The Condor 92:193–198

NEST-SITE SELECTION AND NEST-CAVITY CHARACTERISTICS OF GILA WOODPECKERS AND NORTHERN FLICKERS[1]

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Abstract. We measured and compared the dimensions, height, and orientation of Gila Woodpecker (*Melanerpes uropygialis*) and Northern Flicker (*Colaptes auratus*) nest cavities, and compared saguaros used for nest sites to the saguaros available for both species. Gila Woodpecker nest cavities had smaller entrances, were shallower in the vertical plane of the saguaro, and were deeper in the horizontal plane of the saguaro than Northern Flicker nest cavities. These data can be used to determine whether secondary cavity-nesting species are using Gila Woodpecker cavities, Northern Flicker cavities, or both. The mean height of nest cavities did not differ between species, and the orientation of nest cavities was random for both species. Although saguaro selection differed between the species, both selected the largest saguaros for nest sites. No nests of either species were found in saguaros <5 m tall. The continued existence of the saguaro cavity-nesting community is dependent upon the survival of large saguaros and adequate saguaro reproduction, despite human development of their desert habitat.

Key words: Arizona; saguaro; Carnegiea gigantea; *cavity; Northern Flicker;* Colaptes auratus; *Gila Woodpecker;* Melanerpes uropygialis; *nest.*

INTRODUCTION

Gila Woodpeckers (*Melanerpes uropygialis*) and Northern Flickers (*Colaptes auratus*) excavate cavities in saguaro cacti (*Carnegiea gigantea*) for nesting and roosting. These species are the only common excavators of cavities in saguaros (Bent 1939, Scott and Patton 1975, pers. observ.). Elf Owls (*Micrathene whitneyi*), Brown-crested Flycatchers (*Myiarchus tyrannulus*), Ash-throated Flycatchers (*M. cinerascens*), Purple Martins (*Progne subis*), Western Screech-Owls (*Otus kennicottii*), and American Kestrels (*Falco sparverius*) are native birds that regularly nest in cavities originally excavated by Northern Flickers and Gila Woodpeckers (Bent 1937, 1942; Allen and Nice 1952; Scott and Patton 1975).

The existence of this unique avian community is threatened by the continued human development of the Sonoran Desert and by competition from European Starlings (*Sturnus vulgaris*) for nest cavities (Kerpez 1986). Unfortunately, very little is known about the nesting ecology of native cavity nesters. To understand nest-site selection among the secondary cavity nesters, we must first understand nest-site selection among woodpecker species ultimately responsible for cavity excavation. If Gila Woodpecker and Northern Flicker nest cavities differ in location or orientation, this may be important to understanding the nest-site selection of secondary cavity nesters.

Our objectives were to determine and compare the dimensions, height, and orientation of Gila Woodpecker and Northern Flicker nest cavities, and to examine and compare the selection of saguaros for nest sites by both species.

METHODS

During 1983 and 1984 we randomly located 15 square, 10-ha plots near the Picacho Mountains, Pinal County, Arizona, and the Tucson Mountains, Pima County, Arizona. We searched each plot intensively for several days between 8 April and 4 June in 1983 or 1984 (about half the plots were searched each year) to locate all Gila Woodpecker and Northern Flicker nests. Woodpeckers flying to and from cavities, and nestlings calling from the nest were used to locate active nests. When we were uncertain if a cavity was a nest, we climbed the saguaro with a ladder and looked into the cavity with a mirror and light. Only cavities with eggs or nestlings were considered nests.

For each nest found, we measured the height

[1] Received 29 June 1989. Final acceptance 1 November 1989.

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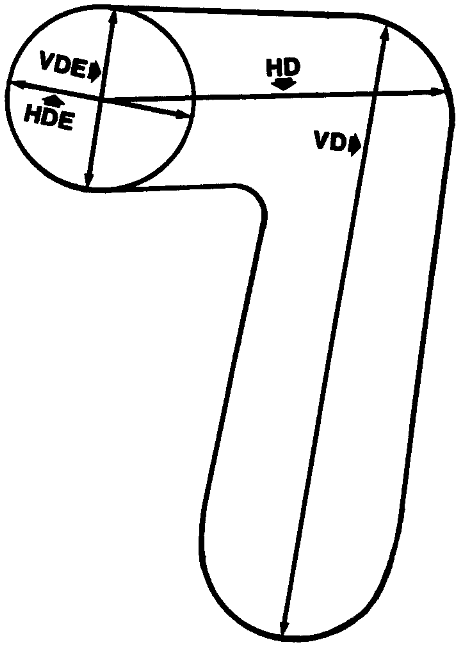

FIGURE 1. Measurements of cavity dimensions: vertical diameter of entrance (VDE), horizontal diameter of entrance (HDE), horizontal depth (HD), and vertical depth (VD).

and orientation of the cavity entrance, the height of the saguaro in which the nest was located (the nest saguaro), and the number of branches on the nest saguaro. Nest-cavity orientation was measured with a compass to the nearest degree. For nests which we were able to reach with a 7.6-m ladder, we measured the vertical and horizontal diameters of the cavity entrance, the horizontal depth of the cavity, and the vertical depth of the cavity (Fig. 1).

To sample the saguaros available for nest sites, 10 points were randomly located in every plot. All saguaros within 30 m of each point were recorded. For each saguaro we estimated its height and counted the number of branches. We practiced estimating heights of saguaros until we were accurate to within 30 cm and we continually checked our estimates throughout the study to maintain this accuracy.

We tested whether the dimensions of Gila Woodpecker and Northern Flicker nest cavities differed with multivariate analysis of variance (MANOVA). We determined which nest-cavity dimensions differed with *t*-tests. Differences in the nest-cavity heights between species were tested with the *t*-test. Nest-cavity height was not

TABLE 1. Heights and number of branches of saguaro classes.

Saguaro class	Description
1	height < 2.5 m
2	2.5 m ≤ height < 4.5 m
3	4.5 m ≤ height < 7.0 m and number of branches < 6
4	height ≥ 7.0 m or number of branches ≥ 6

included in the MANOVA, because the nests for which cavity dimensions were measured were lower than the nests for which cavity dimensions could not be measured. Kolmogorov-Smirnov goodness-of-fit tests (Zar 1984) indicated normal distributions for each variable. All variables were tested for equality of variances between groups with the variance ratio test (Zar 1984). Only the vertical diameter of cavity entrances had significantly unequal variances and the logarithmic transformation (ln[X]) equalized the variances between species.

We tested whether the orientation of nest cavities was nonrandom for each species with the Rayleigh test (Batschelet 1981). Mean vector length (r) is a measure of the concentration of nest orientations around the mean nest orientation and was calculated for each species. It can vary from 0 to 1, with 0 indicating the nest orientations were so dispersed that there was no mean orientation, and 1 indicating that all nests were oriented in the same direction (Batschelet 1981).

For the analysis of saguaro selection, we categorized saguaros into four classes based on their height and number of branches (Table 1). The availability of each saguaro class was calculated from the random sample of saguaros on the plots. Overall differences between the use and availability of saguaro classes were tested for each species with the *G*-test (Zar 1984). Differences between the use and availability of each saguaro class and differences between species in their use of saguaro classes were tested with the binomial test for two proportions (Zar 1984). To maintain an overall alpha of 0.05, the alpha for significance of individual tests was calculated as described by Neu et al. (1974).

RESULTS

We found 64 Gila Woodpecker and 28 Northern Flicker nests and were able to measure the cavity

TABLE 2. Means, standard errors of the means (SE), and ranges of the dimensions and height of Gila Woodpecker and Northern Flicker nest cavities. Differences between species' means were tested with the *t*-test.

Nest-cavity variable	Gila Woodpecker			Northern Flicker			P
	$\bar{x}$	SE	Range	$\bar{x}$	SE	Range	
Entrance vertical diameter (cm)[a]	5.66	0.184	4.0–8.0	6.98	0.455	5.5–12.5	0.002
Entrance horizontal diameter (cm)[a]	6.28	0.207	4.4–9.0	8.30	0.424	5.9–11.0	<0.001
Cavity vertical depth (cm)[a]	27.83	0.985	18.4–42.3	37.57	1.446	28.2–44.0	<0.001
Cavity horizontal depth (cm)[a]	15.69	0.627	8.5–24.0	12.50	0.965	6.5–19.0	0.007
Height of nest (m)[b]	5.80	0.142	3.65–8.86	6.18	0.230	4.11–8.68	0.153

[a] n = 32 for Gila Woodpeckers and n = 15 for Northern Flickers.
[b] n = 64 for Gila Woodpeckers and n = 28 for Northern Flickers.

dimensions of 32 Gila Woodpecker and 15 Northern Flicker nests. The dimensions of Gila Woodpecker and Northern Flicker nest cavities significantly differed (P = 0.0001). Gila Woodpecker nest cavities had significantly smaller entrances (cavity entrance vertical and horizontal diameters), were significantly shallower in the vertical plane of the saguaro (cavity vertical depth), and were significantly deeper in the horizontal plane of the saguaro (cavity horizontal depth) than Northern Flicker nest cavities (Table 2).

The orientation of nest cavities was not significantly different from a random orientation for Gila Woodpeckers (Fig. 2; r = 0.02, P > 0.90, n = 64) and Northern Flickers (Fig. 3; r = 0.16, P > 0.47, n = 28).

The mean heights of Gila Woodpecker and Northern Flicker nest cavities were statistically indistinguishable (Table 2). The ranges of nest heights were almost identical for both species (Table 2).

Gila Woodpeckers and Northern Flickers clearly selected class 4 saguaros, the largest saguaros, for nest sites (Table 3; P < 0.001). Gila Woodpeckers nested in class 3 saguaros significantly less often than expected (Table 3; P = 0.001). No nests of either species were found in class 1 or class 2 saguaros. Gila Woodpeckers nested in class 3 saguaros significantly less often and in class 4 saguaros significantly more often than Northern Flickers (Table 3; $P \le 0.013$).

DISCUSSION

DIFFERENCES IN NEST-CAVITY DIMENSIONS

Northern Flicker nest cavities have larger entrances and are deeper in the vertical plane of the saguaro than Gila Woodpecker nest cavities because Northern Flickers are larger than Gila Woodpeckers. Northern Flickers in Arizona have an average length of about 268 mm (Ridgeway 1914) and an average weight of 111 g (Dunning 1984), and Gila Woodpeckers have an average length of about 220 mm (Ridgeway 1914) and an average weight of 65 g (Dunning 1984).

Gilman (1915, p. 157) reported that for 18 Gila Woodpecker nest cavities the mean entrance diameter was 4.95 cm and the mean depth was "a little more than" 30.5 cm. He also reported that for 36 Northern Flicker nest cavities the mean entrance diameter was 8.33 cm and the mean depth was 32.39 cm. However, Gilman (1915) did not statistically test for differences between the means or provide any measure of variance for the means. Also, he did not describe how he measured entrance diameter and cavity depth. Cavities in saguaros are irregularly shaped with the vertical diameter of the entrance usually differing from the horizontal diameter of the entrance, and depth can be measured vertically or horizontally (Fig. 1). Therefore, it is difficult to compare our data to Gilman's (1915) data. However, his data does support our conclusion that Northern Flicker nest cavities have larger entrances than Gila Woodpecker nest cavities.

McAuliffe and Hendricks (1988) reported that cavities excavated by Northern Flickers were deeper in the vertical and horizontal planes of the saguaro than cavities excavated by Gila Woodpeckers. However, they determined which species excavated the cavities from the size of the entrance. The variation in the size of the entrances of cavities used by each species is large (Table 2). The mean entrance vertical and horizontal diameters (6.8 cm and 8.6 cm, respectively) of the cavities that McAuliffe and Hendricks (1988) classified as excavated by Northern Flickers are within the range of cavities used by Gila Woodpeckers (Table 2). The wide range of cavity entrance diameters suggests that each species may use cavities originally excavated by

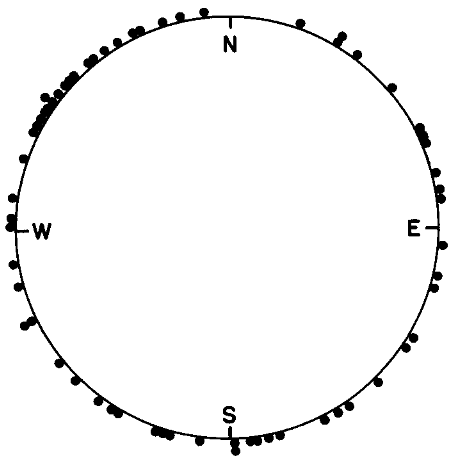

FIGURE 2. The compass orientations of the entrances of Gila Woodpecker nest cavities.

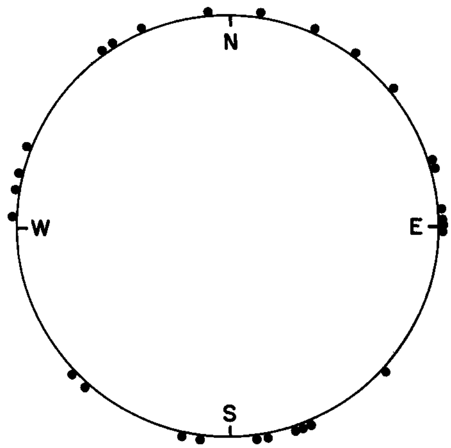

FIGURE 3. The compass orientations of the entrances of Northern Flicker nest cavities.

the other species. Gila Woodpeckers could easily use the larger cavities originally excavated by Northern Flickers, and Northern Flickers could enlarge cavities originally excavated by Gila Woodpeckers. Northern Flickers have been observed usurping nest cavities from Gila Woodpeckers (Brenowitz 1978, Martindale 1982). The use of cavities originally excavated by the other species may explain why some of our results differ from the results of McAuliffe and Hendricks (1988).

RANDOM ORIENTATION OF NEST CAVITIES

Two other studies, Inouye et al. (1981) and Korol and Hutto (1984), investigated the orientation of Gila Woodpecker nest cavities in saguaro cacti and reported that the cavities were not randomly oriented. However, both studies assumed that any hole in a saguaro that they saw from the ground was a Gila Woodpecker nest cavity. When examined closely with a ladder, many holes which appear to be possible nest cavities from the ground penetrate the saguaro only a small distance (pers. observ.). In addition, Northern Flickers also excavate cavities in saguaros, and all cavities excavated in saguaros are not necessarily used as nest cavities.

Inouye et al. (1981) assigned holes to one of four 90°-quadrats centered on north, south, east, and west, and using the chi-square test found a significant difference among quadrats in the number of holes. They also reported the test statistic (r) used in the Rayleigh test, however, they did not report the results of the test. We tested for nonrandom orientation with the Rayleigh test using the r they reported and found that the orientations of the holes were not significantly different from random ($P > 0.05$, $r = 0.24$, $n = 49$). Korol and Hutto (1984) using the Rayleigh test found that the orientations of holes in saguaros were significantly different from random. However, they noted that the orientations of the holes were dispersed ($r = 0.21$) and concluded that the nonrandom orientation was largely a statistical phenomenon.

The very low values of r in our study of verified nest cavities (≤ 0.16) and in previous studies of holes in saguaros (≤ 0.24) indicate that the orientations of both were very dispersed (Figs. 2, 3). Inouye et al. (1981) hypothesized that Gila Woodpecker nest cavities may be nonrandomly oriented in response to thermal constraints. The data does not support this hypothesis.

SELECTION OF NEST SITES

Gila Woodpeckers and Northern Flickers have about the same mean, minimum, and maximum nest heights (Table 2) suggesting that the same factors influence the nest height of both species. The minimum nest height is probably constrained by greater nest predation and ambient temperatures closer to the ground. The maximum nest height may be constrained by factors other than saguaro height. Although saguaros on the study area were as tall as 11.7 m, nests were

TABLE 3. Percent of saguaros in each saguaro class available (n = 1,235) and used for nest sites by Gila Woodpeckers (n = 64) and Northern Flickers (n = 28).

Saguaro class	All saguaros available	Saguaros with Gila Woodpecker nests	Saguaros with Northern Flicker nests
1	30.6	0.0	0.0
2	16.9	0.0	0.0
3	31.7	12.5	35.7
4	20.8	87.5	64.3

never found above 8.9 m. The maximum nest height may be set by energetic constraints of travel to the nest.

McAuliffe and Hendricks (1988) reported that the mean height of cavities excavated by Northern Flickers was greater than the mean height of cavities excavated by Gila Woodpeckers. However, they did not present the means or statistically test for differences between the means. Also, as previously discussed each species may be using cavities originally excavated by the other species.

Gila Woodpeckers and Northern Flickers select class 4 saguaros for nesting (Table 3) because they prefer to nest in cavities >5 m high. Seventy-six percent of the nests were in cavities >5 m high. Only class 4 saguaros and the taller class 3 saguaros are 5 m tall (Table 1), and the diameter of most class 3 saguaros at 5 m is probably not large enough for a suitable cavity. Shorter saguaros have smaller diameters (McAuliffe and Janzen 1986), and the top portion of a saguaro is usually smaller in diameter than are lower portions (pers. observ.). Gila Woodpeckers and Northern Flickers never nested in class 1 or class 2 saguaros (Table 3) because they did not nest in cavities <3.6 m high. Only the tallest class 2 saguaros are 3.6 m high (Table 1), and the diameter of class 2 saguaros at 3.6 m is probably not large enough for a suitable cavity.

IMPLICATIONS

Another step to understanding the community of birds which nest in cavities in saguaros is to study the selection of nest cavities by the secondary cavity nesters. The data from this study can be used to determine whether each species of secondary cavity nesters is using Gila Woodpecker cavities, Northern Flicker cavities, or both. Gila Woodpecker cavities may be too small for larger species like American Kestrels, and Northern Flicker cavities may be too large for smaller species such as Elf Owls. This information could be important for ensuring this community's continued existence.

Gila Woodpeckers and Northern Flickers selected the largest saguaros for nesting. No nests of either species were found in saguaros <5 m tall. Therefore, the continued existence of this cavity-nesting community is probably dependent on the continued existence of large saguaros. Special attention must be given to maintaining large saguaros when their habitat is altered by human development. We must also ensure that adequate saguaro reproduction and survival will provide large saguaros for the future.

ACKNOWLEDGMENTS

We thank R. William Mannan for his advice during the study and for critically reviewing the manuscript and William J. Matter for critically reviewing the manuscript. Bruce D. Leopold assisted with the statistical analysis. We are especially thankful to Barbara Sunshine for her support and help throughout this study and for typing the manuscript. This study was funded by the Arizona Cooperative Wildlife Research Unit, the University of Arizona, and the Arizona Game and Fish Department.

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