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Nest site selection by birds in Acacia trees in a Costa Rican dry deciduous forest.—Little is known about the criteria that tropical birds use to choose nest sites because the spatial complexity of tropical forests allows birds to conceal nests effectively (Skutch 1976). Nests in dry forests are easier for researchers to find and identify than those in wet forests because

trees in the former habitat drop their leaves during the dry season. In a dry forest at Palo Verde National Park, Costa Rica, three species of birds commonly build nests in swollen-thorn acacia trees (*Acacia* spp.): Rufous-naped Wren (*Campylorhynchus rufinucha*), Yellow-olive Flycatcher (*Tolmomyias sulphurescens*), and Streaked-backed Oriole (*Icterus sclateri*). Two species of acacia are found at Palo Verde: *Acacia cornigera,* which occurs in wet or seasonally flooded areas, and *A. collinsii,* a more widespread species found in drier areas. Three species of *Pseudomyrmex* ants live in a mutualistic association with these two *Acacia*: *P. spinicola* (a more aggressive species; Janzen 1966, Young et al. 1990), *P. flavicornis* (less aggressive), and *P. nigrocinta* (occurring on younger *A. collinsii* trees). These ants typically clear a large area, or halo, around one or several acacia trees to defend the plant from potential competitors (Janzen 1966). Two of the three bird species mentioned above (wren and flycatcher) appear to nest almost exclusively in ant-acacias. In Guatamala, Gilardi and Von Kugelgen (1991) described what appeared to be a commensal relationship between two species of Acacia-nesting birds: White-bellied Wrens (*Uropsila leucogastra*) and Yellow-olive Flycatchers. The ants most likely provide the birds with protection from nest predators (Janzen 1969, 1983: p. 763). Young et al. (1990) found that Rufous-naped Wrens nest in Acacia trees occupied by *P. spinicola* twice as often as expected by chance, and that ants occupying trees with Rufous-naped Wren nests were more aggressive than those ants found in trees containing the nests of other species of birds.

We speculated that birds may use some of the characteristics of the acacia trees and their halos as cues to select nest sites. Specifically, we examined nest sites to see whether (1) birds demonstrated a preference for specific species of acacia, (2) birds showed a preference for one species of ant over another, (3) the height and diameter of a tree affected nest site selection, and (4) size of the acacia halo affected nest site selection.

We searched for bird nests by walking foot trails and roads near Palo Verde Biological Station (9466 ha, 10°N, 85°W), Guanacaste Province during February 1993. We identified bird species by nest architecture: Rufous-naped Wrens build dense spherical nests; Yellow-olive Flycatchers build small pendant nests; and Streaked-backed Orioles build relatively larger pendant nests with a narrower attachment to the supporting branch (hereafter birds are referred to as wrens, flycatchers, and orioles). None of the three species of birds nest during the dry season (Stiles and Skutch 1989), but all three build sturdy nests which last from one season to the next. Unlike the other two species, wrens may build several nests during a breeding season, using some for roosting and others as possible dummy nests to distract predators (Collias and Collias 1964, Janzen 1983: p. 559). Thus, relative percentages of observed nests do not necessarily reflect the abundance of the three species. We identified *Acacia* species (*A. collinsii* or *A. cornigera*) and species of ant occupying the tree where ants were present. Trees shorter than 1 m were not included because nests are rarely found in such trees and were not observed in this study. We recorded tree diameter at breast height (dbh), height of tree, height of nest in tree, size of acacia halo (length × width), and number of ≥1 m tall acacia trees within the halo. To account for variations in halo shape, halo area was calculated as the longest length × the longest perpendicular width of the halo.

We used a variety of statistical tests to determine which ecological factors these three species of birds used to choose nest sites. We performed one-way analyses of variance (ANOVAs) to assess the significance of tree height and paired *t*-tests for tree dbh. Because halo area and number of trees within a halo were not normally distributed, we used Kruskal-Wallis non-parametric tests to examine their significance in nest site selection. We used Chi-square tests for homogeneity to assess whether the proportion of nests built in trees with a particular species of ant, and in a halo with varying numbers of trees, was uniform across bird species.

We found 52 wren (80%), eight flycatcher (12.3%), and five oriole (7.7%) nests. All wren, oriole, and five flycatcher nests were in *Acacia collinsii.* We also found two flycatcher nests

TABLE 1

NEST SITE CHARACTERISTICS OF BIRDS NESTING IN ACACIA TREES IN PALO VERDE NATIONAL PARK, COSTA RICA, 1993, INCLUDING TOTAL NUMBER OF NESTS, MEAN HEIGHT OF NESTS AND TREES, MEAN NUMBER OF TREES/HALO, AND MEAN HALO AREA BY BIRD SPECIES

Parameter[a]	Rufous-naped Wren (N = 52)	Yellow-olive Flycatcher (N = 8)	Streaked-backed Oriole (N = 5)
Mean nest height (m)	4.1 (±1.5)	3.8 (±1.1)	6.5 (±2.3)
Mean tree height (m)	6.2 (±1.5)	8.9 (±5.7)	8.0 (±2.0)
Mean number trees per halo	7.7 (±8.4)	2.1 (±3.2)	4.4 (±6.1)
Mean halo area	20.4 (±32.5)	3.3 (±9.4)	6.4 (±12.1)
Mean DBH	5.0 (±1.5)	6.3 (±1.6)[b]	4.3 (±1.4)

[a] All parameters are reported as are means ± one SD.
[b] DBH for Yellow-olive Flycatcher are reported only for *Acacia collinsii* trees.

in *Calycophyllum candidissium* and one flycatcher nest in *Brosimum alicastrum.* Of wren nests found, 85% (N = 44) were in acacias occupied by *P. spinicola,* 11.5% (N = 6) were in trees occupied by *P. flavicornis,* and 4% (N = 2) had no ants. Only half the flycatchers nests were found in trees with ants (N = 3 with *P. spinicola* and N = 1 with *P. flavicornis*) while 60% of oriole nests were in trees with ants (N = 2 with *P. spinicola* and N = 1 with *P. flavicornis*). The proportion of flycatcher and oriole nests built in trees occupied by *P. spincola* was significantly lower (χ^2 = 18.58, df = 4, P <0.001) than wrens. To assess the relative criteria which the three species of birds may use to select nest sites, we compared the characteristics of trees and halos with nests among bird species. Orioles placed their nests significantly higher in trees than either wrens or flycatchers (F = 6.01, df = 64, P <0.05; Table 1). Bird species differed significantly in the height of the tree in which they placed their nests (F = 5.13, df = 64, P <0.05; Table 1). Wrens chose trees that were significantly shorter than trees chosen by flycatchers, but there were no differences between wrens and orioles or between flycatchers and orioles (Bonferroni pairwise comparison, t = 2.46, ns). Flycatchers and orioles nested in trees with significantly different diameters at breast height (t = 3.38, df = 4, P <0.05; Table 1). There were no significant differences between the dbh of the trees wrens placed nests in and the trees in which flycatchers and orioles nested (Table 1).

Halo characteristics were more important criteria for wrens than for the other two species. Wrens chose trees with halos three times and six times the size of orioles and flycatchers, respectively (KW = 13.1, P <0.001, Table 1). Furthermore, wrens chose halos containing significantly more acacia trees than the other two species (KW = 6.28, P <0.05, Table 1).

Wrens built their nests in shorter trees and placed their nests lower in trees than did either flycatchers or orioles. Further, they chose larger acacia halos with more trees than did the other two species. Wrens also built the majority of their nests in trees with the more aggressive *P. spinicola.* These results support the findings of Young et al. (1990) that ant activity is an important criteria to nesting wrens and that dbh of nest trees were not different between wrens and other species.

Pendant nests generally provide greater protection from nest predators than do spherical nests; pendant nests can be placed at the end of thin branches that are difficult for many predators to reach and that provide the nesting bird with an early warning of a predator's approach (Skutch 1976). One explanation for the wren's greater affinity for ant-protected

acacias is that, based on nest architecture alone, its nests may be more vulnerable to predation than are flycatcher or oriole nests. By placing nests in ant-protected acacias, the wren presumably gains additional security for its eggs and nestlings. This may explain why halo characteristics are more important to wrens than to the other two species. These data suggest that larger and more dense halos with high *Pseudomyrmex* activity are the most likely signals which wrens use to assess optimal nest location.

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Notes on the ecology and population decline of the Rota Bridled White-eye.—The Bridled White-eye (*Zosterops conspicillata*) of the Mariana Islands is represented on Rota by the endemic subspecies *Z. c. rotensis,* which once was common and widespread (Baker 1951, E. Taisacan, pers. obs.), but by the 1960s had become uncommon (Engbring et al. 1986). In 1982 the total population, by then restricted to the Sabana plateau region, was estimated at 10,763 compared to 229,138 (*Z. c. saypani*) for the similarly sized island of Saipan (Engbring et al. 1986). J. Engbring (pers. comm.) estimated a further 26% decline on Rota by 1987, although he believed poor weather may have interfered with censuses. By 1991, qualitative but intensive distributional surveys by E. Taisacan and G. Witteman yielded