

Nest-Site Characteristics of Red-bellied and Red-headed Woodpeckers and Northern Flickers in East-Central Ohio¹

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ABSTRACT. In order to understand more clearly what factors limit the reproductive success of primary cavity-nesting birds, it is important to examine and compare the nest-site characteristics of sympatric species in a variety of forest and woodland habitats. To add to the data already available on various woodpecker species in eastern and central North America, several nest-site and habitat characteristics were compared and quantified for 46 red-bellied woodpecker (*Melanerpes carolinus*), 26 red-headed woodpecker (*M. erythrocephalus*), and 44 northern flicker (*Colaptes auratus*) nest cavities. Flicker nest cavities had larger entrances and were located lower in trees than were red-bellied and red-headed woodpecker cavities. Red-bellied woodpeckers excavated fresh nest cavities surrounded by bark in living trees significantly more often than flickers and red-headed woodpeckers. Red-bellied woodpecker cavities were also located in limbs angling downward more often than those of flickers and red-headed woodpeckers, although the difference in frequency was not significant. The compass orientation of nest cavities was random in all species. Red-bellied woodpeckers nested in forested areas with abundant ground vegetation more frequently than did flickers and red-headed woodpeckers. The continued existence of northern flickers and particularly red-headed woodpeckers in the Unglaciated Plateau region of Ohio is probably dependent on the continued existence of large dead trees in the region.

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INTRODUCTION

Woodpeckers and other cavity-nesting birds are largely dependent on dead or dying trees for nest sites (Conner et al. 1976, Evans and Conner 1979, Scott 1979, Mannan et al. 1980, van Balen et al. 1982, Raphael and White 1984) and indeed have become increasingly threatened by a reduction in the number of dead trees (snags) (Raphael and White 1984; Sedgwick and Knopf 1986, 1990). Various lines of evidence suggest that nest sites for primary cavity-nesting birds including woodpeckers are often limited: 1) suitable nest trees are frequently occupied by more than one cavity-nesting species (van Balen et al. 1982, Gutzwiller and Anderson 1987, Ingold 1990); 2) inter-specific nest-site competition among woodpecker species as well as among woodpeckers and various secondary-cavity nesting species is common (Short 1979, Kilham 1983, Ingold 1989a); and 3) the numbers of some woodpecker species including red-headed woodpeckers (*Melanerpes erythrocephalus*) and northern flickers (*Colaptes auratus*) have declined in much of eastern and central North America during the past 25 years (Robbins et al. 1986, Peterjohn and Rice 1991). Thus the availability of suitable nest sites may be important when determining what factors limit the reproductive success of cavity-nesting birds as well as when assessing population numbers and community composition among woodpeckers and other excavator species.

Red-bellied woodpeckers (*Melanerpes carolinus*), red-headed woodpeckers, and northern flickers are primary cavity-nesting species broadly sympatric throughout much of eastern North America. In Ohio, red-bellied woodpeckers (RBW) are locally common permanent

residents while flickers are common breeding residents (Peterjohn and Rice 1991). Red-headed woodpeckers (RHW), however, are generally considered uncommon and only locally distributed in the Unglaciated Plateau region of east-central Ohio (Peterjohn and Rice 1991). Many authors have presented data on the nest-site characteristics of one or more of these species (Dennis 1969, Reller 1972, Conner 1975, Jackson 1976, Kilham 1977, Stauffer and Best 1982, Gutzwiller and Anderson 1987, Harestad and Keisker 1989, Kerpez and Smith 1990, Sedgwick and Knopf 1990), but few have examined the characteristics of all three species concomitantly in a zone of sympatry. Moreover, few studies of this nature have been undertaken in Ohio. The objective of the present study was to quantify and describe various characteristics of the nest sites and nest trees of these species and to compare the results with those of similar studies conducted in other forest and woodland types in different regions.

MATERIALS AND METHODS

From late March through late August 1990-1992, active RBW, flicker, and RHW nest sites were located in and around New Concord, in Muskingum and Guernsey counties, in east-central Ohio. The study area covers about 700 ha and consists of a variety of agricultural and forested habitats (Ingold and Densmore 1992). Within the larger study area, study sites were chosen randomly from a map. Woodpecker nests were located by listening for adults calling or excavating and by observing individuals flying to and from a particular area. Each active woodpecker cavity was observed for a minimum of 30 min once a week to determine occupancy and status.

For each cavity tree a variety of nest-site parameters including cavity height (m), horizontal and vertical diameter of cavity entrance (cm), facing compass direction

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of the entrance (degrees from north), angle of the cavity limb (vertical, facing up or down 1-45°, or facing up or down 46-90°), and diameter at breast height (DBH) of the cavity tree were determined. In addition, the presence or absence of bark around the cavity entrance, whether the cavity tree and limb were living or dead, and whether the cavity was of natural origin or excavated was noted. Finally, the number of small and large trees (2.5-10.0 cm DBH and >10 cm DBH, respectively) was quantified in a circular area of 0.04 ha around the cavity tree, and an estimated percentage of ground vegetation (<1.5 m) around the cavity tree using a profile board (values scored from 0 to 5: zero represented no ground vegetation and 5 represented maximum vegetation; see also Nudds 1977).

Each variable that consisted of continuous data (cavity height, horizontal and vertical diameter of cavity entrance, tree DBH, and number of trees around cavity tree) was tested for equality of variances with the variance ratio test (Zar 1984). The horizontal and vertical diameters of cavity entrances and the number of small trees around the cavity tree had significantly unequal variances and were converted using logarithmic transformations ($\bar{X} = \log^{10}[X+1]$) (Zar 1984). Differences in nest-site parameters among species were determined with one-way analysis of variance. When differences were detected, Scheffe's Tests for multiple comparisons were used to detect differences between species.

The data for state of tree and limb, bark, cavity angle, cavity origin, compass direction, and vegetation height were binomial or ordinal in nature, and with the exception of compass direction, were analyzed using contingency table Chi-square tests. The facing compass direction of nest cavities was tested for randomness in each species using the Rayleigh test which produces an r value (mean vector length) that is a measure of the concentration of nest orientations around the mean nest orientation (Batschelet 1981, Zar 1984; see also Kerpez and Smith 1990).

RESULTS

Forty-six active RBW, 44 flicker, and 26 RHW nest cavities were located, and dimensions of cavity entrances for 23 RBW, 32 flicker, and 18 RHW nests were determined. Five of six cavity-site variables that consisted of continuous data differed significantly among species (Table 1). Flickers had significantly larger horizontal and vertical cavity entrances than did RBWs and RHWs ($P < 0.05$); moreover, RHWs had significantly larger horizontal entrances than RBWs ($P < 0.05$). The mean cavity height for flicker nests was significantly lower than the means for RBW and RHW nests ($P < 0.05$), while the mean DBHs for cavity trees were statistically indistinguishable among species. RBWs chose nest sites in areas with significantly more larger and smaller trees around the cavity tree than did flickers and RHWs ($P < 0.05$), although flickers also nested in areas with significantly more smaller trees than RHWs (Table 1).

Three of six cavity-site variables that consisted of binomial or ordinal data differed significantly among species (Table 2). RBWs nested in freshly excavated nest cavities in living trees with bark around the cavity entrance significantly more often than flickers and RHWs ($P < 0.01$). Conversely, status of the nest limb, angle of the nest limb, and the amount of ground vegetation around the cavity tree did not significantly differ among species (Table 2).

The compass direction of nest cavities was not significantly different from a random orientation for RBWs (Fig. 1; $r = 0.18$, $P > 0.50$, $n = 46$), flickers (Fig. 1; $r = 0.09$, $P > 0.60$, $n = 44$), or RHWs (Fig. 1; $r = 0.07$, $P > 0.70$, $n = 26$).

DISCUSSION

Nest Cavity Characteristics

That northern flickers excavate cavities with larger entrances than RBWs and RHWs is not surprising given their larger size. Kerpez and Smith (1990) and McAuliffe

TABLE 1

Means and standard errors (SE) of the dimensions of woodpecker nest cavities and cavity sites.

Variable	Red-bellied		Flicker		Red-headed		P
	\bar{X}	SE	\bar{X}	SE	\bar{X}	SE	
HCD (cm) ^a	*5.4	0.15	**7.3	0.21	***5.8	0.22	<0.001
VCD (cm) ^b	*5.4	0.10	**8.2	0.43	*5.7	0.18	<0.001
Cavity Ht (m) ^c	*10.5	0.55	**8.4	0.65	*10.2	0.65	0.03
DBH (cm) ^d	49.6	2.77	46.9	2.70	56.9	3.93	0.96
LTACT ^e	**9.4	0.67	*6.7	0.64	*6.5	0.82	<0.01
SMACT ^f	*21.8	2.38	**15.6	2.45	***9.5	1.87	<0.01

Differences between species were tested with one-way ANOVAs (P column in table). Means in the same row with a different number of asterisks are significantly different (Scheffe's Tests: $P < 0.05$).

^aHorizontal Cavity Diameter; $n = 23$ for RBWs, 32 for flickers, and 18 for RHWs.

^bVertical Cavity Diameter; $n = 23$ for RBWs, 32 for flickers, and 18 for RHWs.

^c $n = 46$ for RBWs, 44 for flickers, and 26 for RHWs.

^dDiameter at Breast Height of Cavity Tree (DBH); $n = 45$ for RBWs, 42 for flickers, and 26 for RHWs.

^eNumber of large trees (>10 cm DBH) around the cavity tree (within a 0.04 circular ha); $n = 46$ for RBWs, 44 for flickers, and 26 for RHWs.

^fNumber of small trees (<10 cm DBH) around the cavity tree (within 0.04 circular ha); $n = 46$ for RBWs, 44 for flickers, and 26 for RHWs.

TABLE 2

Qualitative characteristics of woodpecker nest sites.

	Red-bellied ^a		Flicker ^a		Red-headed ^a		P
	N	%	N	%	N	%	
Nest Tree							
1. Living	**36	78.3	*16	36.4	*10	37.0	<0.001
Dead	10	21.7	28	63.6	17	63.0	
Nest Limb							
1. Living	10	21.7	9	20.5	2	7.4	0.263
Dead	36	78.3	35	79.5	25	92.6	
2. Bark	**39	84.8	*19	43.2	*11	42.3	<0.001
No Bark	7	15.2	25	56.8	15	57.7	
3. Angle: Vertical	24	52.2	28	63.6	18	69.2	0.259
Down <45	20	43.5	13	29.6	6	23.1	
Down >45	2	4.3	1	2.3	2	7.7	
Up <45	0	0.0	2	4.5	0	0.0	
Cavity Status							
1. Natural	1	2.2	3	6.8	0	0.0	<0.001
2. Old Excavated	6	13.0	20	45.5	11	42.3	
3. Freshly Excavated	**39	84.8	*21	47.7	*15	57.7	
Vegetation Status ^b							
1. 0.0%	3	6.8	3	7.0	0	0.0	0.090
2. 1-20%	14	31.8	20	46.5	19	70.4	
3. 21-40%	18	40.9	10	23.3	3	11.1	
4. 41-60%	7	15.9	5	11.6	4	14.8	
5. 61-80%	1	2.3	3	7.0	0	0.0	
6. 81-100%	1	2.3	2	4.6	1	3.7	

Differences among species were tested with contingency-table Chi-square tests (values in P column). If among-species comparisons were significant, between-species comparisons were also conducted using contingency-table Chi-square tests. Numbers in a particular row with a different number of asterisks are significantly different ($P < 0.01$).

^aN = 46 for RBWs, 44 for flickers, and 26 for RHWs.

^bPercentage of ground vegetation around the cavity tree (cf Nudds 1977).

and Hendricks (1988) reported mean flicker cavity entrances in Arizona in excess of 6.7 cm while Peterson and Gauthier (1985) found that horizontal and vertical flicker cavity entrances in British Columbia were 6.9 and 7.5 cm, respectively. These data are similar to those in the present study (Table 1). In addition, Jackson (1976) and Ingold (1989a) found that RHWs excavated cavities with entrances that were larger than those excavated by RBWs. Gutzwiller and Anderson (1987) and Sedgwick and Knopf (1990) both report cavity entrances of RHWs that fall between 5.6 and 5.9 cm, which are similar to those found for RHWs in Ohio (Table 1).

Flickers nested in cavities that were significantly lower than those used by RBWs and RHWs (Table 1). Stauffer and Best (1982) also reported that flickers nested in lower cavities ($X = 8.1$ m) than RBWs and RHWs, and Gutzwiller and Anderson (1987) and Sedgwick and Knopf (1990) found that flickers nested in lower cavities than RHWs. In Kansas, Jackson (1976) reported the mean nest height for RBWs and RHWs to be 7.6 and 7.0 m, respectively, while Reller (1972) in Illinois found their mean heights to be 14.3 and 12.4 m, respectively. The present data (Table 1) for these species fall between those of Jackson (1976) and

Reller (1972), and it appears that, as Jackson (1976) suggests, these geographic differences are probably the result of the size and number of available nest trees.

RBWs favored dead nest limbs with bark ($P < 0.01$) while flickers and RHWs also favored dead limbs ($P < 0.001$), but showed no preference with regard to bark (Table 2). Jackson (1976) found that both RBWs and RHWs favored dead limbs but that RHWs favored limbs without bark while red-bellieds showed no preference. The present study seems to reflect a propensity for RBWs to excavate nests in the dead limbs of living trees (cf. Reller 1972, Kilham 1977) that often retain their bark for a few years. The number of living trees with dead limbs on the present study sites far outnumbered the number of dead trees (snags), which may explain why more RHWs and flickers were not found nesting in barkless limbs and trunks. Unlike RBWs, flickers and RHWs are often considered weak excavators (Bent 1939, Short 1982, Harestad and Keisker 1989) and frequently seek out limbs that are in a more advanced state of deterioration in which to excavate a nest than do RBWs (Reller 1972, Jackson 1976).

Although RBWs chose to excavate nest cavities on the underside of downward angling limbs more frequently

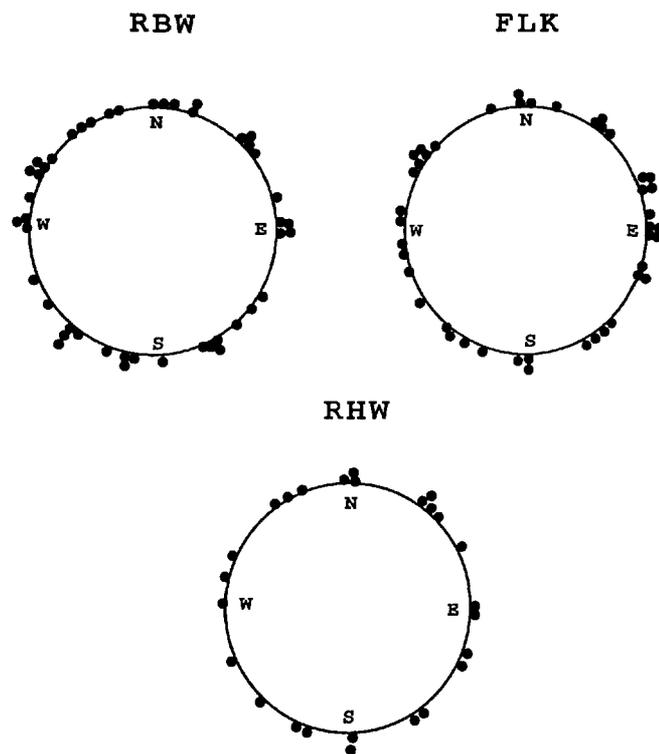


FIGURE 1. Compass orientations for the entrances of red-bellied (RBW), northern flicker (FLK), and red-headed woodpecker (RHW) nest cavities ($N = 46, 44,$ and $26,$ respectively).

(48% of the time) than flickers and RHWs, the difference was not significant (Table 2). On the other hand, Ingold (1989a) found that RBWs in Mississippi used downward facing cavities significantly more often than RHWs, while Jackson (1976) noticed a similar trend for these species in Kansas. Gutzwiller and Anderson (1987) reported that flickers and RHWs in Wyoming occupied downward facing nest cavities at least 50% of the time. None of the species in the present study used downward facing cavities significantly more often than vertical cavities. Although downward facing cavities should provide increased protection from wind and rain and perhaps enhance fungal growth that would facilitate nest excavation (Conner 1975), vertical-facing cavities must be superior in other ways (e.g., lack of parasites, more suitable dimensions; see also Gutzwiller and Anderson 1987). RBWs in the present study were particularly vulnerable to nest-site competition from several species (Ingold and Densmore 1992), and perhaps by excavating downward facing cavities they were afforded increased protection since it is more difficult to perch at the base of and to enter such cavities. However, Ingold (1989a) found that RBWs in Mississippi lost cavities that angled downward to European Starlings (*Sturnus vulgaris*) in disproportionately larger numbers than vertical facing cavities. Thus, although downward facing cavities may afford RBWs protection from some competing species, such cavities could also invite starlings which may prefer them over vertical facing cavities (see also Ingold 1989a,b).

The tendency for RBWs to excavate fresh nest cavities significantly more often than flickers and RHWs (Table 2)

supports the idea that they are a strong excavator species. Flickers and RHWs used previously excavated nest cavities about as often as they excavated new cavities. Jackson (1976) found that RHWs in Kansas almost always initiated nest excavation in a pre-existing crack in a limb or trunk whereas RBWs seldom did. Certainly there are potential advantages to excavating a fresh nest cavity each year (e.g., free of parasites, greater choice in nest placement, etc.), but there must also be time and energy costs. Although the question was not addressed directly in the present study, the data suggest that the benefits of excavating a fresh nest cavity outweigh the costs for RBWs but not necessarily for flickers and RHWs.

Although compass orientation has been reported to be nonrandom for several woodpecker species (Lawrence 1967, Dennis 1969, Reller 1972, Inouye 1976, Inouye et al. 1981), often facing disproportionately to the south and east to allow morning sunlight to warm the nest cavity, this hypothesis is not supported by the present study (Fig. 1). Instead, the findings of Stauffer and Best (1982), who reported the nest orientations of RBWs, flickers, and RHWs to be random and suggested that the primary factor in choosing nest sites was probably the angle of the nest limb rather than compass orientation (see also Conner 1975), are similar to those in this study. Kerpez and Smith (1990) also reported random nest orientations for flickers and gila woodpeckers (*M. uropygialis*) in saguaros, which contradicts the "thermal-constraint" hypothesis. The small r values (mean vector lengths) obtained for the current data indicate that orientations for RBW, flicker, and RHW nest cavities were random, suggesting no significant benefit to excavating cavities facing south or east.

Nest Tree Characteristics

RBWs, flickers, and RHWs nested in trees with similar mean DBHs (Table 1), and the broad range in DBHs for all three species suggest that beyond a given minimum tree size none of these species was selective about the size of the trees in which they nested. It is more likely that these species were influenced to a greater extent by the availability of nest trees with particular nest-cavity characteristics. These data support those reported by Sedgwick and Knopf (1990) who found no significant difference in the DBH of flicker and RHW nest trees in Colorado, and Ingold (1989b) who reported no differences in the size of RBW and RHW nest trees in Mississippi.

Present findings which demonstrate that RBWs nested in living trees significantly more often than flickers and RHWs (Table 2), and significantly more often than expected by chance ($P < 0.001$), are similar to the data reported by Ingold (1989b) for RBWs and RHWs in Mississippi. In addition, Gutzwiller and Anderson (1987) found that RHWs and flickers nested in snags over 70% of the time. However, current data differ from those of Jackson (1976) in which RBWs also nested significantly more often in snags. Whether these species choose to nest in living trees or snags may be influenced by several factors including the relative availability of living trees or snags and perhaps the availability of suitable foraging habitat. For instance, RBWs may select dead or dying

branches of healthy trees because such nest sites may be more numerous in forested habitats where they most frequently reside (see also Bent 1939, Jackson 1976, Kilham 1983). Conversely, RHWs and flickers may choose to nest in dead trees more often because such sites may be more available in open habitats such as woodlands (Ingold 1989b; J. Jackson pers. comm.) which both species, but particularly the RHW, prefer since they depend largely on flycatching and ground foraging for food during the breeding season (Bock et al. 1971, Kilham 1983).

An alternative explanation could be the differences in the abilities of these species to excavate cavities. Though quantification of the number of days members of each species took to excavate fresh cavities (Ingold and Densmore 1992) was not performed in the present study, Ingold found in Mississippi (1989b) that RHWs generally took longer than RBWs (about two weeks versus ten days). Furthermore, in the present study, RHWs and flickers often initiated cavity excavation at the edges of vertical cracks in snags (Jackson 1976), and in some instances reused old nest cavities during successive years. These observations suggest that RHWs and flickers are mechanically less able to excavate cavities (i.e., weak excavators; see also Harestad and Keisker 1989) and thus may choose to nest in snags more frequently because snags are more decayed and hence easier to excavate.

Habitat Characteristics

The propensity for flickers and RHWs to nest in areas with significantly fewer trees than RBWs (Table 1) is supported by previous studies (Bent 1939, Jackson 1976, Short 1982, Ingold 1989a). Jackson (1976) found that RHWs preferred to nest in areas surrounded by 30 m or more of open space, whereas RBWs nested in more forested areas. These findings likely reflect differences in feeding strategies of these species. RBWs spend most of their time gleaning and probing for insects on tree trunks and limbs (Nauman 1930, Bent 1939, Selander and Giller 1959, Reller 1972, Jackson 1976), whereas flickers typically forage for ants and other insects on the ground (Bent 1939, Short 1982, Kilham 1983), and RHWs flycatch and ground forage for insects from a vantage point (Bent 1939, Bock et al. 1971, Short 1982). This niche difference may also explain why RHWs and flickers generally nested in areas with less ground vegetation than RBWs (Table 2), although the difference was not significant. RBWs seldom ground forage and their nest-site selection did not appear to be influenced by the height of ground vegetation in this study (Table 2). On the other hand, flickers and RHWs nested significantly more often ($P < 0.05$) in areas in which there was only 1-20% ground vegetation and were often observed feeding on the ground.

Implications

This study and numerous others suggest that Northern flickers, RHWs, and to a lesser extent RBWs, are fairly dependent on snags in which to nest. It is likely that declining numbers of flickers and RHWs reported in eastern North America (Robbins et al. 1986) are at least partially the result of habitat loss. In Ohio, RHWs are currently considered uncommon to rare in the eastern part of the

state (Peterjohn and Rice 1991). The continued existence of RHWs as well as flickers in the Unglaciated Plateau region of Ohio and other similar habitats is probably dependent on the continued existence of snags.

In addition to these considerations, in order to fully understand the cavity-nesting bird community, one must consider the effects that primary cavity nesting birds have on secondary cavity-nesting species. In eastern North America a variety of secondary cavity-nesting species including eastern bluebirds (*Sialia sialis*), tree swallows (*Tachycineta bicolor*), eastern screech owls (*Otis asio*), American kestrels (*Falco sparverius*), and southern flying squirrels (*Glaucomys volans*) are at least partially dependent on the cavities excavated by woodpeckers for nesting. Data from this and similar studies can be used to determine which woodpecker species are most important in providing nest cavities for these secondary cavity-nesting species.

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