

- bution and biology of seabirds of the Far East. Akademiya Nauk SSSR. Vladivostok, U.S.S.R. (In Russian; English translation by P. T. Gilbert).
- MARSHALL, D. B. 1988. The Marbled Murrelet joins the old-growth forest conflict. *Am. Birds* 42:202-212.
- MARSHALL, D. B. 1988. The Marbled Murrelet joins the old-growth forest conflict. *Am. Birds* 42:202-212.
- McKNIGHT, D. E., AND C. E. KNOBER. 1979. Resource development along coasts and on the ocean floor: potential conflicts with marine bird conservation, p. 183-195. In J. C. Bartonek and D. N. Nettleship [eds.], Conservation of marine birds in northern North America. U.S. Fish and Wildl. Res. Rep. 11. Washington, DC.
- NECHAEV, V. A. 1986. New information on the seabirds of the Sakhalin Island, p. 71-81. In N. M. Litvinenko [ed.], Seabirds of the Far East. Akademiya Nauk SSSR, Vladivostok, USSR. (In Russian, English translation by D. Siegel-Causey.)
- ORNITHOLOGICAL SOCIETY OF JAPAN. 1975. Checklist of Japanese birds. 5th ed. Gadden Co., Tokyo.
- PACIFIC SEABIRD GROUP. 1982. Consideration of Marbled Murrelets in old-growth forest management. A resolution of the Pacific Seabird Group. Pacific Seabird Group Bull. 9:62-63.
- QUINLAN, S. E., AND J. H. HUGHES. In press. Techniques for capture and radio tagging of Marbled Murrelets. *Proc. West. Found. Vert. Zool.*
- SAVILLE, D.B.O. 1972. Evidence of tree-nesting by the Marbled Murrelet in the Queen Charlotte Islands. *Can. Field-Nat.* 86:389-390.
- SEALY, S. G. 1974. Breeding phenology and clutch size in Marbled Murrelets. *Auk* 91:10-23.
- SEALY, S. G. 1975. Aspects of the breeding biology of the Marbled Murrelet in British Columbia. *Bird-Banding* 46:141-154.
- SEALY, S. G., AND H. R. CARTER. 1984. At-sea distribution and nesting habitat of the Marbled Murrelet in British Columbia: problems in consideration of a solitary nesting seabird, p. 737-756. In J. P. Croxall, P.G.H. Evans, and R. W. Schreiber [eds.], Status and conservation of the world's seabirds. International Council for Bird Preservation Tech. Publ. No. 2.
- SIMONS, T. R. 1980. Discovery of a ground-nesting Marbled Murrelet. *Condor* 82:1-9.
- SINGER, S. W., AND D. R. VERADO. 1975. The murrelet's nest discovered. *Pac. Discovery* 28:18-21.
- SOWLS, A. L., A. R. DEGANGE, J. W. NELSON, AND G. S. LESTER. 1980. Catalog of California seabird colonies. U.S. Fish and Wildl. Serv. FWS-OBS 37/80. Washington, DC.

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WIND AS A FACTOR IN THE ORIENTATION OF ENTRANCES OF CACTUS WREN NESTS¹

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The Cactus Wren (*Campylorhynchus brunneicapillus*), an inhabitant of the southwestern deserts of the United States, constructs a closed nest of twigs and fine grass using fur or feathers for lining material. Access to the interior is gained through a long passageway from the side of the nest structure (Woods 1948). Temperatures in the nest interior have been reported to be as much

as 6°C warmer than the ambient temperature when the nest is exposed to direct sunlight (Ricklefs and Hainsworth 1969). Though high temperatures could be advantageous in winter when past-season nests are used by young of the year and adults for roosting (Woods 1948, Anderson and Anderson 1957), in June, second brood nestlings may be exposed to temperatures in excess of 46°C (Ricklefs and Hainsworth 1969). Because such temperatures are several degrees higher than normal nestling body temperatures (Ricklefs and Hainsworth 1968), nestling survival may depend on nest placement and construction.

Bailey (1922) suggested that southwesterly (208-263°) entrance orientations of Cactus Wren nests found near the Santa Rita Mountains, Arizona were influenced by the prevailing direction of the winds and storms that arose in the Gulf of California. Although Ricklefs and

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Hainsworth (1969) also believed that prevailing winds were probably the major factor in breeding nest orientation. Anderson and Anderson (1973) suggested that the apparent orientation observed by Ricklefs and Hainsworth (1969) was an artifact of small sample size. They argued that no directional preference was shown by the wrens in the construction of either roosting or breeding nests.

To test the hypothesis that wind direction influences the direction of orientation of Cactus Wren nest entrances two groups of nests are required: one subjected to wind of constant speed and direction; the other to either no wind or to winds of an erratic and random nature. The two populations of nests, however, should be subject to the same environmental factors other than wind. Given this particular set of circumstances, the following predictions could be made.

First, if prevailing winds are a factor influencing wren nest-entrance orientation, nests in the area of constant wind should be highly oriented in some mean direction relative to the wind whereas those in the other area should be randomly oriented or oriented in relation to some other environmental factor (e.g., sunlight). Conversely, if prevailing winds are not a factor, both groups of nests should be similar in entrance orientation. If other factors play a role, the mean direction of orientation of the two groups may differ due to stochastic independence of the mean angle and the mean vector length in circular uniform or ideal random distributions (Batschelet 1981).

STUDY SITE AND METHODS

The study site was located on and adjacent to Malpais Hill on the western side of the San Pedro River approximately 1.5 km east of Dudleyville, Pinal County, Arizona. Malpais Hill is approximately 0.7 km wide by 2 km long at its base and rises some 410 m above the surrounding area. Lengthwise, the hill was oriented from southeast (145°) to northwest. Three groups of nests were used: eastern slope nests, western slope nests, and a third group located on the desert floor 1 km southwest of the peak.

The vegetation was typical of the lower Sonoran region. Creosote bush (*Larrea tridentata*), white thorn (*Acacia constricta*), palo verde (*Cercidium microphyllum*), cacti (*Opuntia fulgida*, *O. acanthocarpa*, *O. phaeacantha*), and bursage (*Ambrosia deltoidea*) were present on both slopes of the hill, however cacti were more prevalent on the more xeric western slope.

Due to the dynamics of valley and upslope winds (Geiger 1961), the location was well suited for this study. As the sun rose, the air in the valley and on the eastern slope of Malpais Hill became warmer and began to flow upward and over the ridge. A wind sock located at the crest of the hill indicated wind currents on this slope were relatively constant in speed (wind sock generally fully extended) and direction (mean $\approx 247^\circ \pm 10^\circ$) throughout the day until the slope was lost in shadow in the early evening. In contrast, the western or lee slope of the hill was in a wind shadow. Here the winds were gusty, erratic, and changeable in both speed and direction as typical for this type of terrain (Bagnold 1941, Geiger 1961). Wind direction on the desert floor was measured throughout the day using a vane and compass.

Nests were located and the direction of orientation of the entrances were determined 9 and 24 October 1982. Only those nests judged to have been constructed and used during the previous nesting season were used in the analyses.

Prior to vector analysis all magnetic bearings were changed to azimuths reflecting true north. For our data, as well as those presented by previous authors, the length (a measure of the strength of orientation) and direction of the mean vector were calculated by methods outlined in Batschelet (1981). Departure from random was determined by the Rayleigh test (Batschelet 1981). An adaptation of the Mann-Whitney *U*-test (Batschelet 1981, p. 124) was used to test for differences in dispersion between eastern slope and western slope nests.

RESULTS

All nests were found in jumping cholla (*O. fulgida*) which was fairly evenly dispersed on the lower portion of both the eastern and western slopes of the hill and on the desert floor. The numbers of nests found on the eastern slope, western slope, and desert floor were 38, 29, and 50, respectively. The mean angle of entrance orientation ($\bar{\phi}$) of eastern slope nests was in a northerly direction ($\bar{\phi} = 11.9^\circ \pm 10.6^\circ$; Fig. 1). The same was true for western slope nest entrances ($\bar{\phi} = 354.5^\circ \pm 14.0^\circ$; Fig. 1), but, whereas the angular dispersion of western slope nests was random ($P = 0.669$), the orientation of eastern slope nest entrances was significantly different from random ($P = 0.011$). There was also a significant difference between the angular dispersion of entrances of eastern slope and western slope nests ($P < 0.027$).

The winds on the desert floor were somewhat changeable, but generally came from the southeast (115–145° true) in the morning and late afternoon and from the northwest (275–295° true) during the middle of the day. The nests ($n = 50$) located in this area were oriented to the southwest ($\bar{\phi} = 212.8^\circ \pm 10.1^\circ$) and showed a strong trend ($P = 0.073$) toward concentration around the mean angle (Fig. 2).

Circular statistical analyses of data presented by Ricklefs and Hainsworth (1969) and Anderson and Anderson (1973) often indicated nonrandom nest-entrance orientation. Twenty-seven late breeding nests reported by Ricklefs and Hainsworth (1969) were oriented in a southwesterly direction ($\bar{\phi} \approx 243^\circ$) significantly different from random ($P = 0.035$), and 164 breeding and roosting nests located near Kleindale Road in Tucson by Anderson and Anderson (1973) were strongly oriented toward the southeast ($\bar{\phi} \approx 151^\circ$, $P = 0.025$).

DISCUSSION

Entrances of nests constructed on the eastern slope of Malpais Hill were highly oriented relative to wind direction; approximately bisecting the angle formed by the westerly and easterly winds generated by diel temperature cycles on the slope. Nest entrances were likely oriented in a northerly rather than southerly direction to minimize heat input from direct solar radiation. This idea seems to be supported by data from the western slope nests where the mean direction of orientation

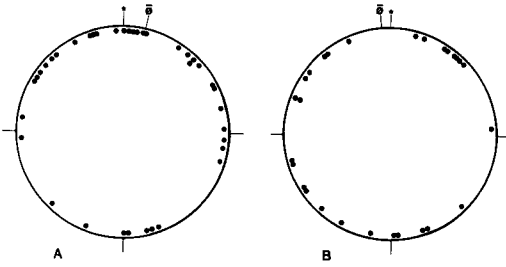


FIGURE 1. Nest-entrance orientation for (A) nests on the eastern slope and (B) nests on the western slope of Malpais Hill. * designates true north; $\bar{\phi}$ the mean angle of orientation.

was also to the north even though nest-entrance orientations were randomly dispersed.

Previous authors (Ricklefs and Hainsworth 1969; Austin 1974, 1976; Inouye 1976; Inouye et al. 1981; Walsberg 1981; Finch 1983) also have reported non-random nest placement or entrance orientation for other species; apparently as a means of thermoregulation. Assuming thermoregulation to be the reason for non-random Cactus Wren nest-entrance orientation when wind is a factor, why wasn't nonrandom orientation reported by Anderson and Anderson (1957, 1959, 1960, 1973)? Perhaps the major reason they contended that wind direction was of no importance in the orientation of the nest entrance (Anderson and Anderson 1973, p. 66-68) was due to an unfamiliarity with circular statistics.

Further substantiation of wind as a major factor in the orientation of the wren nest entrances as reported by Bailey (1922), Ricklefs and Hainsworth (1969), and Anderson and Anderson (1973; our analysis), is provided by the third group of nests we studied. In this case, as in those previous studies cited, nest entrances tended to be oriented at a bearing which bisected the angle formed by the directions of the prevailing winds, allowing wind to flow across or past the entrance rather than away from it or into it as proposed by Ricklefs and Hainsworth (1969). This should create a slight vacuum causing air flow through the sides and rear of the nest and out the entrance. This method of nest-cavity ventilation would provide the most constant environment for the nest occupants allowing increased nesting success (Austin 1974).

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LITERATURE CITED

- ANDERSON, A. H., AND A. ANDERSON. 1957. Life history of the Cactus Wren. Part I: Winter and pre-nesting behavior. *Condor* 59:274-296.
- ANDERSON, A. H., AND A. ANDERSON. 1959. Life history of the Cactus Wren. Part II: The beginning of nesting. *Condor* 61:186-205.
- ANDERSON, A. H., AND A. ANDERSON. 1960. Life history of the Cactus Wren. Part III: The nesting cycle. *Condor* 62:351-369.

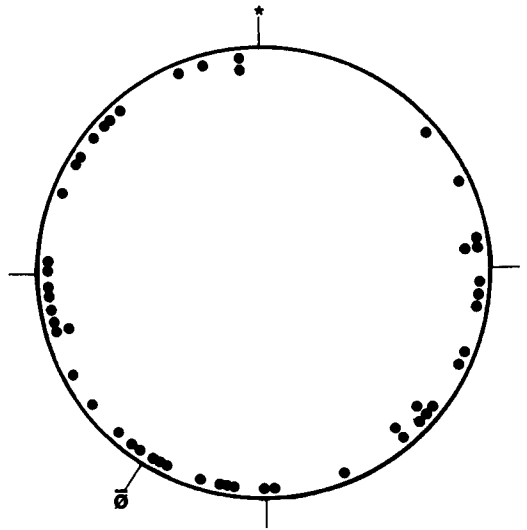


FIGURE 2. Nest-entrance orientation for a group of 50 nests on the desert floor west of Malpais Hill. * designates true north; $\bar{\phi}$ the mean angle of orientation.

- ANDERSON, A. H., AND A. ANDERSON. 1973. The Cactus Wren. Univ. of Arizona Press, Tucson.
- AUSTIN, G. T. 1974. Nesting success of the Cactus Wren in relation to nest orientation. *Condor* 76: 216-217.
- AUSTIN, G. T. 1976. Behavioral adaptations of the Verdin to the desert. *Auk* 93:245-262.
- BAGNOLD, R. A. 1941. The physics of blown sand and desert dunes. Chapman and Hall, London.
- BAILEY, F. M. 1922. Cactus Wrens' nests in southern Arizona. *Condor* 24:163-168.
- BATSCHLET, E. 1981. Circular statistics in biology. Academic Press, London.
- FINCH, D. M. 1983. Seasonal variation in nest placement of Abert's Towhees. *Condor* 85:111-112.
- GEIGER, R. 1961. The climate near the ground. Harvard Univ. Press, Cambridge, MA.
- INOUYE, D. W. 1976. Nonrandom orientation of entrance holes to woodpecker nests in aspen trees. *Condor* 78:101-102.
- INOUYE, R. S., N. J. HUNTLY, AND D. W. INOUYE. 1981. Non-random orientation of Gila Woodpecker nest entrances in saguaro cacti. *Condor* 83: 88-89.
- RICKLEFS, R. E., AND F. R. HAINSWORTH. 1968. Temperature regulation in nestling Cactus Wrens: Development of homeothermy. *Condor* 70:121-127.
- RICKLEFS, R. E., AND F. R. HAINSWORTH. 1969. Temperature regulation in nestling Cactus Wrens: The nest environment. *Condor* 71:32-37.
- WALSBERG, G. E. 1981. Nest-site selection and the radiation environment of the Warbling Vireo. *Condor* 83:86-88.
- WOODS, R. S. 1948. Northern Cactus Wren, p. 219-231. In A. C. Bent [ed.], Life histories of North American nuthatches, wrens, thrashers, and their allies. U.S. Natl. Mus. Bull. 195.