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Feeding ecology of two *Cacicus* species (Emberizidae, Icterinae)

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RESUMO. **Ecologia alimentar de duas espécies de *Cacicus* (Emberizidae, Icterinae).** Estudei a dieta de *Cacicus haemorrhous* e *C. chrysopterus* ao longo de um ano em uma reserva de Mata Atlântica no sudeste do Brasil. A variação na composição da dieta em função da época do ano e da associação em bandos monoespecíficos ou em bandos mistos de aves foi analisada. Embora ambas as espécies sejam omnívoras, pois alimentaram-se de artrópodes, frutos e néctar, *C. haemorrhous* mostrou-se mais frugívora, alimentando-se de frutos especialmente na época chuvosa (verão) quando há uma maior abundância de frutos carnosos na área de estudo. *Cacicus chrysopterus* alimentou-se predominantemente de artrópodes, tanto na época seca quanto na chuvosa. *Cacicus chrysopterus* associou-se mais frequentemente a bandos mistos que sua congênere e, nesta situação, alimentou-se principalmente de artrópodes. A utilização de frutos por *C. chrysopterus* ocorreu apenas quando indivíduos alimentavam-se solitariamente ou em grupos monoespecíficos, o que pode ser explicado pela tendência em explorar o mesmo tipo de alimento procurado pela maioria dos participantes dos bandos mistos (predominantemente insetívoros na área de estudo), e a incompatibilidade entre a exploração de frutos e o acompanhamento de tais bandos.
PALAVRAS-CHAVE: Bandos mistos de aves, *Cacicus*, dieta, ecologia alimentar, frugivoria, Mata Atlântica.

ABSTRACT. A one-year study focusing on the diet and flocking behavior of *Cacicus haemorrhous* and *C. chrysopterus* was conducted in an Atlantic forest reserve in southeastern Brazil. I was especially interested in the influence of season and association with monospecific or mixed-species flocks on the diet of both *Cacicus* species. Although both species included arthropods, fruits, and nectar in their diets, *C. haemorrhous* relied more heavily upon fruits than its congener, especially during the rainy season, a period of general fruit abundance in the study area. *Cacicus chrysopterus* participated more often in mixed-species flocks than *C. haemorrhous*. When in mixed-species flocks, *C. chrysopterus* ate mainly arthropods, while fruits were exploited only by solitary individuals or those associated with monospecific flocks. The differential utilization of food resources by *C. chrysopterus* as a function of flock composition may be viewed as the outcome of the tendency of caciques to explore the same food resource exploited by most mixed-species flock participants (mainly insectivorous bird species in the study area). The incompatibility between the relatively time-consuming exploitation of fruits and the rapid movements of mixed-species flocks through the forest may also play a role.
KEY WORDS: Atlantic forest, *Cacicus*, diet, feeding ecology, flocking, frugivory, mixed-species flocks.

Diet studies are crucial to the comprehension of the ecology and behavior of a bird species (Wiens 1992), as well as to complement community studies (Remsen *et al.* 1993). The diet of a bird species, however, frequently present considerable flexibility, varying not only temporally and spatially in response to the availability of food resources (Wiens 1992), but also according to flock composition in response to social interactions (Valburg 1992).

I studied the diet of the Red-rumped (*Cacicus haemorrhous*) and Golden-winged (*C. chrysopterus*) Caciques in an Atlantic forest reserve in southeastern Brazil. Orians (1985) classified *C. haemorrohous* as an omnivorous species, and *C. chrysopterus* as an insectivorous one. However, the diet of both species in nature is poorly known, and the few reports cite arthropods, fruits and probably nectar (Belton 1985, Sick 1985, Ridgely and Tudor 1989). Both species follow mixed-species flocks (Machado 1991). I was especially interested in: (a) examine the seasonal variation in the diet composition of the two species, and (b) determine the influence of association with mixed-species flocks on food selection by these species.

STUDY SITES AND THE *CACICUS* SPECIES

The study was carried out in two sites located in the Parque Estadual Intervales (hereafter PEI) (24°16'S, 48°25'W), a 49,000 ha reserve located at the Serra de Paranapiacaba mountains of São Paulo State, southeastern Brazil. The study sites, Sede and Carmo, were 9 km from each other and located at an altitude of 850 and 700 m, respectively. At both sites the vegetation consists primarily of old-secondary forest (in the sense of Clark 1996) with trees reaching up 30 m tall, and a great abundance of bamboo tickets (particularly *Guadua angustifolia, Chusquea* spp., and *Merostachis* spp.). Extensive forested areas surround the study sites. Climate is generally wet,

with rain or fog occurring frequently. Annual precipitation is around 1,600 mm, and mean annual temperature for the study period was 17.6°C. There is a dry-cold season from April to August, when temperature often drops below 5°C and frosts may occur, and a wet-hot season from September to March.

Cacicus haemorrhous is larger than *C. chrysopterus* (males weight 39g in *C. haemorrhous*, and 93 g in *C. chrysopterus*; data from Belton 1985), and the sexes of both species are indistinguishable in the field. The distribution of the two species differs markedly along the elevational gradient represented by the study sites at PEI. *Cacicus haemorrhous* was rarely seen at Sede, being much more common at Carmo. *Cacicus chrysopterus*, on the other hand, was more commonly found at Sede, but frequently reached Carmo.

METHODS

The study was conducted from January to December 1993 through monthly visits to the study sites (1-3 days at Sede, 3-8 days at Carmo). Data were collected along several trails and unpaved roads that crossed the study sites totalling approximately 10 km. Sampling was concentrated between 06:00 and 12:00, and between 15:00 and 18:00.

Every time I found a foraging *Cacicus*, I recorded the group size and if the individual(s) was associated with mixed-species flocks or not. The diet of *Cacicus* was quantified by recording only the first foraging maneuver observed for the focal individual (or group).

In an attempt to quantify the availability of fleshy fruits throughout the study, I censused all the fleshy-fruited trees bearing mature fruits along the trails and roads at the study sites each month. Although this method does not provide an estimate of fruit production, it nevertheless reflects the temporal pattern of fleshy fruit availability in the study area (see Blake *et al.* 1990). As the *Cacicus* species under consideration do not (or rarely do) forage in the understory, understory treelets, shrubs, and herbs were not surveyed.

I used Chi-square to test for difference in the association with mixed-species flocks between both species. Due to small sample sizes, G-test was employed to evaluate the effect of season and association with monospecific and mixed-species flocks on the diet of each species, as well as to test for heterogeneity in the number of mature fleshy-fruited plant species along the year. Mann-Whitney U-test with normal approximation was used to compare monospecific flock size between both species. All tests followed Zar (1984).

RESULTS

When in monospecific flocks, *C. chrysopterus* foraged in small groups ($\bar{x} \pm sd = 1.9 \pm 0.8$ individuals, n = 42, range = 1-4), often in pairs (52,4 % of the records). The mean flock size of *C. haemorrhous* (2.0 ± 2.3 individuals, n = 97, range = 1-20) was significantly different from *C. chrysopterus* (U = 1.98, P = 0.04). The former species occurred in a wider range of flock size (figure 1).

I recorded 65 feeding bouts for the *Cacicus* eating arthropods, fruits and also visiting flowers probably in search of nectar (tables 1 and 2). The birds glean for arthropods most often in living foliage, but frequently look

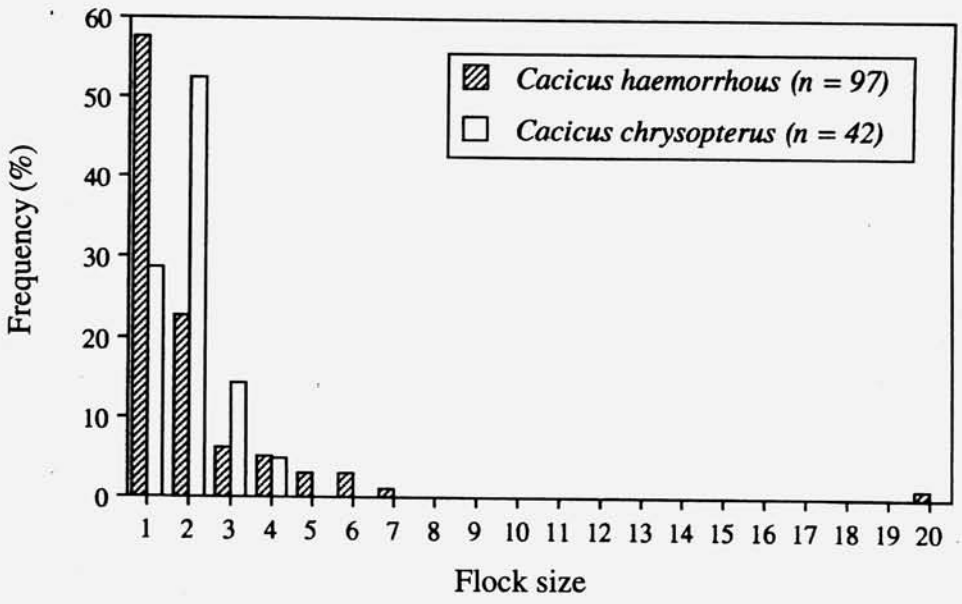

Figure 1. Monospecific flock size distribution of *Cacicus haemorrhous* and *C. chrysopterus* at Parque Estadual Intervales, southeastern Brazil, during 1993.

for them in dead leaves suspended in the vegetation (27.3 % and 18.5 % of the 11 and 27 insectivorous foraging maneuvers recorded for *C. haemorrhous* and *C. chrysopterus*, respectively). Additionaly, *C. chrysopterus* also captured arthopods in the air and in twigs (one capture each), and frequently inspected dry fruits (e.g., *Cassia* sp., Caesalpiniaceae; *Cedrela fissilis*, Meliaceae; *Pithecoctenium* sp., Bignoniaceae; *Tibouchina mutabilis*, Melastomataceae; 25,9 % of its insectivorous foraging maneuvers, n = 27) in search of hiden arthropods. Arilate fruits were frequently eaten by both species (33.3 % of the records on fruits, n = 18), but the infructescences of *Cecropia glaziovii*, heavily exploited by *C. haemorrhous*, were the fruit item most frequently recorded (55.5 %). The flowers visited by the *Cacicus* were either bat- or bird-pollinated ones (table 1).

The *Cacicus* species significantly differed in the proportion of food items eaten. Overall, *C. haemorrhous* ate more fruits than its congener, while *C. chrysopterus* preyed more heavily upon arthropods (table 2).

Effect of season. There was a great number of fleshy-fruited plant species bearing fruits during the wet when compared to the dry season ($G = 20.77$, $P < 0.05$; figure 2).

The diet of *C. haemorrhous* varied in a seasonal basis. Fruits were more often eaten during the wet season, whereas arthropods and nectar predominated in the dry season (table 2). *Cacicus chrysopterus*, on the other hand, did not change the diet throughout the year, and arthropods represented its staple food in both seasons (table 2).

Effect of the association with mixed-species flocks. *Cacicus chrysopterus* was a common species (in the sense of Powell 1985) in the mixed-species flocks recorded at Sede, where the occurrence of *C. haemorrhous* in these associations was rare (14.1 % and 1.4 % of the flocks recorded, respectively, $n = 71$, $\chi^2 = 7.98$, $P = 0.001$). At Carmo, however, both species occurred in the same frequency in mixed-species flocks (3.2 %, n = 311). Overall, *C. chrysopterus* could be equally encountered either associated with mixed-species flocks or not ($\chi^2 = 0.22$, $P > 0{,}50$), but *C. haemorrhous* was more frequently found solitary or in monospecific flocks ($\chi^2 = 37.45$, $P < 0.001$).

While associated with mixed-species flocks *C. chrysopterus* fed almost exclusively on arthropods (n = 15). This species was never observed eating fruits when accompanying the flocks, and three out of four instances of nectar feeding were observed when the birds were out of these flocks (table 2). The diet of *C. haemorrhous* did not differ with mixed-species flock association (table 2).

DISCUSSION

In his monograph about icterids, Orians (1985) designated *C. haemorrhous* as an omnivorous species, and *C.*

Table 1. Plant species from which *Cacicus* took fruits and nectar at Parque Estadual Intervales, southeastern Brazil. Plant families and species are arranged in alphabetical order.

Plant family/species	Item eaten[a]	Fruit/flower type[b]	*Cacicus* species[c]
BOMBACACEAE			
Pseudobombax sp.	ne	q	Ch
Spirotheca passifloroides	ne	o	Ch
CECROPIACEAE			
Cecropia glaziovii	fr	n	Ch
ELAEOCARPACEAE			
Sloanea monosperma	fr	a	Cc
EUPHORBIACEAE			
Alchornea glandulosa	fr	a	Ch, Cc
Tetrorchidium rubrivenium	fr	a	Cc
MELIACEAE			
Cabralea canjerana	fr	a	Ch, Cc
MIMOSACEAE			
Inga sp.	ne	q	Ch
ONAGRACEAE			
Fuchsia sp.	ne	o	Cc

[a] ne = nectar, fr = fruits.
[b] o = ornitophilous (i.e., bird-pollinated) or q = quiropterophilous (i.e., bat-pollinated) flowers, and a = arilate or n = non-arilate fruits.
[c] Ch = *Cacicus haemorrhous*, Cc = *Cacicus chrysopterus*.

Table 2. Number of records of *Cacicus chrysopterus* and *C. haemorrhous* eating arthropods, fruits and nectar at Parque Estadual Intervales, southeastern Brazil. The effects of season and association with mixed-species flocks on the diet of both species are analyzed.

	C. chrysopterus			*C. haemorrhous*		
	Arthropods	Fruits	Nectar	Arthropods	Fruits	Nectar
Season						
Wet	11	4	2	2	8	0
Dry	16	2	2	9	4	5
G-test	G = 1.36, P > 0.50			G = 10.79, P < 0.005		
Mixed-species flock association						
In	14	0	1	3	5	1
Out	13	6	3	8	7	4
G-test	G = 8.06, P < 0.02			G = 0.97, P > 0.50		
Overall[a]	27	6	4	11	12	5

[a] The overall diet of both species differed: G = 7.85, P < 0.025.

chrysopterus as an insectivorous one. Although they differ in the proportion of food items eaten at PEI, I found both species eating arthropods, fruits, and probably nectar in a regular basis, implying that both can be viewed as omnivorous species. In fact, Ridgely and Tudor (1989) have already noted that *C. chrysopterus* "also comes to flowering trees and eat some fruits". However, *C. haemorrhous* seems to be more frugivorous than its congener which in turn relies more heavily upon arthropods.

I could not identify the arthropods captured by the birds, but Robinson (1986) found mainly lepidopteran larvae, orthopterans, and spiders in the diet of the Yellow-rumped Cacique (*C. cela*). Schubart *et al.* (1965) in addition found alated ants in the stomach of a *C. haemorrhous* specimen. In the present study, the arthropods were captured mainly in living foliage, but birds probe so frequenly into dead leaves that at least *C. haemorrhous* may be regarded as a regular user (in the sense of Remsen and Parker 1984) of this kind of substrate. This foraging habit may not be uncommon in the genus *Cacicus* since other species (e.g., *C. cela* and *C. holosericeus*) have already been observed searching for arthopods in suspended dead

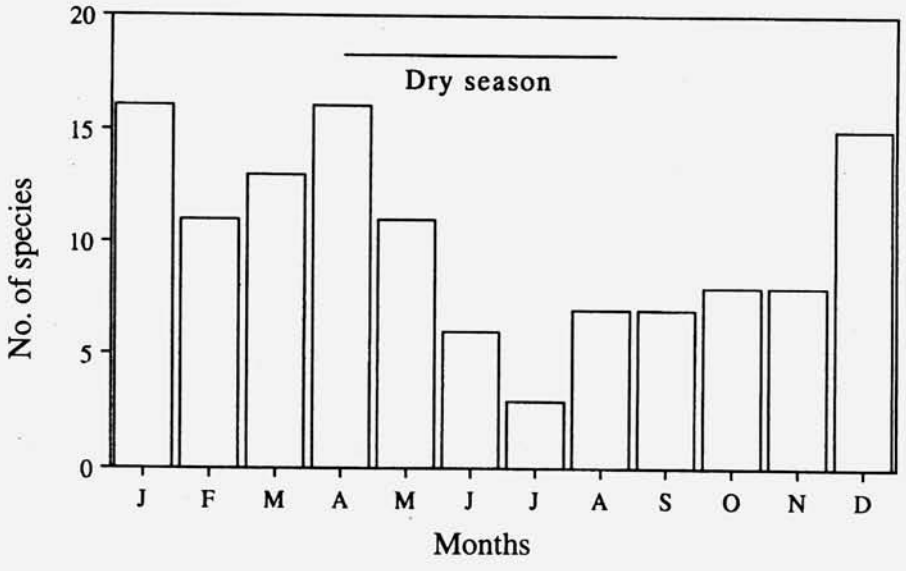

Figure 2. Monthly variation in the number of plant species bearing mature fleshy fruits in the study area during 1993. Plants were sampled along a 10 km-long transect. The horizontal line above the bars indicates the dry season.

leaves (Remsen and Parker 1984, Robinson 1986). Even the less common habit of inspecting dry fruits has also already been observed for *C. cela* (Robinson 1986), although much less frequently than recorded here for *C. chrysopterus*.

I suspect that the birds visited the flowers primarily in search of nectar although, as observed by Skutch (1972) for *C. uropygialis*, arthropod eating is also a possibility. Bat- and bird-pollinated flowers like those recorded here produce copious quantity of nectar (Faegri and Van der Pijl 1971) which may be the cue for the attraction of non-nectarivorous birds (see Sazima *et al.* 1993). In fact, the flowers of *Pseudobombax* sp. and *Spirotheca passifloroides* are visited by birds other than hummingbirds at PEI (pers. obs.). Thus, the supply of nectar may be the crucial feature for the attaction of *Cacicus* species to flowers. For instance, Skutch (1972) observed *C. uropygialis* visiting the bat-pollinated flowers of a *Marcgravia* species (Marcgraviaceae), and Berla (1944) recorded *C. haemorrhous* in the bird-pollinated flowers of an *Erythrina* species (Fabaceae).

Changes in the diet of birds in response to seasonal fluctuations of food resource abundance are common (see examples in Wiens 1992). The decrease in availability of fleshy fruits during the dry season at the study area certainly played a role in the seasonal change of food exploitation by *C. haemorrhous*. Instead of fruits, which predominate in the wet season, arthropods and nectar were favored by *C. haemorrhous* in the dry season. *Cacicus chrysopterus* did not show such a change, which reinforces the label of a predominantely insectivorous species. The frequent association of *C. chrysopterus* with mixed-species flocks, which in the study area are composed primarily by insectivorous species (Machado 1991), probably helps this species to maintain its insectivorous diet even in the dry season when arthropods are likely to be scarce (Janzen 1973, Buskirk and Buskirk 1976, Wolda 1978), but mixed-species flocks are very common (Machado 1991).

The association with mixed-species flocks may direct, in a convergent way, the attention of foraging birds toward the food items sought by most flock participants (Buskirk 1976, Valburg 1992). Valburg (1992) found that the diet of the Common Bush-tanager (*Chlorospingus ophtalmicus*) changed from predominantely frugivorous to chiefly insectivorous whether the birds foraged solitarily and in single-species flocks or associated with predominantely insectivorous mixed-species flocks. *Cacicus chrysopterus* showed the same pattern, eating fruits only when individuals foraged solitarily or in monospecific flocks. When both *Cacicus* species ate fruits, especially large to medium arilate fruits (e.g., *Cabralea canjerana*), they made use of the feet to hold the fruit against a branch and then pick the pulp or aril piecemeal (pers. obs). This is a time-consuming activity, incompatible with the rapid movement of mixed-species flocks, and which probably precludes fruit-eating by *C. chrysopterus* during its participation in mixed-species flocks. *Cacicus haemorrhous*, in contrast, did not change its diet with mixed-species flock association. This species is a rare participant of mixed-species flocks at PEI (Machado 1991, this study), but can occur in large monospecific flocks where birds can forage not only for insects but also for fruits and nectar. In fact, mixed- and single-species flocks may not present the same foraging opportunities (Valburg 1992), since the foraging behavior of birds is likely to differ between these both situations, possibly as a consequence of social interactions occurring most frequently in single-species flocks (Moriarty 1977).

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