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FORAGING AND DIET COMPOSITION OF THE BLACK-CAPPED FOLIAGE-GLEANER (*PHILYDOR ATRICAPILLUS*)

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Resumo. – Forrageamento e composição da dieta do Limpa-folha-coroado (*Philydor atricapillus*). – Vinte e nove amostras regurgitadas pelo especialista em folhas mortas Philydor atricapillus, após a administração do tártaro emético, foram examinadas para determinar a dieta da espécie. A maioria das aves tratadas regurgitou e somente dois indivíduos morreram. Amostras da fauna de invertebrados encontrada em aglomerados de folhas secas suspensos nos galhos foram obtidas para estimar a disponibilidade de presas para as aves. A dieta foi dominada por besouros e aranhas, mas considerando a disponibilidade de presas, a espécie mostrou maior preferência por ootecas e mariposas. Baratas e ortópteros foram ingeridos sem uma preferência especial, embora sejam considerados como presas importantes na dieta destas aves especialistas em folhas mortas. Formigas foram bastante evitadas. Assim, P. atricapillus mostrou preferência por algumas presas, evitando outras, em seu principal substrato de forrageamento.

Abstract. – Twenty nine samples regurgitated from the dead-leaf specialist Black-capped Foliage-gleaner (*Philydor atricapillus*) after administration of tartar emetic were examined to assess the diet of the species. Similarly, samples of invertebrate fauna living in suspended dead-leaf clusters were obtained to estimate prey availability for the birds. Diet was dominated by beetles and spiders, but considering the prey available, the birds showed stronger preference for oothecas and moths. Roaches and orthopterans were ingested without any special preference, although they are considered important prey categories in the diet of dead-leaf specialists. Ants were largely avoided. Thus, in their principal foraging substrate, birds showed preference for some prey categories, avoiding other prey in proportion to their availability. *Accepted 28 October 2000*.

Key words: *Atlantic forest, dead-leaf specialization, foraging ecology, Furnariidae,* Philydor atricapillus, *resources availability, tartar emetic.*

INTRODUCTION

Knowledge of interactions between food resources and consumers is fundamental in ecological studies of tropical birds (Karr & Brawn 1990). Some authors have studied bird abundance and seasonality in relation to feeding habits in the Neotropics (Snow & Snow 1964, Karr 1976, Loiselle 1988). Others have studied foraging behavior and prey availability for insectivorous birds feeding on specific substrates (Rosenberg *et al.* 1982, Gradwohl & Greenberg 1982, 1984, Sherry 1984, Chapman & Rosenberg 1991, Rosenberg 1993). However, the relationship between prey availability and prey selectivity remains poorly documented because of the difficulty in measuring these two parameters.

Leaves falling from the canopy are often trapped by lower vegetation, building dense suspended clusters that are utilized as refuges by many invertebrates, especially arthropods. These dead leaves are considered as an abundant, predictable and renewable resource, easily sampled for arthropod prey in studies of resources available to insectivorous birds, in contrast with living foliage or airspace that possess a more generally distributed and diversified arthropod fauna (Gradwohl & Greenberg 1982, 1984, Rosenberg 1990). A large number of insectivorous bird species forages in this arboreal microhabitat, but only some bird species, principally of the families Thamnophilidae and Furnariidae, specialize in searching for arthropods in dead leaves (Remsen & Parker 1984), considering this food resource when choosing their territories and visiting it repeatedly (Rosenberg 1990). The relative abundance of larger prey may be the single most important factor promoting foraging specialization on dead leaves (Rosenberg 1993).

Furnariidae comprise a large family of Neotropical passerines, essentially insectivorous with dull plumage. *Philydor* is a genus with about ten species of arboreal passerines found widely in humid forests. Considered as a dead-leaf specialist (Remsen & Parker 1984), the Black-capped Foliage-gleaner (*P. atricapillus*) is a fairly common furnarid of the lower growth of the forest in southeastern Brazil, Paraguay and Argentina, whose foraging ecology has not been accurately investigated. The purpose of this study is to make a first approach to the diet and selectivity of prey categories in the Black-capped Foliage-gleaner at a site in southeastern Brazil, where it resulted the most common and more captured dead-leaf specialist species.

METHODS

The study was carried out at the foot of the Serra dos Órgãos (22°31'S, 43°01'W), at 350 m elevation in Rio de Janeiro State, southeastern Brazil. This area is covered by Atlantic forest with a canopy approximately 25–30 m high, and a relatively dense understory with vine tangles, shrubs and palms. The climate, following the definitions of Bernardes (1952), is intermediate between a hot and wet climate and the mesotermic climate with temperate summers. The rainiest season runs from December to March, but there is no well-defined dry season.

The study area is at the southern border of the Parque Nacional da Serra dos Órgãos, including a area of forest estimated at about 3 hectares. The forest of the study area is in an advanced stage of clearing due to the growing demand for timber and heart of palm, and the uncontrolled occupation of the foothills.

Birds were captured at regular intervals over the study period using five mist nets (12 x 2.6 m and 36 mm mesh) in the forest understory, twice a month from February 1996 to June 1997. Each bird was banded, weighed, and forced to regurgitate by administering tartar emetic (Kadochnikov 1967, Tomback 1975). The birds received 0.2 cm^3 of a 1% solution of antimony potassium tartrate, given orally through a 2.8 mm diameter flexible plastic tube attached to a syringe and inserted gently into the bill as far as the lower oesophagus. After treatment, the bird was placed in plastic PVC container for 10 to 15 min. The regurgitated food items were preserved in 70% ethanol. Each regurgitated sample was placed in a 10-cm Petri dish and carefully separated and classified to the lowest taxonomic level possible under a dissecting microscope in the laboratory. The number of individuals prey ingested was estimated by counting the number of heads, mandibles, legs or wings and dividing by the number found in a whole arthropod. The relative frequency of each prey category in the diet was determined as the average of the proportions in the individual samples. Thus, regurgitated samples were not pooled.

Tartar emetic was used in this study to assess the diet of the Black-capped Foliage-gleaner because the effect and efficiency of this emetic in birds has been confirmed by

TABLE 1. Frequency of different invertebrate prey categories in dead leaves and in the diet of the Black-capped Foliage-gleaner.

Prey categories	Dead leaves	Diet	D_{fr} (Level of preference)
Gastropoda	0.03	0	-1 (strong avoidance)
Isopoda	0.05	0	-1 (strong avoidance)
Scorpionida	0.01	0	-1 (strong avoidance)
Pseudoscorpionida	0.01	0	-1 (strong avoidance)
Araneae	0.12	0.32	0.55 (moderate preference)
Opilionida	0.01	0	-1 (strong avoidance)
Acari	0.03	0	-1 (strong avoidance)
Diplopoda	0.03	0	-1 (strong avoidance)
Chilopoda	0.01	0.01	0 (no preference)
Diplura	0.01	0	-1 (strong avoidance)
Thysanura	0.01	0	-1 (strong avoidance)
Collembola	0.05	0	-1 (strong avoidance)
Orthoptera	0.05	0.06	0.09 (no preference)
Blattodea	0.07	0.09	0.13 (no preference)
Isoptera	0.03	0	-1 (strong avoidance)
Isoptera (larvae)	0.01	0	-1 (strong avoidance)
Dermaptera	0.05	0	-1 (strong avoidance)
Embioptera	0.01	0	-1 (strong avoidance)
Psocoptera	0.04	0	-1 (strong avoidance)
Thysanoptera	0.01	0	-1 (strong avoidance)
Heteroptera	0.02	0.02	0 (no preference)
Homoptera	0.01	0	-1 (strong avoidance)
Coleoptera	0.10	0.36	0.67 (moderate preference)
Coleoptera (larvae)	0.03	0.02	-0.20 (slight avoidance)
Lepidoptera	0.01*	0.01	0.82 (strong preference)
Lepidoptera (larvae)	0.03	0	-1 (strong avoidance)
Diptera	0.01	0.01	0 (no preference)
Diptera (larvae)	0.01	0	-1 (strong avoidance)
Formicidae	0.16	0.01	-0.90 (strong avoidance)
Hymenoptera (excluding ants)	0.01	0.01	0 (no preference)
Pupae	0.03	0	-1 (strong avoidance)
Ootheca	0	0.05	1 (strong preference)
Insect eggs	0.01[1]	0.01	0.43 (moderate preference)
Total number of invertebrate individuals	1579	81	

[1]Value < 0.01.

many workers (Kadochnikov 1967, Tomback 1975, Poulin *et al.* 1992, 1994a, 1994b, Poulin & Lefebvre 1995, Mallet-Rodrigues *et al.* 1997). Regurgitated samples can be analysed more accurately than faecal samples because they are less fragmented (Poulin & Lefebvre 1995, Mallet-Rodrigues *et al.* 1997).

Prey availability was estimated through analysis of the invertebrate fauna, sampled monthly during one year from randomly collected dead-leaf clusters suspended in the foliage of the understory. These dead leaves

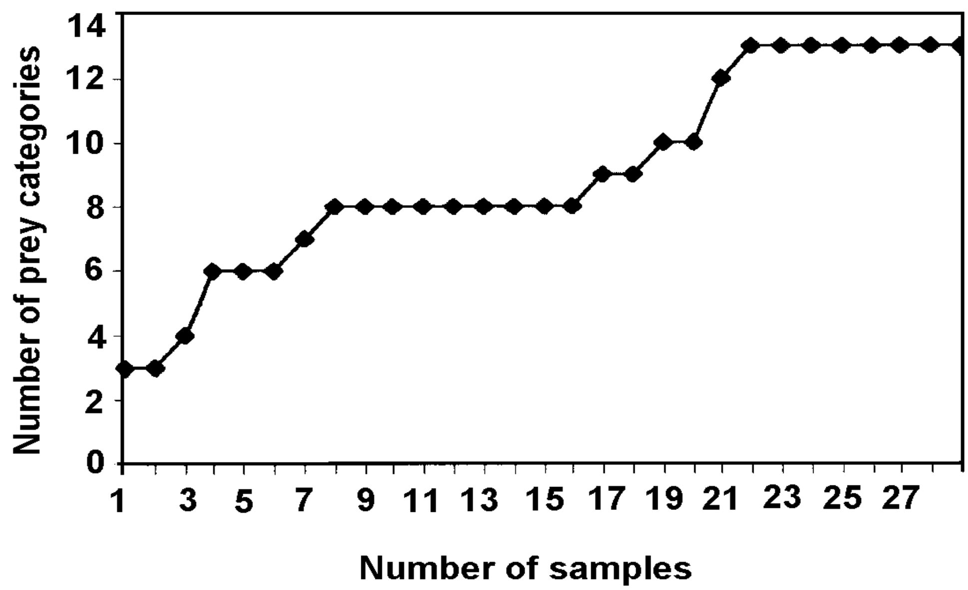

FIG. 1. Number of prey categories in cumulative regurgitated samples.

were collected from up to 3 m above ground, because most dead leaves were concentrated in these first 3 m (Rosenberg 1990). Each cluster found was collected manually, with as little disturbance as possible, and placed in a plastic bag. A standardized quantity of dead-leaf clusters was collected, sufficient to fill three 25 cm^3 plastic bags each month. Later, the invertebrates were killed with insecticide, and individuals were counted, classified to the lowest taxonomic level possible, and preserved in 70% ethanol. The proportion of each prey category in the dead leaves was determined as the average of the proportions in the twelve samples. This material is housed in the Laboratório de Ornitologia, Universidade Federal do Rio de Janeiro (UFRJ).

Although it was possible to identify the arthropods of the dead-leaf sample at family level, this was not done because of the difficult to identifying fragments of prey at the same level.

An index was used, according to Jacobs (1974), to evaluate selectivity for prey in relation to its availability in dead-leaves: $D_{fr} = (r - p)/(r + p - 2rp)$, where r is the proportion of that prey in the diet, and p is the proportion of the same prey in the dead-leaf sample. I follow Morrison (1982) to categorize this index to a level of negative or positive selectivity, ranging from -1 to 0 for avoidance, and from 0 to 1 for preference.

The foraging behavior of individuals searching for prey was noted through 8 x 30 mm binoculars. Whenever a bird was located by chance along forest trails, its foraging behavior was observed taking a single foraging bout lasting 10 sec. Observations were made in the morning from 08:00 to 12:00 h. The terminology of Remsen & Robinson (1990) was used to describe the foraging maneuvers observed.

RESULTS

Thirty tartar emetic administrations were car-

TABLE 2. Foraging substrates and maneuvers used by the Black-faced Foliage-gleaner.

	Frequency
Foraging substrate[1]	
Dead-leaf	0.70
Epiphyte	0.07
Living foliage	0.09
Vine stem	0.13
Maneuvers[2,3]	
Glean	0.11
Reach	0.39
Hang-up	0.32
Hang-down	0.09
Lunge	0.01
Flake	0.08

[1]N = 54.

[2]N = 88.

[3]According to Remsen & Robinson (1990).

ried out on 22 individuals. Twenty-nine (96.6%) administrations produced regurgitated samples for analysis. Two individuals (9.1%) died after the treatment, both regurgitating first.

Thirteen prey categories were found in the diet of the Black-capped Foliage-gleaner (Table 1). Coleoptera (36%) and Araneae (32%) accounted for more than half of the overall diet, with a mean number of 1.7 and 1.5 individuals prey/sample, respectively. The next most frequent prey categories, Blattodea (9%) and Orthoptera (6%), were taken in substantially lower proportion. Only one probable insect egg was found, but it is not known if it was eaten separately or was released by some ootheca during digestion. Ootheca represented 5% of the diet of the species.

The number of items per sample (i.e., individuals prey regurgitated by bird) ranged from one to eight, with a mean of 2.8 items/sample. The number of individuals prey in each prey category within the same sample was always low. Most emetic samples showed a low diversity of prey categories (mean = 2.1 prey categories/sample; range = 1 to 5).

The cumulative number of prey categories in the diet against the number of samples did not stabilize at least until close to 22 samples (Fig. 1).

The Black-capped Foliage-gleaner exhibited dead-leaf-searching behavior, frequently picking small arthropods after introducing the bill or even the head inside dead-leaf clusters. The foraging maneuver most commonly observed was "reach", when the bird extended the neck to reach prey. It was also observed using its legs to suspend the body vertically to search for arthropods in dead-leaves ("hang-up" and "hang-down"). "Glean" occurred when the bird reached prey without acrobatic movements or extension of the neck. "Flake" and "lunge" were less frequently used maneuvers. "Flake" is when the bird dislodged dead leaves or fragments of the suspended cluster by brushing with the bill, and "lunge" when the bird reached prey with rapid leg movements (following Remsen & Robinson 1990). The preferred foraging substrate was suspended dead-leaf clusters where it was recorded most of the time. It was also found foraging along vine stems and searching carefully for arthropods in living-foliage and epiphytes, specially bromeliads (Table 2).

The sample of the invertebrate fauna in the dead-leaves contained 1579 individuals in 32 prey categories, consisting mainly of arthropods (97%), of which insects were the majority (70.6%), followed by arachnids (16.5%) (Table 1). Ants comprised the highest proportion in the samples, but showed large fluctuations during the year. Termites also had a large populational variation. These two taxa were always recorded in larger numbers when a colony was present in the dead leaves collected. The most significant prey categories were Araneae (12%), Coleoptera (10%) and Blattodea (7%) because they

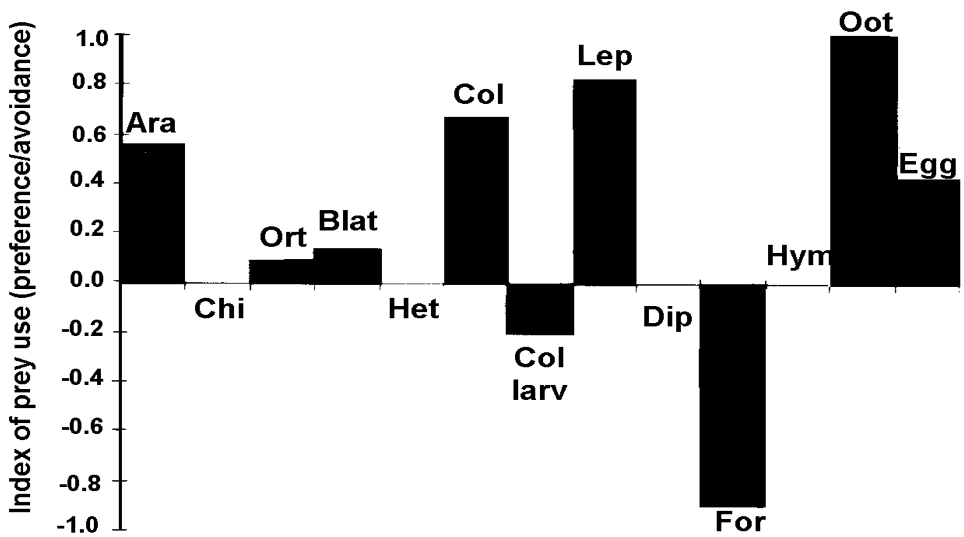

FIG. 2. Index of prey preference for each prey category ingested by Black-capped Foliage-gleaner. Positive values indicate selection and negative values indicate avoidance.

showed a high and more stable proportion throughout the year. Collembola, Isopoda, Dermaptera and Orthoptera were also well represented in the sample.

The Black-capped Foliage-gleaner selected some invertebrate prey categories ingested from a wider range of prey categories available (Fig. 2). Although less numerous in the diet, oothecas and lepidopterans (moths) were strongly selected. Beetles, spiders and eggs were moderately selected. Roaches and orthopterans, both common in dead leaves, were not selected. Ants were the taxon most strongly avoided.

DISCUSSION

The number of individuals prey for sample in this study was very low, comparing with other studies (Sherry 1984, Rosenberg *in litt.*), because the regurgitated material did not reflect the amount of food in the stomach, but it gives an accurate representation of the diet composition (Gavett & Wakeley 1986).

Beetles, orthopterans, spiders, roaches, bugs and wasps have been reported as major prey categories in the diet of Neotropical birds (Sherry 1984, Chapman & Rosenberg 1991, Rosenberg 1993, Poulin *et al.* 1994a, 1994b). Likewise, beetles and spiders appear as the most frequent invertebrate-prey in the diet of the Black-capped Foliage-gleaner. Schubart *et al.* (1965) also found mainly spiders and beetles in the stomach contents of three species of *Philydor* in Brazil (*P. lichtensteini*, *P. rufus* and *P. erythrocercus*). Rosenberg (1997) found high preference for orthopterans, except for roaches that were strongly avoided by *P. erythrocercus* and *P. ruficaudatus.*

Black-capped Foliage-gleaners were more often observed inspecting dead-leaf clusters actively for prey than moving along vine tangles, living foliage and epiphytes, and picking food by reaching. Develey (1997) observed a similar behavior when following mixed species bird flocks in Southeastern Brazil.

Although the abundance of an arthropod taxon in a sample may be very different from the availability of this taxon in the field, due to differing capture probabilities resulting from the selectivity of sampling techniques (Wolda 1990), the method used here can be considered effective because all the local invertebrate fauna is collected with the dead leaves. Invertebrates using this substrate remain generally hidden during the day, becoming more active at night when they are subject to little or no searching by birds. Collecting during the day ensures that practically all the invertebrates are sampled.

Spiders, beetles and roaches were among the most abundant groups found in dead leaves, confirming data of other authors (Chapman & Rosenberg 1991, Rosenberg 1990, 1993, 1997). Ants were the most abundant invertebrates found. However, the preponderance of ants in dead-leaf samples was related to the sporadic capture of these insects' colonies, resulting in large populational fluctuations. The same occurred with termites, although in smaller numbers. In this study, Orthoptera (excluding roaches) was less common in dead leaves than in other studies (Chapman & Rosenberg 1991, Rosenberg 1990, 1993, 1997).

Bird species were considered to be dead-leaf specialists when seen searching in dead-leaves in more than 90% of their foraging attempts (Gradwohl & Greenberg 1982, 1984, Rosenberg 1990). However, Remsen & Parker (1984) considered dead-leaf specialists to be birds that search in that substrate in more than 75% of foraging observations, regular users being species seen in that substrate in 25 to 75% of observations and occasional users the species for which less than 25% of records were in dead-leaves. The Black-capped Foliage-gleaner was observed foraging in dead-leaf clusters in high frequency, being also considered a dead-leaf specialist because it manipulated dead-leaves with its bill. Non specialists rarely manipulate this substrate when searching for prey (Rosenberg 1993, 1997).

The Black-capped Foliage-gleaner selected some prey categories ingested in relation to the prey available in dead-leaves. Although orthopterans (included roaches) are considered the most common prey categories found in stomach contents of dead-leaf specialist birds (Rosenberg 1990, 1993, 1997), in this study they were less important than other groups.

The bird may find prey availability different when foraging in green foliage and vine tangles, because the size and taxonomic composition of arthropods differed considerably between living and dead leaves. Live-leaf arthropods are significantly smaller and less cryptically colored than dead-leaf arthropods (Rosenberg 1990). These prey categories are poorly represented in the diet of the Black-capped Foliage-gleaner. When foraging in epiphytes, it probably finds prey similar to that found in dead-leaves, because dead-leaves frequently accumulate among the leaves of certain epiphytes, such as bromeliads. Sillett *et al.* (1997) found a large proportion of aquatic insect larvae in bromeliads, but terrestrial arthropods and insect eggs were also very common. This is fairly similar to the fauna of suspended dead-leaf clusters, except for the aquatic insect larvae. This differential exploitation of substrates may generate bias in the analysis of food availability for birds with a restricted foraging substrate. This may be the reason why birds that forage in dead leaves sometimes show no significant dietary differences from substrate generalists (Chapman & Rosenberg 1991). The diet of a bird species may also vary over space, time, season and from one individual to another.

Despite to the potential biases related to the differential digestibility of prey and the cumulative curve not quite saturated, the Black-capped Foliage-gleaner showed preference for some prey categories in its principal foraging substrate, avoiding other prey in proportion to its availability. However, Rosenberg (1993) concluded that dead-leaf specialists do not exhibit overall selectivity of prey, nor a particular tendency to avoid prey not normally encountered in nature. This specialization is considered to be the result of a change in search behavior and is not accompanied by a change in prey preference.

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