al.* 2006, Zilio 2006).

Columbidae

This family is composed of frugivorous and granivorous species that can complement their diet with arthropods and mollusks (Sick 1997). *Columbina talpacoti* (N = 10) ingested during the wet season (N = 5) and the dry season (N = 5) seeds and grass seeds. Although Piratelli & Pereira (2002) considered it omnivore, no animal material was found in the samples, indicating that this could be a casual food item. *Leptotila verreauxi* (N = 3) and *L. rufaxilla* (N = 1) had seeds of varying sizes in their stomachs, which is consistent with the literature, as they feed mostly on fruits and also on seeds and arthropods (Moojen *et al.* 1941, Sick 1997, Gondim 2001, Piratelli & Pereira 2002). We also found stones in one of the four *L. verreauxi* stomachs. *Claravis pretiosa* (N = 2) and *Patagioenas speciosa* (N = 1), which are mostly frugivorous (Sick 1997), had stomachs with seeds and grass seeds. *Geotrygon Montana* (N = 1), another frugivore (Cruz 1974, Sick 1997), had nothing but 10 stones in its stomach, which may help digestion by macerating fruits and seeds. *Columbina squammata* (N = 2) had seeds and grass seeds of medium size in its stomachs, as expected, as it is mostly granivore (Sick 1997, Santos 2004). *Patagioenas cayennensis* (N = 2), also a granivore (Pizo 2004), contained seed of varying sizes in their stomachs. It is noteworthy the consumption of corn grains by one of the birds.

Psittacidae

The *Orthopsittaca manilata* (N = 1) and the *Amazona amazonica* (N = 1) stomachs analyzed contained large seeds, corroborating their diet as frugivores specialized on palm fruits and also on some non-palm fruits (Bonadie & Bacon 2000). The stomachs of *Aratinga aurea* (N = 7) analyzed contained seeds, fruit pulp and three of them had stones. The stomachs of *Aratinga cactorum* (N = 2) also had stones. The diet of *A. aurea*, *A. cactorum*, *Aratinga leucophthalma* (N = 1) and *Aratinga solstitialis* (N = 1) is composed mostly of seeds and fruit pulp, flowers and leaf sprout (Sick 1997, Paranhos *et al*. 2009, Peixoto 2010). *Aratinga aurea* eats also termites (de Faria 2007) and *A. cactorum* can feed on latex (Barros & Marcondes-Machado 2000). The seeds found in its stomach are consistent with this description. No animal material was found, corroborating conclusions that arthropods are a complementary food item for this species (Costa 2006). *Brotogeris versicolurus* (N = 1) has a similar diet to *A. aurea*, but it also consumes insects (Costa 2006). The stomach sample of *Pionus maximiliani* (N = 1), collected in the rainy season, was composed by fruit pulp. This species eats mostly seeds, and also flowers and fruits in a lesser amount. In the dry season, however, depending on the availability of the food items, the proportion of its diet may change and it can feed on flower and fruit in greater proportion (Galetti 1993).

Caprimulgidae

The *Nyctidromus albicollis* (N = 1) stomach sample contained 73 food items (60 flying insects and 13 non-flying insects) from five insect orders. This agrees with the large stomach capacity reported for Caprimulgidae (Sick 1997) and the species' flying insectivore hunting behavior (Thurber 2003).

Alcedinidae

All species from this family feed mainly on fish. *Megaceryle torquata* (N = 3) is the largest Brazilian Alcedinidae, and was able to ingest a 10 cm Characiformes fish. *Megaceryle torquata* may sometimes feed on small birds and some arthropods as insects and crustaceans (Willard 1985, Sick 1997, Jackson 2006). All the stomachs of *Chloroceryle amazona* (N = 2) analyzed contained only fish, but it also feeds on arthropods as insects and crustaceans (Willard 1985, Sick 1997). The samples of *Chloroceryle americana* (N = 2) contained only fish, including Chareidae, an abundant shallow water fish in the Cerrado region (P. Podestá, pers. comm.). However, this species sometimes feeds on aquatic insects or even lizards (Willard 1985, Sick 1997, Luz *et al*. 2008).

Galbulidae

Even though *Galbula ruficauda* (N = 1) is insectivorous (Chai 1986, Poulin *et al.* 1994, Pinheiro *et al.* 2003), the sample analyzed was composed by unidentified vegetal material.

Bucconidae

The *Nystalus maculatus* (N = 2) stomachs contained four orders of flying insects, probably due to the fact that it hunts insects in flight or wait on perches (Sick 1997). No other arthropod or vegetal material was found even if it is known to feed on these food items (Sick 1997).

Ramphastidae

Ramphastos toco (N = 1) is considered omnivore (Remsen *et al*. 1993, Sick 1997), but the stomach

analyzed had only arthropods. Differently from *R. toco*, *Pteroglossus inscriptus* (N = 2) is basically frugivorous, feeding on a variety of fruits (Remsen *et al*. 1993, Sick 1997). We confirmed this by finding only seeds on the stomachs, including *Rapanea* seeds, an important food source for birds during the dry season (Pineschi 1990). *Pteroglossus castanotis* (N = 2) fed only on fruits of variable sizes and flowers, but had no arthropods as reported in the literature (Remsen *et al*. 1993).

Picidae

The stomachs of *Colaptes melanochloros* (N = 1) and *Colaptes campestris* (N = 1) contained only insects, confirming their highly insectivorous diet (Beltzer *et al*. 1994, Raw 1997). No vegetal material was found, even though they can also feed on fruit (de la Peña & Pensiero 2003, Tubelis 2007, Francisco & Galetti 2011).

Almost all the species analyzed in this study ingested food items consistent with diet descriptions found in the literature. However, *Galbula ruficauda* had vegetal material in its stomach even though it is considered insectivorous. This study provides information about the diet of non-passerines in the Cerrado, which can be compared with samples of the same species in other biomes. Moreover, as it is reported the month of collection for 69 of the 70 samples, this study may contribute to future investigations about possible seasonal variations in the diet of these species. Studies such as Moojen *et al.* (1941), Hempel (1949) and Schubart *et al.* (1965), which are the most comprehensive studies on Brazilian non-passerine bird diets based on stomach contents, described together only 292 of 809 species of Brazilian non-passerine birds. Furthermore, the number of stomachs analyzed per species is rarely superior to five. The small sample size found in the literature can exclude possible casual food items, thus studies like this are important to complement the knowledge about the diets of Brazilian non-passerine birds.

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APPENDIX

Qualitative and quantitative analysis of the food items observed in 70 stomachs of 36 non-passerine birds. Taxonomy of species follows Remsen *et al.* (2013). The samples were identified with the initials of the area where they were collected as shown in Table 1. The food items were abbreviated in the following way: Orthoptera (Ort.), Mantodea (Man.), Blattaria (Bla.), Isoptera (Iso.), Hemiptera (Hem.), Hymenoptera (Hym.), Araneae (Ara.).

TINAMIDAE
Crypturellus undulatus (Undulated Tinamou)
UHE/May, 1988 = 9 insect legs, unident. veg. material.

Crypturellus parvirostris (Small-billed Tinamou)
UHE/July, 1988 = 1 Ort.

Rhynchotus rufescens (Red-winged Tinamou)
FGA/November, 2001 = 1 Hem. (Heteroptera), 1 Hem. (Auchenorrhyncha), 9 Col., 1 Col. larva.

Nothura maculosa (Spotted Nothura)
FAL/July, 1989 = 1 Ort. (Acrididae), 3 Ort., 1 Iso., 5 Col., 1 Hym. (Formicidae), 1 Hym.
FSB/November, 2001 = 1 Ort. (Gryllidae), 1 Ort., 11 Col., 6 Hym. (Formicidae), stones.
FML/November, 2001 = 1 Col., stones.

ARDEIDAE
Nycticorax nycticorax (Black-crowned Night-heron)
UHE/May, 1988 = insect legs.

ACCIPITRIDAE
Geranospiza caerulescens (Crane Hawk)
FAG/March, 1989 = 6 Blat.

Rupornis magnirostris (Roadside Hawk)
DFE/April, 2010 = 1 Man., 1 Ort., 2 Hym. (Formicidae sp.1), 1 Hym. (Formicidae sp.2), 1 Hym., 1 lizard.
FAG/February, 1989 = 1 feather.
FNI/September, 2003 = 2 Iso., 1 Col., 1 Ara.

FALCONIDAE
Milvago chimachima (Yellow-headed Caracara)
EFL/March, 1989 = 5 Col., 2 Ara.
FAG/February, 1989 = 2 Col. (Scarabaeidae), 1 Ara.

Falco sparverius (American Kestrel)
EFL/March, 1989 = 1 Man., 1 Blat., 4 Ort., 1 Ara.

COLUMBIDAE
Columbina talpacoti (Ruddy Ground Dove)
UHE/November, 1988 = 1 seed (2.5 mm), 2 grass seeds (2.8 mm), 50 grass seeds (4.0 mm).
UHE/November, 1988 = 40 seeds (1.3 mm), 10 grass seeds (4.0 mm), 20 *Davilla* seeds (4.0 mm).
UHE/May, 1988 = 100 *Miconia* seeds (0.8 mm).
SHI/April, 1989 = 7 seeds (1.1 mm), 6 seeds (2.0 mm), 9 seeds (2.5 mm), 5 grass seeds (3.6 mm), 15 grass seeds (5.5 mm).
UHE/November, 1988 = 2 seeds (2.5 mm), 30 grass seeds (2.8 mm), 11 *Davilla* seeds (4.0 mm), 125 grass seeds (4.0 mm).
UHE/November, 1988 = 5 grass seeds (2.8 mm), 5 grass seeds (4.0 mm), 25 *Davilla* seeds (4.0 mm).
BRE/May, 2002 = 100 seeds (1.0 mm), 1 stone.
FRT/November, 2001 = 40 seeds (0.9 mm).
FAA/July, 2011 = 3 grass seeds (3.1 mm), 12 grass seeds (3.8 mm), 10 grass seeds (5.6 mm), 10 stones.
SMV/July, 2011 = 5 seeds (0.9 mm), 33 seeds (1.4 mm), 8 seeds (1.9 mm), 1 seed (3.2 mm).

Columbina squammata (Scaled Dove)
FMB/January, 1989 = 30 seeds (1.0 mm), 5 seeds (2.3 mm), 5 seeds (2.7 mm), 4 grass seeds (3.6 mm), 30 seeds (3.9 mm), 5 grass seeds (4.0 mm).
FAG/February, 1989 = 100 grass seeds (4.0 mm).

Claravis pretiosa (Blue Ground Dove)
FAG/February, 1989 = 15 grass seeds (4.0 mm).
FAG/February, 1989 = 20 seeds (2.5 mm).

Patagioenas speciosa (Scaled Pigeon)
UHE/November, 1988 = 2 seeds (1.6 mm), 7 seeds (2.3 mm).

Patagioenas cayennensis (Pale-vented Pigeon)
FDD/July, 1987 = 10 grass seeds (8.5 mm), 3 corn grains (11.5 mm).
FGA/November, 2001 = 500 seeds (1.4 mm), 3 seeds (12.2 mm).

Leptotila verreauxi (White-tipped Dove)
FMB/February, 1989 = 10 grass seeds (2.4 mm), 20 grass seeds (2.5 mm).
AED/July, 2007 = 100 seeds (2.0 mm), 22 seeds (3.1 mm), 8 grass seeds (3.8 mm), 9 seeds (7.9 mm), 13 seeds (8.8 mm).
SMV/July, 2011 = 20 seeds (1.6 mm), 5 seeds (2.2 mm), 3 seeds (3.0 mm), 1 seed (3.1 mm), 2 seeds (3.4 mm), 1 seed (15.3 mm), 50 stones.

Leptotila rufaxilla (Gray-fronted Dove)
UHE/November, 1988 = 2 seeds (1.7 mm), 4 seeds (2.6 mm), 3 seeds (2.7 mm), 3 seeds (9.6 mm).

Geotrygon montana (Ruddy Quail-dove)
UHE/November, 1988 = 10 stones.

PSITTACIDAE
Orthopsittaca manilata (Red-bellied Macaw)
UHE/November, 1988 = 8 seeds (4.7 mm), 8 seeds (3.6 mm).

Aratinga leucophthalma (White-eyed Parakeet)
EFL/March, 1989 = macerated seed.

Aratinga solstitialis (Sun Parakeet)
IBI/January, 1989 = 30 seeds (3.3 mm).

Aratinga aurea (Peach-fronted Parakeet)
EFL/March, 1989 = 21 seeds (2.5 mm).
EFL/March, 1989 = 1 seed (1.4 mm), 10 seeds (1.8 mm), 1 seed (3.0 mm).
FAG/February, 1989 = 100 seeds (2.3 mm), 4 stones.
FAG/February, 1989 = 50 seeds (2.3 mm), 3 stones.
FAG/February, 1989 = fruit pulp, stones.
FNI/September, 2003 = fruit pulp.
FAA/July, 2011 = 9 seeds (1.9 mm), 1 seed (2.0 mm), 2 seeds (2.6 mm), 10 seeds (2.8 mm).

Aratinga cactorum (Cactus Parakeet)
FAA/July, 2011 = 20 seeds (2.1 mm), 200 seeds (2.9 mm), 20 seeds (4.9 mm).
SMV/July, 2011 = 2 seeds (1.6 mm), 400 seeds (2.9 mm), stones.

Brotogeris versicolurus (Canary-winged Parakeet)
UHE/July, 1988 = 5 seeds (2.4 mm).

Pionus maximiliani (Scaly-headed Parrot)
FGA/November, 2001 = fruit pulp.

Amazona amazonica (Orange-winged Parrot)
UHE/November, 1988 = 50 Melastomataceae seeds (2.2 mm), 4 *Davilla* seeds (4.0 mm), 4 seeds (7.9 mm).

CAPRIMULGIDAE
Nyctidromus albicollis (Common Pauraque)
FNI/September, 2003 = 1 Blat., 11 Ort., 2 Hem (Heteroptera), 11 Col. (Scarabaeidae), 5 Col. (Elateridae), 24 Col. (sp.1), 5 Col. (sp.2), 11 Hym. (Formicidae - *Atta*), 2 Hym. (Formicidae), 1 Hym. (Vespidae).

ALCEDINIDAE
Megaceryle torquata (Ringed Kingfisher)
COU/Ind., 1998 = 1 fish.
COU/March, 1989 = 1 fish (10 cm) (Characiforme).
COU/March, 1989 = Soil clod.

Chloroceryle amazona (Amazon Kingfisher)
UHE/November, 1988 = 1 fish.
UHE/November, 1988 = 1 fish.

Choroceryle americana (Green Kingfisher)
AED/April, 1989 = 1 fish.
UHE/November, 1988 = 1 fish.
UHE/November, 1988 = 1 fish (5 cm) (Characiforme, Chareidae).

GALBULIDAE
Galbula ruficauda (Rufous-tailed Jacamar)
AED/April, 1989 = unident. veg. material.

BUCCONIDAE
Nystalus maculatus (Spot-backed Puffbird)
FAA/July, 2011 = 2 Ort., 1 Col., 2 Hym. (Apidae)
FAA/July, 2011 = 3 Ort. (Acrididae), 1 Hem. (Heteroptera).

RAMPHASTIDAE
Ramphastos toco (Toco Toucan)
ASA/March, 2012 = 1 Ara., 2 membranous wings.

Pteroglossus inscriptus (Lettered Aracari)
UHE/November, 1988 = 7 Rubiaceae seeds (9.6 mm).
UHE/November, 1988 = 100 seeds (2.7 mm), 25 *Rapanea* seeds (3.1 mm).

Pteroglossus castanotis (Chestnut-eared Aracari)
UHE/July, 1988 = 100 *Rapanea* seeds (3.1 mm).
UHE/November, 1988 = 60 seeds (1.8 mm), 4 seeds (12.3 mm), 2 flowers.

PICIDAE
Colaptes melanochloros (Green-barred Woodpecker)
FIG/July, 2011 = 102 Hym. (Formicidae sp.1), 45 Hym. (Formicidae sp.2), 15 Hym. (Formicidae sp.3).

Colaptes campestris (Campo Flicker)
FAA/July, 2011 = 150 Iso.