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## NEST-SITE SELECTION BY WESTERN SCREECH-OWLS IN THE SONORAN DESERT, ARIZONA

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*Key words:* Gila Woodpecker, Gilded Flicker, nest-site selection, *Otus kennicottii*, saguaro cacti, Sonoran Desert, Western Screech-Owl.

The Western Screech-Owl (*Otus kennicottii*) is a small, nocturnal, secondary cavity-nesting bird that is a year-round resident throughout much of western North America and Mexico (Marshall 1957, Phillips et al. 1964, AOU 1983, Johnsgard 1988, Cannings and Angell 2001). Several aspects of Western Screech-Owl biology, including taxonomy (Miller and Miller 1951, Marshall 1957), distribution (Marshall 1957, Johnsgard 1988), food habits (Brown et al. 1986), and breeding density (Johnson et al. 1981), have been studied (see Cannings and Angell [2001] for a review), but no quantitative information on nest-site selection by the species has been published.

During 1995 and 1996 we studied nest-site selection by Western Screech-Owls (hereafter, screech-owls) in the Sonoran Desert of Arizona using a multi-scaled approach. At the scale of the nesting area, we assessed whether features of cavities, trees, and surrounding vegetation were related to nest-site selection. At the scale of the nest tree, we examined whether owls selectively choose cavities from those available.

Our study took place on the Barry M. Goldwater Air Force Range (BMGR) in southwestern Arizona. The BMGR occupies approximately 10,900 km<sup>2</sup> of unpopulated land, one of the largest and best-preserved regions of native desert remaining in the U.S. Two major vegetation types are found on BMGR: the Arizona Upland and the Lower Colorado River valley subdivisions of the Sonoran Desert. The Arizona Upland includes the paloverde (*Cercidium* spp.)–mixed-cacti scrub series and paloverde-catclaw (*Acacia greggii*) xeroriparian associations. The Lower Colorado River

valley includes the creosote (*Larrea tridentata*)–white bursage (*Ambrosia dumosa*) series, and in runnels and washes, the mixed-scrub series (Turner and Brown 1994). Temperatures for the Arizona Upland and Lower Colorado River valley regions average 29°C–30°C in the summer and 11°C–12°C in the winter; mean annual precipitation is 20–30 cm (Sellers et al. 1985). Our study site was in northeastern BMGR in the Saucedo and Sand Tank mountain ranges at 366–853 m elevation.

We searched for nests in association with conducting point-count surveys (see Hardy [1997] and Hardy et al. [1999] for details) for screech-owls and Elf Owls (*Micrathene whitneyi*) in 1995 and 1996. We conducted surveys along 6 point transects consisting of 10 stations each (60 stations total) spaced at 0.8-km intervals. We used compass triangulation data from surveys to identify areas of concentrated singing activity where we later conducted nest searches. We did nest searches during the nestling period (mid-April through late May). Nestling screech-owls were quite vocal and could be heard up to 50 m away.

We centered a 25-m-radius plot (0.2 ha) on each nest. Because we did not measure territory or home range size, we refer to selection at the scale of the nesting area rather than at the scale of the territory or home range.

We surveyed vegetation around each nest along eight 25-m point-intercept transects (Bonham 1989). We spaced intercept points at 5-m intervals at which we collected information on each plant species in 4 vertical height classes: 0 m (ground level), >0 m to 1.0 m (understory), >1.0 m to 2.5 m (mid-canopy),

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and >2.5 m (overstory). We identified live and dead shrubs, trees, and most cacti to species. For each we determined the number of intercepts in each height class with the aid of a graduated extendable pole. We divided this number by total intercept points (40 per nest) to estimate percent cover by height class and percent cover of perennial vegetation.

Within each 25-m-radius plot, we recorded the number of trees and cacti >2.5 m tall with average stem diameter >15 cm (Goad and Mannan 1987) and the number of cavities within these structures. Following Goad and Mannan (1987), we placed saguaro cacti (*Carnegiea gigantea*) into the following structure categories: (1) <3 m tall with no branches, (2)  $\geq$ 3 m tall with no branches or branches <6 cm in length, (3) >4 m tall with branches 6 cm to 1 m in length; (4) >5 m tall with 1–2 branches >1 m in length, (5) >5 m tall with 3 or more branches >1 m in length, or (6) >2 m tall with a broken top. The number of saguaros per plot did not include a nest saguaro.

Features of the nest tree we measured were (1) height, (2) diameter at breast height (dbh), (3) number of cavities per woodpecker species (excluding nest cavity), and (4) structure category (if a saguaro, described above). We measured height as indicated above and dbh with a diameter tape.

We measured the following features of the nest cavity: height, compass orientation of opening, location (branch or stem), and diameter (whether excavated by Gila Woodpecker [*Melanerpes uropygialis*] or Gilded Flicker [*Colaptes chrysoides*]). We used cardboard disks attached to an extendable pole to estimate the excavating woodpecker species following Kerpez and Smith (1990). We did not measure inner dimensions of cavities due to the dangers of climbing saguaros, and hole size is correlated with inside area (McAuliffe and Hendricks 1988, Kerpez and Smith 1990).

For each nest tree, we located the nearest potentially suitable, but unused, tree (McCallum and Gehlbach 1988) meeting the following requirements: positioned >50 m from the nest tree (to avoid plot overlap), possessing at least 1 potentially suitable cavity  $\geq$ 3.2 m high (the lowest height we recorded for a screech-owl nest), and unoccupied by a woodpecker. When necessary, we examined cavities using a mirror attached to an extendable pole to determine occupation. When we located a potential

nest tree, we measured the same features as described above for the surrounding vegetation, nest tree, and nest cavity. If a tree had multiple potential cavities, we randomly selected 1 for comparison. To facilitate inferences about the selection of nest cavities from nest trees, we measured the height, orientation, location, and diameter (as described above) of all potential nest cavities in the nest tree itself.

We used univariate, paired tests to determine which variables differed between used and potential nest sites. For continuous variables we used paired *t* tests. For categorical variables we conducted *G*-tests for homogeneity (Zar 1996:489). We used Raleigh's test (Zar 1996:615) to determine if nest cavity and potential cavity orientations were nonrandom. We set alpha at 0.1. We recognize, however, that our multiple statistical tests are not independent. We chose not to apply experiment-wise adjustment of error (e.g., Bonferroni procedures; Winer et al. 1991:158–166) because we are in the exploratory phase of this research, where an increase in the level of significance is not of major importance. In this phase it is more important to examine and interpret variations in data than to worry about specific alpha levels. Additionally, over-reliance on statistical hypothesis testing can often obscure potentially meaningful biological relationships (e.g., Johnson 1999).

To examine nest-cavity selection within nest trees, we compared features of nest cavities with those of potential cavities within nest trees. We calculated the mean height and orientation (compass direction) for all potential cavities in each nest tree and then paired these means with nest cavity heights and orientations used by the birds using paired *t* tests, *G*-tests, and Raleigh's tests.

In 1996 we located 12 screech-owl nests: 10 in saguaro cavities and 2 in mesquite tree (*Prosopis* spp.) cavities. We searched for nests too late in 1995, finding fledglings but no nests. In 1996, the 3rd year of a prolonged drought, very few screech-owls nested (Hardy 1997, Hardy et al. 1999). A nesting Gilded Flicker concurrently occupied 1 nest in saguaro; all other nest saguaros were occupied solely by screech-owls.

The 2 nests in mesquite were in trees 6.5 m and 7.8 m tall, with cavities at 2.1 m and 2.8 m in height, respectively. Because only 2 screech-

owl nests were in trees, we limited detailed analyses below to nests located in saguaros. Mature ironwoods (*Olneya linearis*), mature paloverde, and the 2 tallest structure classes of saguaros were found in significantly lower densities at screech-owl nest sites than at potential sites (Table 1). The cover of overstory perennial vegetation was also significantly lower around screech-owl nests (Table 1). Note that, except for cavity height, the variance (standard error) associated with each variable describing potential nest sites was greater than that for used nest sites (Table 1).

Nests in saguaros ranged in height from 4.7 m to 10.9 m with a mean of 8.1 m ( $s_{\bar{x}} = 0.64$ ,  $n = 10$ ) and ranged in dbh from 45 cm to 59 cm with a mean of 52.9 cm ( $s_{\bar{x}} = 1.29$ ,  $n = 10$ ). They had a significantly greater dbh than potential nest saguaros (Table 1). The number of potential cavities within nest saguaros ranged from 2 to 15 with a mean of 5.1 ( $s_{\bar{x}} = 1.26$ ,  $n = 10$ ) and did not significantly differ from the number of potential cavities within potential nest saguaros (Table 1). However, the number of Gilded Flicker cavities was greater within nest saguaros than within potential nest saguaros ( $t = 3.06$ , 9 df,  $P = 0.009$ ).

Nine of the 10 screech-owl nests located in saguaros were in cavities excavated by Gilded Flickers, and these cavities were used significantly out of proportion to their potential availability (Fisher's exact test,  $n = 10$ ,  $P = 0.015$ ). The 1 screech-owl nest not in an obvious Gilded Flicker cavity was intermediate in size between a Gila Woodpecker and Gilded Flicker cavity (vertical diameter = 6.2 cm, horizontal diameter = 7.1 cm). Nest cavity height ranged from 3.2 m to 8.6 m with a mean of 6.2 ( $s_{\bar{x}} = 0.55$ ,  $n = 10$ ) and did not significantly differ from potential cavity height (Table 1). The orientation of nest cavities was random ( $r = 0.09$ ,  $P > 0.50$ ,  $n = 10$ ) and the location of nest cavities did not significantly differ from that expected based on location of potential cavities (Fisher's exact test,  $n = 10$ ,  $P = 0.89$ ).

Cavity selection within nest saguaros was similar to that within the nesting area. Screech-owl nests were again located in Gilded Flicker cavities more frequently than expected based on potential availability (Fisher's exact test,  $P = 0.012$ ,  $n = 10$ ). The location of nest cavities did not differ from that expected based on the location of potential cavities (Fisher's exact test,  $P = 0.98$ ,  $n = 10$ ), and the height did not

differ from the height of potential cavities ( $t = 0.69$ , 9 df,  $P = 0.51$ ).

Finding that screech-owls nested in mesquites is significant, because other than in mesic riparian areas (Bendire 1892), screech-owls have not been documented to nest in tree cavities in the Sonoran Desert (Bent 1938, Johnsgard 1988). Hardy (1997) and Hardy et al. (1999) found that Elf Owls nested exclusively in saguaros and suggested this was due to the cooler and more stable microclimate of saguaro cavities relative to tree cavities. Unlike Elf Owls, screech-owls might not be limited to saguaros because they have a wider thermo-neutral zone (Ligon 1969). They are probably limited more by the presence of structures large enough to house cavities than by microclimatic factors in the Sonoran Desert.

Unlike Elf Owls, which seem to prefer Gila Woodpecker cavities (Hardy 1997, Hardy et al. 1999), screech-owls nested nearly exclusively in Gilded Flicker cavities. The larger body size of Western Screech-Owls might limit them from entering Gila Woodpecker cavities, or the much smaller interior of Gila Woodpecker cavities (Kerpez and Smith 1990) may constrain the large brood sizes characteristic of the species (Johnsgard 1988). The fact that screech-owls selected saguaros of large diameter for nesting suggests that cavity volume is a consideration. In Oregon and Washington, Western Screech-Owls used cavities in trees with a minimum dbh of 30.5 cm (Thomas et al. 1979).

Although the total number of cavities (regardless of excavating species) did not differ between nest saguaros and potential nest saguaros, we found significantly more Gilded Flicker cavities in nest saguaros than in potential saguaros. Thus, having alternate Gilded Flicker cavities may be important in nest-site selection by screech-owls. Other studies have shown that the number of alternate suitable cavities surrounding nests is an important factor in nest-site selection by cavity-nesting birds (e.g., Swallow et al. 1986, Martin and Roper 1988). Alternate cavities in the vicinity of the nest provide birds with re-nesting sites in case of nest failure (Rendell and Robertson 1994) or nest usurpation, and in Eastern Screech-Owls alternate cavities may be used as roost, food storage, and alternative nest sites (Gehlbach 1995). Alternatively, if flickers tend to make multiple cavities once they find a suitable

TABLE 1. Features of surrounding vegetation, saguaros, and cavities at nest sites of Western Screech-Owls ( $n = 10$ ) and at unused but potential nest sites, Barry M. Goldwater Air Force Range, Arizona, 1995–1996.

Category Variable	Used		Potential		$P^a$
	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	
Surrounding vegetation <sup>b</sup>					
Class 5 <sup>c</sup> saguaro density <sup>d</sup>	0.3	0.14	0.8	0.23	0.082
Class 4 <sup>c</sup> saguaro density	0.6	0.21	1.3	0.26	0.081
Ironwood density	0.8	0.54	3.0	0.69	0.019
Paloverde density	1.2	0.71	4.2	1.36	0.034
Perennial vegetation					
% cover understory <sup>e</sup>	31.2	6.33	38.8	7.27	0.444
% cover mid-canopy <sup>f</sup>	9.8	2.77	12.7	3.44	0.527
% cover overstory <sup>g</sup>	1.4	0.76	4.2	1.30	0.079
Saguaro					
Total cavities	5.1	1.26	3.7	1.46	0.474
Height (m)	8.1	0.64	8.0	0.66	0.840
DBH (cm)	52.6	1.41	46.4	2.12	0.024
Cavity height (m)	6.2	0.55	5.8	0.41	0.609

<sup>a</sup>Significance of paired  $t$  test

<sup>b</sup>Features of surrounding vegetation measured within 25-m-radius plot centered on nest saguaro

<sup>c</sup>Class 5 saguaros: >5 m tall with at least 3 branches >1 m long; class 4 saguaros: >5 m tall with 1–2 branches >1 m long

<sup>d</sup>Number of structures (e.g., cavities, trees) within 25-m-radius plot

<sup>e</sup>>0–1 m tall

<sup>f</sup>>1–2.5 m tall

<sup>g</sup>>2.5 m tall

cactus, then the presence of multiple cavities could play no role in nest-site selection by owls. Another possibility is that saguaros with more flicker cavities may be more likely to have owl nests simply because of higher availability of suitable cavities. Experimental evaluation of these ideas would be necessary to resolve the primary reasons for using structures with multiple cavities.

Other than their apparent preference for Gilded Flicker cavities, screech-owls did not select cavities based on orientation, height, or location (branch or stem). These findings are consistent with previous studies of nest-site selection (Gehlbach 1995). Although the direction a cavity entrance faces may affect the microclimate within the cavity, our results suggest that entrance orientation is of little importance to screech-owls in our study area, despite extreme summer temperatures. Similarly, Duley (1979) and Belthoff and Ritchison (1990) found that Eastern Screech-Owl nest cavities were randomly oriented.

Screech-owl nesting areas were characterized by lower cover of perennial vegetation, saguaros, ironwood, and paloverde than potential sites. We also found that the variance (standard error) associated with variables describ-

ing potential nest sites was greater than that associated with used sites. This higher variance could also reflect that owls are selecting for a narrower subset of conditions than those available to them. Eastern Screech-Owls and Flammulated Owls (*Otus flammeolus*) also seem to prefer nest sites with open subcanopy space and sparse shrub cover (McCallum and Gehlbach 1988, Robbins et al. 1989, Belthoff and Ritchison 1990, Gehlbach 1995). McCallum and Gehlbach (1988) suggested that the flight behavior of these species near the nest is related to their preference for open vegetation around the nest. Our observations of the flight behavior of screech-owls, although not quantified (unpublished data), are consistent with those described by McCallum and Gehlbach (1988).

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