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NEST-SITE SELECTION BY URBAN MERLINS[1]

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Key words: Merlins; Falco columbarius; *nest-site selection; urban; Saskatchewan.*

With the exception of studies involving cavity-nesting birds dependent upon naturally formed hollows in trees and soil (e.g., Devereaux and Mosher 1984) or cavities created by other species (e.g., Goad and Mannan 1987), comparatively few studies of nest-site selection have considered species for which the actual availability and properties of potential sites are measurable. In order to assess these characteristics, most previous studies have involved random sampling of the surrounding habitat using criteria selected by the researcher. With this inherent bias, habitat where nesting is unlikely might be included or, based on the criteria selected, atypical sites might be excluded.

Like other falcons, the Merlin (*Falco columbarius*) does not build its own nest. Although there are some ground-nesting populations (largely Palearctic; Brown 1976; Newton et al. 1978, 1986; Cramp and Simmons 1980; Bibby and Nattrass 1986), for the most part Merlins use abandoned corvid or hawk nests, usually in conifers, over much of their range (Craighead and Craighead 1940, Lawrence 1949, Beer 1966, Johnson and Coble 1967, Laing 1985). One exception to this is Richardson's Merlin (*F. c. richardsonii*), the subspecies of the North American prairies. Most likely as a reflection of availability, rural populations of this subspecies predominantly use nests in deciduous trees (Fox 1964, Hodson 1975, Houston and Schmidt 1981, but see Ellis 1976 and Becker 1984), while urban populations use nests in conifers (Oliphant 1974, Smith 1978, Oliphant and Haug 1985). Because it is an obligate tree-nester restricted to corvid nests in Saskatoon, this Merlin population provided an ideal opportunity to study nest-site selection.

Previous descriptions of Merlin nest sites have been qualitative. Hodson (1975) provided a detailed description, but gave no indication of the relative availability of the habitat characteristics he described. Bibby (1986) examined the large-scale selection of major vegetation communities and land use patterns around the nest sites of Merlins in Wales. Our objectives were: (1) to provide information on the characteristics of the nests and immediate area surrounding the nests chosen by an urban Merlin population, and (2) to determine whether Merlins chose a particular subset of the available abandoned corvid nests within the city.

METHODS

We studied Merlins breeding in Saskatoon, Saskatchewan, Canada (52°07′N 106°38′W), a northern Great Plains city of approximately 12,200 ha with a population of about 180,000 people. The city is bisected by the South Saskatchewan River; those river bank areas not used for human habitation are typified by steep

[1] Received 24 February 1988. Final acceptance 29 April 1988.

TABLE 1. Descriptions of habitat variables used in analysis of Merlin nest-site selection. Shrubs are defined as woody vegetation with multiple stems at ground level; trees have a single woody stem.

Mnemonic	Description
Tree	Nest-tree species.
Treeht	Height of nest tree in meters.
Dbh	Diameter at breast height of nest tree in centimeters.
Nstht	Height of nest in meters.
Nstype	Type of nest, either crow or magpie.
Congt5	Number of coniferous trees >5 m tall in the 10-m radius plot.
Decgt5	Number of deciduous trees >5 m tall in the 10-m radius plot.
Conlt5	Number of coniferous trees <5 m tall in the 10-m radius plot.
Declt5	Number of deciduous trees <5 m tall in the 10-m radius plot.
Shrub	Percentage of plot covered by shrubs, in one of four categories: 0%, <5%, 5 to 25%, and >25%.
Distbldg	Distance from the nest tree to the nearest building.
Distroad	Distance from the nest tree to the nearest roadway.
Distpole	Distance from the nest tree to the nearest power pole or lamp standard.
Human	Index of human activity identified as low, medium, or high.
Treegt5	Number of trees >5 m tall in the plot (Congt5 + Decgt5).
Treelt5	Number of trees <5 m tall in the plot (Conlt5 + Declt5).
Pnstht	Percentage nest height (Nstht/Treeht × 100).

slopes dominated by native shrub communities of chokecherry (*Prunus virginianus*), pincherry (*P. pennsylvanicus*), Saskatoon berry (*Amelanchier alnifolia*), silverberry (*Elaeagnus commutata*) with some scattered white birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). By contrast, residential and park areas away from the riverbank were planted mainly with introduced tree species soon after neighborhoods were constructed. In areas used by Merlins for nesting, the dominant deciduous trees are white elm (*Ulmus americana*), Manitoba maple (*Acer negundo*), balsam poplar (*Populus balsamifera*), weeping birch (*Betula pendula*), green ash (*Fraxinus pennsylvanicus*), and mountain ash (*Sorbus* spp.). The conifers are predominantly white (*Picea glauca*) and blue (*P. pungens*) spruce with some other exotic and ornamental species.

Nests were located as part of a long-term study of Merlins (Oliphant and Haug 1985); 58 nest sites occupied in the years 1985 to 1987 were included in this analysis. Searches were conducted each spring by visiting sites previously used and by systematically searching new areas for signs of activity. A tape of Merlin vocalizations was employed to elicit a response and check nests for occupancy. Our efforts to find all nests in the city each year were supplemented by reports of nest locations from interested members of the public. For this study, a nest site was defined as the nest tree, containing an abandoned corvid nest, and a circular plot of 10 m radius centered on the nest tree. Table 1 lists the 17 variables considered in the analysis which were either assessed directly or created by aggregation. Height measurements were made to the nearest 0.5 m using a clinometer; all distances were measured from the nest tree. Nest sites were subjectively categorized as being in low, medium, or high areas of human activity. Typical low activity level sites were cemeteries and infrequently used parks; most residential sites were considered medium, while busy areas (in terms of vehicular and/or pedestrian traffic) such as heavily used parks were classified as high human activity areas. Shrub cover was estimated visually and categorized as: 0, <5%, 5 to 25%, or >25%.

Random sampling of corvid nests, both Black-billed Magpie (*Pica pica*) and American Crow (*Corvus brachyrhynchos*), was conducted in the city in the spring of 1987 to characterize the available nesting habitat. Because trees were planted as neighborhoods were developed, the age of a neighborhood affected the extent of vegetation growth. In addition, residential and nonresidential areas may differ in the density of vegetation. Therefore, before initiating the census, the city was divided into strata based on residential, nonresidential, and age-class designations. Neighborhood age was determined from city records, which classified neighborhoods as being built prior to 1946, or from 1946 to 1960, 1961 to 1970, 1971 to 1979, or 1980 to the present. Merlins occupied nests in three of the five age-class categories found in the city (pre-1946, n = 28 nests; 1946 to 1960, n = 25 nests; and 1961 to 1970, n = 5 nests) and in both residential and nonresidential sections of these areas. City blocks and parks within regions of the city which matched the descriptions of the six strata occupied by Merlins were assigned numbers. Using a random number table, the locations of random sites to be searched were generated so that the proportion of randomly-selected sites in each stratum matched that of the occupied Merlin nest sites. Trees in the selected block or park were searched from the ground with binoculars for nests, and one of those found in the area was randomly chosen to be measured.

Of the 17 variables chosen for analysis (Table 1), some were highly correlated, suggesting that they measured the same or similar features of the environment. Where there was a high degree of correlation between variables ($r > 0.7$), only one of the pair was included in subsequent analysis. The variable retained was that which could be most readily used in a biological explanation of the results. Data measured at occupied and randomly-selected unoccupied sites were compared

TABLE 2. Sample means, standard deviations, and ranges of habitat variables for occupied (n = 58) and randomly selected unoccupied (n = 55) nests.

Variable	Occupied	Random	F (ANOVA)	P
Treeht (m)	12.5 ± 2.9 (7.5–19.0)	11.8 ± 2.7 (5.5–19.0)	1.95	ns
Dbh (cm)	40.6 ± 11.8 (19.7–85.9)	37.3 ± 8.7 (18.1–61.7)	2.84	ns
Nstht (m)	8.9 ± 2.7 (4.0–14.5)	7.8 ± 2.8 (4.0–16.5)	4.19	<0.05
Shrub	1.9 ± 0.9 (1–4)	1.9 ± 0.9 (1–4)	0.12	ns
Distbldg (m)	57.2 ± 198.2 (1–1,500)	17.3 ± 22.8 (1–120)	2.20	ns
Distroad (m)	22.4 ± 35.9 (2–200)	14.6 ± 15.6 (1–90)	2.22	ns
Distpole (m)	35.6 ± 37.7 (5–200)	23.5 ± 25.0 (3–150)	3.99	<0.05
Human	1.9 ± 0.5 (1–3)	2.0 ± 0.4 (1–3)	2.07	ns
Treegt5	5.4 ± 4.7 (0–20)	4.6 ± 3.5 (0–19)	1.17	ns
Treelt5	1.3 ± 2.1 (0–8)	0.4 ± 0.9 (0–5)	8.03	<0.01
Pnstht	70.3 ± 10.3 (42.1–93.6)	65.6 ± 14.0 (37.5–93.8)	4.08	<0.05

initially using univariate analysis of variance (ANOVA), and then a multivariate stepwise discriminant function analysis (BMDP, Dixon and Brown 1979) was performed to describe differences in habitat structure between occupied and randomly-selected unoccupied sites. The resulting classification distribution was tested for chance correctness using Cohen's Kappa statistic (Titus et al. 1984), which assesses how well the discriminant analysis improves the classification beyond chance.

RESULTS

During the search for random nest sites, 146 corvid nests were found, of which 130 (89.0%) were in conifers. Eighty (61.5%) of the conifer nests and 13 (81.2%) of the 16 deciduous nests were made by crows; the remaining 53 were magpie nests. Merlins selected nests in coniferous trees exclusively, and showed a strong tendency to avoid magpie nests, using crow nests on 54 (93.1%) of 58 occasions. Thus they chose a significantly different subset of nests from those available (χ^2 = 61.52, df = 3, $P < 0.001$).

The means of the quantitative habitat variables from occupied and random sites are compared in Table 2. Features of the nest and the nest tree were most important in distinguishing between occupied and randomly-selected unoccupied sites. Merlins preferred nests that were further from poles, although other man-made structures such as buildings and roads showed no significant impact on nest-site selection. Along with Dist road and Distbldg, Treeht, Dbh, Shrub, Human, and Treegt5 were apparently unimportant to Merlins choosing a nest site. Typifying most urban environments, the vegetative structure around nest sites was not very complex; there were few trees in either size category and shrub cover indices were lower than generally found in natural forests. Occupied nests were positioned relatively higher in the tree (Pnstht) than those of unoccupied randomly-selected sites. We used the sample of unoccupied randomly-selected nests to compare some characteristics of crow and magpie nests. Crow nests (8.4 ± 2.9 m, n = 39) were built significantly higher (Nstht) than magpie nests (6.5 ± 2.0 m, n = 16; two-tailed t-test t = 2.34, $P < 0.05$). As well, in terms of Pnstht, crow nests (68.2%) were proportionately higher in the tree than magpie nests (58.9%; two-tailed t-test t = 2.388, $P < 0.05$).

The stepwise discriminant function analysis correctly classified 68.1% of all sites as to occupancy; 55 (94.8%) of 58 and 22 (44.0%) of 55 nest sites were correctly classified for occupied and unoccupied, randomly-selected nest sites, respectively. This was significantly better than chance (Z = 3.667, $P < 0.001$; Titus et al. 1984).

DISCUSSION

The movement of Merlins into Saskatoon followed the earlier colonization of the city by corvids during the late 1960s and early 1970s (Houston 1977, Houston and Schmidt 1981). In discussing patterns of nest-site selection among these Merlins, the most appropriate comparisons to make are with the rural populations from which they originated. Rural populations of Richardson's Merlins nest in both coniferous and deciduous trees, with the majority (particularly on the prairies) occurring in the deciduous trees of shelter belts and

TABLE 3. Summary of Merlin productivity (young per successful nest), nest and nest-tree type in study areas on the North American prairies.

Study	Productivity (*n*)	% crow nests used in study area (*n*)	% coniferous nest trees used in study area (*n*)
Fox (1964)	2.6 (10)	52% (25)	16% (25)
Hodson (1975)	3.2 (108)	41% (121)	0% (121)
Smith (1978)	3.6 (19)	33% (30)	0% (38)
Becker (1984)	3.7 (43)	0% (48)	100% (48)
Smith (1978)	3.8 (10) urban	79% (14)	93% (14)
This study	4.2 (61) urban	93% (58)	100% (58)

riparian systems (Fox 1964, Hodson 1975, Oliphant and Thompson 1978). Although no information has been collected regarding the availability of nests in rural areas on the prairies, published reports show that usage favors closed magpie nests over open crow or hawk nests, with 135 magpie and 64 crow nests reported (Fox 1964, Hodson 1975, Ellis 1976, Becker 1984). Beebe (1974), in noting the tendency for these Merlins to use magpie nests more often than crow nests, suggested that this selection was made in order to gain overhead protection from crows through concealment. Hodson (1975) noted nest predation of eggs by crows, as well as the evidence of Great Horned Owl (*Bubo virginianus*) predation on young. In the presence of heavy predation pressure, the selection of closed nests might provide the benefit of concealment not offered by open crow or hawk nests, particularly in deciduous trees.

Consideration of nest productivity may provide additional evidence of the impact of predation pressure on the selection of different nest and nest-tree types. Table 3 summarizes studies of Richardson's Merlin nests at various locations on the prairies. The results suggest an apparent trend among rural sites of lower productivity as the proportion of crow nests increases and the proportion of coniferous trees in the sample decreases. Visibility, or conspicuousness, of the nest may play an important role in the eventual success of the nest; nests in deciduous trees are much more visible than those in conifers, and occupation of an open crow or hawk nest could be more easily ascertained by predators than for closed magpie nests. Further study of Merlin productivity as it relates to nest and nest-tree type at rural sites is needed to test the validity of this hypothesis.

With the move into the city there was a dramatic change in the use of nest sites by these Merlins. Where rural populations demonstrate an extensive dependence upon nests in deciduous trees, the Merlins of Saskatoon used only nests in coniferous trees for the 3 years of this study. In 16 years, only two of 172 Merlin nests (1.1%) were found in deciduous trees. While the comparative availability of deciduous nests is low in Saskatoon, there are larger numbers of magpie nests in conifers which appear to be strongly avoided by Merlin productivity as it relates to nest and nest-tree from the study of rural Merlins. One possible reason for this difference is that the denser cover provided by conifers reduces the need for concealment by the nest. If this enables Merlins to avoid magpie nests, it suggests that there may be negative aspects to using magpie nests. Merlin visibility from a magpie nest may be poorer than from a crow nest, thus giving less warning about potential predators. In addition, the reduced visibility from a closed nest might make any opportunistic hunting from the nest by incubating or brooding adults less likely. Merlins have been observed nesting on top of intact magpie nests rather than in the cavity (L. W. Oliphant, pers. comm.). Another factor involved in the avoidance of magpie nests in the city may be their height; on average they are nearly 2 m lower than crow nests. Lower nests might result in increased mammalian predation, particularly by domestic cats which are numerous in residential areas. Crows also tend to nest closer to the top of the tree than magpies. With the tapered shape of conifers, the higher crow nest may provide Merlins with more room for flying and maneuvering around the tree and allow them to fly directly into the nest without first landing and hopping among branches.

The predictive power of the discriminant analysis is based on the characteristics of nest-tree species, the type of nest used, and the number of trees less than 5 m tall within the plot, with 94.8% of the occupied sites correctly identified. The importance of the number of trees less than 5 m tall within the plot is not easily explained and it may simply be a chance occurrence. Alternatively, small trees may provide cover and nesting habitat for potential prey. Although it is thought that Merlins do not usually take prey from the immediate vicinity of the nest (Wiklund 1982), they may choose a nest site that has potential prey nearby. Because we did not consider prey availability at occupied and unoccupied random sites, this possibility cannot be eliminated. The discriminant function analysis shows that the three characteristics defined above can be used to successfully identify nearly all of the occupied sites, but over half of the unoccupied random sites were "misclassified" as occupied. This suggests that nest sites may not be limiting, at least in terms of the proportion available which are suitable for nesting Merlins according to the variables we considered. However, although we did not test the overall availability of nest sites in the city, 33% of the randomly chosen blocks we searched had no visible nests and five (8.3%) of 60 sites chosen for use as part of the random sample were occupied the following summer. It is possible that these misclassified random sites meet the requirements to become a Merlin nest site, but cannot be occupied due to spacing behavior by nearby Merlins. Further work is needed to ascertain the impact of territoriality on nest-site selection by Merlins.

Field assistance was provided by H. Saunders and E. Labbe. A. R. Smith gave access to his unpublished data on tree and nest types used by Merlins in Alberta. Our thanks to R. G. Clark for his comments during the planning and write-up of the study. L. W. Oliphant and C. S. Houston commented on an earlier draft of the manuscript. Funding was provided by the Natural Sciences and Engineering Research Council of Canada, and the paper was written while the senior author held a University of Saskatchewan Graduate Scholarship.

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