JOURNAL OF FIELD ORNITHOLOGY
Formerly BIRD-BANDING
A Journal of Ornithological Investigation

VOL. 53, No. 4 AUTUMN 1982 PAGES 305–462

J. Field Ornithol., 53(4):305–314

ON SEX-SPECIFIC FORAGING BEHAVIOR IN THE WHITE-BREASTED NUTHATCH

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The White-breasted Nuthatch (*Sitta carolinensis*) is a common member of North American bark-foraging guilds in winter. Because plumage differences between males and females are slight and often difficult to discern in the field, previous reports have routinely lumped records for the sexes while considering foraging behavior and sociality (e.g., Stallcup 1968, Morse 1970, Willson 1970, Austin and Smith 1972, Grubb 1975, 1977, 1978). McEllin (1979) demonstrated that White-breasted Nuthatch (WBN) sexes could be identified in the field if the observer looks carefully with binoculars for the sex-specific field marks. At his study site in Colorado, male and female WBN revealed statistically distinct patterns of foraging height and foraging substrate selection within a montane parkland habitat dominated by ponderosa pine (*Pinus ponderosa*). In contrast with McEllin's findings, male and female WBN from the deciduous woodlands of central Ohio showed statistically indistinguishable selection of branch sizes on which to forage in a laboratory aviary (Pierce and Grubb 1981). However, in the aviary individual WBN foraged in isolation, while in McEllin's field study male and female WBN foraged in close proximity to one another. During the winter of 1980–1981, I pursued field work with Ohio birds to ascertain whether Colorado and Ohio WBN differ in sex-specificity of foraging in nature, or whether some laboratory artifact had been responsible for the apparent discrepancy.

Previous studies of foraging behavior in avian guilds have been faulted for considering only a fraction of environmental factors potentially controlling foraging techniques (Grubb 1979). Therefore, as a second objective of my study, I attempted to relate WBN foraging to variation in time-of-day, day-of-winter, weather conditions, and social environment.

METHOD

My study area in Bennington Township, Morrow County, Ohio, has been described previously (Grubb 1977, 1978). Between 15 November 1980, arbitrarily defined as the first day of winter, and the end of February 1981, when the study was concluded, this 26-ha deciduous woodland supported a minimum of 9 territorial pairs of WBN. As McEllin (1979) found in Colorado, WBN in Ohio foraged in male-female pairs,

maintaining continual intra-pair vocal contact. Estimates of foraging height and substrate diameter, and records of substrate type were taken concurrently for the male and female; this procedure assured that external factors were impinging to the same extent on the foraging of the sexes. To make reasonable the assumption of statistical independence among foraging events, I allowed at least 1 min between successive records, and took no more than 5 records in sequence per pair. Methods for recording weather conditions were those of Grubb (1975), except that solar radiation was noted as watts per square meter ($W \cdot m^{-2}$) with a portable radiometer ("Solar Meter," Dodge Products, Houston, Texas) held so the plane of the photocell was perpendicular to the sun's direction.

To assess the impact of social environment on WBN foraging, I noted all heterospecifics within 25 m of either pair member. This procedure did not distinguish heterospecifics participating in a mixed-species flock with the WBN from those simply aggregating with them (Grieg-Smith 1978). Heterospecifics were divided into those socially dominant or subordinate to WBN on the basis of my unpublished observations that WBN dominate species of smaller body size, and are subordinate to larger species.

Most statistical analyses employed simple and partial Spearman correlation techniques (Conover 1971). While such procedures cannot be used to assess cause and effect relationships, they can help locate, among large quantities of data gathered under uncontrolled circumstances, those relationships warranting closer inspection (Wright 1921, Myers et al. 1981). Because Spearman partial correlation coefficients are not distribution-free, tests of their significance using the Spearman test statistic were only approximate (Conover 1971). Therefore, the results of such tests should be interpreted with caution.

RESULTS

The work was conducted between "days of winter" 10 and 101, during which period temperatures accompanying records of foraging averaged $-4.0°C \pm .5$ SE, wind velocities averaged $1.0\ m \cdot sec^{-1} \pm .0$ SE, radiation levels averaged $242\ W \cdot m^{-2} \pm 27$ SE, and snow depths averaged 7.1 cm $\pm$ .8 SE. The measure for time of day used in further analysis is minutes from solar noon, which averaged 164 ± 7.9 SE during the study. Analysis of variance showed no significant differences between morning and afternoon records of WBN foraging independent of minutes from solar noon. Over the course of the winter, the number of socially dominant and socially subordinate heterospecifics within 25 m of foraging WBN averaged $.3 \pm .0$ SE and $.5 \pm .1$ SE individuals, respectively (Table 1).

A summary comparison over the whole winter between WBN in Colorado (McEllin 1979) and in my Ohio study area showed substantial disagreement in the extent to which foraging was sex-specific. Females in Colorado foraged significantly higher than males (females: 7.70 m $\pm$ .59 S.E., N = 99; males: 2.80 m $\pm$ .41 S.E., N = 167; t-test, $P < .01$);

TABLE 1. Occurrence of other species within 25 m of foraging pairs of White-breasted Nuthatches.

Species	% occurrence (n = 105)	Number of individuals, when present ($\bar{x}$ ± SD)
Brown Creeper[1] (*Certhia familiaris*)	4	1.0 ± 0.0
Carolina Chickadee[1] (*Parus carolinensis*)	11	1.7 ± 0.6
Tufted Titmouse[1] (*Parus bicolor*)	14	1.7 ± 1.0
Downy Woodpecker[2] (*Picoides pubescens*)	22	1.1 ± 0.2
Red-bellied Woodpecker[2] (*Melanerpes carolinus*)	3	1.0 ± 0.0
Red-headed Woodpecker[2] (*Melanerpes erythrocephalus*)	1	1
All subordinate to WBN	27	1.9 ± 1.4
All dominant to WBN	22	1.1 ± 0.3
All	40	1.8 ± 1.3

[1] Subordinate to WBN.
[2] Dominant to WBN.

heights of the sexes in Ohio were indistinguishable (females: 8.4 m ± 0.3 S.E., N = 105; males: 8.5 m ± 0.4 S.E., N = 105; *t*-test, $P > .50$). McEllin (1979) could sensibly divide pine trees into trunk, limb, branch, and twig. This terminology became ambiguous when applied to deciduous growth. Specifically, unlike pine trees, many deciduous trees divide close to the ground into two or more stems. I was unsure whether such stems should be considered trunks or limbs in McEllin's terminology. Therefore, I divided foraging substrates into primary (emerging from the ground), secondary (branching from primary), tertiary (branching from secondary), and quaternary (branching from tertiary) categories. Nevertheless, except for the multiple-stemmed trees in my area, there appears to be a good deal of correspondence between the systems of classification. Foraging Colorado WBN sexes differed markedly in preferred structure (chi-square test, $P < .05$) with males concentrating on trunks and females found mostly on the intermediate, limb, category. In Ohio, both sexes relied on primary and secondary substrates and were statistically identical (chi-square test, $P > .70$, Fig. 1). The branch diameters used by Ohio male (13.0 cm ± 1.0 SE) and female (11.0 cm ± .9 SE) WBN over the course of the winter also were not significantly different (*t*-test, $P > .05$); this measure is not available for the Colorado birds.

The reason(s) why WBN sexes foraged differently in Colorado, but similarly in Ohio, could become more apparent if the factors controlling choice of height, substrate type, and substrate diameter by each sex were known. As a first step, I pursued my second objective by performing a correlation analysis with the Ohio birds.

Correlations with time of day, weather, and seasonal variables.—Comparing the foraging behavior of each sex with day of winter, temperature, wind

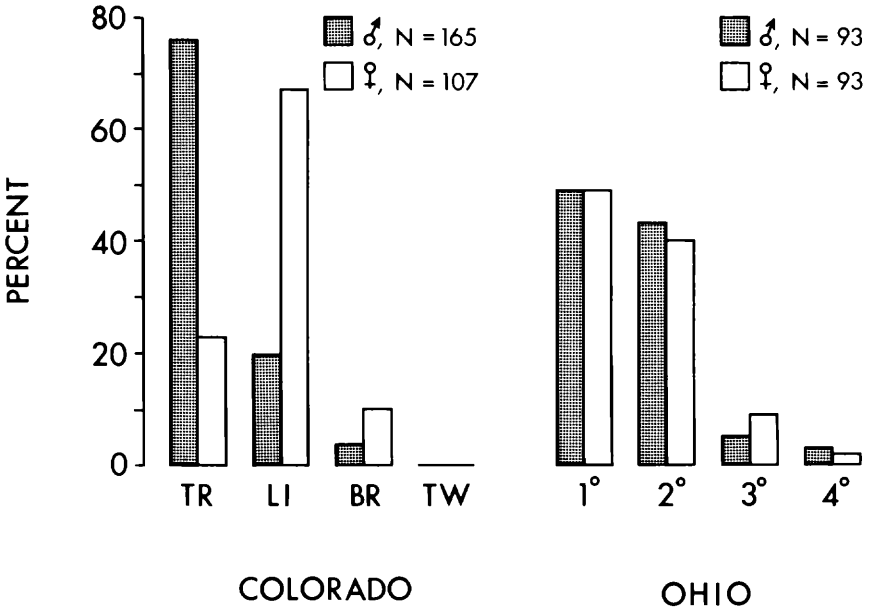


FIGURE 1. Substrate types selected by foraging male and female White-breasted Nuthatches in Colorado and Ohio. For the Colorado birds, TR = trunk, LI = limb, BR = branch, and TW = twig. For the Ohio birds, 1°–4° = primary through quaternary branch categories.

velocity, solar radiation, snow depth, and minutes from noon produced 7 statistically significant relationships (Table 2). Both male and female heights were correlated with minutes from noon and day of winter, but the latter 2 variables were autocorrelated ($r = .61$, $P < .0001$). Analysis of partial correlations showed that when the effect of minutes from noon was held constant, the significant relationship between foraging height and day of winter disappeared for each sex. This result indicated that the correlations between foraging height and day of winter were simply reflections of independent relationships with minutes from noon; time of year apparently had no direct effect on how high in the woodland the WBN looked for food.

Autocorrelation analysis suggested that 2 pairs of variables affected female height independently, minutes from noon and day of winter having been just discussed. Wind velocity and solar radiation, significantly correlated with female height and with each other ($r = -.35$, $P = .0003$), were not related to minutes from noon or to day of winter. When these latter 2 variables were partially correlated with female height, no simple correlation was reduced to non-significance. It appears that wind velocity and solar radiation acted independently on female height.

The only other significant correlation between a foraging variable and

TABLE 2. Significant correlations between White-breasted Nuthatch foraging and environmental variables.

Measure of foraging	Minutes from solar noon	Day of winter	Wind velocity ($m \cdot sec^{-1}$)	Solar radiation ($W \cdot m^{-2}$)	Temperature (°C)	Number of subordinate heterospecifics
Height of male (m)	.43[1] <.0001[2]	.24 .01	—	—	—	−.25 .0009
Height of female (m)	.40 <.0001	.23 .01	−.20 .04	−.19 .05	—	−.21 .03
Substrate type of female	—	—	—	—	.21 .04	—

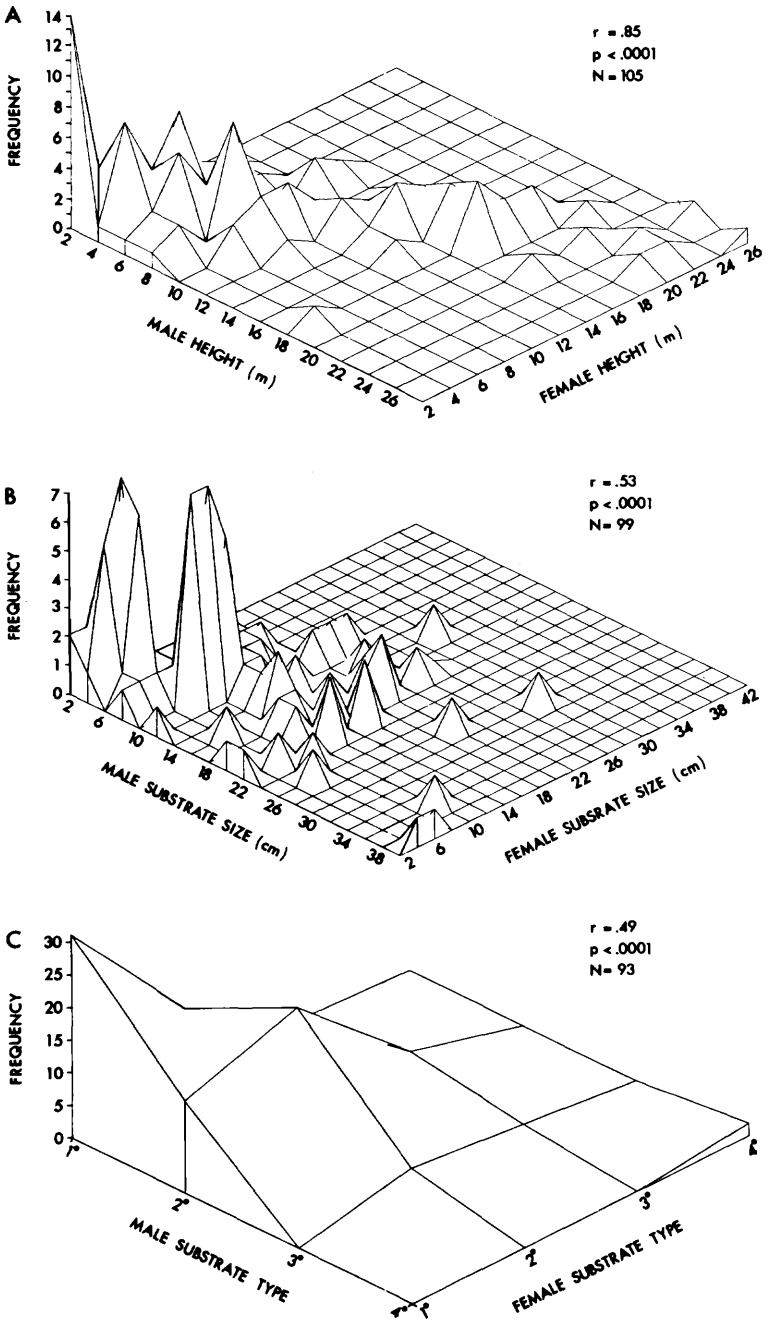
[1] Spearman rank correlation coefficient.
[2] Probability of significance.

an abiotic factor involved a positive relationship between substrate type selected by females and ambient temperature (Table 2). This pairing was not made ambiguous by any autocorrelations involving temperature.

Correlations with social environment.—Male and female WBN foraged significantly lower in the woodland as the number of subordinate heterospecifics in their company increased (Table 2). The number of subordinate heterospecifics near WBN was autocorrelated with minutes from noon, but partial correlations suggested that WBN height and number of subordinates were correlated independently of their relationships with time of day. Other WBN foraging behavior was not related to number of subordinates, and number of dominant heterospecifics within 25 m was statistically independent of where the WBN looked for food.

Correlations among the 3 categories of foraging behavior.—In both WBN sexes, substrate type selected was positively correlated with foraging height ($r = .60$, $P < .001$ in males; $r = .49$, $P < .0001$ in females) and negatively correlated with branch size ($r = -.42$, $P < .0001$ in males; $r = -.46$, $P < .001$ in females). Foraging height and branch size were not related in either males ($r = .16$, $P = .10$) or females ($r = .004$, $P = .96$). The foraging behavior of the sexes was significantly positively correlated in each of the three parameters measured. Heights were most similar, with substrate sizes and types correlated to about the same, lesser extent (Fig. 2).

Dominance and leadership between the sexes.—Field observers commonly attribute social dominance to an individual animal that supplants a second individual from some location in a habitat (Morse 1980). Male WBN supplanted females 5 times during my study, with females never reciprocating. The conclusion drawn from this that males are socially dominant to females agrees with extensive records at bird feeders (Grubb


A
FREQUENCY
r = .85
p < .0001
N = 105
MALE HEIGHT (m)
FEMALE HEIGHT (m)
B
FREQUENCY
r = .53
p < .0001
N = 99
MALE SUBSTRATE SIZE (cm)
FEMALE SUBSRATE SIZE (cm)
C
FREQUENCY
r = .49
p < .0001
N = 93
MALE SUBSTRATE TYPE
FEMALE SUBSTRATE TYPE

unpubl.). On 31 occasions, a pair of WBN flew considerable distances between foraging sites. At these times, an unambiguous designation of leader or follower could be applied to each sex. Males followed females 12 times and females followed males 19 times, a non-significant asymmetry (chi-square test, $P = .21$).

DISCUSSION

The major conclusion from this analysis of WBN foraging in Ohio is that the male and female of each pair mimicked their partner's foraging behavior. The records in Figure 2, taken simultaneously on both birds of a pair, show that as one bird moved higher, used larger branches, or those farther from the trunk, so did the other. The leadership result suggests that even though the male was dominant, the female was as likely to mimic his behavior as he was hers.

After starting the morning high in the trees, the pair descended toward the midday and moved up in the canopy again as the afternoon wore on. The variation in weather conditions was not extensive during this study, and the overall insensitivity of WBN foraging behavior to this range of climatic conditions was in agreement with Grubb's (1975) findings. White-breasted Nuthatches forage close to large substrates; some other members of their foraging guild are not so sheltered from the wind and respond more strongly to weather variation (Grubb 1975, 1977, 1978). Changes in wind velocity, solar radiation, and temperature were weakly correlated with some aspects of female WBN behavior. The negative correlation between WBN height and the number of accompanying individuals of subordinate species appears to have been a consequence of aggregations under mast trees. Many records of WBN low in the woods around midday were of birds searching leaf litter for mast fallen from American beech (*Fagus grandifolia*) trees. Subordinate Carolina Chickadees (*Parus carolinensis*) and Tufted Titmice (*P. bicolor*) often were looking for the same food. Close proximity of dominant heterospecifics had no influence on the nuthatches' foraging behavior.

The disparity in sex-specific foraging of WBN in Colorado and Ohio requires further attention. In both locations, a heterosexual pair of WBN looked for food while moving together through an area they defended against conspecifics. Individuals of other species were permitted in the territory and the WBN sometimes foraged near them.

Selander (1966) has reviewed cases where sex-specific foraging in birds was correlated with sexual dimorphism. However, significant sexual dimorphism was not found in Colorado and Ohio WBN. In both locations, the sexes were statistically indistinguishable in each of 4 morpho-

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FIGURE 2. Correlations between foraging heights (A), substrate sizes (B), and substrate types (C) selected simultaneously by male-female pairs of White-breasted Nuthatches wintering in Ohio. Correlation coefficients, their probabilities of significance, and sample sizes are shown in the figures.

TABLE 3. Morphology of adult male and female White-breasted Nuthatches in Colorado and Ohio.[1]

Measurement	Locality	Male	Female	P[2]
Weight (g)	Colorado	17.8 ± 1.2 (6)[3]	17.6 ± 1.0 (4)	ns
	Ohio	21.6 ± 0.6 (5)	21.2 ± 1.3 (4)	ns
Wing length (mm)[4]	Colorado	90.3 ± 1.6 (6)	89.2 ± 0.9 (4)	ns
	Ohio	89.0 ± 2.2 (6)	90.3 ± 1.3 (6)	ns
Culmen length (mm)	Colorado	19.1 ± 0.5 (6)	18.6 ± 0.5 (3)	ns
	Ohio	20.5 ± 1.3 (6)	20.6 ± 0.8 (6)	ns
Culmen width (mm)[5]	Colorado	4.2 ± 0.0 (6)	4.0 ± 0.0 (3)	ns
	Ohio	4.5 ± 0.2 (6)	4.6 ± 0.0 (3)	ns

[1] Measurements are of specimens in the collections of Colorado State University and The Ohio State University.
[2] t-test between mean values for males and females.
[3] $\bar{x}$ ± S.D. (n).
[4] Flattened chord of right wing.
[5] Measured across the midpoint of the external nares.

logical measurements considered important to foraging behavior (Table 3).

The WBN sexes in Colorado and Ohio were similar in the extent of their physical dimorphism. Therefore, the difference in sex-specificity of foraging between the locations must have been caused by variation in one or more extrinsic factors. The composition, distribution, and abundance of food resources differed between the locations. As a pair of obvious examples, there were no pine seeds in Ohio and no beech nuts in Colorado. The prevailing weather conditions in Colorado surely varied from those in Ohio, although lack of Colorado weather records prevents a direct comparison. The species composition of the bark foraging guild also was not the same at the 2 sites. A listing of all bird species foraging in his Colorado area was not germane to McEllin's report, but his records show that the Pygmy Nuthatch (*Sitta pygmaea*) was there in abundance. This species is unknown in Ohio. Conversely, range maps indicate that several species present in Ohio (Carolina Chickadee, Tufted Titmouse, Red-bellied Woodpecker, Red-headed Woodpecker) would not have been found at the Colorado site. Whether degree of sex-specificity of foraging in the White-breasted Nuthatch is a response to food distribution, prevailing climate, and/or interspecific social environment can only be determined after additional field work has been accomplished in a variety of deciduous and coniferous habitats across the continent-wide range of this species.

SUMMARY

Male and female White-breasted Nuthatches (*Sitta carolinensis*) wintering in a coniferous forest in Colorado displayed significantly different for-

aging niches (McEllin 1979). Sex-specific niches of the same species wintering in deciduous habitat in Ohio were statistically identical; members of each territorial pair were highly correlated temporally in all 3 niche parameters measured. In both Colorado and Ohio, the nuthatch sexes were statistically identical in 4 morphological attributes considered important to foraging behavior.

Further records in a variety of deciduous and coniferous habitats across the extensive range of the species may determine whether sex-specificity of foraging is a behavioral response to local abundance and distribution of food, prevailing weather conditions, and/or species composition of the bark-foraging guild.

ACKNOWLEDGMENTS

I thank L. Vangilder for help with statistics and programming. M. Cunningham measured the nuthatch specimens from Colorado. R. Gifford, W. Riggs, and the heirs of S. Finkbone granted permission to work on their properties. R. N. Conner, S. M. McEllin, and D. H. Morse criticized earlier drafts. This study was supported in part by NSF grants DEB-7821433 and DEB-8018899.

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NOTES AND NEWS

Color-marked Common Terns.—The Canadian Wildlife Service, Ontario Region, is continuing its program of color-marking Common Terns at two colonies in the lower Great Lakes to determine their post-breeding dispersal, migration routes, and winter range. In 1981 adults were marked with orange wing-tags and chicks with pink tags. Many of the adult-tagged birds returned to their colonies in 1982 still carrying their tags. The tagged birds appeared fit and nested normally. Most tags were still clearly legible and showed little wear. In 1982 bright blue wing tags (with black lettering) were put on adult Common Terns and black tags (with yellow lettering) on chicks just prior to fledging. Tags were put on both wings of all birds. All tags have combinations of letters and numbers (the two tags on any bird have the same combination). When you observe a tagged tern would you please report the date, location, color of the tag, and, if possible, the number/letter combination to: BANDING OFFICE, CANADIAN WILDLIFE SERVICE, HEADQUARTERS, OTTAWA, ONTARIO, CANADA, K1A 0E7. All reports will be acknowledged.

Color-marked Kites.—As part of a project to reestablish Swallow-tailed Kites in southern Kansas and to study the population biologies of this species and the Mississippi Kite, individuals of both species are being color banded. Some Mississippi Kites have also been given a colored patagial streamer on each wing. It would be appreciated if observations of these marked individuals, including color and condition of the markers and activity of the birds, were reported to the Office of Migratory Bird Management, Laurel, Maryland 20708 with a copy to Dr. Jim Parker, Department of Sciences and Mathematics, University of Maine at Farmington, Farmington, Maine 04938.