

## WINTER ROOST-SITE SELECTION BY URBAN MERLINS (*Falco columbarius*)

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**ABSTRACT.**—Roost-site selection by Merlins (*Falco columbarius*) wintering in the city of Saskatoon, Saskatchewan, Canada, was examined for five winters beginning in November 1983. Forty-one solitary roosts in conifer trees used by 16 different birds were identified through radiotelemetry and chance observations. These roosts were compared with a random sample of 44 conifer trees based on 14 variables at the roost tree and within a 10 m radius of the roost tree. All roosts were in conifer trees that were significantly taller and had a greater crown volume than random trees. Merlins did not use roost trees at random; characteristics most useful in distinguishing roost from random trees were size, distance to the nearest conifer greater than 5 m tall, and the total number of trees greater than 5 m and less than 5 m tall within a 10 m radius. We found no significant difference between roost trees used by males and females. The availability of suitable roosting trees may have been a limiting factor in the colonization of the northern Great Plains by Merlins as a wintering area.

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Selección de árboles-dormideros por los halcones *Falco columbarius*, en áreas urbanas

**EXTRACTO.**—La selección de árboles-dormideros por los halcones *Falco columbarius* que pasan el invierno en la ciudad de Saskatoon, Saskatchewan, Canada, ha sido examinada durante cinco inviernos desde noviembre de 1983. Cuarentiún dormideros solitarios en árboles coníferos [“Dícese de árboles y arbustos gimnospermos, de hojas persistentes; . . . como el ciprés, el pino y la sabina . . .”] usados por 16 diferentes individuos de la especie estudiada, han sido identificados por medio de radiotelegrafía y observaciones casuales (de chance). Estos 41 árboles-dormideros han sido comparados con una muestra al azar de 44 coníferas, en base a 14 variables correspondientes al lugar de los dormideros con un radio de 10 metros. Todos los dormideros considerados han sido coníferas significativamente más altas y con mayor volumen de copa que cualquiera de las 44 coníferas de la ya mencionada muestra. Los halcones no usaban dormideros al azar; las características mayormente consideradas para distinguir dormideros y árboles de la muestra han sido: el tamaño, la distancia a la más próxima conífera de más de 5 metros de altura, y el total de árboles dentro de un radio de 10 metros. No se encontró diferencias significativas entre dormideros usados por halcones machos y hembras. La disponibilidad de árboles-dormideros adecuados puede haber sido un factor limitante para la colonización de los Grandes Llanos del Norte, como áreas de invierno, para los halcones.

[Traducción de Eudoxio Paredes-Ruiz]

Roosting sites of both communal and solitary roosting birds, have been hypothesized to provide protection from potential predators (Lack 1968), act as information centres (Ward and Zahavi 1973; see Weatherhead 1983, Caccamise and Morrison 1986, 1988 for alternative viewpoints), and provide shelter from inclement weather (Walsberg 1986). Birds wintering in temperate zones may encounter reduced food resources, severe thermal stress, and for diurnal

species at higher latitudes, an extended, overnight, enforced fast. Thus, selection of night roosts may have a substantial impact on winter survival, especially for individuals within a species of small body size.

Several studies have addressed the energetic consequences of roost-site selection, focusing on those features of roosts which minimize thermoregulatory costs through protection from radiative heat loss, wind and precipitation. For cavity-roosting species there is a significantly increased air temperature inside their night roost (Kendeigh 1961, Caccamise

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and Weathers 1977), but not among birds that roost in open vegetation, either with or without other birds in the same roost (Kelty and Lustick 1977, Walsberg and King 1980, Walsberg 1986). Shelter from forced convective heat loss appears to be most important to energy conservation when compared with either local temperature enhancement or improved radiation balance (Walsberg 1986, Webb and Rogers 1988).

In Europe, Merlins (*Falco columbarius*) roost both communally and singly in winter, on the ground and in trees (Dickson 1973, Cramp and Simmons 1980, Sys 1982, van Duin et al. 1984). In North America, Merlins have only been observed roosting singly in conifers during winter (Servheen 1985, Hohn 1986, Warkentin 1986). Although several aspects of the roosting behavior of Merlins have been described previously (Dickson 1973, Sys 1982, van Duin et al. 1984, Servheen 1985, Hohn 1986, Warkentin 1986), there is no quantitative study of roost-site selection. Here, we (1) describe the characteristics of roost-trees and the immediate area surrounding the trees chosen by urban Merlins, and (2) determine whether Merlins choose a particular subset of those conifers available for roosting within the city. We also tested for differences between the sexes in the types of roosts selected.

## METHODS

The study area comprised the city of Saskatoon, Saskatchewan, Canada (52°07'N 106°38'W), at the northern edge of the Great Plains of North America. Saskatoon has a dry continental climate; mean monthly temperatures (°C) in the city during the 5 years of study were: November -8.3, December -12.2, January -12.6, February -11.6. The terrain outside of the city is typical of the Aspen Parklands region (Harris et al. 1983), with large sections of arable land in gently undulating to rolling topography, dotted with small ponds and Trembling Aspen (*Populus tremuloides*) stands. Except for areas immediately adjacent to the South Saskatchewan River, which bisects Saskatoon, most of the trees and shrubs in residential areas of the city were planted (for details of neighborhood age and species composition of the vegetation, see Warkentin and James 1988).

Roosts were located as part of a study conducted from 1983 to 1988 on the winter ecology of Merlins resident in Saskatoon (Warkentin et al., 1990, Warkentin and Oliphant, in press, Warkentin and West, 1990). We used two techniques to identify roost trees: chance observations of unmarked birds entering a roost at dusk, and following radio-tagged birds to their nighttime roosts. Forty-one roosts, occupied by 16 different birds were included in these analyses. In an effort to approach statistical independence, each roost was only used once in the analysis with nine of 16 (56%) birds contributing one observation,

5 birds contributing three observations, and single birds providing 7 and 10 observations each.

The roost site was defined as the roost tree, and a circular plot of 10 m radius centered on the roost tree. Measurements of roost-tree heights were made at most within 18 months of their use, but usually within 4 months (i.e., the following summer). All other measurements were made in April 1988 when random sites were selected and measured. There may have been minor changes in some of the variables included between the time the roosts were used and when the measurements were taken. However, because of the nature of the variables considered (distances and numbers of trees), we suggest that these changes were likely minimal and had little impact on the overall results of our analyses.

Heights were measured to the nearest 0.5 m using a clinometer. Compass bearings to the nearest building (directed at the closest part of that building) were taken to assess the potential influence of buildings on Merlin roosting behavior. Shrub cover was estimated visually and categorized as: 0, <5%, 5 to 25%, or >25%. Vertical distribution of roost tree crown volume was estimated using measurements of tree height, distance from the ground to the lowest live branch, and radius of the crown at the lowest live branch (Mawson et al. 1976). Crown shape was compared to the 15 possible crown shapes described by Mawson et al. (1976) and assigned to that which was the best fit. We calculated the crown volume for 2 m height classes of each tree up to 20 m, using the equation appropriate for the crown shape.

We selected a random sample of potential roost trees from among the conifers in the city to test for the selection of roosts by Merlins. Because trees in the city were planted as neighborhoods were constructed, neighborhood age reflects the extent of tree growth. Therefore, using city records, we divided the city into strata on the basis of age and residential/nonresidential criteria, and selected a random sample from these habitats in proportion to their use for roosting by wintering Merlins. Although trees used by Merlins for nighttime roosts were generally conifers greater than 10 m tall (Warkentin 1986, and see results), Merlins in this population have used trees only 7 m high (Warkentin, pers. obs.). Consequently, we restricted the random sample to conifer trees at least 6 m tall in order to eliminate shorter trees from the sample that would not be selected for roosting by Merlins. Street intersections, within regions of the city which matched the description of strata occupied by Merlins, were assigned numbers. Using a random numbers table, the location of sites to be visited were generated and the conifer tree nearest the centre of the designated intersection was measured for the same variables as roost trees.

The 14 variables considered in the discriminant function analysis (DFA) are listed in Table 1. Some of the variables chosen for analysis were highly correlated, suggesting that they measured the same or similar aspects of the environment. When there was a high degree of correlation between two variables ( $r > 0.7$ ), only one of the variables (that which could be most readily used in a biological explanation of the results) was included in subsequent analysis. Data on 10 of the 14 variables (Table 1, with CONHT > 5, CONHT < 5, DECHT > 5, DECHT < 5 excluded due to

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

MNEMONIC	DESCRIPTION
TREE	Roost-tree species.
TREEHT	Height of roost tree in metres.
DBH	Diameter at breast height of roost tree in centimetres.
CONHT>5	Number of coniferous trees >5 m tall in the 10 m radius plot.
DECHT>5	Number of deciduous trees >5 m tall in the 10 m radius plot.
CONHT<5	Number of coniferous trees <5 m tall in the 10 m radius plot.
DECHT<5	Number of deciduous trees <5 m tall in the 10 m radius plot.
TREEHT>5	Number of trees >5 m tall in the plot (CONHT>5 + DECHT>5).
TREEHT<5	Number of trees <5 m tall in the plot (CONHT<5 + DECHT<5).
SHRUB	Percentage of plot covered by shrubs, in one of four categories: 0%, <5%, 5 to 25%, and >25%.
NEARCON	Distance from the roost tree to the nearest coniferous tree >5 m tall.
DISTBLDG	Distance from the roost tree to the nearest building.
DISTPOLE	Distance from the roost tree to the nearest power pole or lamp standard.
DISTROAD	Distance from the roost tree to the nearest roadway.

cross correlation with TREEHT<5 and TREEHT>5) measured at roost and randomly selected trees were compared initially using univariate analysis of variance. We then performed a multivariate stepwise DFA (Dixon and Brown 1979) to determine differences in habitat structure around roost trees and randomly selected trees. Canonical correlation analysis, based on the most powerful discriminating variables, resulted in a classification distribution for all trees measured. The resulting jackknifed 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. Crown profiles within roost and random tree groups were combined to give average profiles and the resulting values were tested for differences between groups using multivariate analysis of variance (MANOVA; SAS Proc GLM, SAS Institute 1985). We used Raleigh's R to determine the significance of differences in the mean bearings of the building nearest to the roost tree.

## RESULTS

As reported elsewhere for this population (Warkentin 1986, Warkentin and West, 1990), all of the Merlins observed spent winter nights alone in conifer trees (White *Picea glauca* and Blue Spruce *P. pungens*). The means of the habitat variables from 41 occupied roosts and 44 randomly selected trees are in Table 2. TREEHT and DBH were the only variables that demonstrated a statistically significant difference between the two groups. Even when trees in the random sample shorter than the smallest occupied roost tree included in these data (10 m) were omitted from the analysis, the difference between

groups in TREEHT was significant ( $14.5 \pm 2.3$  and  $12.8 \pm 1.9$  m for occupied and random sites, respectively;  $F = 10.97$ ;  $df = 1,72$ ;  $P < 0.01$ ). Twelve trees in the random sample were less than 10 m tall but only one was less than 7 m tall. In the multivariate analysis, the stepwise DFA selected TREEHT, NEARCON, TREEHT<5, and TREEHT>5, as being most important in distinguishing between roost trees and randomly selected trees. The analysis correctly classified 77% of all sites as to their use, 31 (76%) of 41 occupied roosts and 34 (77%) of 44 randomly selected trees were correctly classified; significantly better than expected by chance ( $Z = 4.875$ ,  $P < 0.001$ ). The mean compass bearing to the nearest building was not significantly different from random for either the roost trees or randomly selected trees (occupied: Raleigh's  $R = 5.41$ ,  $P > 0.20$ ; random trees:  $R = 3.48$ ,  $P > 0.50$ , respectively).

Crown profiles of roost trees were significantly different from those of random trees (Fig. 1; MANOVA: Wilk's lambda = 0.75,  $F = 2.45$ ,  $df = 10,74$ ,  $P < 0.05$ ). This overall result was due to significantly greater volumes ( $P < 0.05$ ) for roost trees at all levels except 2-4 m, 16-18 m, and 18-20 m where there was no statistical difference, and the 0-2 m level where random trees had greater volumes than roost trees.

Male Merlins are significantly smaller than females; among wintering adults males are, on aver-

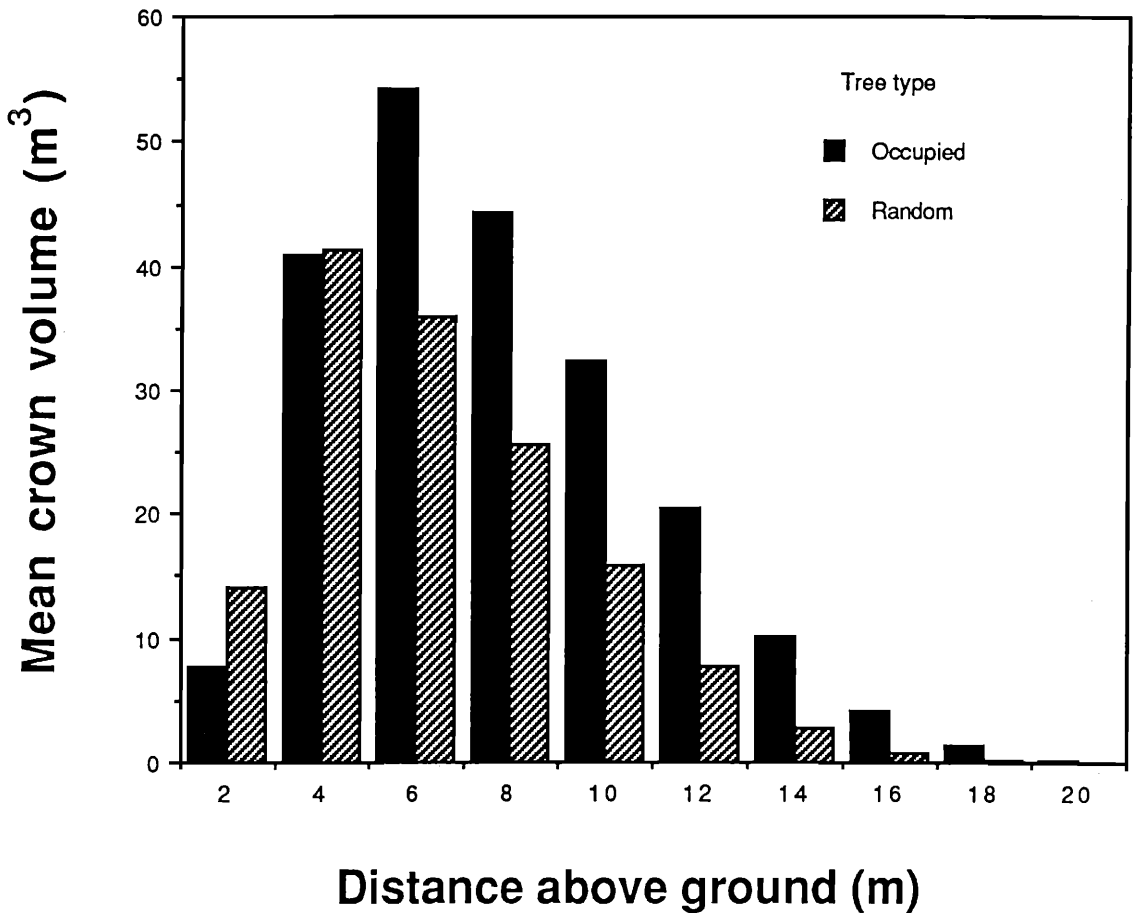


Figure 1. Crown volumes ( $\text{m}^3$ ) of occupied roost trees ( $N = 41$ ) and randomly-selected trees ( $N = 44$ ), at 2-m intervals.

age, 90 g lighter than females (Warkentin et al., 1990). Based on the hypothesis that Merlins are subject to energetic stress while wintering in Saskatoon, and that the use of more protected roosts increases an individual's chance of survival by reducing energetic stress, we predicted that roost sites offering greater protection might be selected more often by males than females. A comparison of roost types for males and females by DFA showed no significant difference when the same variables from the initial comparison were tested (canonical discriminant analysis, SAS Proc CANDISC: Wilk's  $\lambda = 0.71$ ,  $F = 1.25$ ,  $df = 10,30$ ,  $P = 0.30$ ).

#### DISCUSSION

Reduced convective heat loss inside versus outside of the roost has been found in studies of avian nocturnal roosts (Buttemer 1985, Walsberg 1986, Webb and Rogers 1988). Given such findings, we predicted that any substantial sheltering effect from surrounding buildings would be reflected in a significant mean bearing from roost tree to nearby buildings, similar to that of the prevailing winds. Despite prevailing westerly winds, however, there was no apparent use of buildings to provide shelter as indicated by random compass bearings to nearby buildings for both

Table 2. Sample means, standard deviations and coefficients of variation (in parentheses) of habitat variables for winter roosts occupied by Merlins in Saskatoon, Saskatchewan, between 1983 and 1988 (N = 41), and randomly-selected trees in the city of Saskatoon (N = 44).

VARIABLE	OCCUPIED	RANDOM	F(ANOVA)	P <sup>a</sup>
TREEHT (m)	14.3 ± 2.3 (0.16)	11.6 ± 2.5 (0.22)	28.55	<0.001
DBH (cm)	39.5 ± 9.0 (0.23)	31.2 ± 9.2 (0.29)	17.82	<0.001
SHRUB	1.8 ± 0.8 (0.43)	1.8 ± 0.9 (0.48)	0.11	ns
NEARCON (m)	6.6 ± 5.2 (0.79)	8.3 ± 7.6 (0.91)	1.47	ns
DISTBLDG (m)	9.8 ± 9.3 (0.95)	9.5 ± 13.2 (1.39)	0.02	ns
DISTPOLE (m)	19.9 ± 9.4 (0.47)	18.9 ± 10.4 (0.55)	0.21	ns
DISTROAD (m)	9.6 ± 6.7 (0.69)	8.7 ± 6.8 (0.79)	0.40	ns
TREEHT<5	0.9 ± 1.4 (1.54)	0.6 ± 1.0 (1.63)	1.01	ns
TREEHT>5	3.0 ± 2.2 (0.71)	3.2 ± 2.5 (0.80)	0.05	ns

<sup>a</sup> Not significant at 0.05 level.

roost and random trees analyzed. Despite the absence of a major sheltering influence from outside of the roost tree, Merlins usually roosted on the leeward side of roost trees, hopping among the branches before choosing their roost perch (Warkentin, pers. obs.).

Among the variables we considered, the features of primary importance governing the selection of a roost tree by Merlins wintering in Saskatoon appeared to be those of the tree itself, rather than its surroundings. This was apparent in both the univariate analysis (Table 2) and the stepwise DFA in which tree height (TREEHT) was the first variable chosen. The predictive power of the discriminant analysis was based, however, not only on tree height, but also on the distance to the nearest conifer from the roost tree (NEARCON), as well as the number of trees less than, and greater than, 5 m tall within the plot (TREEHT<5 and TREEHT>5). The importance of tree height to roost-site selection was reflected in the comparison of crown volumes for occupied and random trees. Taller trees had greater crown volumes, which was also likely related to the amount of wind reduction experienced by a bird in

its roost, as well as affecting the extent of radiative heat loss through open areas of the canopy above the roost perch. Nearby conifers also may provide added protection from wind and increase the sheltering effect of the roost tree. We found that occupied roosts had a smaller NEARCON distance than did random trees; however, the difference was not statistically significant in the univariate analysis (Table 2). Our inability to detect a significant difference between groups for this distance may reflect our sample size. Similarly, more trees in the vicinity of the roost would be expected if there was a benefit from decreased wind speed in the roost.

It is difficult to determine the importance of predation as a selective pressure for roost-site choices. Although it has been alluded to in the literature (Lack 1968, Walsberg and King 1980), there has been little work in this area. For Merlins resident in urban areas, taller roost trees may be important in reducing mammalian predation, particularly by domestic cats, which are common in the city and often forage at night. Also, Great Horned Owls (*Bubo virginianus*) were observed in the city during each winter of this study. One radio-tagged yearling male

disappeared overnight and apparently was killed while roosting. The bird was radio-tracked to the roost tree at dusk, its position confirmed that night, and monitoring resumed before dawn the next morning when the radio was discovered on the ground underneath the tree. In the absence of other nocturnal avian predators, the lack of remains beneath the roost, except for some tail feathers attached to a piece of flesh, suggested predation by an owl.

One might predict that repeated use of the same roost tree could be dangerous, because predators may be able to detect roosting birds by the accumulating feces and regurgitated pellets. There was no apparent pattern among radio-tagged Merlins in the repeated use of individual roosts; one adult female used the same roost site continuously for a period of 33 nights, yet four other adults were much more varied and used 6 different roosts in an 11-night period, 3 roosts in 11 nights, 10 roosts in 47 nights, and 4 roosts in 51 nights of monitoring. Yearlings ( $N = 3$ ) varied in their roosting behavior from extended use of the same tree (one roost for 7 nights), to at least 4 roosts in a 10-night period. In some cases, differing patterns of winter roost use may reflect the level of commitment to a former or future breeding site within the winter home range (Warkentin and Oliphant, in press), habitat use during the active phase prior to roost entry, or perhaps experience with predators. There is little overlap between daytime perches and nighttime roosts, and little tendency to use night roosts for hunting during the day. On average, only 19% of the daylight phase was spent within 250 m of the main roost by radio-tagged Merlins (Warkentin and Oliphant, in press). Thus, local prey availability has little apparent influence on the selection, or consistency of use, of night roosts.

The phenomenon of nonmigratory individuals among populations of Merlins breeding in the northern Great Plains is a recent development (James et al. 1987). Traditionally, all birds from northern populations were migratory. However, there is now an apparent dichotomy with rural populations remaining strictly migratory and many urban populations displaying partial migration. Because all birds in this and other studies of North American Merlins appear restricted to the use of conifers for winter roosts, the availability of roosts may have been one limiting factor in the colonization of the northern Great Plains as a wintering area. Roosting in conifers provides a savings of about 6% of the total daily energy expenditure for Merlins wintering in

Saskatoon (Warkentin and West, 1990). Considering that most conifers in the city are the result of human planting beginning 60-80 years ago, trees large enough to provide sufficient protection from the elements in winter may only recently have become available. Several studies have suggested that the availability of roosting sites may influence the winter distribution of some species (see Eiserer 1984 for review). Mills (1975) found that the distribution of American Kestrels (*F. sparverius*) wintering in Ohio was closely linked to the availability of old buildings or other such sheltered roosts. The relatively recent availability of conifers may, in part, explain the northward expansion of the Merlin's wintering range. However, it also raises the question of why communal roosting evolved in Palearctic populations of Merlins (where there has been some speculation that roost sites may be limiting, at least in some locations; Sys 1982), but not in an apparently similar local situation in North America, where Merlin density also may have been limited by roost availability.

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