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NEST-BOX VERSUS NATURAL-CAVITY NESTS OF THE EASTERN SCREECH-OWL: AN EXPLORATORY STUDY

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ABSTRACT.—The use of nest boxes versus natural tree cavities by eastern screech-owls (*Otus asio*) in central Texas was explored for 9 yr. Box sites resembled natural-cavity sites vegetatively and physically except that the boxes were positioned somewhat lower. The three box sizes provided spanned the size range of natural cavities used by screech-owls. Box size made no difference in nest site selection, clutch size, or nesting success. Three kinds of wood used in box construction made no difference either. The largest boxes were used more often for replacement nests, and the smallest ones tended to crowd broods, contributing slightly to mortality and early fledging. Overall, nest boxes produced data on frequency of use, clutch size, and fledgling productivity that were equivalent to data from natural cavities.

KEY WORDS: *breeding success; eastern screech-owl; nest boxes; nest-site use;* Otus asio; *tree-cavity nests.*

Nidos en cajas anideras versus cavidades naturales de *Otus asio*: un estudio exploratorio

RESUMEN.—Se exploró por nueve años el uso de cajas anideras versus cavidades naturales ubicadas en árboles por parte de *Otus asio* en el centro de Texas. Las cajas anideras se asemejaron a las cavidades naturales tanto vegetativa como físicamente, excepto que las cajas fueron ubicadas algo más abajo. El tamaño de las cajas utilizadas correspondía al espectro de tamaños de las cavidades naturales usadas por *O. asio*; no se registraron diferencias en la selección de sitio de nidificación, tamaño de la nidada o éxito de los polluelos. Tres tipos de maderas se utilizaron en la construcción de las cajas y tampoco se registraron diferencias. Las cajas más grandes fueron utilizadas a menudo para reemplazo de nidos y en las más pequeñas se tendía a agrupar las crías, aumentando ligeramente la mortalidad y un desarrollo precoz. En general, las cajas anideras producen datos sobre la frecuencia de uso, tamaño de nidada y productividad de volantones que fueron equivalentes a los obtenidos desde cavidades naturales.

[Traducción de Ivan Lazo]

Many raptor researchers employing artificial structures like nest boxes or nesting platforms do not utilize or report simultaneous comparisons with natural structures or distinguish site suitability or availability in studying habitat selection. Møller (1989, 1992) and Clobert and Lebreton (1991) note possible deficiencies in such studies using nest boxes, including the potential for greater nesting success in boxes than natural cavities. Here, I focus on the simultaneous comparison of eastern screech-owls (*Otus asio*) nesting in boxes and natural tree cavities to discover if there was a difference in the use of and breeding success in the two site types.

Field studies of birds may need to be conducted over several years during which investigative biases can multiply errors. Consequently, I tested for biases that might result from using nest boxes prior to conducting a 16-yr population study of the eastern screech-owl (Gehlbach 1994). Among cavity-nesting owls, only the boreal or Tengmalm's owl (*Aegolius funereus*) has been studied in a somewhat similar manner; clutch size and number of fledglings of that species were determined in both nest boxes and natural cavities but not in controlled fashion (Korpimäki 1984).

METHODS

The study was conducted in 135 ha of Woodway, a suburb of Waco, TX, U.S.A., during 1967–75. This area had 508 human residents/km^2 and 25.9% green space averaging 327–1504 trees/ha in lawns and wooded ravines, respectively. Eastern screech-owls and the natural tree cavities they used were located by mapping cavity-advertisement songs and making cavity inspections in December through early March before nesting began. I continued to search for used and unused but apparently suitable cavities (as large or larger than used cavities; McCallum and Gehlbach [1988]) until the cumulative number found versus cumulative search effort indicated that essentially all were known.

Nine nest boxes were constructed, three each of exterior plywood, solid pine, and solid cedar (1.9-cm-thick wood), and were painted dark brown on the outside. Cavity size has been shown to influence clutch size in owls (Korpimäki 1985), and to test its affect on screech-owls I built one box of each wood type with 225, 400, and 625 cm^2 bottoms. All boxes had a 6.8 cm entrance hole 25 cm above the box bottom. The bottom areas of these boxes spanned those of natural cavities. Depth of the boxes was the average of 12–58-cm-deep natural cavities, and the entrance diameter was the mean minimum dimension of the natural entrances.

Box locations depended on landowner permission and were placed 70–300 m from natural cavities used by screech-owls and other boxes on straight tree trunks. Trunk diameters at these positions were equal to or larger than box width. Boxes faced nine different directions and were 3–4 m above ground. Five boxes were paired with the closest previously used natural cavities most like them in orientation, height, and volume. The other four could not be paired because it required several years to discover all natural sites used by screech-owls. I evaluated only first-nest data, since replacement nests are so different (Gehlbach 1994).

A 75-m, 5-point, 20-quarter transect, randomly aligned through each box and cavity tree, was employed to assess vegetational features according to Gehlbach (1988, 1994). These and physical measurements were made before the boxes were positioned, so that box sites would resemble natural cavity sites. Measurements and syntheses concerned tree and shrub density, height, and diversity, the evergreen fraction, canopy coverage, tree species relative importance, nest tree diameter, nest height and bottom area, and distance to the nearest house, permanent water, and suitable/available cavity or box.

Several handfuls of dried leaves were placed in the bottom of each box to simulate an old fox squirrel (*Sciurus niger*) nest because all but one of the used natural cavities had them. Thereafter, box and cavity contents were undisturbed except in a minor way during nest inspections. Fox squirrels and other cavity users and nest predators were not disturbed during the weekly surveys of nest contents which extended through June, and nest debris was not removed between years.

Multifactor box versus natural-cavity environments, high- versus low-use boxes, and used versus unused natural cavities were evaluated with multivariate analyses employing transformed data. Individual parameters were then tested with univariate analysis of variance. Use and reproductive data for the box/cavity pairs were assessed with Wilcoxon signed-ranks tests, while unpaired data were subjected to Mann-Whitney U-tests. Spearman rank correlations were used to test relationships between box size and nest contents. Chi-square analyses were made of nests in boxes versus cavities, use of and results from the different box sizes and wood types, and box versus cavity dispersions among dominant trees.

Means, standard deviations, sample sizes (if not obvious from the designs), and exact probabilities are given except for those >0.10, which I consider non-significant (NS) in two-tailed tests. Probabilities of <0.10 have potential biological meaning in view of my confirmatory study (Gehlbach 1994).

RESULTS

Nest Cavities and Habitat. Of the 23 suitable natural cavities that I found, eastern screech-owls nested in 15 that were deeper (>25 cm) with larger floors (>10 cm minimum dimension) and had smaller entrances (<15 cm maximum dimension) than the others (MANOVA $F = 2.9$, $P = 0.04$). The used sites were 3.7 m (SD = 1.6) above ground in naturally rotted, hollow limbs or tree trunks. At least 10 of these cavities had been enlarged by fox squirrels. The red-bellied woodpecker (*Melanerpes carolinus*), the largest local woodpecker species, did not excavate cavities large enough for screech-owls.

Paired box- and natural-cavity sites were 72–280 m apart and similar in their vegetational and physical features (MANOVA $F = 1.1$, NS). However, the boxes tended to be lower ($\bar{x} = 3.1$ vs. 3.7 m, ANOVA $F = 3.5$, $P = 0.06$) and in smaller diameter trees ($\bar{x} = 26.7$ vs. 32.2 cm, $F = 2.4$, $P = 0.09$). While all nine nest boxes were placed lower in smaller trees than the 15 used natural cavities (ANOVA $F = 3.2$, $P < 0.05$), both site-types were equally distributed among the seven most common trees of the canopy ($\chi^2 = 1.7$, NS). Cedar elm (*Ulmus crassifolia*) was the dominant tree and had the most natural cavities (48%) and boxes (44%).

The frequencies with which screech-owls used paired boxes and natural cavities for nesting were quite similar, and similar to all nine boxes and nine cavities with at least 5-yr records (Table 1). Type of wood and box size made no difference in nest box selection; useage relative to availability ranged from 60% in pine and 67% in small boxes to 70% in cedar and 73% in large boxes ($\chi^2 = 1.7$, NS).

Preferred nesting habitat was distinguished as having more evergreens in the canopy, lower tree density, closer alternate nest site, and lower shrub density in first-to-last order of importance ($F = 4.0$, $P < 0.07$). This combination of features describes a shady, park-like landscape with large, cavity-prone trees at low densities. These habitat characteristics were identified by subjecting 12 high- and 12 low-use nest sites (employing the 60% median use rate of all nine boxes plus 15 cavities) to stepwise discriminant analysis.

Reproduction. Clutch size and number of fledglings/clutch in the nest boxes were statistically like those in natural cavities (Table 1). Clutch size in the 29 nests in boxes were not related to bottom area of the box ($r_s = 0.17$, NS) unlike the situation in

Table 1. Eastern screech-owl use of and breeding success in nest boxes and natural cavities, 1967–75. Means ± standard deviations and sample sizes (in parentheses) are of first nests only.[a]

PARAMETERS CAVITIES	NEST BOXES	NATURAL
Site use (%)		
Pairs[b]	64.2 ± 13.0 (5)	75.8 ± 19.1 (5)
All[b]	70.5 ± 15.3 (9)	77.5 ± 16.2 (9)
Successful nests (%)[c]		
Pairs[b]	67.8 ± 21.2 (5)	81.1 ± 12.4 (5)
All[b]	70.7 ± 18.6 (9)	72.8 ± 15.7 (9)
Clutch size	3.9 ± 0.5 (29)	3.8 ± 0.6 (16)
Fledglings/eggs (%)	51.3 ± 16.8 (29)	57.0 ± 19.4 (16)

[a] Wilcoxon $Z < 0.9$, NS, for all paired data comparisons; Mann-Whitney $U < 19$, NS, for all unpaired data comparisons.
[b] Pairs = five boxes each paired with a natural tree cavity having similar environmental features; all = the paired boxes and cavities plus four more boxes and four cavities with at least 5-yr records.
[c] At least one chick fledged.

boreal owls (Korpimäki 1985). But when chick losses occurred, they were 21% higher in the smallest boxes versus larger ones and slightly more frequent there (31% vs. 20%; $\chi^2 = 1.7$, NS). Also, chicks fledged somewhat sooner from smaller boxes ($r_s = 0.39$, $P = 0.06$). Successful nests tended to be more frequent in paired natural cavities but not significantly so, and the larger samples of nine sites each were essentially alike (Table 1).

Possible Inspection Biases. Screech-owls used only 65.6% (SD = 18.6) of the available paired boxes and tree cavities in 1968–71 compared to 78.1% (SD = 20.9) in the following 4 yr (Wilcoxon $Z = 2.0$, $P = 0.04$). Demand for nesting space was apparently not a factor because the mean use of 20 suburban boxes was not significantly different over the next 16 yr despite a nearly two-fold flux in population density ($\bar{x} = 75.6\%$, SD = 16.1; Mann-Whitney $U = 11$, NS; Gehlbach 1994). Moreover, productivity in the paired boxes plus cavities was only 45.9% (SD = 39.3) in 1968–71 but rose to 55.6% (SD = 40.7) in 1972–75 (Wilcoxon $Z = 1.4$, NS) and remained about the same in the following 16 yr (53.8%, SD = 15.6; Mann-Whitney $U = 19$, NS).

DISCUSSION

Clearly, nest boxes are essentially equivalent to natural tree cavities and hence are a legitimate tool in the study of eastern screech-owls. By contrast, Korpimäki (1984) found more eggs and fledglings of boreal owls in boxes than natural cavities, although he did not study both site-types concurrently. Southern (1970 and pers. comm.) made same-season comparisons of cavity- and box-use by tawny owls (*Strix aluco*), but did not enumerate cavity-nest contents. He found that 33–75% of the owls used boxes annually. Most students of cavity-nesting raptors assume that nest boxes provide natural data, even though Korpimäki (1984) suggests otherwise (also see Gauthier 1988, Robertson and Rendell 1990).

The overall 67% use rate of boxes in my study is considerably higher than 4–13% values reported for eastern screech-owls by Van Camp and Henny (1975), McComb and Noble (1981), and Fowler and Dimmick (1983). Perhaps this is because I placed boxes in sites similar to natural cavities after making environmental measurements. The high use was not due to an unusually dense or protected suburban population, or to a scarcity of suitable natural cavities which outnumbered the boxes. In fact, a much sparser rural population with twice as many natural nest sites per breeding pair of owls had box-use rates averaging 61% concurrently with a 70% use in suburbia (Gehlbach 1994).

Nest boxes closely matching used natural cavities furnish vital information on nest-site selection and the influence of cavity size on chick mortality and fledging. Korpimäki (1984, 1985) obtained results different from mine using different size boxes but his study did not attempt to differentiate among the variety of available natural sites. When boxes are used to compensate for the scarcity of natural tree cavities to manage owl populations (e.g., Saurola 1989), I suggest that one simulate the range of natural nest cavities, since cavity size can influence some aspects of reproduction.

Comparing environmental features used by a species versus randomly selected environmental features is incorrectly called habitat selection (e.g., Cody 1985). Habitat that is suitable for a species must be distinguished from all available habitat. In fact, some randomly chosen sites may be unsuitable, and raptors may not use all possible sites unless forced to by population pressure. Studies of habitat selection must include environments that have been and could be used besides those now used, and thus furnish a spectrum of conditions for selection by birds under various population densities. Measurements are based on criteria like the mean-minimum dimensions of past and current use (McCallum and Gehlbach 1988).

Although the nest-box method proved to be valid for studying eastern screech-owls, I believe boxes attracted deleterious human attention early in my study when they were novel. In addition, my own learning of inspection techniques may have inadvertently focused on the lower and hence readily accessed boxes despite attempts to treat all paired sites equally. This could have produced the disparate early- versus late-study results, because frequency of site use and productivity did not change appreciably during population flux over the next 16 yr. Thus, I advise that population investigations be preceded by explorations that refine all investigative approaches, not just the use of substitute habitats.

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