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Predation on vertebrates by Neotropical passerine birds

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Abstract
We investigated if passerine birds act as important predators of small vertebrates within the Neotropics. We surveyed published studies on bird diets, and information on labels of museum specimens, compiling data on the contents of 5,221 stomachs. Eighteen samples (0.3%) presented evidence of predation on vertebrates. Our bibliographic survey also provided records of 203 passerine species preying upon vertebrates, mainly frogs and lizards. Our data suggest that vertebrate predation by passerines is relatively uncommon in the Neotropics and not characteristic of any family. On the other hand, although rare, the ability to prey on vertebrates seems to be widely distributed among Neotropical passerines, which may respond opportunistically to the stimulus of a potential food item.

Keywords: diet, Neotropical region, passerines, vertebrate predation

Introduction

Studying the diet of birds in the tropical forests of Panama, Poulin et al. (2001) recorded a surprisingly high number of passerine birds preying on frogs and lizards. These evidences suggested that the traditional view of passerines as vertebrate prey rather than predators may be flawed, and that those birds may carry out an important role as vertebrate predators in tropical environments. Although predation on small vertebrates by passerines has been recorded in the literature by a vast number of authors (e.g. Bent 1942, 1946, 1948, 1949, 1950, 1958; ffrench 1991; Schubart et al. 1965; Sick 1997; Skutch 1954, 1960, 1969; Stiles & Skutch 1989; Wetmore 1972; Wetmore et al. 1984), such reports are generally scattered among a wide array of diet and natural history studies, or even textbooks, which makes the location of these records difficult.

Until now, the only study conducted in the Neotropics estimating the frequency of vertebrate consumption by passerines was that of Poulin et al. (2001).

The goal of our study was to investigate if Neotropical passerines are important predators on small vertebrates and, thus, deserve more attention in the analysis of food webs. We also present a review of the available reports of vertebrate predation by Neotropical passerines and discuss the patterns observed.

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Material and methods

We compiled the results of stomach content analyses of Neotropical birds presented by several authors (Marelli 1919; Aravena 1928; Zotta 1932, 1936, 1940; Moojen et al. 1941; Hempel 1949; Olrog 1956; Schubart et al. 1965; Nacinovic & Schloemp 1992; Ribeiro 2001; Lopes et al. in press), as well as the information contained on labels of specimens deposited in the Field Museum of Natural History in Chicago (The Field Museum, 2003). The use of information contained in museum labels was decided considering Remsen Jr. et al. (1993) investigation on the accuracy of label notations. Those authors found them to be remarkably accurate.

With the aim to perform an independent analysis, we did not include the data presented by Poulin et al. (1994, 2001) in our study. We counted the number of stomach contents analyzed for each family, recording the number and the taxonomic group of the vertebrate preys ingested. For each family of passerines we calculated the percentage of vertebrate predation.

Additionally, we provided a synthesis of all records of vertebrate predation by Neotropical passerines that we could find in a bibliographic survey (Appendix). Although extensive, this survey is but a sample of what probably exists in the huge related literature. For this reason, it certainly does not provide the total number of Neotropical passerines able to prey on vertebrates, or the frequency in which those species consume any of the different groups of vertebrates listed. The list in the appendix results from both stomach content analyses and field observations.

We considered as Neotropical, every species listed by Stotz et al. (1996), including the Neartic migrants. We only computed data derived from birds captured or collected within the Neotropics. Families typical of other regions and poorly represented in the Neotropics, such as Alaudidae, Laniidae, and Paridae were omitted. Neotropical species recorded preying upon vertebrates in other biogeographic regions were listed only in the appendix. The taxonomic system employed is that proposed by Dickinson (2003), except for the genus *Euphonia*, *Habia*, *Nesospingus*, *Phaenicophilus*, *Piranga*, and *Rhodinocichla*, which were retained in the Thraupidae.

Due to differences among methodologies employed in the studies considered, as well as to the impossibility to control the number of species and sample size for each family, or even collection locality and season, we did not perform any statistical analysis of the data compiled. Nevertheless, we are confident that the great taxonomic, geographic, and seasonal coverage of the data used is sufficient to provide at least a broad view of the patterns observed within the Neotropics.

Nevertheless, in order to access the robustness of our data, we investigated the hypothesis that the investigator ability in detecting vertebrate remains during stomach content analysis could influence the result of this study. Given that the detection of vertebrate prey in stomachs is not so simply and, sometimes, is achieved only through the observation of a few small fragments of tiny whitish bones, or inconspicuous fish scales (B. Poulin pers. com.), differences between investigators could result in a severe bias.

We hypothesized that, if vertebrate predation is a widespread phenomenon across the Neotropics, two studies performed by the same researcher, and with the same species, would result in similar percentage of vertebrate predation. To test this hypothesis we compared the results of the study of Poulin et al. (2001) in Panama with those of Poulin et al. (1994) in Venezuela. On the other hand, if a high incidence of passerines preying on vertebrate is a local characteristic of the Panamanian tropical forests, we would expect to found differences between the study of Poulin et al. (1994) and Poulin et al. (2001), but no differences between Poulin et al. (1994) in Venezuela, and a compilation of studies conducted in countries other than Panama (Zotta, 1936, 1940; Moojen et al., 1941; Berla, 1944; Schubart et al., 1965; Sturm et al., 1970; Rocha & Peñaranda, 1992; Poulin et al., 1994; Ribeiro, 2001; Marini et al., 2002; The Field Museum, 2003; Lopes et al., in press). For comparison between the simple percentages of stomachs containing vertebrate remains, we performed the Fisher exact test or the χ^2 test (Zar, 1996), adopting a significance level of 5%.

Results

We compiled data from 5,221 stomach contents. Of these, 18 (0.3%) presented evidence of vertebrate predation (Tab. 1). Eight of them contained remains of frogs, four of lizards, two of eggs, one of fish, one of bird, one of mouse and one contained unidentified bones. The bibliographic survey yielded records of predation on vertebrates for 203 passerine species (Appendix), roughly representing 9% of all passerine birds recorded in the Neotropics (Stotz et al., 1996).

Our data suggest that Neotropical passerines rarely eat vertebrates, and none of the families studied showed any trend toward specialization of its consumption. The consumption of frogs and lizards was widely distributed among the different passerines families (Appendix), and only about 18% of the bird species recorded preying upon vertebrates were recorded eating something other than frogs and lizards.

Within each bird family, the proportion of samples containing bones or other evidence of vertebrate predation was generally lower than 1.5% (Tab. 1). The only exception to this pattern was the Formicariidae, with 3.3% of the stomachs containing vertebrates.

Unfortunately, there are only few species in common between the Venezuelan and the Panamanian studies of Poulin, none of them with an adequate sample size. In order to circumvent such problem, we pooled the data at the genus level (only *Thamnophilus* and *Xiphorhynchus* provided an adequate sample size). *Xiphorhynchus* preyed more frequently on vertebrates in Panama than in Venezuela, and no significant difference was observed for *Thamnophilus* (Tab. 2).

When comparing the Panamanian study of Poulin et al. (2001) with a pool of other studies, we observed that the predation on vertebrates were significantly commoner in Panama than in Venezuela (Tab. 3). Given that vertebrate predation by passerines was an extremely rare phenomena outside Panama, we were not able to perform any statistical comparison between the Venezuelan study of Poulin et al. (1994) and other studies.

Table 1 - Percentage of stomachs containing evidence of vertebrate predation by Neotropical passerine birds. Data compiled from several studies based on the analysis of stomach contents and on information on labels of specimens deposited in the Field Museum of Natural History.

Bird families	Number of stomachs		
	Analyzed	**Containing vertebrates**	**% of predation**
Pipridae	189	0	0.0
Cotingidae	88	0	0.0
Tyrannidae	1073	3	0.3
Thamnophilidae	624	3	0.5
Conopophagidae	76	0	0.0
Rhinocryptidae	34	0	0.0
Formicariidae	30	1	3.3
Furnariidae	399	2	0.5
Dendrocolaptidae	265	1	0.4
Vireonidae	131	2	1.5
Corvidae	79	1	1.3
Hirundinidae	78	0	0.0
Troglodytidae	159	0	0.0
Polioptilidae	32	0	0.0
Mimidae	36	0	0.0
Turdidae	203	0	0.0
Motacilidae	23	0	0.0
Fringillidae	10	0	0.0
Parulidae	275	0	0.0
Icteridae	250	3	1.2
Coerebidae	34	0	0.0
Emberizidae	347	2	0.6
Thraupidae	674	0	0.0
Cardinalidae	112	0	0.0

Table 2 - Comparison between the percentage of predation on vertebrates by species of two passerine genera in tropical forests of Panama and dry habitats in Venezuela. Significant results are presented in bold.

Genera	**Panamanian tropical forests** (Poulin et al. 2001)		**Venezuelan dry habitats** (Poulin et al. 1994)		**Statistics**
	Without vertebrates	**Containing vertebrates**	**Without vertebrates**	**Containing vertebrates**	
Xiphorhynchus	11	7	24	0	**Fisher, p = 0.001**
Thamnophilus	82	11	27	0	χ^2 = 3.52, p = 0.068

Table 3 – Comparison between the percentage of predation on vertebrates by species of six passerine genera in tropical forests of Panama and several other Neotropical sites. Significant results are presented in bold.

Genera	**Panamanian tropical forests** (Poulin et al. 2001)		**Various habitats** (several sources*)		**Statistics**
	Without vertebrates	**Containing vertebrates**	**Without vertebrates**	**Containing vertebrates**	
Dendrocincla	29	21	48	0	**Fisher, p = 0.000**
Formicarius	2	13	13	1	**Fisher, p = 0.001**
Gymnopithys	48	13	16	0	**Fisher; p = 0.0357**
Sclerurus	14	5	18	0	**Fisher; p = 0.0267**
Xiphorhynchus	11	7	124	0	**χ^2 = 50.72, p = 0.000**
Thamnophilus	82	11	174	0	**χ^2 = 21.46, p = 0.000**

* Zotta (1936, 1940), Moojen et al. 1941, Berla (1944), Schubart et al (1965), Sturm et al. (1970), Rocha & Peñaranda (1992), Poulin et al. (1994), Ribeiro (2001), Marini et al. (2002), The Field Museum (2003) and Lopes et al. (in press).

Discussion

The small percentage of passerine birds recorded preying on vertebrates in our study strongly contrasts with the high rates observed by Poulin et al. (2001) in a Panamanian tropical forest. Those authors analyzed the contents of 1,086 stomachs, founding 75 lizards and 53 frogs. At last one of which was present in 26.0% of the samples obtained from insectivorous birds. For comparison, in our study, members of the families Dendrocolaptidae, Furnariidae, and Thamnophilidae, a typically insectivorous group (Lopes et al., 2003), presented only up to 0.5% of stomachs containing small vertebrates (mainly lizards and frogs). An exception to this rule, the family Formicariidae, was represented by a small sample (n = 30), which could be influencing this result. Nevertheless, *Formicarius analis*, a typical member of that family, was the species exhibiting the highest frequency of frog consumption in the study by Poulin et al. (2001), with a mean frequency of 0.47 individuals per sample (n = 15). In the same study, *F. analis* also frequently preyed upon lizards, with a mean of 0.40 individuals per sample.

The fact that our data differ so strongly from those of Poulin et al. (2001) is puzzling. Our results are closer to those of Poulin et al. (1994), who examined the stomach content of 3,419 Venezuelan birds and found no record of vertebrate predation. The comparison between the Venezuelan and the Panamanian studies of Poulin et al. (1994, 2001) revealed differences between the percentages of *Xiphorhynchus* stomachs containing vertebrates (Tab. 2) in both sites. Although we found no differences between both sites for the genus *Thamnophilus*, the apparently low consumption of vertebrates by species in this genus [only three of 25 species of *Thamnophilus* (12%) are known to prey on vertebrates, while seven of 14 species of *Xiphorhynchus* (50%) are known to do so] yield samples too small for easy statistical detection of differences between species. These facts suggest that the differences observed between our study and Poulin's et al. (2001) may not be attributable to investigator bias alone, and that real differences exist between sites. This hypothesis was supported by the many species recorded preying frequently on vertebrates in the Panamanian forests but not in other sites (Tab. 3).

The evidences presented here, together with Poulin's et al. (1994) suggest that a high frequency of vertebrate predation by passerines is not a pattern observed across the entire Neotropical region but, conversely, may be particularly common in some localities, such as the Panamanian forests, maybe under special circumstances still not recognized.

Even for the Corvidae, believed to be voracious predators of eggs and small vertebrates (Bent, 1946; Santos, 1979; Sick, 1997), we found only one record of vertebrate predation among 79 stomachs analyzed (Appendix). This percentage is even smaller than those observed for the Formicariidae and Vireonidae. Thus, our results suggest that Neotropical Corvidae may not be as voracious predators as Neartic species. Even for many North American species of Corvidae, which are traditionally considered to be predators of eggs and small vertebrates, Bent (1946) noted that no confirmed record of predatory behavior exists. Within the Neotropics, species in the genus *Corvus* are probably most of the few members of the family to prey regularly upon vertebrates.

With the only exception of *Cinclodes antarcticus*, we recorded only Corvidae consuming carrion, especially members of the genus *Corvus*, which usually feed on dead fishes or even carcass of large mammals such as caribou and whales (Bent, 1946). The South American Corvidae have not been recorded feeding on carrion, but we observed some of them taking small pieces of meat hung in the open to dry or even ingesting the remains of meat adhering to cattle skin drying in the sun (L.E.L., pers. obs.). Surprisingly, *Thraupis palmarum* and *T. sayaca* (Thraupidae), two typically frugivorous species, have been observed doing the same (Appendix).

Even tiny birds, such as *Dendroica adelaidae*, which weighs around 7 g (Dunning Jr., 1993) preyed upon vertebrates, probably reflecting the small size of many reptiles and amphibians, which can be even smaller than many arthropods habitually consumed by birds. The small number of species recorded preying on salamanders, despite their small size, is probably only an effect of their scarcity or even absence from most Neotropical habitats (Duellman & Trueb, 1986).

Various reports of vertebrate predation by members of typically frugivorous families, such as Cotingidae and Thraupidae (Appendix), contradict the argument by Poulin et al. (2001) that, besides the morphological constrains, the physiological adaptations of Pipridae to the assimilation of fruits are incompatible with the digestion of vertebrates. Furthermore, many highly frugivorous nonpasserines, such as Ramphastidae, regularly consume vertebrates and large invertebrates (Remsen Jr. et al.,1993). We hypothesize, then, that vertebrate predation by Pipridae may be primarily restricted by morphological rather than by physiological traits, since all Pipridae are typically small (mostly in the weight range 8-30 g), with stout body, short tail, and short bill (Snow, 2004), suitable for handling small fruits. Skutch (1969) reported the only record known to us on an attempt to predate on a vertebrate by a species of Pipridae. He witnessed *Pipra mentalis* trying to ingest a small lizard that slipped from its bill and escaped. This is consistent with our hypothesis of morphological constraint. On the other hand, the large size of the Cotingidae [some species of this family, such as *Cephalopterus glabricollis* (385 g), *Pyroderus scutatus* (357 g), and *Perissocephalus tricolor* (340 g), are among the largest passerines of the world] and the strong bill of Thraupidae, provide the means for capturing and subjugating large preys.

A few passerine species seem to prey regularly on vertebrates as, for example, *Pitangus sulphuratus*, that shows a great ability to fish (Beltzer, 1983; Latino & Beltzer, 1999), *Attila spadiceus*, which preys on small vertebrates in the interior of forests (Stiles & Skutch, 1989; Poulin et al. 2001), and *Formicarius analis*, which is a vertebrate predator on the leaf litter (Schubart et al.,1965; Stiles & Skutch,1989; Poulin et al., 2001). However, the data we have gathered suggest that, in general, vertebrate predation by Neotropical passerines is a relatively uncommon event, not characteristic of any family occurring in the Neotropical region. Although being a rare behavior, the ability to prey on vertebrates seems to be widely distributed among passerine families.

As our knowledge on the diets of Neotropical birds growths, certainly much more species will be recorded ingesting vertebrates. Such information will enhance our understanding of the impact of passerine predation upon vertebrates in most Neotropical habitats.

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Appendix

Species of Neotropical passerines recorded preying or attempting to prey upon vertebrates. The numbers represent the information sources, which are listed in brief at the end of the table. References cited in this Appendix are cited in full below it. A question mark indicates a doubtful record; an asterisk indicates captive bird records. The term "meat" refers to the consumption of carrion, pieces of meat hanging to dry, or meat remains adhering to the skin of cattle. We present only up to two records of consumption of each vertebrate group per bird species, avoiding, thus, an extremely long reference list. The sources selected are: 1st) information derived directly from stomach content analysis or field observation; 2nd) chronologically older citations.

TAXA	VERTEBRATE GROUP												
	Fish	Tadpole	Frog	Salamander	Turtle	Snake	Lizard	Bird egg	Nestling	Bird	Mammal	Undetermined vertebrate	Meat
Pipridae													
Pipra mentalis							69						
Cotingidae													
Cephalopterus glabricollis			75,100				75,100						
Cephalopterus ornatus							100						
Cephalopterus penduliger			100			100	100						
Cotinga amabilis							69,75						
Laniocera rufescens							75,100						
Lipaugus vociferans							82,100						
Perissocephalus tricolor							33				82,100		
Pyroderus scutatus									55?	7,71			
Rupicola peruvianus			100				94*,100						
Rupicola rupicola			55,100				55,100						
Tityra semifasciata							69,75						
Xipholena punicea							94*						
Tyrannidae													
Agriornis lividus			100				57,100	100	57,100	57	100		
Agriornis micropterus			100				100	100	100		100		
Agriornis montanus			100				100	100	100	88?	88,100	88	
Agriornis murinus			100				100	100	100		100		
Attila cinnamomeus			100										
Attila rufus			43,55										
Attila spadiceus	13		54,80				54,80						
Cnipodectes subbrunneus			54										
Contopus virens	16												
Corythopis delalandi			100				100						
Corythopis torquata			100				100						
Megarynchus pitangua	55,80		64				27,80					88,100	
Myiarchus antillarum			79,100				100						
Myiarchus cinerascens							100				100		
Myiarchus crinitus							10	10					
Myiarchus tyrannulus							89,100			30,100			
Myiodynastes maculatus							33,80						
Myiotheretes striaticollis												100	
Myiozetetes similis		68,75											
Myiozetetes sp.								55?	55?				
Neoxolmis rufiventris							29,100						
Pitangus lictor	96												
Pitangus sulphuratus	32,42	68,75	32,42		56	32,75	32,42	75?	23,32	55,90?	42,75	68,93	97
Pyrocephalus rubinus	3												
Sayornis nigricans	3,51												
Sayornis phoebe	100												
Tyrannus caudifasciatus			21				100						
Tyrannus cubensis							100		100				
Tyrannus dominicensis	41,93						78,89			65,100			
Tyrannus melancholicus			68										
Tyrannus tyrannus	50		100									100	
Tyrannus verticalis			10					10					
Tyrannus vociferans											100		
Thamnophilidae													
Batara cinerea			55,95			20,55	95	55,61	55,61		19,76	27	
Cercomacra tyrannina			54										
Cymbilaimus lineatus			63,95				75,95						
Formicivora erythronotos			95										
Gymnocichla nudiceps							95						
Gymnopithys leucaspis			54,69				54,69						
Gymnopithys rufigula							95						
Hylophylax naevioides			54,69				54,69						
Hylophylax poecilinotus							95						
Mackenziaena leachii			95			95	95	61,95	61,95				

continued...

Appendix 1. Continued.

TAXA	VERTEBRATE GROUP												
	Fish	Tadpole	Frog	Salamander	Turtle	Snake	Lizard	Bird egg	Nestling	Bird	Mammal	Undetermined vertebrate	Meat
Pipridae													
Mackenziaena severa			95			95	95	95	95				
Myrmeciza atrothorax			95										
Myrmeciza exsul			54,69				54,69						
Myrmeciza immaculata			75,95				75,95						
Mymeciza ruficauda			95										
Myrmotherula fulviventris			54										
Myrmotherula hauxwelli							95						
Percnostola rufifrons						95	95						
Phaenostictus mcleannani							54,95					75	
Phlegopsis nigromaculata							95						
Pithys albifrons							95						
Pygiptila stellaris			95										
Pyriglena leuconota							95						
Pyriglena leucoptera							95						
Sakesphorus canadensis							93						
Schistocichla leucostigma							76						
Taraba major	95	95	95				69,75				93,95		
Thamnomanes ardesiacus							95						
Thamnomanes schistogynus							95						
Thamnophilus atrinucha			54				52,54						
Thamnophilus doliatus							93						
Conopophagidae													
Conopophaga lineata			87										
Formicariidae													
Formicarius analis			54,63			69,75	54,69						
Formicarius nigricapillus			75,95			75?	75?						
Grallaria gigantea		29	29										
Grallaria guatimalensis			75										
Grallaria quitensis			95?										
Hylopezus perspicillatus			54										
Pittasoma michleri			75			75?	75?						
Furnariidae													
Automolus infuscatus							95						
Automolus melanopezus			95										
Automolus ochrolaemus			75,95				62,75						
Automolus rubiginosus			75,95				75,95						
Automolus rufipileatus			95										
Cinclodes antarcticus								95					95
Cinclodes aricomae			95										
Cinclodes excelsior			29,95										
Cinclodes nigrofumosus	95												
Cinclodes palliatus			29,95										
Furnarius rufus			60										
Hyloctistes subulatus			75,95				75,95						
Lochmias nematura			43										
Philydor fuscipenne							95						
Pseudocolaptes boissonneautii			95										
Pseudocolaptes lawrencii				75,95									
Pseudoseisura lophotes								55,95					
Sclerurus albigularis			75,95										
Sclerurus guatemalensis			54				54						
Sclerurus scansor									55				
Syndactyla subalaris			75,95				75,95						
Thripadectes rufobrunneus			69,75	69,75			69,95						
Thripadectes virgaticeps							95						
Dendrocolaptidae													
Campylorhamphus trochilirostris												48	
Dendrocincla anabatina							54,69						
Dendrocincla fuliginosa			25,54				25,85						
Dendrocincla homochroa			54				54						
Dendrocincla merula			25				25,49						
Dendrocolaptes certhia			75,95				75,95						
Dendrocolaptes picumnus			95				86,95					62	
Dendrocolaptes platyrostris			14,44										
Dendrocolaptes sanctithomae							95						
Lepidocolaptes angustirostris			95										
Hylexetastes perrotii			95				95						
Nasica longirostris			95				95						
Xiphocolaptes albicollis								55,95				43,95	
Xiphocolaptes major			37,95			37,95					39,95		

continued...

Appendix 1. Continued.

TAXA	VERTEBRATE GROUP												
	Fish	Tadpole	Frog	Salamander	Turtle	Snake	Lizard	Bird egg	Nestling	Bird	Mammal	Undetermined vertebrate	Meat
Xiphocolaptes promeropirhynchus			95										
Xiphorhynchus elegans			25				25					95	
Xiphorhynchus erythropygius			75,95	75,95									
Xiphorhynchus flavigaster							95						
Xiphorhynchus guttatus	49												
Xiphorhynchus lachrymosus			95				75,95						
Xiphorhynchus picus							36,95						
Xiphorhynchus sussurans			25,75				75,80						
Vireonidae													
Cyclarhis gujanensis			31				47						
Vireo altiloquus			79										
Vireo griseus							24						
Corvidae													
Aphelocoma coerulescens			8,17		17		8,17	17,99	17,99		8,99		
Aphelocoma ultramarina							99	99	99				
Calocitta formosa			75				75	75,76	75				
Corvus brachyrhynchos	17		17,99			17	17,99	17,99	17,99	17,99	17,99		17,99
Corvus corax	17	17	17,99			17,99	17,99	17,99	17,99	17,99	17,99		17,99
Corvus cryptoleucus			17				17	17,99	17,99		17		17
Corvus jamaicensis								99		99			
Corvus leucognaphalus			99						99				
Corvus palmarum							99						
Cyanocitta stelleri			17					17,99	99		17		
Cyanocorax affinis			75				81,75						
Cyanocorax caeruleus			4				4	32?	4,32?	26,32?			14,26
Cyanocorax chrysops								26,61	99	61	61	77	
Cyanocorax cristatellus								55	5,92				5
Cyanocorax cyanomelas													55,92
Cyanocorax dickeyi								99	99				
Cyanocorax morio			75				68,75	75?	68,75?				
Cyanocorax mystacalis								99					
Cyanocorax samblasiana							99						
Cyanocorax violaceus							99						
Cyanocorax yncas								70,99	70,99				99
Cyanolica turcosa								99	99				
Cyanolyca argentigula			75	75			75						
Cyanolyca cucullata												75	
Gymnorhinus cyanocephalus								17	17				
Hirundinidae													
Riparia riparia	22												
Troglodytidae													
Campylorhynchus griseus								64					
Cyphorhinus phaeocephalus			54										
Thryothorus ludovicianus			12			12	12						
Troglodytes aedon							55						
Mimidae													
Margarops fuscatus			53,79				45	72	72	59	59		
Mimus gilvus							89,93	93					
Mimus polyglottos							7						
Turdidae													
Catharus minimus			54										
Sialia sialis			11				11						
Turdus albicollis			28										
Turdus grayi						27	68						
Turdus leucomelas							35						
Turdus migratorius	46					18					73		
Turdus nudigenis							89						
Turdus plumbeus			79										
Parulidae													
Dendroica adelaidae			79										
Oporornis formosus							54						
Icteridae													
Amblyramphus holosericeus			63										
Cacicus cela								55?	55?				
Cacicus uropygialis												75	
Chrysomus cyanopus			63										
Icterus dominicensis			53,79										
Icterus galbula							9	9					
Icterus pustulatus								76	93				
Psarocolius decumanus								61					
Psarocolius montezuma			98?				98?		88			75	

continued...

Appendix 1. Continued.

TAXA	VERTEBRATE GROUP												
	Fish	Tadpole	Frog	Salamander	Turtle	Snake	Lizard	Bird egg	Nestling	Bird	Mammal	Undetermined vertebrate	Meat
Psarocolius sp.								55?	55?			83	
Psarocolius wagleri			75				75						
Quiscalus lugubris							74,89	6	6				
Quiscalus mexicanus	67,81	67	67,81				75	67,81	67,81	40,81	67		
Quiscalus niger			79										
Quiscalus spp.	70		70	70		70	70	70	70		70		
Emberizidae													
Arremonops conirostris			67				67						
Coryphospingus pileatus							58?						
Embernagra platensis	15		15,63				91?						
Thraupidae													
Eucometis penicillata							54						
Habia fuscicauda						38							
Neothraupis fasciata							2						
Nesospingus speculiferus		21,79					53,79						
Phaenicophilus palmarum							34						
Piranga flava							94						
Piranga rubra							1						
Ramphocelus passerinii											67		
Ramphocelus bresilius		55	55										
Rhodinocichla rosea			38,81										
Thraupis palmarum													92
Thraupis sayaca													27
Number of passerine species preying upon each group	**21**	**9**	**109**	**6**	**3**	**18**	**122**	**75**	**37**	**14**	**23**	**17**	**12**

Sources: 1 - Aborn & Froehlich, 1995; **2 -** Alves, 1991; **3 -** Andrews & Sullivan, 1996; **4 -** Anjos, 1995; **5 -** Antas & Cavalcanti, 1988; **6 -** Babbs et al., 1987 *apud* Collar et al., 1992; **7 -** Beal, 1907 *apud* Bent, 1948; **8 -** Beal, 1910 *apud* Bent, 1946; **9 -** Beal, 1910 *apud* Bent, 1958; **10 -** Beal, 1912 *apud* Bent, 1958; **11 -** Beal, 1915 *apud* Bent, 1949; **12 -** Beal et al., 1916 *apud* Bent, 1948; **13 -** Beebe, 1916 *apud* Schubart et al., 1965; **14 -** Belton, 1994; **15 -** Beltzer, 1990; **16 -** Bendire, 1895 *apud* Bent, 1942; **17 -** Bent, 1946; **18 -** Bent, 1949; **19 -** Berla, 1944; **20 -** Berlepsch & Ihering, 1885 *apud* Schubart et al., 1965; **21 -** Biaggi, 1973 *apud* Pérez-Rivera, 1997; **22 -** Bottomley, 1993; **23 -** Brehm, 1913 *apud* Schubart, 1965; **24 -** Chapin, 1925 *apud* Bent, 1950; **25 -** Chapman & Rosenberg, 1991; **26 -** Descourtilz, 1983; **27 -** Feduccia, 1971; **28 -** Fichberg et al., 1997; **29 -** Fjeldså & Krabbe, 1990; **30 -** Gamboa, 1977; **31 -** Ghizoni Jr. et al., 2000; **32 -** Gollan & Lopez, 1952; **33 -** Gross ,1950; **34 -** Guerrero, 1981 *apud* Pérez-Rivera, 1997; **35 -** Haverschimidt, 1968 *apud* Foster, 1987; **36 -** Haverschimidt, 1968 *apud* Hayes & Argaña, 1990; **37 -** Hayes & Argaña, 1990; **38 -** Isler & Isler, 1987; **39 -** Juan Mazar Barnett, pers. com.; **40 -** Lamb, 1944; **41 -** Lefebvre & Spahn, 1987; **42 -** Longo et al., 2000; **43 -** Lopes et al., in press; **44 -** Marcos Maldonado-Coelho, pers. com.; **45 -** McLaughlin & Roughgarden, 1989; **46 -** Michael, 1934; **47 -** Moojen et al., 1941; **48 -** Naumburg, 1930; **49 -** Novaes & Lima, 1998; **50 -** Oberholser, 1938 *apud* Bent, 1942; **51 -** Oberlander, 1939; **52 -** Oniki, 1975; **53 -** Pérez Rivera, 1997; **54 -** Poulin et al., 2001; **55 -** Reinhardt, 1870 *apud* Schubart et al., 1965; **56 -** Richard, 1986 *apud* Latino & Beltzer, 1999; **57 -** Ridgely & Tudor, 1994; **58 -** Rodrigues & Nascimento, 1997; **59 -** Rolle, 1965; **60 -** Sander & Voss, 1982; **61 -** Santos, 1979; **62 -** Schauensee & Phelps Jr., 1978; **63 -** Schubart et al., 1965; **64 -** Serna & Madrigal, 1988; **65 -** Seutin & Apanius, 1995; **66 -** Sick, 1997; **67 -** Skutch, 1954; **68 -** Skutch, 1960; **69 -** Skutch, 1969; **70 -** Skutch, 1996; **71 -** Snow, 1982 *apud* Foster, 1987;**72 -** Snyder & Taapken, 1977 *apud* McLaughlin & Roughgarden, 1989; **73 -** Sprot, 1926 *apud* Bent, 1949; **74 -** Stamps, 1983; **75 -** Stiles & Skutch, 1989; **76 -** The Field Museum, 2003; **77 -** Vigil, 1973 *apud* Foster, 1987; **78 -** Wetmore, 1916 *apud* Bent, 1942; **79 -** Wetmore, 1916 *apud* Pérez-Rivera, 1997; **80 -** Wetmore, 1972; **81 -** Wetmore et al., 1984; **82 -** Whittaker, 1995; **83 -** Wied, *apud* Schubart ,1965; **84 -** Willis, 1967 *apud* Wetmore, 1972; **85 -** Willis, 1972; **86 -** Willis, 1982; **87 -** Willis et al., 1983; **88 -** Wolf, 1971; **89 -** Wunderle Jr., 1981; **90 -** Zotta, 1936; **91 -** Zotta, 1940; **92 -** L.E.L., pers. obs; **93 -** ffrench, 1991; **94 -** Delgado & Brooks, 2003.; **95 -** del Hoyo et al., 2003; **96 -** Remsen Jr., 1997; **97 -** Skutch, 1997; **98 -** Orians, 1969; **99 -** Goodwin, 1976; **100 -** del Hoyo et al., 2004.

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