

SEASONAL AND DIURNAL VARIATION IN PACIFIC PARAKEET *ARATINGA STRENUA* FLOCK SIZES IN NICARAGUA

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SUMMARY.—*Seasonal and diurnal variation in Pacific Parakeet Aratinga strenua flock sizes in Nicaragua.* Flock sizes of the Pacific Parakeet *Aratinga strenua* varied diurnally according to birds' activity and seasonally. In the morning, parakeet groups flew along well-defined paths to feeding grounds, where they united in larger feeding congregations. The parakeets' routes to the feeding grounds and back gradually shifted westwards through the study, perhaps reflecting shifts in feeding sites. Foraging and flying groups were larger in the dry season than in the rainy one, possibly to find food more efficiently and/or to better escape predation.

Key words: *Aratinga strenua*, parakeets, flock size, flight paths, Nicaragua.

RESUMEN.—*Variación estacional y diaria en el tamaño de grupos de Aratinga strenua en Nicaragua.* El tamaño de los grupos de *Aratinga strenua* varía durante el día según la actividad que desarrollen, cambiando también entre estaciones. En la mañana los grupos de aratingas vuelan en direcciones bien determinadas hacia sus áreas de alimentación donde se forman grupos más grandes. Las rutas y zonas de alimentación se desplazan gradualmente al oeste a lo largo del estudio, posiblemente asociado a cambios de las zonas de alimentación. Tanto los grupos de alimentación como de vuelo fueron más grandes durante la época seca que en la de lluvias, probablemente para encontrar más eficazmente el alimento y/o para escapar mejor a la depredación.

Palabras clave: *Aratinga strenua*, Aratingas, tamaño de grupo, rutas de vuelo, Nicaragua.

INTRODUCTION

The Pacific Parakeet *Aratinga strenua* ranges along Pacific slopes of Central America from Oaxaca, Mexico, to southwest Nicaragua (Sibley & Monroe, 1990), and is known to travel, forage and roost in flocks (Salas *et al.*, 1992). They feed mainly on fruit (Wermundsen, 1997), the availability of which varies with location and season in the tropical dry forests of Central America (Chapman *et al.*, 1989). It has been hypothesized that flocking in parrots is an adaptation to find food (Brereton, 1971; Cannon, 1984) or avoid predators (Westcott & Cockburn, 1988). Parrot flock sizes (Cannon, 1984; Chapman *et al.*, 1989; Blake, 1992; Pizo *et al.*, 1997) and activity (Blake, 1992) have been observed to vary hourly. In addition, parrots may shift habitats to track food availability (Pizo *et al.*, 1995; Terborgh *et al.*, 1990; Loiselle, 1998; Lanning & Shiflett, 1983). The present study provides new information on the patterns of diurnal and seasonal flocking beha-

viour of the Pacific Parakeet. More specifically, it addresses the following questions: Do flock sizes vary diurnally according to the birds' activity? Does such variation differ from season to season?

STUDY AREA AND METHODS

This study was carried out in the District of Masaya (12°00 N, 86°20 W) in Nicaragua between March 1993 and March 1994. In this area, Pacific Parakeets nest and roost in Santiago and San Pedro Craters of Nindirí Volcano in the Masaya Caldera, a roughly oval, steep-walled basin 6 to 12 km in diameter. Nindirí Volcano, located in the middle of the caldera, is active and emits gases, mainly water vapour but occasionally large amounts of sulphur dioxide (Salas *et al.*, 1992). The vegetation is tropical dry forest surrounded by farmland. For more details see Incer and Gutiérrez (1975) and Salas *et al.* (1992).

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The climate of the region is characterized by a wet season from May to October and a dry season, with very little rainfall, from November to April, when most trees lose their leaves. Annual rainfall averages 1500 mm (Salas *et al.*, 1992).

Parakeet flocks were classified into morning departing flocks, daytime foraging flocks and night roosting flocks (Chapman *et al.*, 1989). Departing flocks were counted from 07:00 to 09:00 on the border of the roosting volcano or on the Managua-Masaya highway, which runs northwest to southeast. Foraging flocks were counted from 09:00 to 18:00. The number of roosting parakeets per crater was counted from 14:00 to 19:30, when the birds entered the crater in the evening via permanent entrances. The points where the birds' flight path crossed the highway were determined from personal observations and information obtained from the park guards.

Sizes of foraging and departing flocks were log-transformed to normalize distributions. Analyses of variance (ANOVA) followed by Tukey's tests were carried out to compare the flock sizes of foraging and departing groups

between the first half of the dry season (November-January), the second half of the dry season (February-April), the first half of the rainy season (May-July) and the second half of the rainy season (August-October). The Mann-Whitney U-test was used to compare the numbers of roosting parakeets in the dry season and the rainy season.

RESULTS

Flock sizes varied diurnally and seasonally. Departing flocks were smaller than foraging ones ($F_{7,2845} = 110.12$, $P < 0.0001$; Fig. 1, Table 1). Feeding parakeets called when conspecific birds flew overhead, whereupon the latter joined those feeding.

From September to June, Pacific Parakeet flocks flew regularly to feeding sites and back. In the morning they flew along well-defined routes to feed, returning in the evening by the same paths. One of the flight paths which crossed the Managua-Masaya highway shifted gradually westwards (Fig. 2) during the period September to February. The parakeets did not

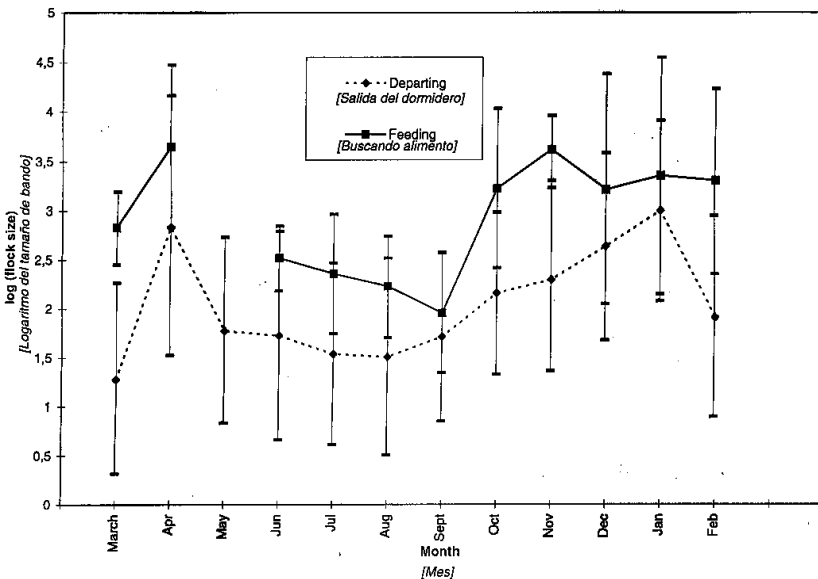


FIG. 1.—Monthly variation in mean log-transformed flock sizes of departing (broken line) and feeding (solid line) Pacific Parakeets. Vertical lines represent standard deviations.

[Variación mensual (transformado logarítmicamente) en el tamaño de los bandos de salida del dormitorio (línea discontinua) y en los bandos de alimentación (línea continua) de *Aratinga strenua*.]

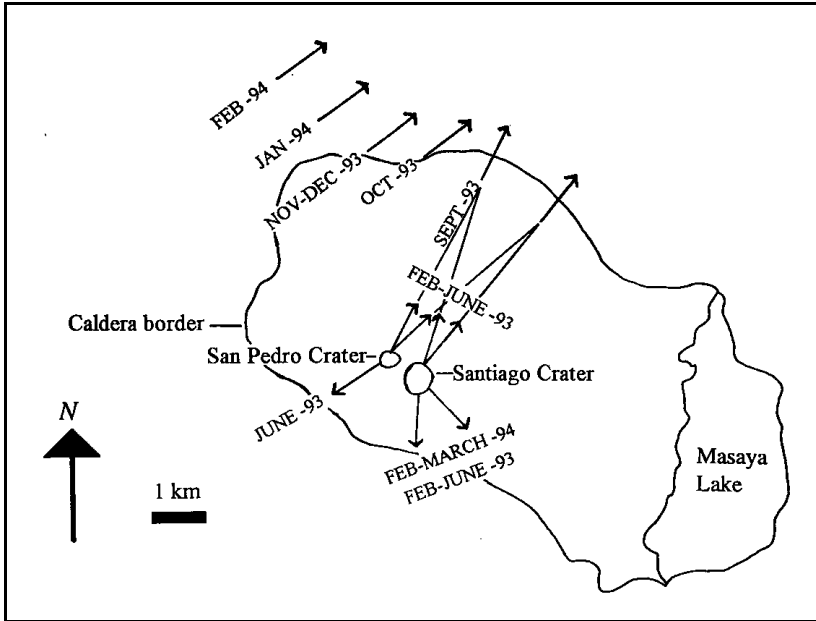


FIG. 2.—Outside the breeding season, parakeets had well-defined flying routes to feeding grounds and back. They left the place where they spent the night (Cráter San Pedro and Cráter Santiago) in the morning and came back in the afternoon. Arrows show morning flight directions. Parakeets roosted in the craters mainly in the rainy season.

[Fuera de la estación reproductora *Aratinga strenua* tiene rutas bien definidas hacia los lugares de alimentación. Parten del lugar donde pasan la noche (Cráter de San Pedro y Cráter de Santiago) por la mañana, volviendo por la tarde. Las flechas indican las direcciones de vuelo matinales. Los dormitorios de *Aratingas* durante el periodo de lluvias se encuentran principalmente en los cráteres.]

use well-defined routes during the breeding season (July-August).

Departing flocks during the rainy season averaged less than half as large as those during the dry season, a significant difference (ANOVA, $F_{3,2479} = 96.09$, $P < 0.0001$ and Tukey's test, $P < 0.05$). Flock sizes varied significantly also within the dry season. Feeding flocks were also significantly smaller in the rainy season than in the dry season (ANOVA, $F_{3,366} = 19.60$, $P < 0.0001$ and Tukey's test, $P < 0.05$), but did not vary in size within seasons (Table 1).

The numbers of roosting parakeets per crater were higher in the rainy season than in the dry season (Mann-Whitney U-test, $Z = -5.72$, $P < 0.0001$); (Table 1). In the dry season, most of the parakeets roosted in groups in trees outside the park. No parakeets roosted in Santiago in December, and San Pedro was totally empty in December and January (Fig. 3).

DISCUSSION

While parrots often flock with other species (Cannon, 1984; Westcott & Cockburn, 1988; Forshaw, 1989), Pacific Parakeets flocked only with conspecific birds. However, Orange-fronted Parakeets, which also occur in the study area, flock with other parrot species (Chapman *et al.*, 1989). Furthermore, feeding Pacific Parakeets called conspecific birds flying overhead to join the feeding group like Orange-fronted Parakeets (Hardy, 1965). When leaving a roost, groups of Golden Parakeet *Aratinga guarouba*, Crimson-fronted Parakeet *Aratinga finschi*, Scarlet-fronted Parakeet *Aratinga wagleri*, Red-masked Parakeet *Aratinga erythroga* and Hispaniolan Parakeet *Aratinga chloroptera* follow conspecifics to feeding sites via permanent routes (Oren & Novaes, 1986; Forshaw, 1989), and flying groups of Caatinga Parakeet *Aratinga cactorum* join foraging groups (Fors-

TABLE I

Mean size (\pm SD) of departing and foraging Pacific Parakeet flocks during the wet and dry season in Nicaragua, and means and ranges of parakeet roosts. Sample sizes are in parentheses.
 [Tamaño medio (\pm SD) de bandos a la salida del dormitorio y de bandos de alimentación de *Aratinga strenua* en la estación seca y en la estación de lluvias en Nicaragua.]

| Activity [Actividad] | Early dry season [Comienzos estación seca] | Late dry season [Finales estación seca] | Early wet season [Comienzos estación húmeda] | Late wet season [Finales estación húmeda] |
|-------------------------|--|---|--|---|
| Departing [salida] | 22.4 \pm 18.8 (275) | 18.3 \pm 21.6 (401) | 9.1 \pm 12.5 (1346) | 8.8 \pm 10.8 (461) |
| Foraging [alimentación] | 44.9 \pm 39.1 (144) | 37 \pm 33.3 (90) | 13.3 \pm 7.4 (37) | 19.7 \pm 17.3 (99) |
| Roosting [dormideros] | 73.8 [0-357] (12) | 167.3 [4-440] (6) | 915.5 [427-1383] (18) | 18705.3 [212-1208] (10) |

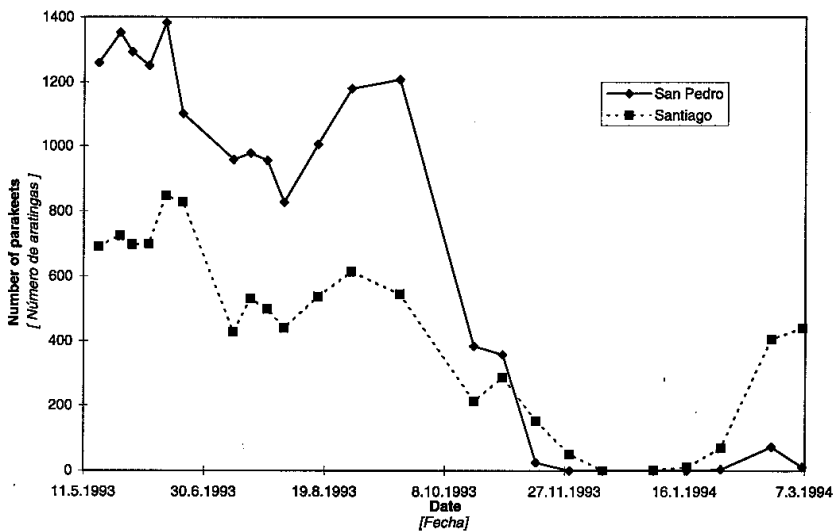


FIG. 3.—Size of night roosting flocks in San Pedro Crater and Santiago Cráter.
 [Tamaño de los dormitorios nocturnos de *Aratinga strenua* en los cráteres de San Pedro y de Santiago.]

haw, 1989). In some parrots, however, departing groups are larger than foraging ones (Chapman *et al.*, 1989).

Pacific Parakeets leave the caldera when their young fledge (Wermundsen, 1998), perhaps because resources around the volcano have been depleted. Outside the breeding season the parakeets gradually shifted their path to feeding grounds suggesting that they use one feeding sector at a time, especially in the dry season. Perhaps they deplete one feeding sector and then shift to a neighbouring one.

Parrots may form larger flocks to find scarce food patches efficiently (Breteron, 1971; Cannon, 1984; Pizo *et al.*, 1995). In the dry season,

fruit trees are located in scarce patches in tropical dry forests of Central America (Chapman *et al.*, 1989). However, some parrot species form smaller flocks in the dry season (Chapman *et al.*, 1989; Pizo *et al.*, 1995). Pacific Parakeets nest in the rainy season (Wermundsen, 1998), when flocks were smallest like those of Orange-fronted Parakeet (Hardy, 1965), although small flock size is not always associated with nesting in parrots (Westcott & Cockburn, 1988).

Parrots may join flocks to minimise the risk of predation (Westcott & Cockburn, 1988). In Australia, Budgerigar *Melopsittacus undulatus* groups are largest in open habitats (Wynd-

ham, 1980), where the risk of being attacked by a predator is highest. Grey Hawks *Asturina plagiata* and American Kestrels *Falco sparverius* have been observed to attack Pacific Parakeets (Wermundsen, 1998). Pacific Parakeets rest and feed mainly in trees (Wermundsen, 1997). In the dry season, most trees in Central American tropical dry forests lose their leaves. Thus, it is easier for predators to find the green parrots, and Pacific Parakeets may form larger groups in order to detect predators more efficiently.

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