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RESEARCH ARTICLE

Richness, composition and detectability of Psittacidae (Aves) in three palm swamps of the Cerrado sensu lato in central Brazil

Riqueza, composición y detectabilidad de los Psittacidae (Aves) en tres pantanos del Cerrado sensu lato en el Brasil central

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ABSTRACT

The objectives of this study were: (1) to investigate the richness and composition of the Psittacidae in palm swamps; (2) to determine if the sizes of flocks vary seasonally; (3) to compare detectability rates according to species. Psittacid communities were observed from November 2006 to November 2007 in semimonthly visits to the area using fixed-point observation. A total of 1616 individuals from eight species were registered in 199 contacts. The palm swamps were highly similar (H > 0.62), and their diversity was above 1.56. The Yellow-chevroned Parakeet was considered resident in the three palm swamps (Fr > 60 %). The White-eyed Parakeet and Red-bellied Macaw were the most abundant species in the three areas. Most of the species (n = 5) were more abundant in one of the seasons. The most abundant species in the rainy season were the White-eyed Parakeet and Yellow-chevroned Parakeet (42.16 ± 30.77 individuals), whereas in the dry season the most prevalent was the Red-bellied Macaw (68.50 ± 39.35 individuals). The highest detectability rate was for the Yellow-chevroned Parakeet, which demonstrates the inter-species differences and the need to adapt the methods of research, unclear for this family.

Key words: Cerrado (savanna), detectability rate, palm swamp, Psittacidae.

RESUMEN

Los objetivos de este estudio fueron: (1) investigar la riqueza y la composición de pstácidos en pantanos, (2) determinar si el tamaño de los grupos varía estacionalmente, (3) comparar las especies de acuerdo con sus tasas de detectabilidad. Ensambles de psitácidos han sido observados entre noviembre de 2006 y noviembre de 2007 con visitas quincenales en cada área a través de observación de punto fijo. Un total de 1616 individuos de ocho especies fueron registrados en 199 contactos. Los pantanos fueron muy similares (H > 0.62), y su diversidad de Psittacidae fue 1.56. *Brotogeris chiriri* ha sido considerada residente en los tres pantanos estudiados (Fr > 60 %). *Aratinga leucophthalma* y *Orthopsittaca manilata* fueron las especies más abundantes en las tres áreas. La mayoría de las especies (n = 5) fueron más abundantes en una de las estaciones. Las especies más abundantes en la época de lluvias fueron *A. leucophthalma* y *B. chiriri* (42.16 ± 30.77 individuos), mientras que en la estación seca la mayor abundancia fue *O. manilata* (68.50 ± 39.35 individuos). La tasa de detectabilidad más alta fue de *B. chiriri*, lo que demuestra las diferencias entre las especies y la necesidad de adaptar los métodos de investigación para esta familia.

Palabras clave: Cerrado (sabana), pantano, Psittacidae, tasa de detectabilidad.

INTRODUCTION

The family Psittacidae is found primarily in tropical habitats, but also occurs in subtropical and temperate climates. There are about 344 species in the world (Sick 1997), with 83 occurring in Brazil (CBRO 2007), 15 of which are endangered (IBAMA/CEMAVE 2003). The main factors that reduce populations of the Psittacidae are: habitat loss (e.g., Red-tailed Parrot *Amazona brasiliensis* [Linnaeus, 1758] and Blue-winged Macaw *Primolius maracana* [Vieillot, 1816]), poaching for the pet trade, subsistence hunting, competition with other species for nesting sites (e.g., Hyacinth Macaw *Anodorhynchus hyacinthinus* [Latham, 1790], Glaucous Macaw *Anodorhynchus glaucus* [Vieillot, 1816], and Spix's Macaw *Cyanopsita*

spixii [Wagler, 1832]) (Guedes et al. 1999, Galetti et al. 2006), a very specialized diet in some cases, and restricted geographical distribution (Bennett & Owens 1997).

Several psittacid species (e.g., Red-bellied Macaw *Orthopsittaca manilata* [Boddaert, 1783] and Red-shouldered Macaw *Diopsittaca nobilis* [Linnaeus, 1758]) use the buriti palm, *Mauritia flexuosa* L. f. (Arecaceae) and Mauritia palm, which is common in the palm swamps of central Brazil and used for shelter, food, and nesting sites (Sick 1997, Bonadie & Bacon 2000, González 2003, Brightsmith 2005). The palm swamps, therefore, are important for the maintenance and preservation of this family.

Even though research on psittacids has been increasing over the last decade (Masello & Quillfeldt 2002), including studies on palm swamps (González 2003, Brightsmith & Bravo 2006), little is known about the ecology of this group (e.g., sizes of the flocks, species abundance, and detectability). Thus, in order to contribute information about psittacids in palm swamps, the objectives of this study were: (1) to determine the richness and composition of psittacids in palm swamps; (2) to evaluate whether the sizes of the flocks vary between the rainy and the dry seasons; (3) to compare detectability rates according to species.

METHODS

Area of the study

The study was conducted in three palm swamps in the metropolitan area of the city of Uberlândia, Minas Gerais State, Brazil (Fig. 1): (1) The private nature reserve of the Clube Caça e Pesca Itororó (18°59'32" S and 48°18'17" W) includes the phytophysiognomies campo sujo and cerrado sensu stricto, in which a palm swamp is located (Rocha-Filho & Lomônaco 2006) that covers 24.5 % of the 450-hectare reservation (Fig. 2A); (2) Nova Uberlândia (18°57'10" S and 48°18'21" W) is located in the Bons Olhos Brook Natural Reserve, which includes a palm swamp covering 36 % of the total area of 7.78 hectares (Fig. 2B); (3) Camaru (18°55'13" S and 48°14'43" W) is located in the Camaru Exposition Park, which has a total area of 31.45 hectares, 6.5 % of which is palm swamp (Fig. 2C). The following abbreviations will be used for the above-mentioned palm swamps: (1) CP = Caça e Pesca, (2) NV = Nova Uberlândia, (3) CM = Camaru.

The weather of the region is Aw according to the Köppen climate classification system, featuring hot, humid summers and cold, dry winters (Rosa et al. 1991). During the study period, the median monthly precipitation was 22.5 mm during the dry season and 254.36 mm during the rainy season (Source: Climatology Laboratory of Universidade Federal de Uberlândia).

Data collection

Before the beginning of data collection, a thirty-six hour observational period was carried out between June and November of 2006 to determine the peak activity times. These preliminary observations occurred between 6 AM and 6 PM.

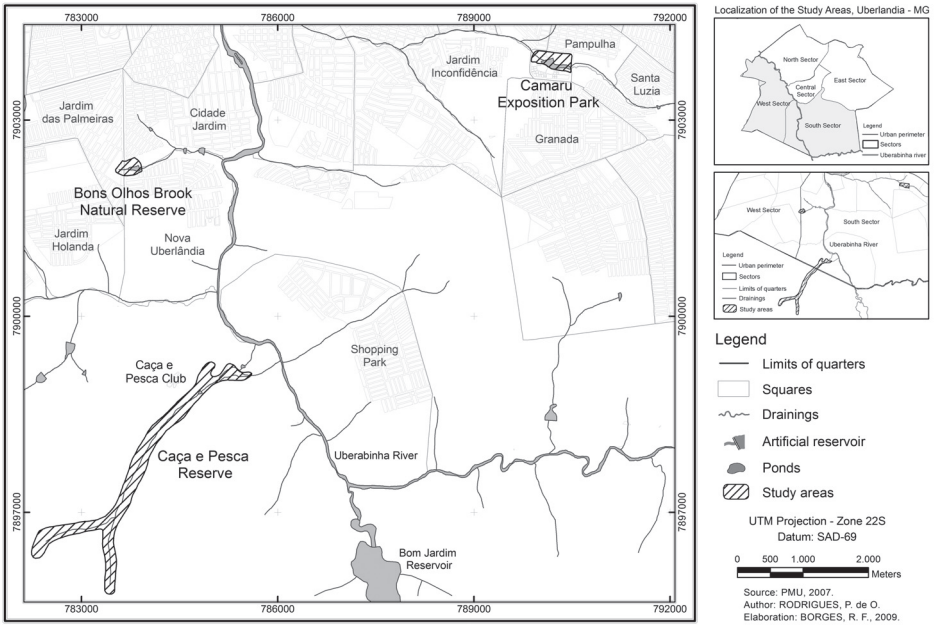

Fig. 1: Location of the study areas.

Localización de las áreas de estudio.

Data were collected between November of 2006 and November of 2007, during both the rainy and dry seasons. A total of 24 semi-monthly visits were made to each site. Each visit included a one-hour observation session that alternated either between 6:00-9:00 AM or 4:00-6:00 PM. This study used the fixed-point method to estimate the size of the psittacid populations. This technique has been recommended for studies performed in areas of tall, dense vegetation or in rough terrain (Reynolds et al. 1980), as well as for studies involving the entire community, despite being a less selective method (Anderson et al. 1979, Develey 2003).

All species flying into or leaving the palm swamp were registered. The only number considered was the highest number of individuals seen simultaneously, in order to avoid duplicate counting of individuals. All species sighted during the one-hour period were used to determine richness. The birds were identified visually using binoculars (7 x 35) and field guides (Sigrist 2006). The nomenclature of the CBRO 2009 - Brazilian Ornithological Records Committee was adopted for this study.

Data analysis

The communities were compared using the Jaccard similarity coefficient (Cj). The Shannon-Wiener index and Pielou's evenness index were used to verify species homogeneity (richness and abundance).

In all three palm swamps, the relative abundance of each species was calculated by the total number of visits in which it was observed (1 to 24). In order to verify any interseasonal variation in population, the abundance of each species was calculated according to season by the number of visits (12) independent of sightings.

The sighting frequency (Fr) was determined by the percentage of visits when each species was observed, and then the species were classified into the following categories: (R) residents (Fr ≥ 60 %), (P) probable residents (60 % > Fr > 15 %) and (O) occasional visitors (Fr ≤ 15 %) (Mendonça-Lima & Fontana 2000).

The detectability test (D) (Pomeroy & Dranzoa 1997) was applied to each species. This test gives a score from 1 to 6 every 10 minutes during a one-hour interval when the species is sighted; the species recorded in the first minute of that hour will have higher scores.

The Mann-Whitney (U) test was used to compare interseasonal flock size, with the significance level set at 5 % ($P < 0.05$) (Zar 1999). Before applying the test, non-normal data were $\log_{10}$ transformed. Statistical analysis was performed with SYSTAT v10.2.

RESULTS

Richness and composition

A total of 1616 individuals was registered from 199 sightings (CP = 606; NV = 433; CM = 577), distributed over eight psittacid species: Blue-fronted Parrot *Amazona aestiva* (Linnaeus, 1758); Peach-fronted Parakeet *Aratinga aurea* (Gmelin, 1788); White-eyed Parakeet *Aratinga*

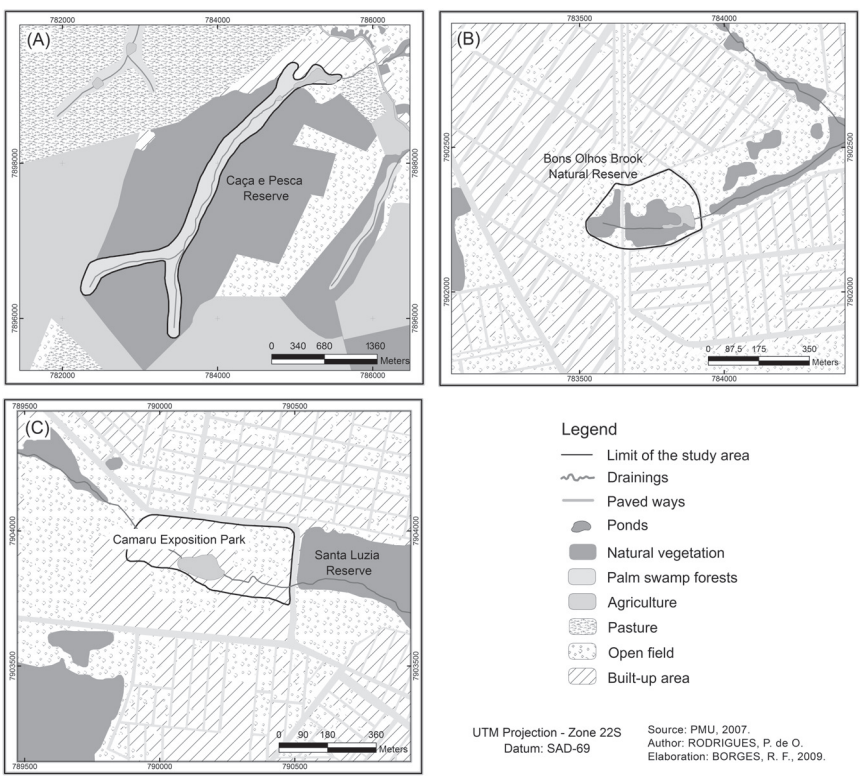

Fig. 2: Land use and vegetation covering: Caça e Pesca Reserve (A), Bons Olhos Brook Natural Reserve (B), Camaru Exposition Park (C).

Uso de la tierra y cobertura vegetal: Reserva Caça e Pesca (A), Corriente Bons Olhos (B), Parque de exposiciones Camaru (C).

leucophthalma (Statius Müller, 1776);Yellow-chevroned Parakeet *Brotogeris chiriri* (Vieillot, 1818); Red-shoufdered Macaw *Diopsittaca nobilis* (Linnaeus, 1758); Blue-winged Parrotlet *Forpus xanthopterygius* (Spix, 1824); Red-bellied Macaw *Orthopsittaca manilata* (Boddaert, 1783) and Scaly-headed Parrot *Pionus maximiliani* (Kuhl, 1820). CP was the richest palm swamp (N = 7 species), followed by NV and CM (N = 6 species each) (Table 1).

CP and NV were the most similar palm swamps ($Cj_{CP;\ NV}$ = 0.85); the least similar were CP and CM ($Cj_{CP;\ CM}$ = 0.62). The three palm swamps had similar values on the similarity and evenness indices ($1.53 \leq H' \leq 1.70$ and $0.80 \leq J \leq 0.95$) (Table 1). The only resident species were the White-eyed Parakeet in three palm swamps (Fr > 60 %), Red-bellied Macaw in CP and CM (Fr > 80 %), and White-eyed Parakeet in CM (Fr = 66.6 %) (Table 1).

Population size and variation

The White-eyed Parakeet and Red-bellied Macaw were the most abundant in the three areas (Table 1), whereas the least abundant were the Blue-fronted Parrot in CP and NV, and Peach-fronted Parakeet in CM (Table 1).

The most abundant species during the rainy season were the White-eyed Parakeet and Yellow-chevroned Parakeet (Mean of individuals: 42.16 ± 30.77), whereas during the dry season the Red-bellied Macaw (Mean of individuals: 68.50 ± 39.35) was the most abundant (Fig. 3). Only Red-bellied Macaw flocks differed significantly between seasons (U = 188; Gl = 1; P = 0.006), being larger in the dry season (14.6 ± 10.95 individuals) and smaller in the rainy season (6.54 ± 5.05 individuals) (Fig. 4).

Detectability rate

The species with the highest D were the Yellow-chevroned Parakeet, which was generally detected within 10 min (D = 5.04) and White-eyed Parakeet and Red-bellied Macaw, which were mainly detected between 11-20 min (D = 4.22 and 4.12, respectively) after the beginning of the visit (Table 4).

The detectability rate was significantly correlated with sighting frequency (r = 0.572; n = 24; P = 0.004).

DISCUSSION

Richness and composition

Psittacid species such as macaws and parrots are among the principal birds that use the resources of the palm swamps. Although these areas suffer from fragmentation, they still sustain large populations (Bonadie & Bacon 2000). During this study, eight species were found using these resources. In Peru, between

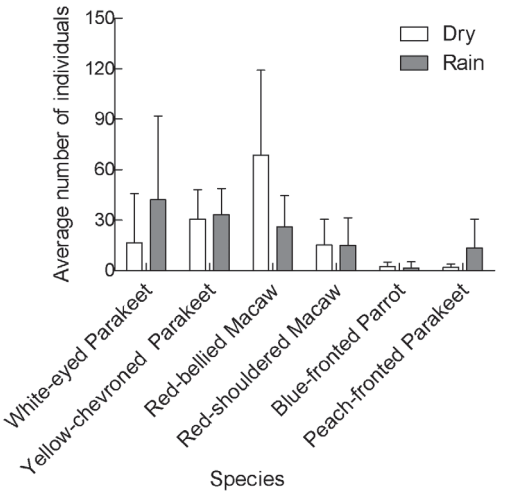

Fig. 3: Average numbers of individuals in the rainy and dry seasons, with a standard error.

Media general de individuos de acuerdo con las estaciones lluviosa y seca, con un error estándar.

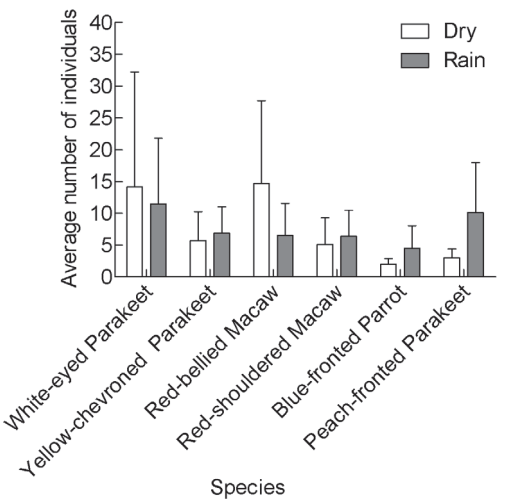

Fig. 4: Sizes of flocks in the dry and rainy seasons, with a standard deviation.

Tamaño de los grupos en las estaciones seca y lluviosa, con una desviación estándar.

TABLE 1

Mean number of individuals and Standard deviation (± SD) by contact, relative abundance, number of species in each area (N) and frequency of record in each Palm Swamp. X = no record of species; Fr = for frequency of record, resident species (Fr ≥ 60 %), likely residents (60 % > Fr > 15 %), and occasional residents (Fr ≤ 15 %).

Media de individuos ($\overline{X}$) y desviación estándar (± DE) por contacto, la abundancia relativa, el número de especies en cada área (N) y la frecuencia de registro en cada pantano. X = ningún registro de la especie, Fr = frecuencia de registro, Especies residentes (Fr ≥ 60 %), residentes probables (60 % > P > 15 %), y los residentes ocasionales (Fr ≤ 15 %)

	Caça e Pesca Reserve (N = 7)				Nova Uberlândia (N = 6)				Camaru Exposition Park (N = 6)			
Species	Mean (± SD)	Contact	Relative abundance	Frequency of record	Mean (± SD)	Contact	Relative abundance	Frequency of record	Mean (± SD)	Contact	Relative abundance	Frequency of record
White-eyed Parakeet	34.33 (± 22.3)	3	0.48	12.5	9.37 (± 7.9)	16	0.24	66.6	9.9 (± 8.5)	10	0.26	41.6
Yellow-chevroned Parakeet	4.87 (± 3.5)	16	0.06	66.6	6.18 (± 3.5)	22	0.16	91.6	7.35 (± 5.36)	23	0.19	95.8
Red-bellied Macaw	11.04 (± 9.7)	21	0.15	87.5	9.5 (± 7.0)	10	0.24	41.6	11.5 (± 13.6)	21	0.31	87.5
Red-shouldered Macaw	5.57 (± 5.27)	14	0.07	58.3	5.42 (± 1.81)	7	0.14	29.1	6.0 (± 3.8)	11	0.16	45.8
Blue-fronted Parrot	2.5 (± 1.87)	9	0.03	37.5	2.0 (± 1.15)	1	0.05	4.1	X	X	X	0
Peach-fronted Parakeet	8.88 (± 7.8)	9	0.12	37.5	6.0 (± 4.25)	2	0.15	8.3	1	1	0.002	4.1
Blue-Winged Parrotlet	X	X	X	0	X	X	X	0	1	1	0.002	4.1
Scaly-headed Parrot	4.0 (± 2)	3	0.05	12.5	X	X	X	0	X	X	X	0

TABLE 2
Detectability rate (± SD) of each species in the three palm swamps. 0 = no species record.
Tasa media de la detectabilidad (± DE) de cada especie en los tres pantanos. 0 = sin registro de especies.

Species	CP	NV	CM	Average
White-eyed Parakeet	3.6 (± 2.52)	4.56 (± 1.82)	4.5 (± 1.90)	4.22 (± 0.54)
Yellow-chevroned Parakeet	4.875 (± 1.45)	4.95 (± 1.29)	5.3 (± 0.76)	5.04 (± 0.23)
Red-bellied Macaw	4.33 (± 1.59)	3.8 (± 1.75)	4.23 (± 1.72)	4.12 (± 0.28)
Red-shouldered Macaw	4.14 (± 1.88)	3.71 (± 2.25)	5 (± 1.09)	4.28 (± 0.66)
Blue-fronted Parrot	4.33 (± 2.29)	6	0	3.44 (± 3.10)
Peach-fronted Parakeet	5.44 (± 1.67)	4 (± 2.82)	1	3.48 (± 2.27)
Blue-winged Parrotlet	0	0	4	1.33 (± 2.31)
Scaly-headed Parrot	2 (± 1.0)	0	0	0.67 (± 1.75)

seven to fifteen psittacid species were found nesting in *Mauritia* palms (González 2003, Brightsmith 2005). Other studies carried out in palm swamps have demonstrated that palms become key resources for avian frugivores, including many psittacids, helping to maintain them during periods of resource scarcity (Bonadie & Bacon 2000, Brightsmith & Bravo 2006).

Of the eight species registered during this census, the least frequent, Scaly-headed Parrot and Blue-winged Parrotlet, despite conspicuous vocalization and size (12 to 28 cm) (Sick 1997, Sigrist 2006), were probably least observed because the Scaly-headed Parrot prefers forests and pine groves (Galetti 1993) and the Blue-winged Parrotlet is typically found in forest borders (Sick 1997, Juniper & Parr 1998). The sporadic sightings of these species, therefore, could have been a result of environmental alterations to their original habitats and/or opportunism. It has been observed that the White-eyed Parakeet, Peach-fronted Parakeet and Yellow-chevroned Parakeet are flexible regarding habitat, frequenting even anthropogenic areas (Galetti & Pizo 2002b). Thus, their seeking refuge in palm swamps could be seen as an advantageous strategy. In addition to palms such as *Mauritia*, other plant species such as *Miconia chamissois* might offer resources during the dry season (Maruyama et al. 2007), maintaining the local avifauna during unfavorable conditions.

The elevated frequency and relative abundance of the Red-bellied Macaw in the three areas is a result of its dependency on the buriti, primarily during the reproductive period when it utilizes the hollow trunks of dead palms for nesting and feeds on the fruit. As a specialist frugivore it remains near buriti, occasionally foraging in cultivated areas (Juniper & Parr 1998).

Population size and variation

A social gathering pattern is typical of psittacids that relocate seasonally in search of food (Sick 1997, Juniper & Parr 1998). However, as a result of the reproductive cycle and seasonal fluctuation in abundance of food resources, the flock sizes of these species can vary throughout the year (Pizo et al. 1995, Alonso 2001, Galleti & Pizo 2002a). This probably applies to the Red-bellied Macaw in which the average number of individuals varied significantly between rainy and dry seasons.

Alternatively, these seasonal fluctuations could be related to a less conspicuous vocalization principally during the mating season. This is when pairs form and the species reduces its abundance (Cannon 1984, Chapman et al. 1989, Rodriguez-Estrella et al. 1992), which makes sightings difficult. A low number of Red-bellied Macaw individuals were also observed by Roth (1984), who attributed this reduction to the mating season when the species explores

a larger area, resulting in a reduced density of individuals, many of whom may be in search of nesting sites.

The majority of plants has one or more periods of relative scarcity during the year (Van Schaik et al. 1993), forcing frugivorous birds either to alter their diet (Galetti 1993) or migrate in search of new feeding grounds (Wheelwright 1983, Loiselle & Blake 1991, Kinnaird et al. 1996). *Mauritia flexuosa* yields fruit throughout the year, which could account for the large quantity of individuals, mostly species such as the Red-bellied Macaw (PA Silva, pers. comm. 2009) and Red-shouldered Macaw. The results obtained in this study, along with those of other authors (Bonadie & Bacon 2000, González 2003, Brightsmith 2005, Brightsmith & Bravo 2006), demonstrate the importance of the palm swamps in maintaining the regional populations of psittacids.

Detectability rate

Emlen (1971) demonstrated that the detectability coefficient of each species is dependent on its conspicuousness, and represents the proportion of an area's population that is actually detectable by an observer. Surveys and census studies have standardized the maximum time per point at 20 min (Sutherland et al. 2005). In this study, however, the time necessary to sight two species was longer. The Blue-fronted Parrot and Peach-fronted Parakeet were detected around 40 minutes after the beginning of the observation session. For this reason, in order to register the presence of some species of less-conspicuous psittacids such as the Blue-fronted Parrot and Peach-fronted Parakeet, a longer observation session is advisable.

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