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Daily variation in activity and flock size of two parakeet species from southeastern Brazil.—Psittacids are wide-ranging birds usually occurring in large flocks, making direct density estimates of parrots difficult. Researchers often are obliged to rely on indirect methods to estimate their abundances (see Terborgh et al. 1990, Pizo et al. 1995). These estimates are based on the number of flocks contacted in a given period (average encounter rate) and on the mean flock size of the species considered. However, both measures can vary on a daily basis (Blake 1992, Cannon 1984, Chapman et al. 1989), implying that parrot counts should be concentrated in a given period of the day to save time and to ensure a more realistic estimate (Blake 1992). Some attempts have been made to assess daily variation in detectability of Neotropical parrot species (Blake 1992). This author noted that detections of canopy bird species, such as parrots, tend to increase from the first to second hours after sunrise in a tropical wet forest in Costa Rica. Hourly variation in flock sizes of parrots, however, has hitherto received little attention. Chapman et al. (1989) observed that mixed-species flocks of parrots in Costa Rica were significantly larger during late afternoon, just before they move to a communal roosting site, than at other times of the day.

Here we report on the daily activity and flock size of two common parakeet species occurring in the Atlantic forest of southeastern Brazil, the Maroon-bellied Parakeet (*Pyrrhura frontalis*) and the Plain Parakeet (*Brotogeris tirica*). We address the following ques-

tions: (1) Do flock sizes vary on a daily basis? and (2) Does such variation differ among seasons?

Maroon-bellied Parakeets (26 cm length, 85 g weight) and Plain Parakeets (23 cm length, 80 g) are the most abundant parrots at our study site (Pizo et al. 1995) and are among the most common ones in southeastern Brazil, where the latter species can occur even in urban areas (Ridgely 1981; pers. obs.). Flock sizes of Maroon-bellied Parakeet at the study site range from 1 to 34 ($\bar{x}$ = 5.1 ± 3.8 SD, N = 499) and those of Plain Parakeet from 1 to 40 ($\bar{x}$ = 4.5 ± 4.2 SD, N = 438) (Pizo et al. 1995). These flocks are regularly seen flying over the canopy. Populations of both species decline during the dry seasons, probably due to habitat shifts (Pizo et al. 1995).

Study site and methods.—We carried out this study at Parque Estadual Intervales (PEI hereafter), Ribeirão Grande, São Paulo State (24°16′S, 48°25′W), a 49,000 ha reserve in the Serra de Paranapiacaba mountains of southeastern Brazil at an elevation of 700 m. The vegetation there was composed of primary forest with 30 m trees and patches of second growth near human settlements. The climate generally is wet, with rain or fog ocurring frequently. Annual precipitation is around 1600 mm with a dry season from April to August (winter), when the temperature often drops below 5°C and frosts may occur, and a wet season from September to March. Seasonal variation in temperature is pronounced, ranging from a minimum mean temperature of 13.4°C in winter to 21.6°C in summer. Sunrise occurred between 05:11 and 06:18 h in the wet seasons and between 06:15 and 06:45 h in the dry seasons.

We counted flocks from Dec. 1989 to Dec. 1991, and from August 1992 to January 1994 during monthly visits (4–10 days each) to PEI. We looked for the parakeets during walks conducted along several trails (approximately 20 km) that cross the study site. These walks were distributed between 06:00 and 18:00 h, and usually lasted for 4–5 h. Overall, about 533 and 366 h were spent conducting counts in wet and dry seasons, respectively. Whenever a flock was encountered we recorded the species, flock size, and time of day. The hourly mean flock size was based only on flocks which were seen and which could be counted. As parakeet populations declined during the dry seasons, we recorded few flocks per hour. Consequently, inter-seasonal comparisons of mean flock size were based on flocks observed during three four-hour categories: morning (06:00–09:59 h), midday (10:00–13:59 h), and afternoon (14:00–17:59 h) flocks.

We used the hourly average encounter rate (AER) as a measure of activity. AER was based on data collected from August 1990 to December 1991, encompassing two dry and two wet seasons (289 and 198 h of field time in the wet and dry seasons, respectively). AER was based on aural and visual detections, i.e., on all flying or perched flocks seen or heard during walks.

We used parametric one-way ANOVA followed by a Tukey multiple comparison test to detect hourly differences in mean flock sizes. A t-test was used for inter-seasonal comparisons of mean flock size. Data on flock size were log-transformed to achieve normality prior to statistical tests. All tests follow Zar (1984).

Results.—During the study of daily AER, we detected 708 and 961 flocks of Maroon-bellied and Plain parakeets, respectively. AER of both species varied during the day, particularly during the wet season (Fig. 1A and B). Maroon-bellied Parakeets were detected more frequently in the second and third hour after sunrise during the wet season, and experienced a decrease in detectability of 23–47% between 09:00 and 11:00 h. A second peak in activity was recorded just after 12:00 h. In the dry season, AER varied less during the day with a slight decrease around 12:00 h (Fig. 1A). In contrast, Plain Parakeets were detected most often just after dawn during the wet season, experiencing a 40% decrease in

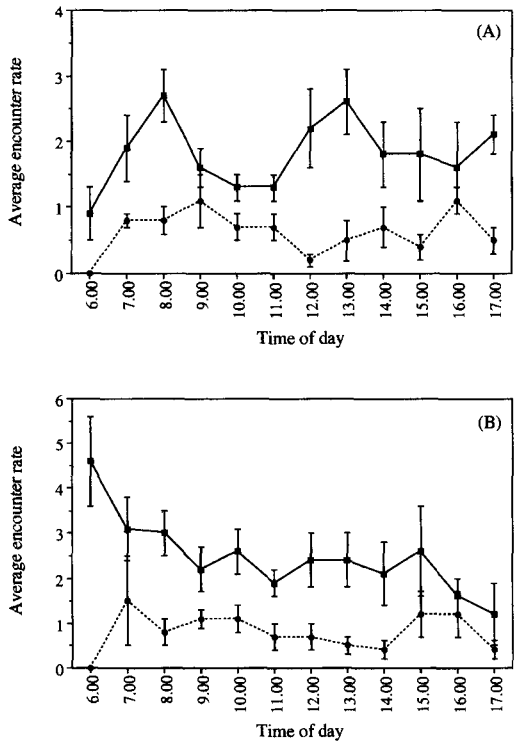

FIG. 1. Daily variation in the average encounter rate of (A) Maroon-bellied Parakeet and (b) Plain Parakeet during the wet (solid line) and dry (dotted line) seasons at Parque Estadual Intervales. Vertical lines represent standard errors.

detectability one hour later. In the dry season, Plain Parakeets were also uniformly detected through the day (Fig. 1B).

Combining data from wet and dry seasons, mean flock size of Maroon-bellied Parakeets did not differ during the day ($F = 0.91$, $df = 11$, $P > 0.50$) (Fig. 2A), but mean flock size of Plain Parakeets did ($F = 1.92$, $df = 11$, $P < 0.05$) (Fig. 2B). A Tukey multiple comparison test showed that the mean flock size of Plain Parakeet was significantly lower from 10:00 to 12:00 h, when 82% of the counted flocks ($N = 11$) were composed by one or two birds, than during other hours.

Considering morning, mid-day and afternoon periods, there were no inter-seasonal differences in mean flock size of either species except for afternoon flocks of Plain Parakeets (Table 1). Plain Parakeet flocks observed between 14:00 and 17:59 h were smaller during the dry than during the wet season.

Discussion.—Daily activity patterns of birds in general are influenced by several factors, including weather, season, and habitat (see references in Ralph and Scott 1981) but patterns are likely to differ among species (Blake 1992, Blake et al. 1991, Cannon 1984, Robbins 1981). Our data indicate that daily activity (here considered in terms of vocal, flying, and

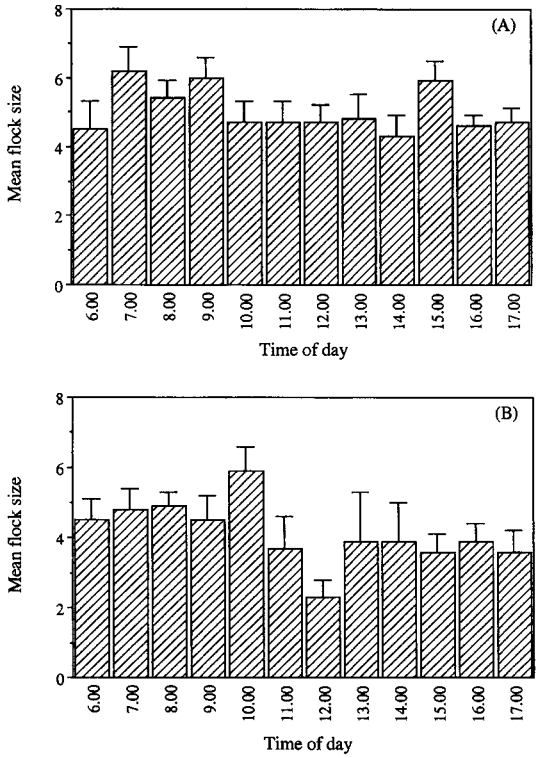

FIG. 2. Daily variation in mean flock size of (A) Maroon-bellied Parakeet and (B) Plain Parakeet at Parque Estadual Intervales. Standard errors are shown.

TABLE 1

MEAN SIZE (±SD) OF FLOCKS OF MAROON-BELLIED AND PLAIN PARAKEETS DURING THE WET AND DRY SEASONS AT PARQUE ESTADUAL INTERVALES

Period	Maroon-bellied Parakeet		Plain Parakeet	
	Dry season	Wet season	Dry season	Wet season
Morning	6.4 ± 4.6 (43)	5.5 ± 4.6 (145)	4.0 ± 2.6 (22)	4.8 ± 4.4 (230)
Mid-day	5.4 ± 3.7 (23)	4.5 ± 3.2 (106)	3.1 ± 2.8 (13)	4.9 ± 4.7 (72)
Afternoon	5.6 ± 2.7 (43)	4.7 ± 3.4 (121)	2.1 ± 0.7 (20)***	4.0 ± 3.4 (93)

*** *t*-test applied to log-transformed data: $P < 0.001$; Sample sizes are in parentheses.

foraging activity) and flock size of two parakeet species vary both hourly and seasonally. In addition, daily activity differed between both species, particularly during the wet season.

Roth (1984) suggested that the daily activity of parrots may be influenced by temperature, particularly in summer. This author observed a decrease in flying and feeding activity of 16 parrot species during the hotter hours of the day (11:00–14:00 h) in an Amazonian forest site. In fact, many parrot species exhibit a period of general inactivity during the hotter hours of the day (Hardy 1965, Snyder et al. 1987 and references there in) when they typically spend their time resting amidst the vegetation, where they are difficult to locate (Snyder et al. 1987). During the present study, Maroon-bellied Parakeets were very active, flying and vocalizing, during the second and third hours after sunrise during the wet season, but decreased their activity coincidently with the beginning of the hotter period of the day (09:00–15:00 h). However, their activity level increased again while the air temperature was still very high (just after midday). Plain Parakeets, on the other hand, were most active during the first hour after sunrise, but did not become active again even when the air temperature decreased during late afternoon (17:00–18:00 h). The hotter conditions that typically prevail during the wet season undoubtedly contributed to the well-marked daily activity patterns then observed. The low temperatures occurring in the dry season (winter) may have accounted for the more uniform daily activity patterns during that season. However, such a relative uniformity should be interpreted with care because the low abundance of parakeets during the dry seasons (Pizo et al. 1995) might have masked daily activity patterns.

The hourly variation in mean flock size of Plain Parakeets is somewhat intriguing. It is also possible that the high temperatures registered between 10:00 and 12:00 h play a role on the small flocks recorded during this period.

The smaller afternoon flocks of Plain Parakeets during the dry seasons may be related to the previously cited lower overall population densities of this species during the period (Pizo et al. 1995). However, factors other than population densities or weather conditions also may influence daily variation in flock size. During the breeding period, for example, flocks tend to be smaller than at other times because breeding pairs often keep separate from other individuals (Cannon 1984, Chapman et al. 1989, Rodriguez-Estrella et al. 1992). At our study site, reproduction takes place in the wet season (Forshaw 1989), but we failed to detect any effect on flock size associated with breeding. It is possible that breeding pairs of the species studied here travel with flocks more often than do larger parrots such as members of *Amazona* genus (see Martuscelli 1995, Snyder et al. 1987).

Future studies that address the distribution patterns of daily flock sizes of parrots should take into account the environmental (e.g., temperature) and physiological determinants of avian circadian rhythms (see a brief review in Meier and Russo 1985), as well as social factors (Moriarty 1977) to properly assess the tendency for parrots to join flocks through the day.

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Male-biased breeding ground fidelity and longevity in American Golden-Plovers.—The American Golden-Plover (*Pluvialis dominicus*) and its close relative the Pacific Golden-Plover (*P. fulva*) are seasonally monogamous with both parents sharing in defense of the breeding territory, incubation, and care of the young (for a detailed treatment of breeding