

## ROOSTING BEHAVIOR OF THE BROWN-THROATED PARAKEET (*ARATINGA PERTINAX*) AND ROOST LOCATIONS ON FOUR SOUTHERN CARIBBEAN ISLANDS

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**Resumen.** – **Dormideros nocturnos del Perico Carisucia (*Aratinga pertinax*) en cuatro islas en el sur del Caribe.** – Las cuatro subespecies del Perico Carisucia (*Aratinga pertinax*) endémicas a las islas de Aruba, Bonaire, Curaçao y Isla Margarita forman dormideros nocturnos de varias docenas hasta centenares de individuos. La ubicación de los dormideros fue estable durante nuestras visitas de una a dos semanas realizadas en las cuatro islas durante los primeros meses del 2001. Más tarde en el año 2001 en Bonaire, los números de pericos incorporándose a los dormideros fue en general más baja, pero casi todos de estos dormideros seguían siendo usados al fin del año. En Aruba, hay evidencia que un dormidero ha sido utilizado continuamente por lo menos por ocho años. Los dormideros en Aruba son compartidos por los pericos y grandes números de columbiformes nativos. Sugerimos que la protección de dormideros debe ser incluida en planes de conservación y manejo de la fauna de estas islas. Por la escasa y baja vegetación en Aruba, los psitácidos y columbiformes de esa isla pueden ser especialmente vulnerables a la destrucción de los pocos sitios tradicionalmente usados para dormideros, lo cual hace necesaria la protección inmediata y a largo plazo de estas áreas.

**Abstract.** – The four subspecies of the Brown-throated Parakeet (*Aratinga pertinax*) endemic to the southern Caribbean islands of Aruba, Bonaire, Curaçao, and Margarita form nocturnal roosts of several dozen to several hundred birds on their respective islands. The locations of the roosts were stable during our one-to two-week visits to each of the islands early in 2001. On Bonaire, overall numbers of parakeets at roosts were lower later in 2001, but most of the same roosting sites were still being used. On Aruba, one roosting site reportedly has been used for at least eight years. The Aruban roosting sites are shared by Brown-throated Parakeets with large numbers of native columbids. We suggest that protection of roosting sites be included in the conservation and habitat management plans of these islands. Because of the island's relatively low, sparse vegetation, Aruba's native psittacine and columbid populations may be especially vulnerable to the destruction of their few, traditional nocturnal roosting sites, necessitating immediate and long-term protection of these areas from anthropogenic disturbance. *Accepted 25 May 2002.*

**Key words:** *Aratinga pertinax*, Brown-throated Parakeet, Parrot, Roost, Caribbean, Netherlands Antilles, Aruba, Bonaire, Curaçao, Margarita, Venezuela.

### INTRODUCTION

Many species of diurnally active birds congre-

gate in larger groups at night than during their principal, daytime activity periods (Zahavi 1971, Allen & Young 1982, Eiserer 1984). The resulting nocturnal roosting aggregations vary in species composition from single-spe-

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cies to multi-species groups (Gadgil 1972, Eiserer 1984). In addition, the degree to which given roosting locations are repeatedly used varies, ranging from traditional locations that remain unchanged through time, to highly variable locations chosen anew each night (Eiserer 1984).

*Parrot roosting behavior.* Parrots tend to roost in groups, often in the tops of trees, as well as in tree hollows, on cliffs, or in communal nests (Juniper & Parr 1998). In some species, nocturnal roosts are found in traditional, invariant locations, whereas in other species roosting sites change nightly. Roosting behavior can vary among parrot species coexisting in the same habitat; e.g., in northwestern Costa Rica, Yellow-naped Amazons (*Amazona [ochrocephala] anropalliata*) use traditional roosting sites (Wright 1996), whereas groups of Orange-fronted Parakeets (*Aratinga canicularis*) and Orange-chinned Parakeets (*Brotogeris jugularis*) roost in a different site each night (J. W. Bradbury pers. com.).

Here we describe the roosting behavior, and locations of encountered roosts on four southern Caribbean islands, of four subspecies of the Brown-throated Parakeet (*Aratinga pertinax*), each of which is endemic to a different island. In addition, we report that on Aruba, Brown-throated Parakeets share roost sites with several species of columbids.

*General description of Brown-throated Parakeets.* The Brown-throated Parakeet is broadly distributed from Panama to the Guianas and northern Brazil, as well as several southern Caribbean islands, and in the 19<sup>th</sup> century became established on St. Thomas, U.S. Virgin Islands (Juniper & Parr 1998). The species has also been introduced on the islands of Tortola, St. John, Saba, Dominica, Guadeloupe, Martinique, Puerto Rico, Culebra, and Vieques, but there have been no recent confirmed sightings on the latter three islands

(Raffaele et al. 1998). Fourteen subspecies of *A. pertinax* have been described, however several of these are probably clinal intermediates (Forshaw 1989, Juniper & Parr 1998). Five subspecies are endemic to Caribbean islands: *A. p. arubensis* on Aruba; *A. p. pertinax* on Curaçao, Netherlands Antilles; *A. p. xanthogenia* on Bonaire, Netherlands Antilles; *A. p. margaritensis* on Margarita Island, Venezuela; and *A. p. tortugensis* on La Tortuga Island, Venezuela.

The Brown-throated Parakeet is the only native parrot remaining on Aruba, Curaçao, and La Tortuga Island. Bonaire and Margarita Island have a second native parrot, the Yellow-shouldered Parrot (*Amazona barbadensis*), and Margarita Island has a third, the Blue-crowned Parakeet (*Aratinga acuticaudata neoxena*). On all of these islands, the Brown-throated Parakeet is the most common parrot; the populations of the other species are small and considered to be threatened (Juniper & Parr 1998, Low 1981, Rodríguez & Rojas-Suárez 1995).

During the day, Brown-throated Parakeets generally travel in pairs or small groups, feeding on the fruits, flowers, and seeds of a variety of plants (Voous 1983, Forshaw 1989, Silvius 1995, Petit & Freeman 1997). In the only published accounts of the species' crepuscular behavior that we have found, Lowe (1907: 557) observed that "large flocks used to fly over regularly in the evening from the tall mangrove trees lining the large lagoon at the west end of the island [Margarita Island], making their way towards the foot-hills, where apparently they roosted", and Voous (1983: 147) reports that "evening flights towards communal sleeping roosts [are] locally conspicuous" in the southern Netherlands Antilles.

## METHODS

*Description of the visited islands.* Aruba, Bonaire

and Curaçao are dry islands, receiving low and irregular rainfall (an annual mean of 560 mm was reported for Willemstad, Curaçao) (Voous 1983). The dry season extends from February to September, with a somewhat wetter wet season from October to January, but heavy rains are unpredictable and may occur at any time of year (Voous 1983). The average temperature for Willemstad, Curaçao, is 27°C and varies little during the year (Voous 1983). Because of the low rainfall, high temperatures, and constant trade winds, the vegetation on these islands is characteristically arid-adapted.

Aruba is the smallest (175 km<sup>2</sup>) of the four islands that we visited, and compared with the others, woody vegetation is shorter and sparser on Aruba. Much of the original thorny woodland has been cleared and has become replaced by aloe (*Aloe barbadensis*) plantations and *Opuntia* spp. thickets (Voous 1983). Among the taller plant species, the most common are *Acacia tortuosa*, *Caesalpinia coriaria*, *Prosopis juliflora*, and two species of columnar cacti (*Stenocereus griseus* and *Subpilocereus repandus*). Mangroves (consisting primarily of *Rhizophora mangle*) occur along several stretches of the southwestern coast.

Curaçao is larger (472 km<sup>2</sup>), and its more varied topography supports a greater variety of vegetation. Secondary *Acacia* and cactus scrub predominate, and include the species listed above. There are also numerous abandoned fruit plantations (locally known as *bofis*), which have taller trees than the surrounding vegetation. Many of these *bofis* have been invaded by manchineel (*Hippomane mancinella*), which contributes to relatively thick, closed canopies in the groves. Extensive mangroves are found along portions of the southwestern coast.

Bonaire is intermediate in size (265 km<sup>2</sup>), with vegetation that is similar to that of Curaçao but with few *bofis* (Voous 1983). The southern end is dominated by a saline lake,

and mangroves surround Lac Bay on the southeastern margin.

Margarita Island is the largest (934 km<sup>2</sup>) of the islands that we visited. The western lobe of the island, referred to as the Macanao Peninsula, is connected to the eastern lobe by a narrow sand spit called La Restinga. Mean annual rainfall is 700 mm, but rainfall is variable among years, and also across the island, with the eastern part being wetter than the Macanao Peninsula (Hoyos 1985). Vegetation varies greatly between eastern and western ends of the island – the Macanao Peninsula is mostly cactus and thorn scrub, with some taller riparian vegetation, whereas vegetation on the somewhat wetter eastern end ranges from lowland thorn scrub to stunted cloud-forest on the mountain peaks (elev.: 900 m). Extensive mangroves border La Restinga lagoon, as well as Laguna de las Marites and much of the southeastern coast.

Brown-throated Parakeets appear to be absent or rare east of La Restinga lagoon (P. Vernet pers. com.; KEH & JRE pers. observ.), even though a century ago Lowe (1907) found Brown-throated Parakeets to be common residents of the entire island's lowland areas. The current, principal habitat of the parakeets on Margarita Island is therefore similar to that found on the other islands we visited.

*Observations.* Our observations were made in early 2001, during visits to Aruba (17–23 January), Curaçao (24 January–11 February), Bonaire (12–25 February), and Margarita Island (28 February–12 March). Additional observations were made by one of us (JRE) on Bonaire during September–November of the same year.

We located Brown-throated Parakeet roosts through a combination of our own observations and suggestions from residents of the islands. On all four islands, parakeets arrived at their nocturnal roosts around sun-

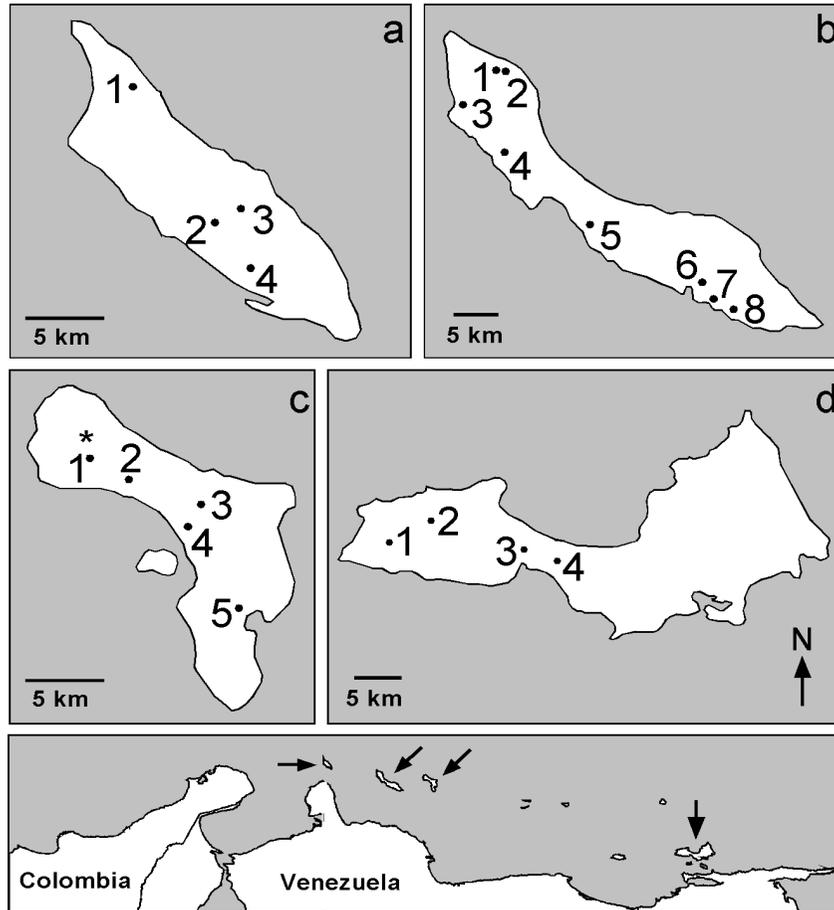


FIG. 1. Verified roosts of the Brown-throated Parakeet (*Aratinga pertinax*) on four southern Caribbean islands during early 2001. The scale bars indicate the scales used for the different maps. The numbers on the maps correspond to the roost locations listed below. (a) Aruba: 1, *cadusbi* thicket at Alto Vista hilltop; 2, *cadusbi* thicket on Masiduri hillside; 3, *cadusbi* thicket at Cunucu Arikok hilltop; 4, *cadusbi* thicket on small hill north of Savaneta. (b) Curaçao: 1, Mahogen Bos east of Savonet; 2, manchineel stand near Savonet; 3, east of Santa Cruz Bay; 4, manchineel stand east of San Juan Plantation House; 5, dam at Lago Disparsé (Malpais); 6, Zuikertuintje; 7, east side of Jan Thiel bay; 8, eastern edge of Spaansbaai. (c) Bonaire: 1, hillside south of Seru Juwa; 2, hillside just south of Altamira Unjo; 3, north of Seru Largu; 4, east of Republic; 5, manchineel grove on west side of Lac Bay; an asterisk (\*) indicates the estimated location of a roost in Washington-Slagbaai National Park. (d) Margarita Island: 1, sand extraction area in the Rio El Muco valley; 2, west of town of San Francisco; 3, mangroves at Boca del Pasadero; 4, mangroves north of Las Tetas de María Guevara.

set and left around sunrise (KEH & JRE pers. observ; see Results). During late afternoons and early evenings, we were therefore able to

determine the locations of roosts by observing the flight paths of parakeets and by following the general directions of their

movements. In our attempts to find most of each island's roosts, we observed crepuscular movement patterns from elevated observation points (e.g., hilltops or overlooks) and along roads stratified throughout the islands.

On each island, we visited most of the located roosts on at least two occasions separated by more than one night. These visits provided data on group sizes, species present at roosts, roost characteristics, and timing of the birds' arrival to and departure from the roosts.

At one roost on Aruba (Alto Vista, evening of 23 January 2001) and two roosts on Curaçao (Santa Barbara, evening of 8 February 2001, and at Jan Thiel, evening of 9 and morning of 10 February 2001), we positioned ourselves so that we could readily count all birds crossing our direct line-of-sight for a fixed distance. Our direct line-of-sight was perpendicular to the flight paths of parakeets arriving into or departing from roosts. We had unobstructed, direct lines-of-sight for 20 m on Aruba, 100 m at Santa Barbara, and 50 m at Jan Thiel. We were 50 m from the estimated center of the Alto Vista roost, and approximately 400 m from the two roosts on Curaçao. From these positions, we recorded the group sizes of all birds arriving or leaving roosts over our direct line-of-sight within 5-min intervals beginning 1.5 h before sunset and 0.5 h before sunrise, respectively. We terminated observations when no birds flew past within a 10-min period. These data provide quantitative descriptions of arrival and departure of birds, including group sizes, species composition, and timing of arrival and departure from roosts relative to sunset and sunrise, respectively. Whereas the data allow us to estimate the number of parakeets using the observed roosts, it was not our intention to attempt population-level counts on the islands. Additional observations were made at the remaining roosts on all four islands.

## RESULTS

*Roost locations.* We located four Brown-throated Parakeet roosts on Aruba, eight on Curaçao, five on Bonaire, and four on Margarita Island (specific locations are given in the legend of Fig. 1). With the exception of one roost on Aruba, all of the roost locations were verified by observing the arrival or departure of large numbers of parakeets. In addition, we inferred use by parakeets of the Masiduri roost on Aruba by the presence of parakeet feathers on the ground, the abundance of bird droppings on the ground and vegetation, and the tops of tall columnar cacti that had been denuded of thorns. Based on our observations of late-afternoon movements of parakeets throughout the islands, the locations of verified roosts, the sizes of roosting aggregations, and the sizes of the islands, we estimate that we were able to locate most or all of the parakeet roosts on Aruba, Bonaire and Margarita Island, and over half of the roosts on Curaçao.

All of the roosts on Aruba were on the leeward sides of hills, in exceptionally dense stands of tall (to 15 m) columnar cacti (*Stenocereus griseus* and *Subpilocereus repandus*), known locally as *cadushi* thickets. The roosts found on Curaçao were in stands of trees that were taller and with denser canopy foliage than the surrounding vegetation. These stands were often in abandoned *bofjís* that had been invaded by manchineel. One of Bonaire's roosts was in a manchineel stand near mangroves; the others were found in locations whose vegetation was not obviously distinct – neither floristically nor physiognomically – from the surrounding vegetation. Margarita Island's roosts were found either in non-distinct locations or in mangroves.

The location of roosts did not change during the one to two weeks that we spent on each island. In the case of the Alto Vista roost on Aruba, a resident (Mrs. Angela) liv-

ing just downhill from the site stated that the roost had been used for at least the previous eight years. She also noted that approximately five years earlier, during the time that a large water tank was being built atop the hill, the number of parakeets using the roost declined drastically and had never completely returned to pre-disturbance levels. Several other roosts (e.g., Cunucu Arikok and the hill behind Savaneta on Aruba, and the Mahogen Bos near Savonet on Curaçao) are well-known to residents as places with lots of parakeets, suggesting that they are traditional roost sites that have been used over long periods of time.

Later observations made on Bonaire during September–November 2001 indicate that the use of roosting areas varies through the year. Smaller numbers of parakeets were roosting at some of the sites located in February (e.g., roosts 1, 2, 4, and 5 in Fig. 1c), and none at another (roost 3 in Fig. 1c). Intensive searches for roosts on the island yielded no additional sites, so the parakeets were evidently aggregating less in the evenings at that time of year. The breeding season for Brown-throated Parakeets on these islands occurs approximately from February through April, following the wet season rains.

*Roosting behavior.* Brown-throated Parakeets approach roosts in pairs or small groups. At the Alto Vista roost on Aruba, sizes of arriving groups that crossed our line-of-sight ranged from one to six birds (mean =  $2.15 \pm 0.99$  birds,  $n = 39$  groups, comprising 84 birds). On Curaçao, group size ranged from one to 13 (mean =  $2.40 \pm 2.01$ ,  $n = 62$  groups, comprising 149 birds) and one to 11 (mean =  $3.26 \pm 1.87$ ,  $n = 74$  groups, comprising 241 birds) for parakeets arriving into the Santa Barbara and Jan Thiel roosts, respectively. The median and modal group sizes arriving into roosts were two in all cases. Parakeets sometimes coalesced into larger groups near roosts before flying into the roosts

themselves. Average group sizes of parakeets leaving the Jan Thiel roost on Curaçao (mean =  $3.97 \pm 3.73$ , median = 2.00, mode = 2.00,  $n = 59$  groups, comprising 234 birds) did not differ from average group sizes arriving into that roost the night before (unpaired t-test,  $p = 0.19$ ).

On Aruba, roosts were used not only by Brown-throated Parakeets, but also by four species of columbids: Bare-eyed Pigeons (*Columba corensis*), Common Ground-Doves (*Columbina passerina*), Eared Doves (*Zenaidura macroura*), and White-tipped Doves (*Leptotila verreauxi*). During our first two visits to the Alto Vista roost we were impressed by the large numbers of Brown-throated Parakeets and columbids arriving into the roost. We were able to walk around approximately half of the perimeter of the roost and we could see a taller hillside beyond the inaccessible side of the roost. We were therefore able to gauge the approximate center of density of roosting birds reasonably accurately. On our third visit we observed 84 Brown-throated Parakeets, 15 Bare-eyed Pigeons, 25 Eared and White-tipped doves, and two Common Ground-Doves arrive across our 20-m line-of-sight perpendicular to and 50 m from the roost (total = 126 birds). On all three visits we observed birds arriving uphill to the roost from all directions within our purview. Since the arrival rate undoubtedly varies over different points outside of the roost, we chose to count birds crossing a line-of-sight that was long enough to average point-to-point variation. To provide a conservative estimate of the total number of birds using the Alto Vista roost, we will make the assumptions that our line-of-sight can be treated as a 20-m arc of a circle with a 50-m radius surrounding the center of density of the roost, and that the frequency of arrival was uniform around the roost along the arc's circle. By making these provisional, but reasonable, assumptions we estimated the total number of birds that

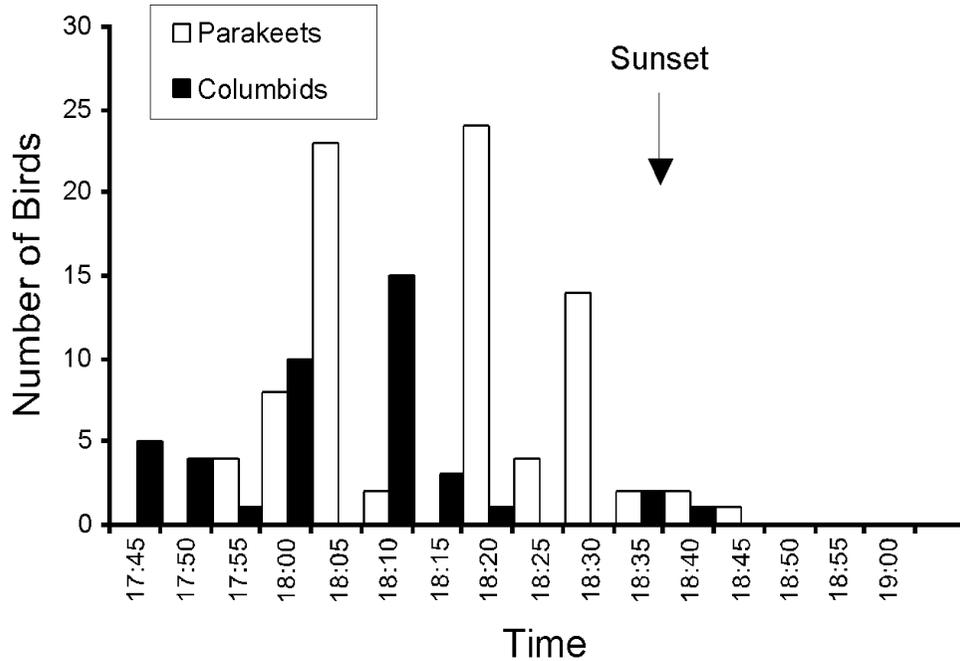


FIG. 2. Arrival of Brown-throated Parakeets (*Aratinga pertinax*) and columbids into the roost at Alto Vista, Aruba, on 23 January 2001. Each bar represents the total number of birds arriving across a 20-m line-of-sight perpendicular to incoming flight paths within the 5-min interval beginning at the time indicated beneath the bar. Sunset occurred at 18:39 h.

arrived into the roost was at least 1978.

In the mixed-species roosting aggregations on Aruba, birds of different species were intermingled on perches within the roosts. In contrast, on Curaçao and Bonaire, Brown-throated Parakeet roosts sometimes included a few doves and pigeons, but these columbids generally used independent, single-species roosts (A. O. Debrot pers. com., KEH & JRE pers. observ.). We saw no columbids enter, perch within, or leave parakeet roosts on Margarita Island, even though two of the columbids (i.e., Bare-eyed Pigeon, Eared Dove) found on the other islands are also found in parakeet habitat on Margarita Island (de Schauensee & Phelps 1978).

On all islands, Brown-throated Parakeets, along with columbids on Aruba, arrived and

departed from roosts relatively synchronously (e.g., Figs 2 and 3). The parakeets appeared to depart roosts slightly more synchronously than they arrived, which is consistent with a flatter frequency distribution of numbers of groups arriving relative to groups departing (Fig. 3).

Brown-throated Parakeets did not form roosting aggregations with other resident parrots on Bonaire or Margarita Island during our January–March observations. On Curaçao, where we saw several exotic parrots (e.g., *Amazona* spp., *Ara* spp.), a few were seen flying into or out of Brown-throated Parakeet roosts. During September and early October, near Lac Bay on Bonaire, approximately 100 native Yellow-shouldered Parrots roosted in a few trees

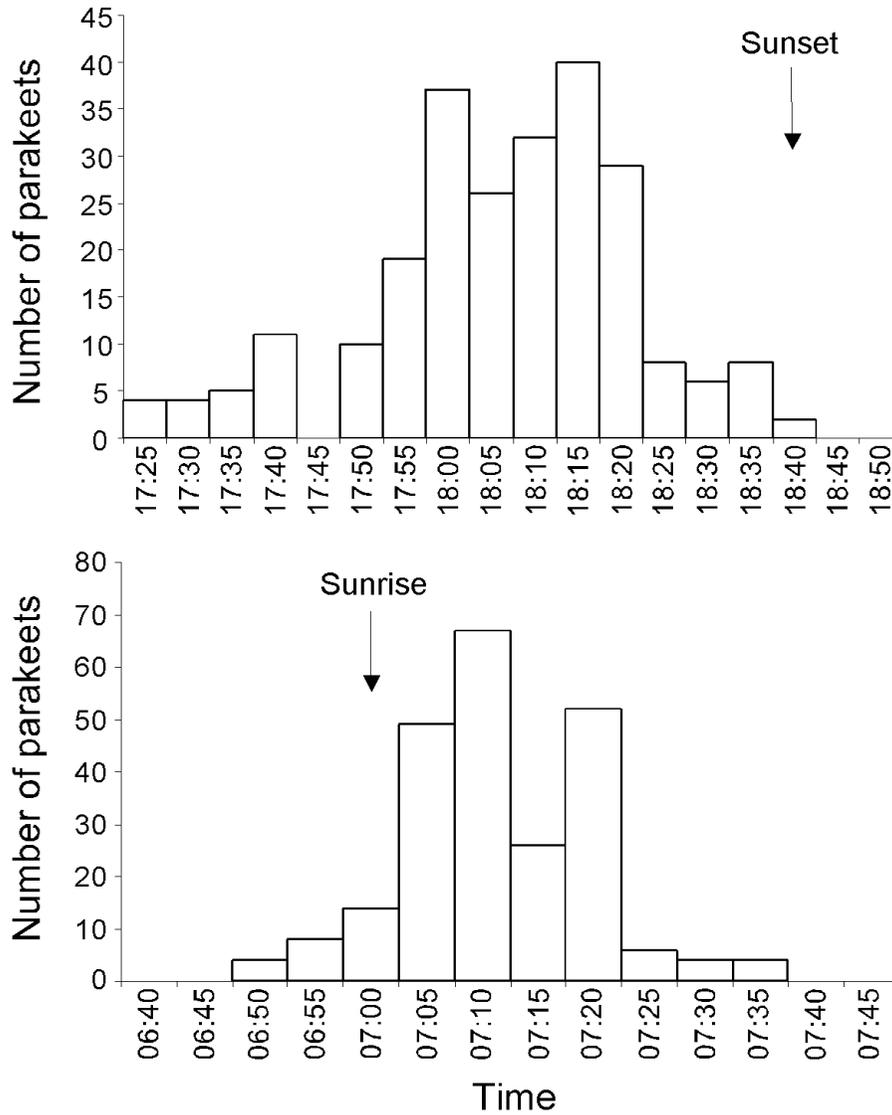


FIG. 3. Arrival into (top panel) and departure from (bottom panel) the Jan Thiel, Curaçao, roosting site by Brown-throated Parakeets (*Aratinga pertinax*) on 9 February (sunset at 18:41 h) and 10 February 2001 (sunrise at 07:00 h). Each bar represents the total number of birds arriving (top panel) or departing (bottom panel) across a 50-m line-of-sight perpendicular to arrival or departure flight paths, respectively, within the 5-min interval beginning at the time indicated beneath the bar.

within the grove of manchineel used by roosting Brown-throated Parakeets. Smaller numbers (c. 50) of Yellow-shouldered Parrots

were also seen roosting along with the parakeets at Bonaire's Alto Vista roost during October.

## DISCUSSION

On the islands of Aruba, Curaçao, Bonaire, and Margarita, the Brown-throated Parakeet was one of the most common birds. As is typical of parrots, these parakeets slept in communal nocturnal roosts on all four islands, but the types of roost sites chosen varied somewhat among islands. On Aruba, roosts were in dense stands of columnar cacti; roosts on Curaçao were found in abandoned *bofis*, and in manchineel or mangrove stands; whereas on Bonaire and Margarita Island most of the roosts were in patches of trees that did not appear to differ from the surrounding vegetation. Of the islands that we visited, Aruba is the only one where the Brown-throated Parakeet shared its roosts with large numbers of other species – pigeons and doves.

*Why do Brown-throated Parakeets form roosting aggregations?* The causes may differ for the origin vs. maintenance of nocturnal aggregation behavior (Eiserer 1984, Weatherhead 1983). Furthermore, the causes of aggregation may be multiple and may differ among islands, much as the reasons for joining communal roosts may differ among individuals (Weatherhead 1983).

Our limited observations do not permit us to discriminate definitively among alternate hypotheses for either the origin or maintenance of nocturnal roosting behavior by Brown-throated Parakeets. Nevertheless, predator avoidance (e.g., Lack 1968, Hamilton 1971, Pulliam 1973) seems likely to be among the causes for forming roosting aggregations on the islands we visited, because roosts generally occurred in vegetation that was denser or taller than surrounding vegetation (e.g., cactus thickets, manchineel groves), or relatively inaccessible (e.g., mangroves). The presence of several species at the roosts on Aruba coincides with

the low availability of tall, dense vegetation on that island. We do not know of any records of predation on Brown-throated Parakeets for these islands, however potential nocturnal predators include feral house cats (*Felis catus*), Burrowing Owls (*Arbene canicularia*, found on Aruba and Margarita; Voous 1983, Meyer de Schauensee & Phelps 1978), Barn Owls (*Tyto alba*, on Bonaire, Curaçao and Margarita; Voous 1983, Meyer de Schauensee & Phelps 1978), Tropical Screech Owls (*Otus choliba*, on Margarita; Meyer de Schauensee & Phelps 1978), and snakes (e.g., *Crotalus* spp. on Aruba and Margarita).

Nocturnal roosts might also be social centers where individuals can assess other members of the population for information not related to food; e.g., as potential future breeding partners or future flock-mates, much as Wagner (1993) has suggested that nesting colonies might permit females to assess potential partners for extra-pair copulations. Because parrots are long-lived (Forshaw 1989) and apparently must learn how and where to forage via social interactions (McInnes & Carne 1978, Rowley & Chapman 1986), social affiliations are likely to be essential for survival and reproduction. We also cannot rule out the possibility that these parakeets use nocturnal roosts as information centers in the original meaning of Ward & Zahavi (1973). Our observations from Bonaire indicate that roosts are more heavily used in the early breeding season (February), than during the non-breeding season (September–November). This could imply a relationship between breeding activity and roosting; however, the availability of food may also drive roosting behavior, since the breeding season follows the rains and is a time of year during which many food trees are fruiting (KEH & JRE pers. observ.).

*Nocturnal roosts and avian conservation.* Our data are only a snapshot of the roosting behavior

of Brown-throated Parakeets on four islands, but they reveal inter-island differences that are relevant to the management and conservation of bird populations on the islands. In addition to the Brown-throated Parakeet, several other bird species that are resident on the islands have been reported to roost communally. Large roosting aggregations are reported for Eared Doves on the Venezuelan mainland (Lord & Yunes-G. 1986) and Trinidad (ffrench 1976), and J. Wells (pers. com.) noted large flocks of Eared Doves arriving into night roosts near the hotels at the northern end of Aruba. In addition, flocks of over 500 have been reported for Bare-Eyed Pigeons in Venezuela (Meyer de Schauensee & Phelps 1978). Nevertheless, none of these sources described mixed-species roosting aggregations like those we observed on Aruba.

National parks and conservation areas on Aruba, Curaçao, Bonaire, and Margarita Island provide important habitats and refuges for many species. Nevertheless, species often require a diversity of habitat types to complete their life cycles or daily activities, such that a single protected area may not provide sufficient habitat diversity, or abundance of a limited resource (e.g., roosting locations), for an entire population (Gilbert 1977). Vulnerability of night roosts to human disturbance, especially outside protected areas, may determine the population viability of communally roosting species.

Traditional roost locations of the islands' Brown-throated Parakeets, as well as other avian species, should be considered valuable conservation targets, especially in the case of the mixed species roosts on Aruba. Since multiple species heavily use the few nocturnal roosts on that island, it seems likely that suitable roosting sites may be especially limited there. We recommend enacting local measures to protect these sites from anthropogenic destruction, especially outside of

currently established national parks.

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## REFERENCES

- Allen, H. L., & L. S. Young. 1982. An annotated bibliography of avian communal roosting. Washington State Game Dept., Olympia, Washington.
- Eiserer, L. 1984. Communal roosting in birds. *Bird Behav.* 5: 61–80.
- ffrench, R. 1976. A guide to the birds of Trinidad and Tobago. Revised ed. Harwood Books, Valley Forge, Pennsylvania.
- Forshaw, J. 1989. Parrots of the world. 3<sup>rd</sup> revised ed. Landsdowne Editions, Willoughby, New South Wales, Australia.
- Gadgil, M. 1972. The function of communal roosts: relevance of mixed roosts. *Ibis* 114: 531–533.
- Gilbert, L. 1977. Food web organization and the conservation of Neotropical diversity. Pp. 11–33 *in* Soulé, M. E., & B. A. Wilcox (eds.). Conservation biology. Sinauer Assoc., Sunderland, Massachusetts.
- Hamilton, W. D. 1971. Geometry of the selfish herd. *J. Theoret. Biol.* 31: 295–311.
- Hoyos, J. 1985. Flora de la Isla Margarita.

- Monografía No. 34, Sociedad y Fundación La Salle de Ciencias Naturales, Caracas, Venezuela.
- Juniper, T., & M. Parr. 1998. Parrots: a field guide to parrots of the world. Yale Univ. Press, New Haven, Connecticut.
- Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen, London, UK.
- Lord, R. D., & F. Yunes-G. 1986. Colonial breeding of the eared dove (*Zenaida auriculata*) in northwestern Venezuela. *Vida Silvestre Neotrop.* 1: 62–67.
- Low, R. 1981. The Yellow-shouldered Amazon (*Amazona barbadensis*). Pp. 215–225 in Pasquier, R. P. (ed.). Conservation of new world parrots. Technical Pub. No. 1, International Council for Bird Preservation, Smithsonian Institution Press, Washington, D.C.
- Lowe, P. R. 1907. On the birds of Margarita Island, Venezuela. *Ibis Ser.* 9, 1: 517–570.
- McInnes, R. S., & P. B. Carne. 1978. Predation of cossid moth larvae by Yellow-tailed Black Cockatoos causing losses in plantations of *Eucalyptus grandis* in north coastal New South Wales. *Aust. Wildl. Res.* 5: 101–122.
- Meyer de Schauensee, R., & W. H. Phelps, Jr. 1978. A guide to the birds of Venezuela. Princeton Univ. Press, Princeton, New Jersey.
- Petit, S., & C. E. Freeman. 1997. Nectar production of two sympatric species of columnar cacti. *Biotropica* 29: 175–183.
- Pulliam, H. R. 1973. On the advantages of flocking. *J. Theor. Biol.* 38: 419–422.
- Raffaele, H., J. Wiley, O. Garrido, A. Keith, & J. Raffaele. 1998. A guide to the birds of the West Indies. Princeton Univ. Press, Princeton, New Jersey.
- Rodríguez, J. P., & F. Rojas-Suárez. 1995. Libro rojo de la fauna venezolana. PROVITA, Caracas, Venezuela.
- Rowley, I., & G. Chapman. 1986. Cross-fostering, imprinting, and learning in two sympatric species of cockatoo. *Behaviour* 96: 1–16.
- Silvius, K. M. 1995. Avian consumers of cardon fruits (*Stenocereus griseus*: Cactaceae) on Margarita Island, Venezuela. *Biotropica* 27: 96–105.
- Voous, K. H. 1983. Birds of the Netherlands Antilles. De Walburg Pers.
- Wagner, R. H. 1993. The pursuit of extra-pair copulations by female birds: a new hypothesis of colony formation. *J. Theor. Biol.* 163: 333–346.
- Ward, P., & A. Zahavi. 1973. The importance of certain assemblages of birds as “information-centres” for food-finding. *Ibis* 115: 517–534.
- Weatherhead, P. 1983. Two principal strategies in avian communal roosts. *Am. Nat.* 121: 237–243.
- Wright, T. F. 1996. Regional dialects in the contact call of a parrot. *Proc. R. Soc. Lond. Ser. B. Biol. Sci.* 263: 867–872.
- Zahavi, A. 1971. The function of pre-roost gatherings and communal roosts. *Ibis* 113: 106–109.

