

LITERATURE CITED

- BALGOOYEN, T. C. 1976. Behavior and ecology of the American Kestrel (*Falco sparverius* L.) in the Sierra Nevada of California. Univ. Calif. Publ. Zool. 103: 1-83.
- BROWN, L. H., & D. AMADON. 1968. Eagles, hawks, and falcons of the world. New York, McGraw-Hill.
- BRYANT, H. C. 1918. Evidence on the food of hawks and owls in California. Condor 20: 126-127.
- . 1921. California hawks: How to identify them. California Fish Game 7: 133-147.
- GREER, J. K., & D. S. BULLOCK. 1966. Notes on stomach contents and weights of some Chilean birds of prey. Auk 83: 308-309.
- JAKSIĆ, F., & J. YÁÑEZ. 1978. Variación anual de la composición comunitaria de micromamíferos en Los Dominicos, Santiago. Noticiario Mensual, Museo Nacional Historia Natural (Chile) 267: 10-11.
- , & ———. 1979. The diet of the Barn Owl in central Chile and its relation to the availability of prey. Auk 96: 619-621.
- , ———, & R. P. SCHLATTER. 1980. Prey of the Harris' Hawk in central Chile. Auk 97: 196-198.
- JOHNSON, A. W. 1965. The birds of Chile and adjacent regions of Argentina, Bolivia, and Peru. Buenos Aires, Platt Establecimientos Gráficos.
- ROEST, A. I. 1957. Notes on the American Sparrow Hawk. Auk 74: 1-19.
- SCHLATTER, R. P., B. TORO, J. L. YÁÑEZ, & F. M. JAKSIĆ. 1980a. Prey of the White-tailed Kite in central Chile and its relation to the hunting habitat. Auk 97: 186-190.
- , J. L. YÁÑEZ, H. NÚÑEZ, & F. M. JAKSIĆ. 1980b. The diet of the Burrowing Owl in central Chile and its relation to prey size. Auk in press.
- SOKAL, R. R., & F. J. ROHLF. 1969. Biometry. San Francisco, California, W. H. Freeman.
- THROWER, N. J. W., & D. E. BRADBURY (Eds.). 1977. Chile-California mediterranean scrub atlas: a comparative analysis. Stroudsburg, Pennsylvania, Dowden, Hutchinson, and Ross.

Received 10 December 1979, accepted 7 February 1980.

Nest-site Selection in the Brown Jay

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The choice of nest sites by many species of birds is known to be affected by topographic or climatic variables (Welty 1975). Among corvids, nest-sites vary widely and may be chosen with respect to protection from predators or weather (Goodwin 1976). Eurasian Crows (*Corvus corone cornix*), for instance, prefer to nest in conifers, where predation is lower than in deciduous trees (Loman 1979). Piñon Jays (*Gymnorhinus cyanocephalus*) place their nests to maximize insolation but do not distinguish between windward and leeward sides of trees (Balda and Bateman 1972).

Little is known about the ecological correlates of nest-site selection in neotropical jays. As part of a study of the breeding behavior of a montane population of Brown Jays (*Psilorhinus morio*) in Monteverde, Costa Rica, we found that two opposing factors in nest-site selection are predation and wind.

Brown Jays are communal breeders with helpers at the nest (Skutch 1935, Lawton and Guindon in press). Unlike most species, especially in the tropics, Brown Jays are conspicuous and noisy while breeding. Throughout incubation, breeding birds spend extended periods whining loudly from their nests. After eggs hatch, nest attendants fly directly to the nest, often calling as they land. That such behavior does not result in predation of many nests probably derives from two phenomena. First, Brown Jays are large, aggressive birds, well able to defend their nests against many diurnal predators. In Monteverde we have seen flocks drive off Broad-winged Hawks (*Buteo platypterus*), Common Black Hawks (*Buteo gallus anthracinus*), red-bellied squirrels (*Sciurus variegatoides*), white-faced monkeys (*Cebus capucinus*), and domestic cats (*Felis catus*). Second, the position of nests probably reduces nocturnal predation by animals that hunt the forest canopy. In Monteverde these include the opossum (*Didelphis virginianum*), the margay (*Felis weidii*), the ocelot (*F. pardalis*), a weasel (*Mustela frenata*), and assorted snakes.

Observations of 30 nesting attempts over two breeding seasons showed that the jays most commonly (86%) build in isolated trees, well away from windbreaks or patches of woods. All five nests built in trees whose crowns touched others were destroyed by nocturnal predators. Only one of the 25 nests built in isolated trees failed because of predation of any sort. Brown Jays in other parts of their range also tend to build in isolated trees (Skutch 1960), suggesting that throughout their range Brown Jays choose nest sites in response to strong predation pressure.

In Monteverde, however, the search for a suitably isolated tree is complicated by the presence of strong prevailing winds. The study area is located just below the continental divide in the Cordillera de Tilaran. Throughout the year the climate is dominated by the Atlantic trade winds. Strong windstorms are common in the breeding season, January–May. For instance, during a 4-day storm in mid-April 1978, winds blew at 70 kph throughout the study area. Ten of 12 broods under study were destroyed: young were blown out of 6 nests, eggs fell out of three, and the entire nest, with eggs, was blown out of another tree. We conclude that Brown Jays in Monteverde must be forced to seek nest trees that are isolated but also protected from the wind.

In order to evaluate our ideas, we designed a test of the null hypothesis that nest trees are chosen at random with respect to wind exposure. Using a 1977 aerial photograph we numbered all isolated trees in pastures or old fields over a 150-ha area. The area corresponded with the known home ranges of four flocks whose breeding behavior and success were known for 1977 and 1978. We chose 20 test trees at random, 5 from each home range.

During a 4-day windy spell, 24–27 November 1978, we sampled the effects of wind on the 20 test trees; 13 nest trees were also sampled on the same home ranges. These represented all nesting attempts of the four flocks over 2 yr. We assessed the wind strength using the Beaufort Scale, an objective measure of windiness that allows one to judge relative wind speed from the visible effect on trees (Strahler 1965, Miller and Thompson 1970). We used the Beaufort Scale rather than hand-held anemometers because the latter give an estimate of the wind only at the observer's level, not at the height at which nests are built, which is generally 10–15 m above the ground. Moreover, the topography of the study area is so varied that a hand-held gauge would reveal nothing about the windiness of the home ranges in general, but rather would be biased by the very microclimatological differences that, if present, are the object of the test.

While samples were taken throughout the study area, a third observer, located in a central portion of the study area, sampled a "central control-tree," an emergent canopy tree, at 20-min intervals. The control-tree samples indicated strong Atlantic winds (30–60 kph, or 5 to 7 on the Beaufort Scale) throughout the sample period.

The data collected on the 20 test trees showed a population markedly skewed to the higher end of the scale ($\bar{x} = 5$, range = 1–7). This demonstrates that isolated trees, chosen at random, tend to be wind-shaken.

The four home ranges examined were, in general, equally windy. Analysis of variance of the effect of wind on the 20 test trees revealed no significant differences between home ranges ($F = 0.184$, $P > 0.25$). The general windiness of the home ranges is, however, less important than the existence of unusual, particularly protected trees.

The average value of wind disturbance on the 13 nest trees was lower ($\bar{x} = 3.6$), and the range was more restricted (2–6). A large sample approximation of the Wilcoxon Rank Sum Test (Hollander and Wolfe 1973) strongly rejected the null hypothesis that nest trees and randomly selected trees are chosen from the same population ($W = 2.8$, $P < 0.003$). Brown Jays select nest sites in isolated trees that are more protected from the wind than a random sample of isolated trees.

Using fledging as a measure of success, we divided 20 nesting attempts on eight home ranges into successful and unsuccessful. The level of wind disturbance on successful nests ($\bar{x} = 3.45$) was lower than the mean for unsuccessful nests ($\bar{x} = 4.6$). Similarly, the range of values for successful nests (2–5) was lower than that of unsuccessful nests (3–6). A Wilcoxon Rank Sum Test again rejected the null hypothesis that all nest trees are drawn from the same population ($W = 132.5$, $P = 0.022$). Nests placed in wind-protected trees are more likely to be successful.

Brown Jays at Monteverde must make complex choices in the selection of nest sites. On the one hand, predators force them to seek isolated nest sites. Conversely, strong prevailing winds force them to seek relatively sheltered nest sites. We have shown that all flocks build nests in relatively sheltered but isolated trees. In addition, we have shown that flocks that build in more wind-protected sites are more likely to fledge young than are flocks that build in more exposed sites. This can be explained in two ways: (1) some flocks make better choices than others; or (2) some flocks have better choices to make, i.e. they

control better home ranges than others, at least with respect to available nest sites. These possibilities need not be mutually exclusive, nor can they be distinguished with our data.

Nest sites have been suggested as a limiting resource in some hole-nesting and colonial species (Lack 1968, Welty 1975, Brown 1975), but the possibility that they also may be limiting in tree-nesting species has received scant attention (Balda 1970). In Monteverde the number of isolated trees is limited. Most of these are too greatly disturbed by the strong prevailing winds to be suitable nest sites for Brown Jays. Our results do not demonstrate that nest sites are a limiting resource, because they do not show that some birds are excluded from good nest sites. They do demonstrate, however, that Brown Jays make complex decisions in choosing nest sites, and they suggest a quantitative method for testing the hypothesis that nest sites may be a limiting resource in tree-nesting species.

This study was supported by grants from the Frank M. Chapman Fund of the American Museum of Natural History and from the Henry Hinds Fund for Evolutionary Research. We wish to thank Carlos Guindon and Susan Trostle for field assistance. Peter Stacey provided valuable comments on the manuscript.

LITERATURE CITED

- BALDA, R. P. 1970. Effects of spring leaf-fall on composition and density of breeding birds in two southern Arizona woodlands. *Condor* 72: 325-331.
- , & G. C. BATEMAN. 1972. The breeding biology of the Piñon Jay. *Living Bird* 11: 5-42.
- BROWN, J. L. 1975. The evolution of behavior. New York, W. W. Norton & Co.
- GOODWIN, D. 1976. Crows of the world. Ithaca, New York, Cornell University Press.
- HOLLANDER, M., & D. A. WOLFE. 1973. Nonparametric statistical methods. New York, John Wiley and Sons.
- LACK, D. 1968. Ecological adaptations for breeding in birds. London, Methuen.
- LAWTON, M. F., & C. F. GUINDON. In press. Flock composition, breeding success, and learning in the Brown Jay (*Cyanocorax morio*). *Condor*.
- LOMAN, J. 1979. Nest tree selection and vulnerability to predation among hooded crows (*Corvus corone cornix*). *Ibis* 121: 204-207.
- MILLER, A., & J. C. THOMPSON. 1970. Elements of meteorology. Ohio, Charles E. Merrill.
- SKUTCH, A. 1935. Helpers at the nest. *Auk* 52: 257-273.
- . 1960. Life histories of Central American birds. II. Pacific Coast Avifauna No. 34.
- STRAHLER, A. N. 1965. Physical geography, 3rd. ed. New York, John Wiley and Sons.
- WELTY, J. C. 1975. The life of birds, 2nd ed. Philadelphia, W. B. Saunders.

Received 17 December 1979, accepted 12 March 1980.

Age Differences in Foraging Black-necked Stilts in Texas

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Seabirds exhibit delayed maturity in that most species do not begin breeding until they are 3 yr or older (Lack 1967). One reason often given for delayed breeding is that young have difficulty mastering foraging techniques and learning foraging areas (Lack 1968). Orians (1969) first noted age differences in the foraging ability of Brown Pelicans (*Pelecanus occidentalis*): young had lower diving success than adults. Similarly, Recher and Recher (1969) found age-related success differences in Little Blue Herons (*Florida caerulea*). The authors in both studies concluded that the inefficiency of juveniles was an adequate explanation for the deferment of reproduction. Since that time, age-related differences in foraging success or abilities have been found in all seabirds examined, including Olivaceous Cormorants (*Phalacrocorax olivaceus*) (Morrison et al. 1978), Royal Terns (*Sterna maxima*) (Buckley and Buckley 1974), Glaucous-winged Gulls (*Larus glaucescens*) (Barash et al. 1975, Searcy 1978), and Herring Gulls (*L. argentatus*) (Verbeek 1977a, b; Ingolfsson and Estrella 1978). Among shorebirds, the foraging behavior