

SPATIAL ASPECTS OF ROOST-SITE SELECTION IN BREEDING MALE DARK-EYED JUNCOS¹

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With the exception of a few species that roost communally or in cavities (e.g., Kluyver 1957, Meanley 1965, Kilham 1971, Pitts 1976, Swingland 1977, Lyon and Caccamise 1981, Morrison and Caccamise 1985, Stouffer and Caccamise 1991), roost-site selection is one of the more poorly known aspects of habitat use in passerine birds (Cody 1985). Available studies indicate that roost sites are chosen with respect to energetic considerations (Kendeigh 1961; Buttemer 1985; Walsberg 1986, 1990; Buttemer et al. 1987) or predator avoidance (Lack 1968, Walsberg and King 1980). Although it is also recognized that roosts (particularly communal ones) may be positioned with respect to local resource availability (e.g., Morrison and Caccamise 1985, Caccamise and Morrison 1988), roost-site selection may play a broader role in the spatial activity of birds. Choice of a particular roost might determine not only access to feeding sites, but also a variety of other behavioral options open to an individual at dawn (e.g., territory defense, intrusion onto neighboring territories). Conversely, behavioral demands at dawn might constrain roost-site selection (Chandler and Tolson 1990 provide an example for male lizards).

In this note we describe spatial aspects of roost-site selection in breeding male Dark-eyed Juncos (*Junco hyemalis*). The purpose of our analysis was to explore the possible role that roost sites might play in the overall spatial activity of a male passerine bird during the breeding season. Specifically, our objectives were to quantify (1) the spatial distribution of roost sites relative to the diurnal activity of male juncos, (2) the short-term (3–5 days) stability of these sites, and (3) the physical characteristics of summer roost sites.

METHODS

We studied juncos (*J. h. carolinensis*) at Mountain Lake Biological Station, Giles County, Virginia (37°22'N, 80°32'W) during the summers (May–July) of 1990 and 1991. Juncos are abundant summer residents at this montane site in southwestern Virginia (see Chandler et al. 1994 for a complete description). Males establish territories in March or April, pair socially with a single

female (polygyny is very rare), and feed nestlings at rates equal to those of the female (Ketterson et al. 1992). Since 1983, almost all of the 150–200 juncos occurring in the vicinity of Mountain Lake each summer have been banded with U.S. Fish and Wildlife Service bands and marked with a unique combination of color bands.

We quantified the roost sites of 13 individuals as part of a broader study of the effects of testosterone on spatial activity in male juncos (Chandler et al. 1994). All birds involved in this study had received small, subcutaneous silastic implants earlier in the spring (April). Control males received empty implants and testosterone males received implants filled with crystalline testosterone (which maintained their testosterone levels at spring maxima throughout the summer; Ketterson and Nolan 1992). Although we identify the treatment status of all birds used in the analysis of roost sites, the effects of testosterone were not the focus of this study (for details of this work see Ketterson et al. 1991, 1992; Ketterson and Nolan 1992; Chandler et al. 1994). The majority ($n = 9$) of birds used in this analysis were control males (no hormone manipulation), and there were no apparent differences in roost sites between the two treatment groups (see below).

Roosts were found by placing a small radiotransmitter (from Wildlife Materials, Inc., Carbondale, IL in 1990; AVM Corp., Livermore, CA in 1991) on each male. Males were captured near their nests in mist nets or traps, equipped with a transmitter, and returned to their territories within 30 min. The transmitters were no more than 5% of the body mass of any individual and were attached with eyelash glue and cyanoacrylate to the birds' upper back (Chandler et al. 1994 provide details of the attachment procedure). Individuals were located using a hand-held Yagi antenna and a Wildlife Materials Merlin 24 receiver. Transmitters had no detectable effect on male activity.

Roosting juncos were located between 22:00 and 24:00 for 3–5 consecutive nights during the time when they had active nests containing eggs or nestlings. We followed transmitter signals to their source, approached to within approximately 10–20 m of the roost (being careful not to disturb the bird), and determined the tree being used as a roost site. In dense forest we carefully circled the site to identify the source of the signal with precision. Each site was then flagged and we returned later to identify the species of tree used for roosting, to estimate the height of the tree (to the

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TABLE 1. Summary of roost-site selection by male Dark-eyed Juncos.

	Number of nights tracked	Number of roost sites	Number of sites off territory	Number of nights spent off territory	Mean distance (m) between sites (\pm SE)
Control males					
1	4	4	0	0	62.9 (19.1)
2	3	2	1	1	216.3
3	3	2	1	1	195.9
4	5	4	0	0	98.4 (31.1)
5	4	1	0	0	—
6	4	1	1	4	—
7	3	2	0	0	46.0
8	4	1	0	0	—
9	5	3	2	3	158.3 (46.3)
Testosterone males					
10	4	4	2	2	176.1 (39.1)
11	3	2	0	0	81.2
12	4	1	0	0	—
13	3	2	1	1	325.1
Mean	3.8	2.2	0.6	0.9	

nearest meter), and to map the location (Chandler et al. 1994).

RESULTS

We located 49 roost sites of 13 individual juncos (Table 1). Nine of these individuals (69%) used multiple sites, with three individuals using as many as four different sites over 4–5 nights. Male juncos averaged slightly more than two roost sites per individual over an average of about four nights (Table 1). In those individuals with multiple roosts, the mean distance between sites ranged from 46–325 m (Table 1).

Not only was the use of multiple sites common, but some individuals roosted beyond the apparent boundaries of their territory. These off-territory roosts were identified conservatively as sites (1) located beyond the daily activity range of an individual (as indicated by diurnal radiotelemetry during the same time period; Chandler et al. 1994) and (2) known to be in areas defended by another male. Using these criteria, 46% (6/13) of males had at least one site located off their territory. In one case, a male failed to roost on his territory on any of four consecutive nights (male #6; Table 1).

Off-territory sites ($n = 8$) were often considerable distances from a male's own nest ($\bar{x} = 243.2 \text{ m} \pm 34.9 \text{ SE}$; range 110–427 m). However, the exact spatial significance of these sites was not always clear. The off-territory roost of male #6 was located within 10 m of a frequent song perch of a neighboring male. Male #10 roosted for a single night within 20 m of a nest where a neighboring female was in the process of laying a clutch. Male #13 roosted for a single night directly above a favored feeding site of a neighboring pair of birds.

All junco roosts were located in coniferous trees (33

in hemlocks, *Tsuga canadensis*; 11 in pines, *Pinus* spp.; and 5 in ornamental spruce, *Picea* spp.), despite the fact that deciduous trees outnumbered conifers on the territories of all juncos involved in this study. Height of roost trees ranged from 2 m (ornamental spruce) to about 25 m (mature hemlock) ($\bar{x} = 10.6 \text{ m} \pm 1.3 \text{ SE}$). We could not determine precise heights of the actual perch, but if the height of the tree permitted most juncos roosted several meters above the ground.

DISCUSSION

Our results demonstrate that male juncos during the breeding season show considerable short-term variability in choice of a roost site, that these sites are occasionally located off an individual male's territory, and that coniferous trees are used for roosting.

Some other passerines are known to change roost sites nightly (Pitts 1976) or over other short time periods (Nolan 1978, Morrison and Caccamise 1985, Atkinson 1993). In the case of juncos, at least for within-territory shifts of roost site, the most likely explanation for this frequent movement is predator avoidance. Frequent changes in the location of a roost would minimize visual (droppings) and olfactory cues that might attract predators (Pitts 1976). There are other passerines that use the same roost for extended periods of time, but these tend to be nest, cavity, or communal roosters (e.g., Kilham 1971, Balda et al. 1977). The need for predator avoidance through frequent changes of roost site may be greater in species (like juncos) that roost solitary in foliage. Another possibility is that some male juncos simply roost wherever nightfall overtakes them. However, several juncos, including some of those individuals with multiple sites, were observed to fly considerable distances to a roost site at dusk.

Predator avoidance is unlikely to explain the off-territory roosts of some male juncos. Shortage of appropriate roost sites is probably not a factor either. Although deciduous trees outnumber conifers on almost all junco territories at Mountain Lake, all males involved in this study had many coniferous trees available as potential roost sites on their territories (trees that appeared identical to those used as off-territory roosts). We cannot eliminate the possibility that appropriate roosts are limiting on some junco territories, but we believe it is unlikely.

It seems more likely that off-territory roosts are an active part of territorial intrusions by male juncos. Male passerines frequently intrude onto neighboring territories (e.g., Nolan 1978, Leary and Sullivan 1991) and might facilitate successful intrusion by moving onto those territories in the poor light of dusk and being present, unseen, at dawn. These males may gain extra-pair fertilizations (Birkhead and Møller 1992; P. Parker, E. D. Ketterson, V. Nolan, Jr., unpubl. data for this population of juncos), useful information about their neighbors' activities or territory quality, or temporary use of a high-quality feeding site before returning to their own territory shortly after dawn. The possible role of roost sites in the more general spatial activity of breeding male birds deserves further study.

During the breeding season, male juncos roosted exclusively in coniferous trees. Wintering juncos also favor coniferous trees as roost sites (Gottfried and Franks

1975, Webb and Rogers 1988). The use of conifers by wintering juncos has been interpreted as an energy-saving strategy, but the evidence for energy savings is equivocal (Webb and Rogers 1988, Walsberg and King 1980) and the preference for conifers persists in the breeding season when energetic concerns are likely to be minimal (nighttime temperature during the study did not drop below approximately 10°C). The dense foliage of conifers probably makes a more important contribution to reducing predation (e.g., Walsberg and King 1980).

In summary, the roost sites used by male Dark-eyed Juncos are variable in both space (occurring both on and off territory) and time (often shifting from night to night). We suggest that this variability may reduce predation rates (for shifts within the territory) and may affect male diurnal spatial activity by facilitating intrusions onto neighboring territories. The possible use of roost sites to facilitate territorial intrusions by male birds adds another factor to those known to influence selection of a roost site. More generally, the spatial distribution of roosts in breeding birds that traditionally have been thought to restrict all activities to an all-purpose Type-A territory (Hinde 1956) deserves greater attention.

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GENETIC VARIATION AND NESTING BALD EAGLES¹

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As habitats become fragmented, once-contiguous populations may be spatially isolated and reduced in size. In addition, new populations may arise through dispersal and colonization. When this occurs, the founding population is often small and there is a reduced chance that the founding individuals represent the full genetic complement found in the parent population. Resulting populations may be characterized by reduced heterozygosity and allelic diversity. We assessed genetic variation in two nesting populations of Bald Eagles (*Haliaeetus leucocephalus*): a small isolated one in Colorado and a large contiguous one in Ontario, Canada. We predicted that the Colorado population would have reduced heterozygosity and allelic diversity when compared with the Ontario population.

STUDY AREA AND METHODS

The Colorado Bald Eagle population is apparently recent in origin and, at the time of our study, consisted of 14 breeding pairs and was at least 300 km away from any other nesting population (i.e., Arizona and Yellowstone, in Montana and Wyoming). The northwestern Ontario population is part of a large contiguous population of nesting eagles which stretches from the Atlantic seaboard to the Pacific Ocean and numbers close to 10,000 nesting pairs (Stalmaster 1987). The study populations and sites are described in detail elsewhere (Grier 1974, Grier 1982, Kralovec et al. 1993).

During the breeding seasons of 1988–1991, we collected tissue samples from 72 nestlings (Colorado = 20 birds; Ontario = 52 birds) when young were 6–10

weeks old. Tissues included mature pin feathers, blood cells and serum and were analyzed using starch-gel electrophoresis (Stangel et al. 1992). Electrophoretic conditions and general staining procedures were those of Selander et al. (1971) and Harris and Hopkinson (1976). Each sample was scored at 32 presumptive genetic loci (Appendix 1). Buffer codes are identified as follows: A = amino propylmorpholine citrate—pH 6.0 (Clayton and Tretiak 1972); B = lithium hydroxide—pH 8.1 (Selander et al. 1971); C = tris citrate—pH 8.0 (Selander et al. 1971); D = tris maleate—pH 7.4 (Selander et al. 1971). Stain recipes were taken from Selander et al. (1971), Siciliano and Shaw (1976), Harris and Hopkinson (1977), and Lydeard et al. (1989). The following systems were not adequately resolved in our analyses: enolase, glyoxalase 1; guanylate kinase, inosine triphosphate, pyruvate kinase and triosephosphate isomerase.

RESULTS AND DISCUSSION

All loci were monomorphic except peptidase 2. There were eight heterozygotes and no homozygotes for the rare allele observed among the 52 birds from Canada (frequency of 8% [8/104]). Peptidase 2 was monomorphic among the birds from Colorado. The probability of not detecting this rare allele in Colorado from a sample of 20 birds is quite low (0.036 [0.92⁴⁰]).

Although the two eagle populations we studied differed dramatically in spatial isolation and population size, we found virtually no allozymic genetic variation between and within them. This study is one of very few cases where an apparent lack of variation was reported for a bird species in which a relatively large number of individuals and loci were screened (Bar-

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