ORNITOLOGIA NEOTROPICAL 20: 421–430, 2009

BIRD FORAGING IN *ANACARDIUM* PATCHES IN CENTRAL BRAZILIAN FIRE BREAKS: RELATIONSHIP BETWEEN FLOCK SIZE AND PATCH SIZE

Dárius Pukenis Tubelis

Departamento de Ecologia, Instituto de Biociências, Universidade de São Paulo, São Paulo-SP, 05508-900, Brasil. *E-mail:* dtubelis@yahoo.com

Resumo. – Exploração de manchas de *Anacardium* por aves em aceiros no Brasil central: relação entre tamanho do grupo e o tamanho da mancha. – O manejo de fogo pode aumentar a biomassa de algumas espécies vegetais em aceiros em reservas do Cerrado. Por exemplo, numerosas e grandes manchas de cajuzinhos-do-Cerrado (*Anacardium humile*, Anacardiaceae) fornecem abundantes recursos para a fauna no estrato baixo de vegetação manejada com fogo. O objetivo deste estudo foi examinar a exploração de *A. humile* por aves em campos cerrados manejados (aceiros) no Parque Nacional das Emas, sudoeste do Brasil. A relação entre tamanho do grupo e o tamanho das manchas de *Anacardium* também foi investigada. Aceiros foram amostrados em setembro e outubro de 2006, quando flores e frutos eram abundantes. *Ara ararauna* foi a espécie mais freqüentemente registrada explorando recursos de *Anacardium*. Esta e outras espécies de psitacídeos (*Amazona aestiva*, *Alipiopsittaca xanthops* e *Diopsittaca nobilis*) consumiram sementes quando pousadas no solo ou em gramíneas ao redor das manchas. Membros de bandos de *Aratinga aurea* e *Ramphastos toco* comeram pseudo-frutos. Os maiores bandos registrados foram de *A. aurea* e *A. ararauna*. Grupos de *A. ararauna* que exploraram manchas de maior tamanho tenderam a ser maiores do que aqueles que forragearam em manchas menores. Este estudo sugere que interações intra- e inter-específicas, e características das manchas de *Anacardium* e da vegetação ao redor estão envolvidas na ecologia alimentar de aves no estrato mais baixo de *campos cerrados* manejados. Manchas de *Anacardium* em frutificação atraem numerosas aves frugívoras a aceiros no Parque Nacional das Emas. Novas pesquisas são necessárias para melhor compreender a influência do manejo de fogo sobre aves no Cerrado.

Abstract. – Fire management can increase the biomass of some plant species at fire breaks in reserves of the Cerrado. For example, numerous and large patches of monkey-nuts (*Anacardium humile,* Anacardiaceae) provide abundant food resources for wildlife in the lower strata of savanna woodlands managed by fire. The objective of this study was to examine the exploitation of *A. humile* patches by birds in managed savanna woodlands (fire breaks) at Emas National Park, southwest Brazil. The relationship between flock size and the size of *Anacardium* patches were also investigated. Fire breaks were sampled in September and October 2006, when fruits and flowers were abundant. *Ara ararauna* was often recorded exploiting resources of *Anacardium* patches. This species and other psittacids (*Amazona aestiva*, *Alipiopsittaca xanthops,* and *Diopsittaca nobilis*) consumed seeds usually on the ground around fruiting patches. Members of *Aratinga aurea* flocks and *Ramphastos toco* consumed pseudo-fruits. Larger flocks detected were those of *A. aurea* and *A. ararauna*. Groups of *A. ararauna* that exploited larger patches tended to be larger than flocks that exploited smaller patches. This study suggests that intra- and interspecific interactions and characteristics of *Anacardium* patches and of the surrounding vegetation are involved in the feeding ecology of birds in the lower stratum of managed woodlands. Fruiting *Anacardium* patches attract numerous frugivorous birds to fire breaks at Emas National Park. Further research is needed to a better understanding of the influence of fire management on birds in the Cerrado. *Accepted 31 July 2009.*

Key words: Cerrado, savanna, flock size, fire management, Psittacidae, *Ramphastos toco*.

INTRODUCTION

Fire is an important ecological factor in the Cerrado, the savanna ecosystem that dominates central Brazil (Coutinho 1982, Miranda *et al.* 2002). Natural fire can have positive and negative impacts on the Cerrado's biota (Miranda *et al.* 2004, Miranda & Sato 2006). For example, plant species might have their reproductive parts stimulated or destroyed by fire (Coutinho 1982, Medeiros & Miranda 2008).

Although plant and animal species have evolved simultaneously with fire in the Cerrado, recent human activities have been changing its influence on biodiversity (Villalobos 2001, Miranda *et al.* 2002). For example, the frequency of burning of native vegetation has partly increased as a result of annual burning of pastures and post-harvested agricultural fields to renew or eliminate parts of exotic vegetation. To avoid the spreading of wild fires originating in land adjacent to nature reserves, park managers have established a fire management in several protected areas since the 1990s (Ramos Neto & Pivello 2000, Pivello 2006). The most common practice of fire management is the maintenance of fire breaks – bands of woodland or grassland vegetation that are burned every 1–2 years to act as barriers to stop fire spreading within reserves (Pivello 2006, França *et al.* 2007).

Despite substantial knowledge about vegetation response to fire, the responses of animals to fire management in the Cerrado remain poorly known (Coutinho 1982, Miranda *et al.* 2002, 2004). Studies on birds are lacking, as investigations involved only natural or accidental fire (Marini & Cavalcanti 1996, Cavalcanti & Alves 1997). Thus, the use of fire breaks by avian visitors remains not investigated in the Cerrado, despite the availability of numerous food resources in these recent landscape elements. For example, patches of the monkey-nut (*Anacardium humile*, Anacardiaceae) are major components of the herbaceous layer of fire breaks at Emas National Park (pers. observ.). These plants usually provide large quantities of flowers, succulent pseudo-fruits, and dry fruits during nearly three months of the year (August to October) in this nature reserve. Despite this high food offer, its use by birds has not been examined in detail.

The objective of this study was to investigate the exploitation of *A. humile* by birds in savanna woodlands managed for fire control at Emas National Park, southwest Brazil. The feeding habits and flock sizes of bird visitors to flowering and fruiting patches (hereafter called '*Anacardium* patches') were examined. For species with sufficient records I also tested the hypothesis that flock size would increase with the increasing size of *Anacardium* patches due to a higher availability of food resources which might attract more birds (Galetti 1997, Renton 2001, Ragusa-Netto 2004). Results are discussed in view of the ecology of birds feeding in open woodlands.

METHODS

Study area. This study was conducted from September–October 2006 at Emas National Park, a 132,000 ha reserve located in southwest state of Goias, southwest Brazil (18º02'S, 52º51'W), in the central portion of the Cerrado region (Eiten 1972, Oliveira & Marquis 2002). Most of the park consists of flat tableland and elevations range from 720 to 900 m (França *et al.* 2007). Grasslands and woodlands are the main matrix types and cover most of the upland. The northwest and southeast portions of the park were sampled as they comprise 3500 ha of mosaics of

savanna woodlands (*campos cerrados*) and grasslands (*campos sujos*) crossed and surrounded by unpaved roads.

The regional climate is tropical and strongly seasonal, with well defined dry and wet seasons (Assad 1994). Dry seasons occur between May and September. Most of the annual precipitation falls between October and March. Annual rainfall ranges between 1200 and 2000 mm. Temperatures may fall to 0ºC in Austral winter and reach up to 40ºC in summer (Assad 1994). Fires in the park can be natural or human-induced (Ramos Neto & Pivello 2000, França *et al.* 2007). Management of fire is basically restricted to the maintenance of fire breaks (*aceiros*), bands of grasslands or woodlands adjacent to unpaved roads. Fire breaks are usually burned in the early dry season (June) every 1–2 years in attempt of containing the spread of dry season fires originating in adjacent farmlands (França *et al.* 2007).

Study sites. Fire breaks were 20 to 80 m wide strips of managed savanna woodlands located between two unpaved roads. The study sites were dominated by *capim flecha* grass (*Tristachya leiostachya* Ness). In most fire breaks, *capim flecha* and other grasses were 10–25 cm high, as park managers burned them in June 2005. At a few fire breaks (not burned in 2005 and 2006), the height of *capim flecha* was about 70 cm. Further information on woodlands and fire breaks was provided by Castro & Kauffman (1998) and França *et al.* (2007).

Observations. Foraging birds were searched within 14 km of fire breaks in mornings (09:00–10:30 h) and afternoons (15:30–17:30 h) on 18 days in September and October 2006. Thus, sampling involved 63 h of surveys/observations. Bird flocks were located by walking along fire breaks or driving a vehicle through roads adjacent to them. Whenever possible, food items of foraging birds were identified through direct observation. Each flock found was observed for up to 7 min. Subsequently, I approached a flock by walking to induce their take off. When they flew away, I determined the exact flock size as birds hidden in the vegetation also were detected. However, only monospecific flocks exploiting exclusively *Anacardium* patches were considered. After leaving a foraging site, birds were not followed.

Measurement of vegetation. The size of *Anacardium* patches was estimated through the direct measurement of the dimensions (radius, or width x length) of an area occupied by one patch (Sutherland 1998). *Anacardium* patches occurred as homogeneous and compact areas of vegetation with nearly circular, elliptical, or rectangular shapes. They usually measured 30–40 cm in height. These estimates of patch size occurred in two situations. First, the size of the patch where all or most flock members were foraging was estimated (= "size of the main patch"). Secondly, the size of all *Anacardium* patches located within 10 m from the centre of a flock (only applied to *A. ararauna*) was estimated. In this case, the area of each patch was measured individually, and then summed (= "size of patches"). These estimates of patch size were rounded to whole numbers.

Analyses. The number of individuals found in a monospecific group of feeding birds was called flock size. The detection of a lone bird or a monospecific group was considered as a single record. For species with enough records, the relationship between flock size and the size of *Anacardium* patches was examined in two situations: 1) the size of the main patch and 2) the size of patches. These two linear correlations were run considering the Pearson coefficient and using BioEstat 2.0 (Ayres *et al.* 2000). A level of significance of 5% was considered in this study.

RESULTS

Bird species, flock size, and foraging resources. Six species were recorded exploiting resources of *Anacardium* patches. Five of them were members of the Psittacidae: the Blue-and-yellow Macaw (*Ara ararauna*), the Peach-fronted Parakeet (*Aratinga aurea*), the Blue-fronted Parrot (*Amazona aestiva*), the Yellow-faced Parrot (*Alipiopsitta xanthops*) and the Red-shouldered Macaw (*Diopsittaca nobilis*). Additionally, the Toco Toucan (*Ramphastos toco*, Ramphastidae) was recorded. The species most often seen feeding on *Anacardium* patches was *A. ararauna*, totalling near 75% of all feeding events. Records of other species were substantially less numerous (Fig. 1).

The largest monospecific flocks exploiting *Anacardium* patches included *A. ararauna* and *A. aurea*, with up to 32 and 46 individuals, respectively. The smallest flocks of *A. ararauna* included only two birds, while those of *A. aurea* comprised at least six members. Flocks of other species had ≤ 16 birds, and *R. toco* was the only species to occur solitary (Fig. 2).

Bird species used the resources of *Anacardium* patches in different ways. Members of *A. ararauna* flocks always landed on bare ground or on grasses around *Anacardium* patches to gather their fruits. Individuals of *A. ararauna* rarely were detected within these dense patches of vegetation. Some macaws perched on shrubs, short trees, or termite nests after obtaining a branch bearing fruits. Seeds were the only resource eaten by this macaw species. The mid-size species (*A. aestiva*, *A. xanthops*, and *D. nobilis)* were seen foraging for seeds on the ground of fire breaks. Some left the surroundings of *Anacardium* patches with a single fruit in the bill. In other cases, feeding members of *A. aurea* groups gathered pseudo-fruits while walking on the ground or perching on branches of *Anacardium* plants or nearby shrubs. Individuals of *A. aurea* were only observed eating pseudo-fruits. Some of them took a pseudo-fruit with the bill when leaving a feeding site. The only *R. toco* detected was on the ground while swallowing an entire pseudo-fruit. The consumption of flowers of *Anacardium* patches was not recorded.

Size of Anacardium patches. Only *Ara ararauna* had statistically sufficient records to verify the relationship between group size and patch size. The size of *Anacardium* patches and the size of macaw flocks were recorded in 22 of 41 feeding events (Figs. 3, 4). These flocks included 2–31 macaws. The correlation between flock size and the size of the main patch was positive, strong, and highly significant (Pearson $r = 0.614$, $df = 20$, $P = 0.002$). The correlation between flock size and the size of patches within 10 m from the flock centre was weaker but still significant (Pearson $r = 0.487$, $df = 20$, $P = 0.02$). Thus, the size of feeding groups was more related to the main patch of *A. humile* than to the area of these patches within 10 m from the centre of *A. ararauna* flocks (Figs. 3, 4).

DISCUSSION

Bird species, flock size, and foraging resources. My study is the first to identify *Anacardium humile* as part of the diet of the six species recorded. Although Bianchi *et al.* (2000) observed the consumption of *Anacardium* resources by psittacids in the Cerrado, bird species were not informed. In addition, during a detailed study of the feeding habits of *Ramphastos toco* at Emas National Park no exploitation of *A. humile* was observed (Ragusa-Netto 2008). There may be two reasons for the absence of records of *A. humile* as feeding plant of the six species in the Cerrado. First of all, most detailed studies of fruit and seed consumption by birds in the Cerrado involved exclusively trees or high shrubs in woodlands (e.g.,

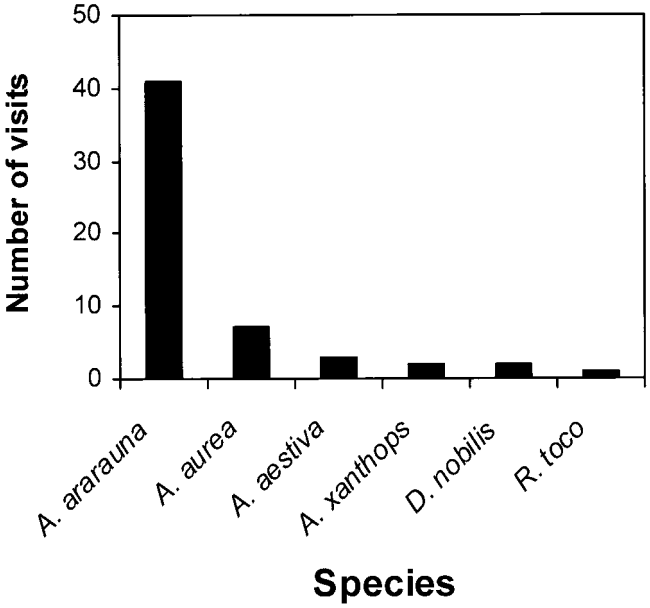

FIG. 1. Number of bird visits to *Anacardium* patches in savanna woodland fire breaks at Emas National Park, Brazilian Cerrado (September–October 2006).

Rojas & Ribon 1997, Melo 2001, Ragusa-Netto 2006). Secondly, no studies on feeding birds have been carried out at fire breaks (pers. observ.). It is likely that further observations of *Anacardium* patches in unmanaged or managed vegetation reveal more species that feed on these resources in the Cerrado. The exploitation of A. *humile* by the six species recorded in my study has also not been observed in other regions as documented by major reviews on their biology (Forshaw 1989, Del Hoyo *et al.* 1997, Sick 1997, Juniper & Parr 1998).

Information on the group size of feeding birds in the Cerrado is scarce (Macedo 2002, Pizo 2002). For example, Antas & Cavalcanti (1988) reported sizes of flocks of the same parrot species as recorded in my study to reach dozens of individuals. However, they referred to flying birds. The lack of information for adequate comparisons highlights the scarcity of data on the size of bird flocks usually recorded in studies of the feeding ecology of birds in the Cerrado.

Foraging groups of *A. ararauna* had between 2 and 34 individuals in managed savanna woodlands. Studies on this species in the Cerrado reported feeding groups of four to eight macaws in *veredas* (Villalobos 1994), two to six macaws in a forest remnant (Ragusa-Netto 2006), and single individuals in savanna woodlands (Faria *et al.* 2007). Thus, group sizes of some flocks in my study are the largest recorded to date in the Cerrado. As these studies provided only brief comments on the sizes of flocks, my study is the first to examine factors which influence variation in size of *A. ararauna* feeding flocks.

Flock size and patch size. The results are in agreement with my hypothesis that flock size would increase with the size of *A. humile* patches in managed woodlands. Several factors might be involved in this pattern. To for-

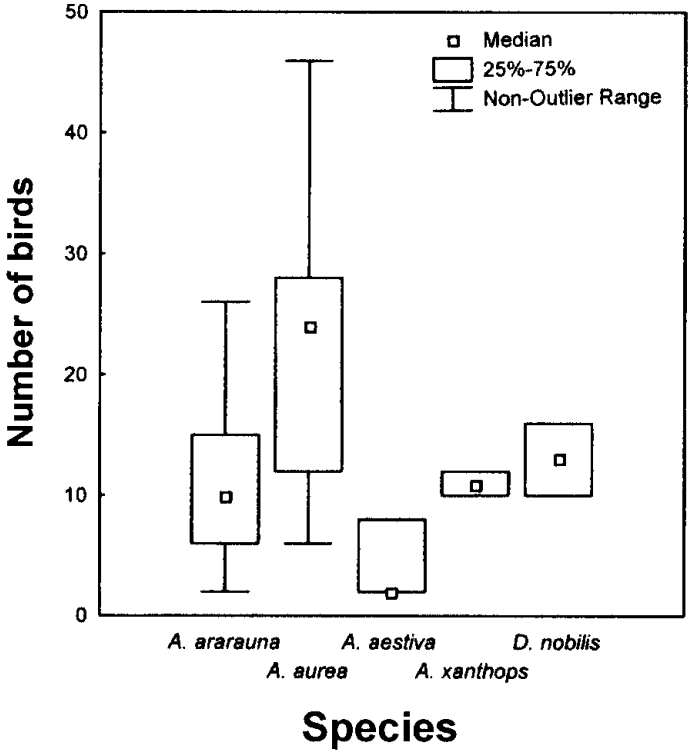

FIG. 2. Sizes of feeding flocks of psittacids exploiting resources of *Anacardium* patches at Emas National Park, Brazilian Cerrado (September–October 2006).

age for *Anacardium* seeds, macaws landed on grass adjacent to fruiting patches. Thus, they usually kept distances of 10–300 cm from each other around the patches. Due to longer perimeters, larger patches permit a more spread distribution of feeding macaws than smaller patches. Due to increased competition for food access (Delestrade 1999), small patches of *Anacardium* would not provide suitable space for large groups of macaws. Thus, small patches were visited only by small groups. Exploitation of small patches by small flocks might increase the probability of foraging on patches not previously exploited by large groups of macaws.

The flock size of feeding macaws was more related to the main *Anacardium* patch than to the area occupied by this plant species within a circumference of 10 m ratio from the centre of the flock. This might have occurred, in part, because most macaws of a given flock tended to forage on a large *Anacardium* patch when landing on woodlands. Higher amounts of *Anacardium* plants in a given site might increase the attraction of macaws. The detection of food sources themselves might be increased by the yellow or orange colours of pseudo-fruits that make *Anacardium* patches highly conspicuous to straggling bird flocks. Patches could be detected by myself even at distances > 100 m and might be easily detected by macaws during flight.

Trees and shrubs provide perches above the grass for sentinel members of flocks. Maned Wolves (*Chrysocyon brachyurus*) occasionally prey on psittacids in the Cerrado (Jua-

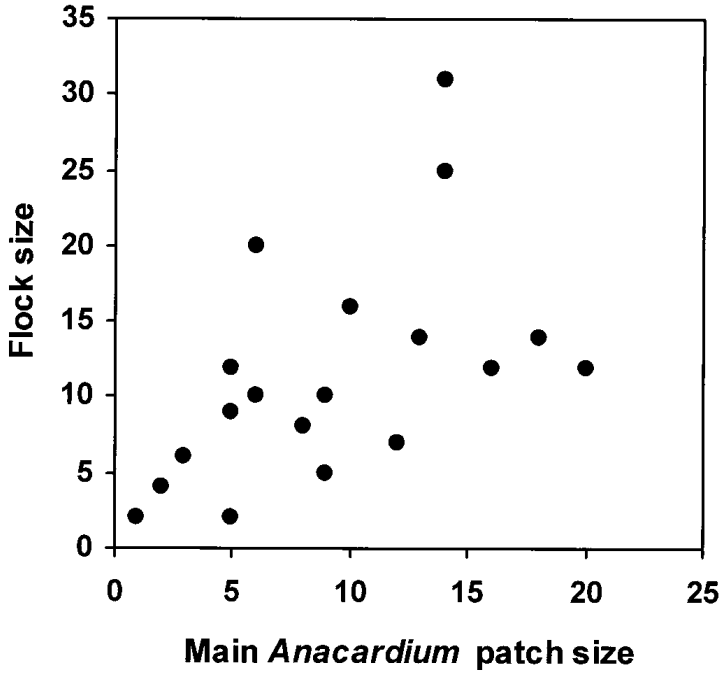

FIG. 3. Relationship between flock size and size (m^2) of main patches of *Anacardium humile* exploited by *Ara ararauna* flocks in savanna woodland fire breaks at Emas National Park, Brazilian Cerrado (September–October 2006).

rez & Marinho 2002) and I recorded this carnivore several times in fire breaks during the sampling period. The presence of sentinels perched on trees and shrubs might decrease the probability of successful attacks by wolves on macaws located in the lower strata of woodlands. Due to this and other predation threats, it might be more appropriate for macaws to forage in larger rather than smaller flocks. Collective anti-predatory vigilance and threat detection tend to be higher in larger groups of foraging birds rather than in smaller ones (Pulliam 1973, Lima & Zollner 1996). As individual vigilance levels tend to decrease with increase in group size, birds can spend more time feeding in larger rather than smaller flocks (Elgar 1989, Beauchamp 2003, Fernández *et al.* 2003). Thus, macaws might try to form larger rather than smaller groups when foraging in woodlands. On a few occasions, I could observe 2–3 flying macaws joining mid-size or large groups that were foraging at fire breaks.

Overview of foraging use of fire breaks by birds. At Emas National Park, woodlands managed for fire control provide suitable foraging conditions for some frugivorous bird species. This is suggested by frequent visits to *Anacardium* patches and a wide range of flock sizes of feeding birds. Besides aspects of vegetation, intra-specific interactions and predator threats appear to be involved in the formation, cohesion, and movements of bird flocks in woodlands. Further studies on behavioral aspects, including detailed investigations of foraging activities (e.g., Delestrade 1999, Beauchamp 2004, Sirot 2006), would contribute to a better understanding of the biology of feeding bird flocks in the Cerrado.

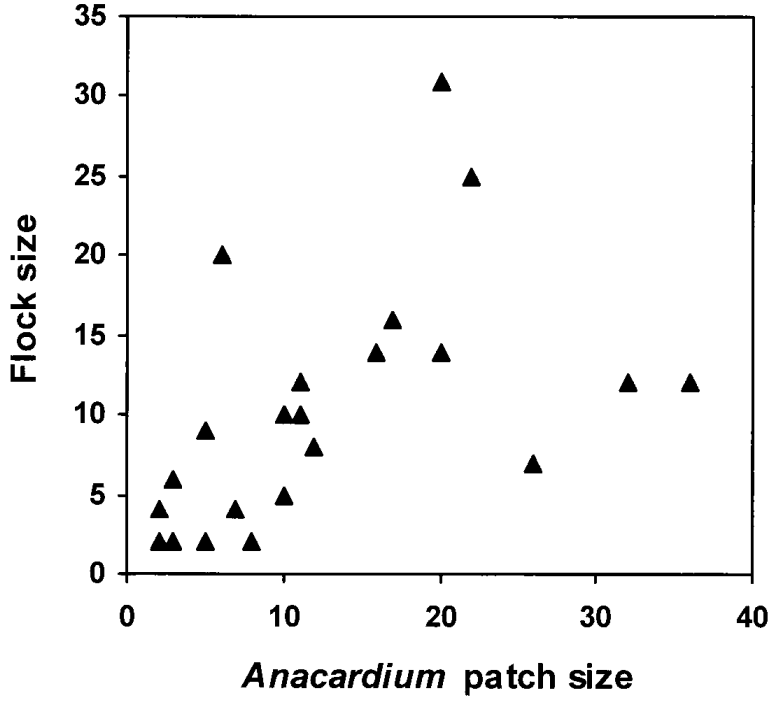

FIG. 4. Relationship between flock size and size (m^2) of patches of *Anacardium humile* within 10 m from the centre of the *Ara ararauna* flock in savanna woodland fire breaks at Emas National Park, Brazilian Cerrado (September–October 2006).

ACKNOWLEDGMENTS

I thank the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis for providing a license for research at Emas National Park. R. O. Souza assisted with logistic support. M. B. Ramos-Neto provided a vegetation map of the study area. M. N. Sato gently identified the plant species. A. Fujikawa, G. Levy, J. Roper, A. Weller, and three anonymous reviewers improved this manuscript with numerous constructive suggestions. This study received financial support from the Fundação de Amparo à Pesquisa do Estado de São Paulo (proc. 05/00773-3), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (proc. 471360/2006-6), and Idea Wild.

REFERENCES

Antas, P. T. Z., & R. B. Cavalcanti. 1988. Aves comuns do Planalto Central. Editora Univ. Brasília, Brasília, Brazil.

Assad, E. D. 1994. Chuva nos cerrados. Análise e espacialização. Embrapa/SPI, Brasília, Brazil.

Ayres, M., M. Ayres Jr., D. L. Ayres, & A. S. Santos. 2000. BioEstat 2.0. Aplicações estatísticas nas áreas das ciências biológicas e médicas. Sociedade Civil Mamirauá, Belém, Brazil.

Beauchamp, G. 2003. Group-size effects on vigilance: a search for mechanisms. Behav. Proc. 63: 11–121.

Beauchamp, G. 2004. Reduced flocking by birds on islands with relaxed predation. Proc. R. Soc. Lond. Biol. Ser. 271: 1039–1042.

Bianchi, C. A., M. A. Bagno, & K. M. Juarez. 2000. Predation of *Ara ararauna* and *Amazona aestiva*

(Psittaciformes, Psittacidae) by *Chrysocyon brachyurus* (Carnivora, Canidae) in the Cerrado, Brazil. Ararajuba 8: 49–50.

Castro, E. A., & J. B. Kauffman. 1998. Ecosystem structure in the Brazilian Cerrado: a vegetation gradient of aboveground biomass, root mass and consumption by fire. J. Trop. Ecol. 14: 263–283.

Cavalcanti, R. B., & M. A. S. Alves. 1997. Effects of fire on savanna birds in central Brazil. Ornitol. Neotrop. 8: 85–87.

Coutinho, L. M. 1982. Ecological effects of fire in Brazilian Cerrado. Ecol. Stud. 42: 273–291.

Del Hoyo, J., A. Elliott, & J. Sargatal. 1997. Handbook of the birds of the world. Volume 4: Sandgrouse to Cuckoos. Lynx Edicions, Barcelona, Spain.

Delestrade, A. 1999. Foraging strategy in a social bird, the Alpine chough: effect of variation in quantity and distribution of food. Anim. Behav. 57: 299–305.

Eiten, G. 1972. The Cerrado vegetation of Brazil. Bot. Rev. 38: 205–341.

Elgar, M. A. 1989. Predator vigilance and group size in mammals and birds: a critical review of the empirical evidence. Biol. Rev. 64: 13–33.

Faria, I. P., T. L. S. Abreu, & C. A. Bianchi. 2007. Seed and fruit predation of *Kielmeyera* (Guttiferae) and *Qualea* (Vochysiaceae) species by six Psittacid species in the Brazilian Cerrado. Ecotropica 13: 75–79.

Fernández, G. J., A. F. Capurro, & J. C. Reboreda. 2003. Effect of group size on individual and collective vigilance in Greater Rheas. Ethology 109: 413–425.

Forshaw, J. 1989. Parrots of the world. 3rd ed. Landsowne Editions, Willoughby, Australia.

França, H., M. B. Ramos Neto, & A. Setzer. 2007. O fogo no Parque Nacional das Emas. Ministério do Meio Ambiente, Brasília, Brazil.

Galetti, M. 1997. Seasonal abundance and feeding ecology of parrots and parakeets in a lowland Atlantic forest of Brazil. Ararajuba 5: 115–126.

Juarez, K. M., & J. Marinho Filho. 2002. Diet, habitat use, and home ranges of sympatric canids in central Brazil. J. Mammal. 83: 925–933.

Juniper, T., & M. Parr. 1998. A guide to the parrots of the world. Pica Press, Sussex, UK.

Lima, S. L., & P. A. Zollner. 1996. Antipredatory vigilance and the limits to collective detection - visual and spatial separation between foragers. Behav. Ecol. Sociobiol. 38: 355–363.

Macedo, R. H. F. 2002. The avifauna: ecology, biogeography, and behaviour. Pp. 242–263 *in* Oliveira, P. S., & R. J. Marquis (eds.). The Cerrados of Brazil. Columbia Univ. Press, New York, New York.

Marini, M. Â., & R. B. Cavalcanti. 1996. Influência do fogo na avifauna do sub-bosque de uma mata de galeria do Brasil Central. Rev. Bras. Biol. 56: 749–754.

Medeiros, M. B., & H. S. Miranda. 2008. Post-fire resprouting and mortality in the Cerrado woody plant species over a three-year period. Edinb. J. Bot. 65: 1–16.

Melo, C. 2001. Diurnal bird visiting of *Caryocar brasiliense* Camb. in central Brazil. Rev. Bras. Biol. 61: 311–316.

Miranda, H. S., M. M. C. Bustamante, & A. C. Miranda. 2002. The fire factor. Pp. 51–68 *in* Oliveira, P. S., & R. J. Marquis (eds.). The cerrados of Brazil: ecology and natural history of a Neotropical savanna. Columbia Univ. Press, New York, New York.

Miranda, H. S., & M. N. Sato. 2006. Efeitos do fogo na vegetação lenhosa do Cerrado. Pp. 95–103 *in* Scariot, A., J. C. Sousa-Silva, & J. M. Felfili (eds.). Cerrado: ecologia, biodiversidade e conservação. Ministério do Meio Ambiente, Brasília, Brazil.

Miranda, H. S., M. N. Sato, S. M. A. Andrade, M. Haridasan, & H. C. Morais. 2004. Queimadas de Cerrado: caracterização e impactos. Pp. 69–103 *in* Aguiar, L. M. S., & A. J. A. Camargo (eds.). Cerrados - ecologia e caracterização. Embrapa Cerrados, Brasília, Brazil.

Oliveira, P. S., & R. J. Marquis. 2002. The cerrados of Brazil. Ecology and natural history of a Neotropical savanna. Columbia Univ. Press, New York, New York.

Pivello, V. R. 2006. Fire management for biological conservation in the Brazilian Cerrado. Pp. 129–154 *in* Mistry, J., & A. Berardi (eds.). Savannas and dry forests - linking people with nature. Ashgate, Hants, UK.

Pizo, M. A. 2002. Padrões e causas da variação no tamanho de bando de psitacídeos neotropicais. Pp. 49–62 *in* Galetti, M., & M. A. Pizo (eds.).

Ecologia e conservação de psitacídeos no Brasil. Melopsittacus Publicações Científicas, Belo Horizonte, Brazil.

Pulliam, H. R. 1973. On the advantages of flocking. J. Theor. Biol. 38: 419–422.

Ragusa-Netto, J. 2004. Flowers, fruits, and the abundance of the Yellow-chevroned Parakeet (*Brotogeris chiriri*) at a gallery forest in the South Pantanal (Brazil). Braz. J. Biol. 64: 867–877.

Ragusa-Netto, J. 2006. Dry fruits and the abundance of the Blue-and-yellow Macaw (*Ara ararauna*) at a Cerrado remnant in central Brazil. Ornitol. Neotrop. 17: 491–500.

Ragusa-Netto, J. 2008. Toco toucan (*Ramphastos toco*) feeding ecology and local abundance in a habitat mosaic in the Brazilian Cerrado. Ornitol. Neotrop. 19: 354–359.

Ramos Neto, M. B., & V. R. Pivello. 2000. Lightning fires in a Brazilian savanna national park: rethinking management strategies. Environ. Manage. 26: 675–684.

Renton, K. 2001. Lilac-crowned parrot diet and food resource availability: resource tracking by a parrot seed predator. Condor 103: 62–69.

Rojas, R., & R. Ribon. 1997. Guilda de aves em *Bowdichia virgilioides* (Fabaceae: Faboidae) em área de Cerrado de Furnas, Minas Gerais. Ararajuba 5: 189–194.

Sick, H. 1997. Ornitologia brasileira. Editora Nova Fronteira, Rio de Janeiro, Brazil.

Sirot, E. 2006. Social information, antipredatory vigilance and flight in bird flocks. Anim. Behav. 72: 373–382.

Sutherland, W. J. 1998. Ecological census techniques. A handbook. Cambridge Univ. Press, Cambridge, UK.

Villalobos, M. P. 1994. Guilda de frugívoros associada com o buriti (*Mauritia flexuosa*: Palmae) numa vereda no Brasil central. M.Sc. thesis, Universidade de Brasília, Brasília, Brazil.

Villalobos, M. P. 2001. Effects of fire on the abundance of large mammalian herbivores in Mato Grosso, Brazil. Mammalia 65: 55–62.