

## Species composition and seasonal occurrence of mixed-species flocks of forest birds in savannas in central Cerrado, Brazil

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**RESUMO. Composição de espécies e ocorrência sazonal de bandos mistos de aves florestais em savanas no Cerrado central, Brasil.** Bandos mistos de aves florestais forrageando em savanas (cerrado *sensu stricto*) adjacentes a matas de galeria foram estudados no sul de Goiás: Caldas Novas (1999 e 2000) e Distrito Federal (2000 e 2001). Doze espécies de aves participaram de bandos mistos (n = 9) em Caldas Novas, enquanto que 32 espécies foram registradas nesses grupos heteroespecíficos (n = 34) no Distrito Federal. Algumas características dos bandos mistos foram similares em ambas as localidades: 1) os bandos formaram-se nas matas de galeria e eventualmente tiveram sua riqueza de espécies aumentada nas savanas; 2) *Hemithraupis guira*, *Tangara cayana* e *Dacnis cayana* foram as espécies nucleares; 3) bandos foram mais frequentes e tiveram mais espécies fora do período reprodutivo do que na estação de reprodução dos membros dos bandos; 4) as espécies nucleares foram atraídas às savanas principalmente por flores abundantes, como as do pequi *Caryocar brasiliense*; 5) frutos de olho-de-pomba (*Miconia* spp.) foram um importante recurso consumido por membros dos bandos. Estes foram os primeiros registros de bandos mistos de aves florestais forrageando em savanas no Cerrado. Novos estudos são necessários para revelar os processos envolvidos nesse movimento.

**PALAVRAS-CHAVE:** bando misto, borda de hábitat, Cerrado, matriz de paisagem, savana.

**ABSTRACT.** Mixed-species flocks of forest birds foraging in savannas (cerrado *sensu stricto*) adjacent to gallery forests were studied in southern Goiás: Caldas Novas (1999 and 2000) and Distrito Federal (2000 and 2001). Twelve bird species participated in mixed-species flocks (n = 9) at Caldas Novas, while 32 species were recorded in such flocks (n = 34) at Distrito Federal. Some characteristics of these mixed-species flocks were similar in both localities: 1) flocks were formed in the gallery forest and eventually had their species richness increased in the savannas; 2) *Hemithraupis guira*, *Tangara cayana* and *Dacnis cayana* were the nuclear species; 3) flocks were more frequent and had more species in the non-breeding period than in the breeding season of flock members; 4) the nuclear species were attracted to savannas mainly by abundant flowers, such as those of *Caryocar brasiliense*; 5) fruits of *Miconia* spp were a major resource consumed by flock members. These were the first records of mixed-species forest bird flocks foraging in savannas in Cerrado. Further studies are necessary to reveal the processes involved in such patch-matrix movements.

**KEY WORDS:** Cerrado, habitat edge, landscape matrix, mixed-species flocks, savanna.

Mixed-species flocks are bird aggregations found in diverse landscapes around the world (Morse 1977, Diamond 1981, Powell 1985, Terborgh 1990). Formation of mixed-species flocks has been considered as remarkably seasonal in temperate regions (Morse 1970, Bell 1980). These flocks, however, are generally formed along the year in the tropics, where their structure and frequency can be stable (Jullien and Thiollay 1998) or present considerable seasonal variations (Powell 1985, Alves and Cavalcanti 1996, Machado 1999, Develey and Peres 2000).

In South America, mixed-species flock biology has been investigated mainly in forests (Powell 1985, Terborgh 1990, Develey 2001, Jullien and Thiollay 2001). In Cerrado, most research on mixed-species flocks has focused on bird species typical of open habitats foraging within savannas and grasslands (e.g. Silva 1980, Silva and Oniki 1988, Willis and Oniki 1990, Alves and Cavalcanti 1996, Parker and Willis 1997, Silveira 1998, Ragusa-Netto 2000, 2002) and forest birds within forests (e.g. Silva and Oniki 1988, Marini 1992, Olmos and Boulhosa 2000).

Despite wide recognition of savanna use by forest bird species in Cerrado (Cavalcanti 1992, Lins 1994, Tubelis 2000, Bagno and Marinho 2001, Tubelis *et al.* 2004), records of mixed-species flocks do not mention such forest bird aggregations moving across forest/savanna boundaries (see

review in Macedo 2002). Thus, the objective of this study was to examine the seasonal occurrence and the species composition of mixed-species flocks of forest birds foraging in adjacent savannas in two Cerrado's localities in central Brazil. This study also investigated the major savanna resources used by such flocks.

### MATERIAL AND METHODS

*Study area.* This study was conducted at two localities in the southern region of Goiás State, central Brazil: Caldas Novas and Distrito Federal. Landscapes in this region are generally dominated by a gradient of savanna vegetation varying from pure grasslands to open woodlands (Eiten 1972, 1993). The cerrado *sensu stricto* is the dominant vegetation. In valleys, the savanna is interrupted by habitats associated with water courses, such as gallery forests, wet grasslands and marshes (Eiten 1972, 1993).

The cerrado *sensu stricto* is classified as open savanna woodland (Eiten 1972, 1993). Trees usually range from 3 to 7 m high, usually reaching canopy covers of 30 to 40%. Shrubs are abundant and highly variable in size and height. The cover of trees and shrubs allows the development of a continuous herbaceous stratum of about 40 cm in height (Eiten 1993, Castro and Kauffman 1998). Gallery forests

contain trees of 20 to 25 m in height, with occasional emergent trees of 30 m. Canopy covers range from 70 to 95%. The understorey is well developed, with young trees and shrubs. The herb stratum is absent or poorly developed (Eiten 1993, Ribeiro 1998, Ribeiro and Walter 1998).

According to the Köppen climatic classification, the regional climate is Aw, tropical with a strongly seasonal rainy period. Most (about 90%) of the 1500 mm annual precipitation falls between October and April. A dry season occurs between May and September (Eiten 1993). Additional information on landscapes typical of central Cerrado can be found in general references (Eiten 1972, Sano and Almeida 1998, Oliveira and Marquis 2002).

*Study sites.* The study sites at Distrito Federal were eight extensive savanna (*cerrado sensu stricto*) patches located in five protected reserves (15° 31'S to 15° 55'S, and 47° 32'W to 47° 57'W): "Estação Ecológica de Águas Emendadas", "Reserva Ecológica do IBGE", "Estação Ecológica do Jardim Botânico de Brasília", "Fazenda Água Limpa da Universidade de Brasília", and "Parque Nacional de Brasília". Surveyed areas at each study site were adjacent to extensive gallery forests farther than 2 km from any other forest.

The study sites at Caldas Novas were two extensive patches of rocky cerrado (*cerrado rupestre* - see Eiten 1972, 1993, Ribeiro and Walter 1998). They were located in the surroundings of the urban area of this municipality (17° 42'S to 17° 58'S and 48° 27'W to 48° 30'W). The cover of trees and shrubs was slightly less dense than that of savanna patches at Distrito Federal. However, the cover of herbs was much less dense due to rock outcrops on the soil surface. The two study sites were adjacent to a lake created due to the construction of a hydro-electric dam in the Corumbá river. This dam led to the flooding of vegetation growing along the major course of the river, such as gallery forests, marshes and areas of savannas in contact with gallery forests. Other landscape features not reached by the flooding were rocky grasslands and ramifications of gallery forests located on the upper portions of valleys.

*Bird sampling.* In both localities, sampling was conducted in the breeding and non-breeding periods of flock members. This division is in agreement with an investigation of the reproduction of forest birds conducted in western Cerrado (Piratelli *et al.* 2000).

At Distrito Federal, a 700 m long transect was established in each study site. This transect was located in savanna vegetation running parallel to and 30 m distant from the forest edge. Each sample consisted of walking 700 m in 40 min. The transect located in "Fazenda Água Limpa" was only 350 m long and was walked twice, in opposite directions, after 10-20 min intervals. Each flock seen within a 60 m wide band of savanna along forests (within 30 m from each side of the observer) was recorded. Each study site was sampled for two mornings during each of four sampling periods: February and March 2000, and January 2001; June to July 2000 (non-breeding period); September to October 2000; November to December 2000 (breeding period). Thus, a total of 32 samples were conducted during both the breeding and non-breeding periods.

At Caldas Novas, each sample consisted of walking randomly through a savanna patch over 90 min on one morning. Each study site was equally sampled for three

mornings during each of four sampling expeditions: August 1999 and June 2000 (non-breeding period), and November 1999 and November 2000 (breeding period). Thus, a total of 12 samples were conducted during both the breeding and non-breeding periods.

At both Caldas Novas and Distrito Federal, observations were done between sunrise and 08:00h. All bird species participating in each mixed-species flock were recorded. The nomenclature of bird species followed Sick (1997).

*Mixed-species bird flock.* I took into account major concerns usually involved in decisions about formation or not of mixed-species flocks: (1) the cohesion of species within a determined foraging area during a certain period; (2) movements of groups in different directions; (3) behavioural attributes of birds, such as alarm calls and sentinel behaviour (Stotz 1993, Jullien and Thiollay 1998, Hino 2000, Kubota and Nakamura 2000). Identification of flocks and its members was possible because: 1) walking close to forests allowed the recording of movements by birds leaving and then returning to the forest, after spending variable amounts of time in the savannas; 2) I walked slowly at both localities, thus being able to spend considerable time observing each bird aggregation. When in doubt, I did not consider bird aggregations as mixed-species flocks.

*Analyses.* The ratio between the number of samples in which mixed-species flocks were recorded and the total number of samples was called frequency of occurrence of flocks. The seasonal difference (breeding and non-breeding periods) in this frequency at Distrito Federal was verified using the chi-square test. The exact test of Fisher was used for the data obtained at Caldas Novas, due to lower numbers of flocks and samples.

The Kruskal-Wallis test was used to compare the mean number of species per flock recorded in each sampling period (breeding and non-breeding seasons). The exact test of Fisher was used to verify the existence of significant difference between the frequency of participation of species in mixed-species flocks during the breeding and non-breeding periods. All analyses in this paper were conducted using the program BioEstat 2.0 (Ayres *et al.* 2000).

## RESULTS

*Distrito Federal.* A total of 32 forest species was recorded in 43 mixed-species bird flocks. *Hemithraupis guira*, *Dacnis cayana* and *Tangara cayana* were the most frequent species in such flocks (table 1). They were considered nuclear species because they guided other flock members and emitted alarm calls. All flocks presented at least one of these three species. Other flock members participated in less than half of the number of flocks attended by nuclear species. Occasional flock members, which participated in less than 10% of the flocks, dominated the overall species richness found in these flocks (table 1).

Overall, the number of species per flock ranged from two to 16, although flocks with two to four species were more frequent (figure 1). Eight flocks were recorded in the breeding season, while 35 flocks were found in the non-breeding period, a statistically significant difference ( $\chi^2 = 11.1$ ,  $df = 1$ ,  $P < 0.001$ ). In total, 32 species were recorded in flocks in the non-breeding period, while only

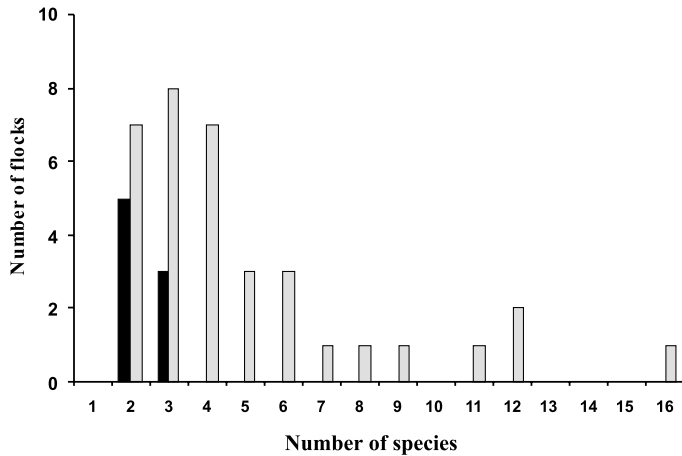


Figure 1. Number of species recorded in 43 mixed-species flocks of forest birds using savannas during the breeding (black bars) and non-breeding (gray bars) seasons at Distrito Federal, central Cerrado, in 2000 and 2001.

seven species participated in flocks in the breeding season (table 1). The species richness per flock ranged from two to 16 species in the non-breeding period, while flocks recorded in the breeding season had only two or three species (figure 1). The mean numbers of species recorded per flock in the breeding ( $2.4 \pm 0.5$ ) and non-breeding ( $5.0 \pm 3.4$ ) periods were significantly different ( $H = 8.15$ ,  $df = 1$ ,  $P = 0.004$ ). None of the bird species differed in the participation in mixed flocks between the breeding and non-breeding periods.

During their respective flowering periods, the species *Caryocar brasiliense*, *Phoradendron crassifolium*, *Qualea grandiflora* and *Roupala montana* were the major resources attracting mixed-flocks to savannas. The nuclear species and other frequent flock members, such as *Coereba flaveola*, *Parula pitiayumi*, *Conirostrum speciosum* and *Tachyphonus rufus*, often foraged on nectar, petals and insects on these plants. Despite seasonal differences in the flowering period, these four species together provided flowers during all months of the year (table 2). Fruits of *Miconia albicans*, *M.*

Table 1. Number (and percentage) of mixed-species bird flocks in which forest species were found foraging in adjacent savannas at Distrito Federal (2000, 2001) and Caldas Novas (1999, 2000), in central Cerrado, Brazil. Data relative to Caldas Novas was not divided in breeding and non-breeding seasons due to the low number of flocks recorded.

Species	Distrito Federal		Caldas Novas	
	Breeding (n=8)	Non-breeding (n=35)	Total (n=43)	Total (n=9)
<i>Hemithraupis guira</i>	5 (63%)	26 (74%)	31 (72%)	7 (78%)
<i>Dacnis cayana</i>	4 (50%)	25 (71%)	29 (67%)	7 (78%)
<i>Tangara cayana</i>	5 (63%)	23 (66%)	28 (65%)	4 (44%)
<i>Coereba flaveola</i>	0	14 (40%)	14 (33%)	1 (11%)
<i>Poliophtila dumicola</i>	0	8 (23%)	8 (19%)	1 (11%)
<i>Parula pitiayumi</i>	1 (13%)	6 (17%)	7 (16%)	3 (33%)
<i>Sittasomus griseicapillus</i>	0	7 (20%)	7 (16%)	0
<i>Tachyphonus rufus</i>	1 (13%)	5 (14%)	6 (14%)	0
<i>Cyclarhis gujanensis</i>	0	5 (14%)	5 (12%)	1 (11%)
<i>Trichothraupis melanops</i>	1 (13%)	4 (11%)	5 (12%)	0
<i>Picumnus albosquamatus</i>	0	5 (14%)	5 (12%)	0
<i>Antilophia galeata</i>	0	4 (11%)	4 (9%)	0
<i>Conirostrum speciosum</i>	0	4 (11%)	4 (9%)	2 (22%)
<i>Basileuterus culicivorus hypoleucus</i>	0	4 (11%)	4 (9%)	0
<i>Myiarchus ferox</i>	0	3 (9%)	3 (7%)	1 (11%)
<i>Casiornis rufa</i>	0	3 (9%)	3 (7%)	1 (11%)
<i>Veniliornis passerinus</i>	0	3 (9%)	3 (7%)	0
<i>Thamnophilus caeruleus</i>	0	3 (9%)	3 (7%)	0
<i>Euphonia chlorotica</i>	1 (13%)	1 (3%)	2 (5%)	0
<i>Philydor rufus</i>	0	2 (6%)	2 (5%)	0
<i>Hylocryptus rectirostris</i>	0	2 (6%)	2 (5%)	0
<i>Phyllomyias fasciatus</i>	0	2 (6%)	2 (5%)	0
<i>Turdus leucomelas</i>	0	2 (6%)	2 (5%)	0
<i>Nemosia pileata</i>	0	2 (6%)	2 (5%)	0
<i>Eucometis penicillata</i>	0	2 (6%)	2 (5%)	0
<i>Piranga flava</i>	0	2 (6%)	2 (5%)	0
<i>Synallaxis frontalis</i>	0	1 (3%)	1 (2%)	0
<i>Saltator similis</i>	0	1 (3%)	1 (2%)	0
<i>Turdus amaurochalinus</i>	0	1 (3%)	1 (2%)	0
<i>Ramphocelus carbo</i>	0	1 (3%)	1 (2%)	0
<i>Vireo chivi</i>	0	1 (3%)	1 (2%)	0
<i>Tityra cayana</i>	0	1 (3%)	1 (2%)	0
<i>Tolmomyias sulphurescens</i>	0	0	0	1 (11%)
<i>Pachyramphus polychopterus</i>	0	0	0	1 (11%)

Table 2. Seasonal occurrence of flowers and fruits of the plant species most often visited by members of mixed-species forest bird flocks using adjacent savannas at Distrito Federal, central Cerrado, in 2000 and 2001. The asterisk (\*) indicates the record of fruits and flowers in the study sites.

Plant species (Family)	Habit	Months											
		J	F	M	A	M	J	J	A	S	O	N	D
<u>Flowers</u>													
<i>Caryocar brasiliense</i> (Caryocaraceae)	Tree								*	*	*		
<i>Phoradendron crassifolium</i> (Viscaceae)	Epiphyte	*	*	*	*								
<i>Qualea grandiflora</i> (Vochysiaceae)	Tree	*	*									*	*
<i>Roupala Montana</i> (Proteaceae)	Shrub						*	*	*				
<u>Fruits</u>													
<i>Miconia</i> spp (Melastomataceae)	Shrub/tree	*										*	*

*fallax*, *M. ferruginata* and *M. rubiginosa* were those most often eaten by flock members. *Hemithraupis guira*, *Tangara cayana*, *Dacnis cayana*, *Antilophia galeata*, *Tachyphonus rufus*, *Thamnophilus caerulescens*, *Myiarchus ferox*, *Casiornis rufa*, *Pachyramphus polychopterus* and *Conirostrum speciosum* consumed *Miconia* fruits. *Turdus leucomelas* consumed fruits of *Byrsonima lancifolia*. Insects were consumed by most species.

*Caldas Novas*. A total of 12 forest species participated in nine mixed-species flocks (table 1). The most frequent species considered as nuclear species were *Hemithraupis guira*, *Dacnis cayana* and *Tangara cayana*. Flocks presented two to seven species, but those with only two species were the most frequent. A flock with two species and another flock with four species were recorded during the breeding season (November 2000). On the other hand, flocks with two ( $n = 4$ ), three ( $n = 1$ ), six ( $n = 1$ ) and seven ( $n = 1$ ) species were found during the same sampling effort in the non-breeding period (June and August). No seasonal difference in the frequency of occurrence of flocks was detected (Fisher test,  $P = 0.19$ ).

Besides the nuclear species, *Coereba flaveola*, *Conirostrum speciosum*, *Parula pitiayumi* and *Polioptila dumicola* foraged on flowers of *Caryocar brasiliense* (June and August 1999). *Hemithraupis guira* and *Dacnis cayana* were seen eating fruits of *Miconia* sp. (November 1999, 2000). Most species fed on insects.

*Both localities*. The mean numbers of species recorded per flock at Caldas Novas ( $3.3 \pm 1.9$ ) and Distrito Federal ( $4.5 \pm 3.2$ ) were not significantly different ( $H = 1.45$ ,  $df = 1$ ,  $P = 0.23$ ) because flocks with only two or three species predominate in both localities (figure 1).

At Caldas Novas, flocks found in savannas returned to the adjacent forest or flew to other patches of gallery forest distant 300-400 m. Such inter-forest patch movements did not occur at Distrito Federal because other forests were located at least 2 km from the studied forest/savanna boundaries. In both localities, presence of flocks in savannas could be shorter than 30 s.

Seven bird species associated to open vegetation physiognomies eventually participated in the mixed-species flocks studied. In Caldas Novas, *Thraupis sayaca* participated in

one flock. At Distrito Federal, *Camptostoma obsoletum*, *Elaenia flavogaster* and *Elaenia chiriquensis* participated in two (5%) flocks, while *Thraupis palmarum*, *Lepidocolaptes angustirostris* and *Coryphospingus cuculatus* participated in 2.5% of flocks. These seven non-forest bird species were not included in the values of species richness mentioned in this paper.

## DISCUSSION

*Species composition and richness in mixed-species flocks*. *Hemithraupis guira* was the most important nuclear species not only due to its high frequency of occurrence in flocks but also because of its more frequent alarm calls and usual dominance over *Dacnis cayana* and *Tangara cayana* in the guidance and maintenance of cohesion of flocks. Therefore, the nuclear species at these forest/savanna boundaries were social species also found in mono-specific groups when not participating in mixed-species flocks. Similarly, detailed studies also reported social birds (*Neothraupis fasciata*, *Cypsnagra hirundinacea* and *Suiriri suiriri*) as nuclear species of mixed-species flocks in savannas in Cerrado (Silva 1980, Alves and Cavalcanti 1996, Ragusa-Netto 2000, 2002).

The three nuclear species in my study are not among the reported members of mixed-species flocks foraging in gallery forests (Marini 1992), nor in flocks dominated by savanna birds using savanna vegetation in central Brazil (Silva 1980, Alves and Cavalcanti 1996). However, they were found in mixed-species flocks in forest (Silva and Oniki 1988, Willis and Oniki 1990, Olmos and Boulhosa 2000) and savanna (Silveira *et al.* 2001) vegetation in other Cerrado regions, but their role as nuclear species was not mentioned.

The lower species richness participating in flocks at Caldas Novas, when compared to Distrito Federal, may have three major causes. First, study sites at Caldas Novas were adjacent to relatively small fragments of gallery forest not reached by the flooding of the river. The avifauna in these forest fragments was considerably less rich than that found in larger gallery forests adjacent to the study sites at Distrito Federal (pers. observ.). Second, the slightly lower density of savanna vegetation in Caldas Novas may have discouraged

some forest bird species to leave the forests. Lower number of shrubs and trees might lead to less protection against predators and to lower food availability. Third, the sampling effort was lower at Caldas Novas than at Distrito Federal.

*Flock formation and movement.* At both localities, mixed-species flocks were formed in gallery forests, and their richness eventually increased in the savannas. In several occasions, I observed small flocks with two to four species, such as *Hemithraupis guira*, *Tangara cayana*, *Dacnis cayana*, *Parula pitiayumi*, *Coereba flaveola* and *Conirostrum speciosum* moving through the canopy of gallery forests and then flying to savanna areas. Usually, when such small flocks were at more than 20–30 m from forests, other forest bird species did not join them. These flocks with few species usually moved quickly (without stopping) between trees with numerous flowers, where they spent usually 10 to 60 s. This fast movement of the flock through the savanna vegetation was likely facilitated by the presence of species searching mainly for nectar and other resources (e.g. insects and petals) found in flowers. On the other hand, when flocks were less than 20 m from forest edges, other forest species could join the flocks. In two occasions, I observed forest birds, such as *Thamnophilus caerulescens*, *Antilophia galeata*, *Philydor rufus*, *Basileuterus culicivorus hypoleucus* and *Trichothraupis melanops* apparently willing to join a flock foraging about 5–15 m from the forest. Some of them joined the flock after a short period of reluctance to leave the forest.

With the presence of more species, flocks tended to move more slowly through the savanna vegetation - basically foraging on most vegetation along the way. This reduced speed appeared to facilitate the participation of more species, even when the flocks were at greater distances (>20–30 m) from the forest. Apparently, the participation of a higher number of species with distinct food requirements from those of nuclear species tended to slow down the movements of flocks through the vegetation. Although the speed of movement was not presented in this paper, the observations mentioned above could be easily noted, but will require further research.

Flocks were eventually joined by bird species associated with open habitats. Because flocks with forest and savanna birds spent considerable time in the savannas, I could not discover if these savanna species abandon or follow the flocking forest species in their return to the gallery forests. Participation of bird species typical of distinct landscape units (e.g. forest and savanna) in a given flock is poorly investigated worldwide and could receive more research attention in the Cerrado.

*Savanna resources used by flock members.* At both localities, abundant flowers were the major resources responsible for attracting the nuclear species to savannas. As the most often visited plant species were common in the study sites, the nuclear species probably do not face periods of shortage of their major food items in savannas. Although these and other 32 forest species attending flocks frequently fed on other savanna food items (fruits and insects), flowers are major resources indirectly attracting part of the forest bird communities to savannas in central Cerrado.

Little information on resource use by members of mixed-species flocks in Cerrado is available. Willis and Oniki (1990) reported the use of fig trees and inflorescences of

*Mabea sp* by mixed-species flocks in Mato Grosso. In this same state, forest flocks were seen feeding on fruits of Melastomataceae species in gallery forests (Silva and Oniki 1988). Olmos and Boulhosa (2000) observed mixed-species flocks foraging on inflorescences of *Mabea fistulifera* in a *cerradão* patch in eastern Cerrado. Flock members fed on insects, fruits, grains and seeds in savannas at Distrito Federal (Alves and Cavalcanti 1996). Other studies mentioned the use of seeds by flocks guided by *Sporophila*, but the plant species were not specified (Silva and Oniki 1988, Silveira 1998). Thus, the use of savanna plant species in my study has not been recorded by previous investigations on mixed-species flocks in Cerrado. Melo (2001) also recorded *Hemithraupis guira*, *Tangara cayana* and *Dacnis cayana* foraging on *Caryocar brasiliense*, but the occurrence of mixed-species flocks was not mentioned.

*Seasonality.* At Distrito Federal and Caldas Novas, mixed-species flocks of forest birds were found in savannas during both the breeding and the non-breeding periods of flock members. In Cerrado, such occurrence had been previously reported in investigations of mixed-species flocks in savannas (Silva 1980, Alves and Cavalcanti 1996) and forests (Marini 1992). Considerable seasonal variations in flock frequency and structure were observed at both localities in my study. Flocks presented more species and were recorded more frequently during the non-breeding period of forest birds. This pattern is similar to that showed by mixed-species flocks of open habitat birds in savanna patches in Cerrado (Silva 1980, Alves and Cavalcanti 1996) and by mixed flocks of forest bird species in other tropical ecosystems (Powell 1985, Machado 1999, Develey and Peres 2000).

According to Powell (1985), seasonal variation in the occurrence and structure of mixed-species flocks is due to two major seasonal factors. First, birds would tend to participate in mixed-species flocks more frequently during periods of shortage of their food resources to enhance increased foraging efficiency. Second, activities related to the nesting phase - nest building, incubation, brooding and nestling care - would discourage birds to form or join mixed-species flocks during their breeding seasons (Powell 1985). The patterns observed in the studied savannas appear to agree with this last argument. Conclusions on the influence of food availability on the formation of these mixed-species flocks in savannas will require the quantification of food items in both forests and savannas.

*Concluding remarks.* Records of mixed-species flocks in Cerrado involve bird species moving within patches of their major habitat (e.g. Silva 1980, Silva and Oniki 1988, Willis and Oniki 1990, Marini 1992, Alves and Cavalcanti 1996, Parker and Willis 1997, Silveira 1998, Olmos and Boulhosa 2000, Ragusa-Netto 2000, 2002). Although patch-matrix movements by mixed-species flocks have been recorded in other ecosystems (Stouffer and Bierregaard 1995, Dolby and Grubb 1998), the findings of my study are the first records of mixed-species flocks of forest birds moving into savannas in Cerrado.

A considerably high richness of forest bird species was found in mixed-species flocks using food resources in savannas. As the nuclear species left forests mainly to forage on nectar, flowers are major savanna resources directly and

indirectly influencing the expansion of the foraging areas of forest birds into savannas adjacent to gallery forests in Cerrado. Further clarification of the implications of the formation of these flocks to the forest and savanna bird communities will require detailed research in forest and savanna vegetation.

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