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SEASONAL CHANGES IN ROOST COUNTS OF THE NON-NATIVE WHITE-WINGED PARAKEET (*BROTOGERIS VERSICOLURUS*) IN SAN GERMÁN, PUERTO RICO

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Abstract: The White-winged Parakeet (*Brotogeris versicolurus*), introduced to Puerto Rico from its native South America, has proved to be a successful colonizer, but surveys have been sporadic and little is known about seasonal changes in population size and its daily roosting behavior. We conducted monthly roost counts from August 2005 to July 2006 in San Germán, southwestern Puerto Rico, a site colonized since the 1960s, and at present one of the largest populations in the island. Population size fluctuated significantly throughout the year showing the existence of two main periods, one from January to March, with the lowest number of individuals (range = 656–801 individuals), presumably when most individuals were breeding, and another from April to December, in which the number of individuals was higher (range = 1,186–1,529 individuals). The drop in number of individuals from pre-breeding to breeding months suggests that approximately 255 pairs (39% of population) abandoned the roost to initiate nesting activities. Post-breeding data implies the recruitment of 226 new individuals (17% population increase). The number of flocks departing the roost differed significantly throughout the year. However, a large number of flocks departing the roost was related to fewer individuals per flock. Total time to leave the roost also changed significantly throughout the year, ranging from 10 min in October and January to 81 min in April. Time to leave the roost was correlated with the number of departing flocks, but not with the mean number of individuals per flock. Given the high breeding potential of the White-winged Parakeet, it is recommended that both population trends and diurnal dispersal patterns are monitored in the long-term.

Key words: Brotogeris versicolurus, non-native species, population surveys, Puerto Rico, roost counts, seasonal changes, White-winged Parakeet

Resumen: CAMBIOS ESTACIONALES EN EL TAMAÑO POBLACIONAL DEL EXÓTICO PERIQUITO ALIAMARILLO (*BROTOGERIS VERSICOLURUS*) EN SAN GERMÁN, PUERTO RICO. El Periquito Aliamarillo (*Brotogeris versicolurus*), introducido a Puerto Rico desde su nativa Suramérica, ha probado ser un colonizador exitoso, pero los inventarios han sido esporádicos y poco se conoce sobre los cambios estacionales en tamaño poblacional y su conducta diurna en los dormideros. Realizamos censos mensuales en los dormideros desde agosto de 2005 hasta julio de 2006 en San Germán, suroeste de Puerto Rico, un sitio colonizado desde los 1960, y al presente una de las mayores poblaciones en la isla. El tamaño poblacional fluctuó significativamente a través del año mostrando la existencia de dos periodos principales, uno entre enero y marzo, con el número más bajo de individuos (rango = 656–801 individuos), probablemente cuando la mayoría de los individuos estaban en reproducción, y otro desde abril hasta diciembre, en el cual el número de individuos era más alto (rango = 1.186–1.529 individuos). La caída en el número de individuos desde los meses pre-reproducción a reproducción sugiere que aproximadamente 255 parejas (39% de la población) abandonó el dormidero para iniciar las actividades de anidaje. Los datos post-reproductivos implican el reclutamiento de 226 nuevos individuos (17% de aumento poblacional). El número de bandadas partiendo del dormidero se varió significativamente a través del año. Sin embargo, un gran número de bandadas partiendo del dormidero estaba relacionado a menos individuos por bandada. El tiempo total en salir del dormidero también cambió significativamente a través del año, variando de 10 min en octubre y enero hasta 81 min en abril. El tiempo de salir del dormidero estuvo correlacionado al número de bandadas partiendo, pero no con el número promedio de individuos por bandada. Dado el alto potencial reproductivo del Periquito aliamarillo, es recomendado que ambos, las tendencias poblacionales y los patrones de de dispersión diurna, sean monitoreados a largo plazo.

Palabras clave: Brotogeris versicolurus, cambios estacionales, conteos en dormideros, especie no-nativa, inventarios poblacionales, Periquito Aliamarillo, Puerto Rico

Résumé : LES VARIATIONS SAISONNIÈRES DES EFECTIFS AU DORTOIR DE TOUI À AILES VARIÉES (*BROTOGERIS VERSICOLURUS*), ESPÈCE NON-INDIGÈNE À SAN GERMAN, PORTO RICO. Le Toui à ailes variées (*Brotogeris versicolurus*), originaire d'Amérique du Sud et introduit à Porto Rico, s'est révélé être un colonisateur efficace, mais les études le concernant sont sporadiques et peu de choses sont connues au sujet des variations saisonnières de la taille de la population et de ses regroupements quotidiens en dortoir. Nous avons effectué des comptages mensuels au dortoir d'août 2005 à juillet 2006 à San Germán, sud-ouest de Porto Rico, un site colonisé depuis les années 1960, et

abritant aujourd'hui l'une des plus grandes populations de l'île. La taille de la population a fluctué considérablement au cours de l'année mettant en évidence deux périodes principales, l'une de janvier à mars, avec les plus faibles effectifs (656 à 801 individus), correspondant probablement au moment où la plupart des individus se reproduisent, et l'autre d'avril à décembre, avec des effectifs plus élevés (1 186 à 1 529 individus). La diminution des effectifs en période prénuptiale et nuptiale suggère qu'environ 255 couples (39% de la population) ont abandonné le dortoir pour entreprendre des activités de nidification. Les données postnuptiales impliquent le recrutement de 226 nouveaux individus (augmentation de la population de 17%). Le nombre de groupes quittant le dortoir a changé significativement au cours de l'année. Cependant, un nombre élevé de groupes au départ du dortoir était corrélé à un nombre d'individus plus faible dans chaque groupe. Le temps total nécessaire pour quitter le dortoir a également varié de manière significative au cours de l'année, allant de 10 min en octobre et janvier à 81 min en avril. Le temps pour quitter le dortoir était corrélé au nombre de groupes au départ, mais pas au nombre moyen d'individus par groupe. Étant donné le fort potentiel de reproduction du Toui à ailes variées, il est recommandé de suivre sur le long terme les tendances démographiques et les modèles de dispersion diurne.

Mots clés : Brotogeris versicolurus, changements saisonniers, comptage au dortoir, espèce non-indigène, Porto Rico, suivi de populations, Toui à ailes variées

Population surveys are necessary to implement management measures of non-native species if they become a threat to the local biota. However, to be able to conduct accurate surveys it is necessary to understand the daily and seasonal fluctuations in population sizes. For instance, surveys may be inefficient, or result in underestimates, if conducted at a time when individuals are dispersed. Thus, the roosting behavior of some species, like Neotropical psittacids, provides an opportunity to easily count all individuals in a population. Moreover, a comparison of pre- and post-breeding roost counts can even provide an indirect measure of annual recruitment (Matuzak and Brightsmith 2007).

The White-winged Parakeet (*Brotogeris versicolurus*) was introduced to Puerto Rico from South America in the 1960s and rapidly spread throughout the island establishing breeding populations in lowland habitats. One of the first reports was from a population established in the San Germán campus of the Inter American University (hereafter San Germán) by 1968 (Pérez-Rivera *et al*. 1984). Flocks of 100 individuals were regularly observed in this site by 1981 (Raffaele and Kepler 1992), and by 1985 the population was estimated as > 900 individuals (Pérez-Rivera 1992). At present, the White-winged Parakeet is considered the most common exotic species in Puerto Rico (Raffaele *et al*. 1998), with the San Germán population being one of the largest in the island (Camacho-Rodríguez *et al*. 1999).

Although the White-winged Parakeet has proved to be a successful colonizer, surveys have been sporadic and little is known about seasonal or annual changes in population size and its daily roosting behavior. In this study we monitored the species's population size in San Germán by conducting monthly roost counts for 1 yr. Fluctuations in count values were taken as an indirect measure of the initiation or ending of breeding activities. Specific objectives were to determine: (1) how the parakeet population size changed through a year period, (2) if changes were related to differences in the number of flocks and the number of individuals per flock, and (3) if there was a relationship between the time taken to leave the roost and the number of individuals and flocks leaving each morning. With this project we intended to investigate the optimal time of the year to conduct roost surveys, the approximate annual recruitment to the population, and describe aspects of the parakeet's daily dispersal patterns.

STUDY AREA AND METHODS

STUDY AREA

The San Germán campus of the Inter American University lies in the alluvial valley of the Guanajibo River, which is part of the subtropical moist forest life zone (Ewel and Whitmore 1973). Data from a weather station only 5 km from campus (Hoconuco Bajo) indicate that the average annual precipitation and temperature are 1,489 mm and 24.5°C, respectively. The campus consists of 102.8 ha, with 36% of the area used for buildings and development whereas the remaining 64% is covered by secondary forest. White-winged Parakeets are common residents of the university campus where they can be seen flying in flocks of two or more individuals, or heard while feeding in trees scattered among buildings and open areas. Numerous flocks can be observed leaving or returning to roost in four contiguous trees of *Calophyllum brasiliense* on a hill adjacent to a parking lot. These trees cover an area of 0.03 ha.

POPULATION SIZE

Parakeet population size was measured through roost surveys from August 2005 to July 2006. The yearly period was expected to include a breeding season starting in January, as has been found in parakeets of the genus *Brotogeris* (Collar 1997, Brightsmith 1999). A reliable population size estimate was expected from roost counts since all individuals congregate at night, and a single roosting site is known from the campus and its vicinity. We conducted the counts at dawn when flocks were consolidated, parakeets left the roost in discrete periods of time, and dispersed toward foraging locations outside the campus following a single flight path, thus eliminating the chances of double-counting individuals. In contrast, before dusk, flocks fly back and forth erratically while feeding around the roosting trees for a few hr (Tossas pers. obs.).

Observers reached three vantage points before dawn to avoid disturbing the birds. Each of the points was 20–28 m from the roost trees and had a unique view of the departure route. In each count we recorded the number of individuals in each departing flock, total number of flocks, and total time taken from the departure of the first individual until the last one in the roost.

STATISTICAL ANALYSES

Analyses of variance were conducted to compare the total number of individuals, mean number of individuals per flock, and time taken to leave the roost among months. Also, the relationship of number of flocks, mean number of individuals per flock, and time taken to leave the roost was examined with correlation analyses. These statistical tests were performed using the software SPSS version 16.0. A probability of type I error of 0.05 or less was accepted as significant. Data presented are $\bar{x} \pm$ SD.

RESULTS

White-winged Parakeet population size fluctuated significantly throughout the year ($F = 226.0$, $P < 0.001$; Table 1). These fluctuations showed the existence of two main periods, one with the lowest number of individuals (range = 656–801 individuals) from January to March, presumably the extent of the breeding season, and another from April to December, in which the number of individuals remained high (range = 1,186–1,529 individuals). The population reached its largest size in June, with 1,529 individuals, and its smallest size in February, with 656 individuals. The drop in number of individuals from pre-breeding (December) to breeding (January) months suggests that approximately 255 pairs (39% of population) abandoned the roost to initiate nesting activities. Similarly, a comparison of pre- (December) and post-breeding (June) estimates implies the recruitment of 226 new individuals (17% population increase) during the study-year.

The number of flocks departing the roost differed significantly throughout the year ($F = 97.2$, $P <$

Table 1. Results of monthly roost surveys (August 2005 to July 2006) of White-winged Parakeets in San Germán, Puerto Rico.

Date	Number of Individuals	Number of Flocks	Mean Flock Size ± SD (Range)	Time to Leave Roost (Min)
Aug 2005	1,318	145	9.1 ± 9.8 (1-50)	16
Sep 2005	1,318	147	9.0 ± 9.2 (1-45)	15
Oct 2005	1,335	89	12.4 ± 16.0 (1-107)	10
Nov 2005	1,309	106	12.3 ± 10.9 (2-60)	20
Dec 2005	1,303	88	14.8 ± 19.6 (1-100)	20
Jan 2006	793	92	8.6 ± 8.0 (1-55)	10
Feb 2006	656	104	6.3 ± 5.7 (1-31)	15
Mar 2006	801	104	7.7 ± 9.1 (1-65)	25
Apr 2006	1,230	160	7.7 ± 6.1 (1-46)	81
May 2006	1,186	219	5.4 ± 4.2 (1-22)	73
Jun 2006	1,529	198	7.7 ± 11.1 (1-110)	79
Jul 2006	1,217	119	10.2 ± 9.2 (2-49)	16
Annual mean (± SD)	1,166 ± 267.2	131 ± 43.2	9.3 ± 2.7	32 ± 28.1

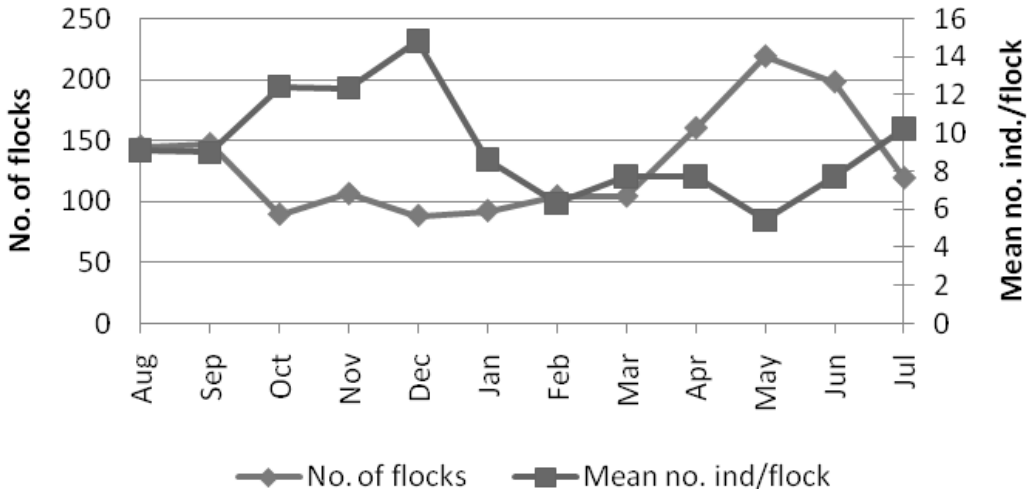

Fig 1. Number of White-winged Parakeet flocks and mean number of individuals per flock at San Germán, Puerto Rico (August 2005 to July 2006).

0.001). From 88 to 219 flocks (annual $\bar{x}$ = 131 flocks ± 43.6) left the roost every morning, but the largest number of flocks was observed in post-breeding months. The mean number of individuals per flock also changed significantly throughout the year (F = 4.5, P = 0.05; annual $\bar{x}$ = 9.3 ± 2.7). A large number of flocks departing the roost was related to fewer individuals per flock (r = −0.61, P = 0.03; Fig. 1).

Total time taken to leave the roost changed significantly throughout the year (F = 9.5, P = 0.005), ranging from 10 min in October and January to 81 min in April (annual $\bar{x}$ = 32 min ± 28.1). This period was shorter from July to March (15–20 min), previous to and during the breeding season, than in the post-breeding months, from April to June (73–81 min). Time to leave the roost was correlated with the number of departing flocks (r = 0.82, P < 0.001; Fig. 2), but not with the mean number of individuals per flock (r = −0.49, P = 0.11).

DISCUSSION

The present study reveals that the best time to conduct annual surveys of the White-winged Parakeet population is during the nonbreeding months, from July to December. Otherwise, marked seasonal fluctuations in parakeet numbers may result in inaccurate estimates. For instance, parakeet counts almost halved from January to March, presumably due to the abandonment of the roost by pairs initiating nesting activities. This 3-month period coincides with the incubation and nestling periods of 1 mo and 2 mo, respectively, observed in White-winged Parakeets in Florida (Schroads 1974). However, estimates of the San Germán population increased gradually during three additional months, showing that nesting did not occur synchronously in all pairs, or probably as a result of renesting attempts.

The highest number of parakeets was recorded in June, marking the end of a 6-mo breeding season with the return of pairs and their young. An extended breeding season was also found for the species in Florida (Schroads 1974), and is typical of other species, like the Pacific Parakeet (*Aratinga strenua*) in Nicaragua (Wermundsen 1998). However, the onset of the breeding time varied, with some species of Central and South America breeding in the rainy months late in the year. For instance, the Pacific Parakeet in Nicaragua breeds from June to October (Wermundsen 1998), while Tui Parakeet (*B. sanctithomae*) chicks have been observed from September to mid-November in Peru (Brightsmith 2004).

Flocks behaved differently during breeding and nonbreeding months. A larger roost size in the post-breeding months was related to more flocks departing the roost every morning, but each with fewer individuals. These flocks probably represented pairs with juveniles, since the mean number of young per successful pair was 4.77 (Schroads 1974, Brightsmith 1999). Moreover, the last 3 months of the breeding season were characterized by a higher amount of time taken to leave the roost. Two to 3 months before breeding, flocks became larger, coherent, and left the roost more quickly.

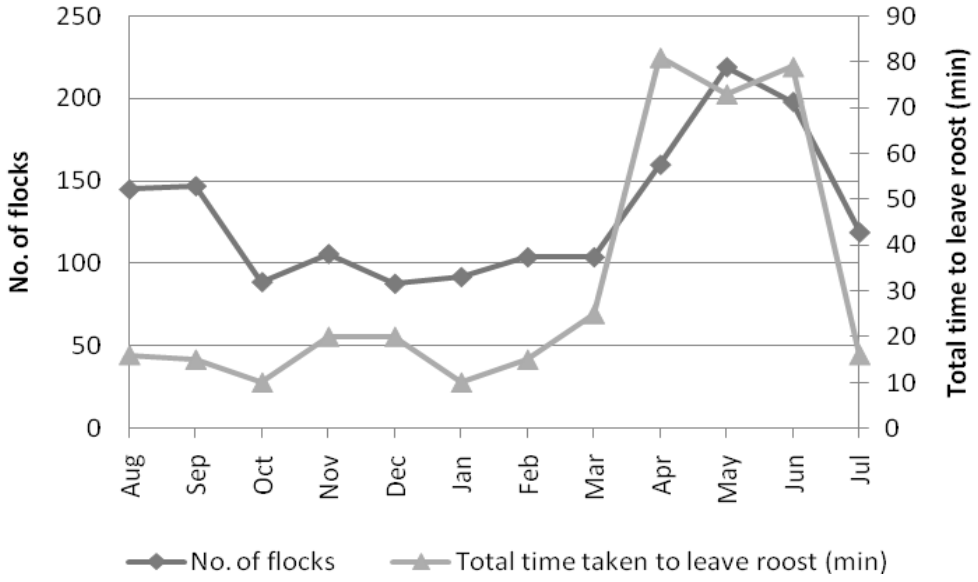

Fig 2. Number of White-winged Parakeet flocks and total time leaving the roost at San Germán, Puerto Rico (August 2005 to July 2006).

The difference between the highest and lowest parakeet estimates suggests a population recruitment of 23% after the 2006 breeding season. These numbers, compared with previous White-winged Parakeet counts in San Germán, suggest that the population will remain stable or will keep growing gradually. In contrast, the species has steadily declined in Florida with only 13% of the population breeding (Brightsmith 1999).

The population recruitment of the White-winged Parakeet also contrasts with estimates of population growth of other psittacids. For instance, parakeet population growth is very high when compared to the annual reproductive growth of the only native psittacid in the island, the endemic and endangered Puerto Rican Parrot (*Amazona vittata*). According to Beissinger *et al*. (2008), the wild population of this species in Luquillo Forest grew only by an average of 1.6 ± 4.2 individuals per year ($\bar{x}$ ± SD) from 1973 to 2000. This low level of annual increase occurred even in years when no hurricanes affected the population. Similarly, parakeet recruitment in San Germán almost doubles the reproductive rate of the Yellow-naped Parrot (*Amazona a. auropalliata*) nesting in Costa Rica (Matuzak and Brightsmith 2007). In a roost of 300 parrots, 23% of the pairs were observed with young, but only 12.5% of the population consisted of young in the post-breeding months of June and July.

Despite an intensive search during the study-year within the vicinity of the campus, we could not find parakeets during the day or any evidence of breeding activity. We believe that they are dispersing a considerable distance from the roost toward their foraging and breeding grounds. Given the parakeet's high breeding capacity, it is recommended that future work focus on the growing trends of the San Germán population, since it seems to have acted as a source of individuals for the initiation of new subpopulations in southwestern Puerto Rico. Moreover, the diurnal dispersal patterns of the species should be monitored by means of radio-tracking technology.

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