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ORIENTATION AND VERTICAL DISTRIBUTION OF RED-NAPED SAPSUCKER (*SPHYRAPICUS NUCHALIS*) NEST CAVITIES

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ABSTRACT.—It has been hypothesized (1) that the compass direction in which woodpeckers excavate breeding cavities depends on nest thermoregulatory needs, and (2) that when multiple cavities are placed in the same tree across years, each new cavity is placed above previous cavities. We tested these hypotheses for Red-naped Sapsuckers (*Sphyrapicus nuchalis*) in central Nevada and found some evidence that cavities are oriented for thermoregulatory advantage, but we rejected the hypothesis that active cavities are always the highest.

Key words: woodpecker, habitat use, microhabitat use, behavior.

Primary cavity nesters, such as woodpeckers, select where on a tree to excavate a cavity. Decisions might be driven by predator avoidance (Nilsson et al. 1991), by efforts to manipulate nest microclimate (Inouye et al. 1981, Korol and Hutto 1984), in response to physical characteristics of the nest tree, such as the presence of heart rot fungus or bole slope (Conner 1975, Conner et al. 1976), or to avoid prevailing weather conditions (Conner 1975). One choice, vertical placement (i.e., how high from ground, above or below existing cavities), has been shown to be nonrandom in some woodpeckers (e.g., McAuliffe and Hendricks 1988). Avian studies also report nonrandom nest orientation for a variety of species, apparently intended for thermoregulatory advantage (Austin 1974, Högstedt 1978, Martin and Roper 1988) or to avoid prevailing winds or rains, which also could be thermoregulatory (Ferguson and Siegfried 1989, Haggerty 1995). Patterns of cavity orientation have been examined in woodpeckers, with some species showing distinct patterns while others do not. For example, Locke and Conner (1983) found a westward cavity orientation in Red-cockaded Woodpeckers (*Picoides borealis*), while there are conflicting reports for Gila Woodpeckers (*Melanerpes uropygialis;* no pattern: Kerpez and Smith 1990; pattern: Inouye et al. 1981, Korol and Hutto 1984), and Gutzwiller and Anderson (1987) found no patterns for Red-headed or Downy Woodpeckers (*M. erythrocephalus* and *P. pubescens,* respectively).

Here we present results from a study of cavity placement by Red-naped Sapsuckers (*Sphyrapicus nuchalis*) nesting in central Nevada. This species, a riparian specialist in this habitat, is thought to be a keystone species (Daily et al. 1993). Red-naped Sapsuckers in Colorado are reported to excavate progressively higher nest cavities in the same tree year after year (Daily 1993). Published studies examining the orientation of sapsucker nest cavities report nonrandom patterns, with a southern bias (Inouye 1976) or a bimodal distribution (Red-naped Sapsucker, east and southwest [Dobkin et al. 1995]; Yellow-bellied Sapsuckers [*S. varius*], southeast and west [Lawrence 1967]). It is not known whether these orientations are for thermoregulatory advantage. We tested the hypotheses that Red-naped Sapsucker cavity orientation is nonrandom and consistent with thermoregulatory needs in this desert-riparian community, and that when multiple cavities are placed in the same tree, the active cavity is above other cavities.

METHODS

We located Red-naped Sapsucker nests in multiple stream basins of the Toiyabe Range of central Nevada (Lander and Nye counties), USA (39°N, 117°W). Study sites were located

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in narrow strips of riparian habitat composed primarily of aspen or cottonwood (*Populus* spp.) intermingled with willow (*Salix* spp.) and western birch (*Betula occidentalis*), and surrounded by either pinyon-juniper (*Pinus monophylla–Juniperus* spp.) woodlands or sagebrush (*Artemisia* spp.). Further descriptions of the area can be found in Linsdale (1938).

During May–July 1994 and 1995, we systematically searched riparian habitat with mature aspens for signs of sapsucker activity. Early in the season we located nests by looking for fresh woodpecker excavations and by following adult birds. Later in the season, nests were located by listening for food-begging calls of chicks in the cavity and by following adults that were carrying food. Inactive cavities were recorded only when we thought they were made by sapsuckers, a designation made based on size and shape of the cavity entrance (Fleury 2000). At the termination of breeding activities, we measured tree height, number and height of cavities, relative position of active cavities in trees with multiple cavities, nest entrance orientation, whether or not the cavity was used during the current breeding season, and whether or not the nest tree was alive. Tree heights were measured using a clinometer. Heights of cavities below 7 m were measured with a tape measure; cavity heights above 7 m were measured using a clinometer. Nest entrance orientation was measured with a compass and placed into 1 of 16 classes (N, NNE, NE, ENE, E, etc.).

Using Arc/Info Grid Module, we ran the Arc Macro Language program Solarflux (Hetrick et al. 1993) using a 30-m horizontal resolution digital elevation model provided by Rick Connell at the Toiyabe National Forest. The following independent variables were estimated: (1) daily insolation on summer solstice (21 June), which indicated the amount of solar radiation incident at the cavity tree's location for clear skies, and (2) number of hours of direct sunlight expected on summer solstice, which was used to estimate the amount of solar radiation received at the nest cavity. Values for cavity tree locations were obtained by overlaying locations onto the derived insolation grids. Because these methods are indirect, they do not account for the potential of local shading by adjacent trees.

We used a *t* test to compare heights of active nest cavities in trees containing multiple cavities to heights of nest cavities in trees containing a single cavity. Orientation data were analyzed using a Rayleigh test (Zar 1996), including calculating mean angle and angular deviation. Correlations of orientation data with insolation data and hours of sunlight were done by ignoring the east–west aspect of the orientation (i.e., values range from 0° to 180°, and so cavities facing NE and NW received the same value) and finding the Pearson correlation coefficient between north–south orientation gradient and insolation variables.

RESULTS

We found nests in 9 different stream basins, 7 of which drained to the west of the range, 2 to the east. We made measurements on 38 active nests and 51 inactive nest cavities in trees containing active nests. The number of cavities per nest tree ranged from 1 to 6, with a mean of 2.3 (±1.4 *s*). Nest trees ranged in height from 1.5 m (broken top) to 20.0 m (mean = 11.7 ± 4.4 m). Most nest trees (60%; 23/38) contained more than one cavity, although only a single active nest. The active cavity was in the highest position in 43% (10/23) of the trees containing more than one cavity, and in the lowest position in 43% (10/23; Table 1). Mean height of active cavities in trees containing more than one cavity (4.4 ± 2.2 m, N = 23) was not significantly different from the height of active cavities in trees containing only one cavity (3.5 ± 3.5 m, N = 15; t = 0.86, df = 21.0, corrected for unequal variance, P = 0.40).

We found nest cavity entrances facing all compass directions. When combined, active and inactive nests (N = 89) tended to be oriented in southern or eastern directions, although there was high variability; mean angle

Table 1. Relative position of the active nest cavity in trees with multiple cavities.

Relative position	Number of cavities in trees 2	3	4	5	6
Top	2	6	1	1	—
2nd	5	1	—	—	—
3rd		2	2	—	—
4th			1	—	—
5th				—	—
6th					2

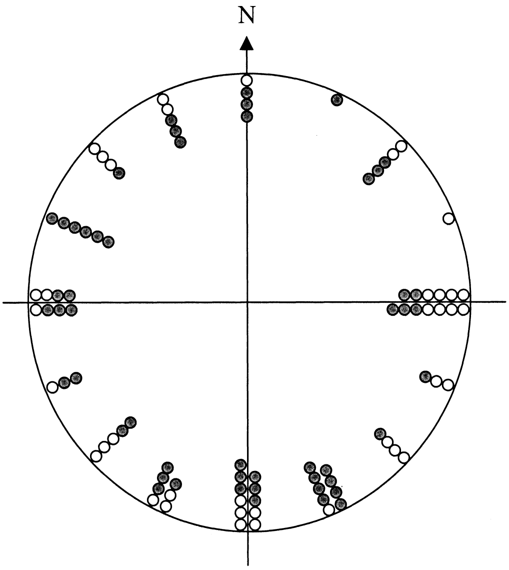

Fig. 1. Circular distribution of nest entrance holes; open dots are active cavities and closed dots are inactive cavities.

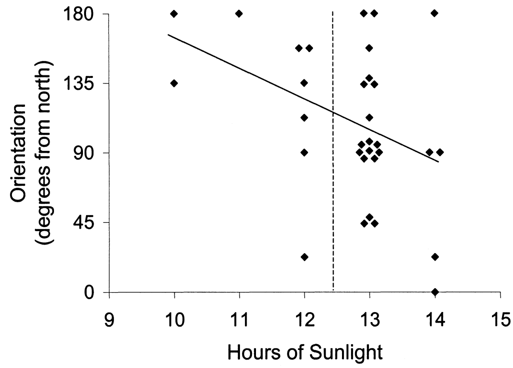

Fig. 2. Relationship between nest orientation and hours of sunlight. East–west directions were ignored, and so due east and west are 90°. Regression line is significant, $r = -0.4$, $P = 0.02$. Vertical line represents a proposed threshold where cavities receiving less than the marked amount of solar radiation (left) are oriented toward the sun, while those receiving more (right) are not; see text for discussion.

= 180°, angular deviation = 73° ($Z = 2.82$, $P < 0.05$; Fig. 1). It is possible that other woodpecker species excavated some of the inactive nest cavities (e.g., Hairy Woodpeckers [*Picoides villosus*] and Downy Woodpeckers are present in low densities in the study area). Thus, we repeated the analysis using only active nest cavities ($N = 38$). Again, there was a predominantly southern orientation with high variability (mean angle = 148°, angular deviation = 71°), but the pattern was not statistically significant ($Z = 1.97$, $P > 0.1$; Fig. 1).

GIS data were available only for the 32 nests located during the 1995 breeding season. A significant negative correlation was found between the north–south orientation gradient and the number of hours of direct sunlight received at the nest site on the summer solstice (Pearson product-moment correlation, $r = -0.41$, $P = 0.02$; Fig. 2). This result was strongly influenced by 3 nests at 10 and 11 hours; if they are removed, the result loses significance ($P > 0.1$). We did not find a significant relationship between the orientation gradient and insolation. Our data suggest a threshold in hours of sunlight and orientation (represented by a vertical line in Fig. 2). Although not statistically significant, we found that nest cavities receiving fewer than 12 hours of sunlight per day were oriented southward, while nest cavities receiving 12 or more hours of sunlight per day were oriented in any direction ($t = 1.6$, $P = 0.11$).

DISCUSSION

Active Red-naped Sapsucker nests in our study were located in the highest position in only 43% of the trees with multiple cavities, with the same proportion being the bottommost cavity. Also, we found no significant difference in the heights of active nest cavities in trees containing one cavity versus multiple cavities. These patterns differ from those reported by Daily (1993) for this species in Colorado. In trees containing multiple cavities, Daily (1993) found the active cavity in the highest position 86% of the time and never in the lowest position. Daily (1993) also found that active nest cavities in trees containing no other cavities were significantly lower than active nest cavities in trees containing multiple cavities. From these data, Daily hypothesized that Red-naped Sapsuckers excavate progressively higher nest cavities in subsequent nesting in an attempt to minimize predation risk from non-arboreal predators. Our data do not support this hypothesis. Either the pattern Daily found was a sampling artifact or sapsuckers there were responding to selective pressures not present in our study area.

When we include both active and inactive cavities in our analyses, we find a significant southerly orientation for all woodpecker cavities recorded in our study, which is consistent with other studies (Inouye 1976, Dobkin et al. 1995). However, the pattern was not strong, and possibly some of the inactive woodpecker cavities were misclassified as being excavated by Red-naped Sapsuckers. When only active cavities are included in the analysis, the mean orientation is still southerly, but statistically the cavities are oriented randomly. We found a significant correlation between the north–south aspect of orientation and the number of hours of direct sunlight received at the nest site. This is consistent with the hypothesis that nest orientation is influenced by thermoregulatory needs. A tree's trunk is significantly warmer on the side facing the sun (Derby and Gates 1966). Derby and Gates (1966) found that aspen at 3000 m elevation in Colorado showed as much as 12°C difference in trunk temperature between the tree side facing the sun during daylight hours and the side facing away. From the plot of our data, we hypothesize that there is a threshold amount of sunlight that falls on a potential cavity site, below which the cavity tends to be oriented to capture sunlight (southerly) and above which orientation is random. We propose this threshold to be at approximately 12 hours of sunlight on summer solstice. If this pattern is supported by other research, it suggests that cavities in central Nevada placed on trees that receive relatively low amounts of direct sunlight are oriented to maximize exposure to sunlight for heat to maintain the desired microclimatic characteristics of the nest cavity.

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