COMPOSITION OF MIXED-SPECIES FORAGING FLOCKS ASSOCIATED WITH RED-COCKADED WOODPECKERS

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Abstract: Red-cockaded woodpeckers (*Picoides borealis*) are known to be regular members of mixed-species foraging flocks. We censused avian species associated with foraging red-cockaded woodpeckers in longleaf pine (*Pinus palustris*) habitat and in mixed loblolly pine (*P. taeda*)-shortleaf pine (*P. echinata*) habitat in eastern Texas during the non-breeding season. We also censused random points in similar habitat. A statistical evaluation of the census data indicated which species were most likely to be associated with red-cockaded woodpeckers. A large percentage of the species detected were significantly more likely to be found with these mixed-species flocks than at random points. Behavioral observations revealed that the foraging flock begins to assemble in the vicinity of the red-cockaded woodpecker cavity tree cluster well before the emergence of the woodpeckers. This assemblage indicates that red-cockaded woodpeckers are an important constituent of the foraging flock. Red-cockaded woodpeckers fit most of the characteristics used to describe nuclear members of foraging flocks, such as conspicuous plumage and vocalization. They also appear to be joined and followed more often than they themselves join and follow other species.

Key words: foraging flock, habitat, *Picoides borealis*, red-cockaded woodpecker, Texas.

Mixed-species foraging flocks have long attracted the interest of researchers. Questions regarding the advantages and disadvantages of flock membership, species composition and relative abundance, and roles within the flock are just a few for which answers have been sought (Morse 1970, 1977; Gradwohl and Greenberg 1980; Hutto 1988). Increased foraging efficiency and enhanced predator detection are the leading hypotheses to explain the benefits of mixed-species flock formation (Powell 1974, Morse 1977, Diamond 1981, Sullivan 1984).

Several authors have defined or categorized members of mixed-species foraging flocks according to the role they play within the flock. Simply stated, some species are referred to as nuclear or core species which are instrumental in flock formation and appear to direct the flock's movements. Others are termed attendant or satellite species and are flock followers (Davis 1946, Moynihan 1962, Munn and Terborgh 1979, Diamond 1981, Hutto 1994). Mixed-species foraging flocks in tropical localities are often well-structured assemblages of permanently resident species which will defend a territory from neighboring flocks of similar composition (Munn and Terborgh 1979, Gradwohl and Greenberg 1980). In temperate localities, mixed-species foraging flocks are most conspicuous during the non-breeding season (Morse 1977).

The red-cockaded woodpecker inhabits mature, open pine forests of the southeastern United States and regularly associates with mixed-species foraging flocks (Morse 1970, Conner et al. 2001*a*). Historical accounts describe it as abundant to fairly common in suitable habitat (Audubon 1839, Woodruff 1907). The species has since been extirpated from most of its former range, and its rarity now precludes it from being a significant flock associate in most of its current range. Researchers regularly find red-cockaded woodpeckers foraging in close association with a number of other bird species (Morse 1970, Bowman et al. 1999, Conner et al. 2001*a*). Morse (1970) encountered red-cockaded woodpeckers

in mixed-species flocks in longleaf pine forests of southeastern Louisiana where he described its role as that of an attendant or "absolute follower" within the flock.

In this paper we examined the propensity of different bird species to be associated with mixed-species foraging flocks where red-cockaded woodpeckers were present. We also present observational data regarding the role red-cockaded woodpeckers have in flock formation and membership.

STUDY AREA AND METHODS

We censused red-cockaded woodpecker mixed-species foraging flocks on the Angelina National Forest (ANF; 31°15'N, 94°15'W) and the Davy Crockett National Forest (31°21'N, 95°07'W) in eastern Texas. Data were collected between 18 September 1989 and 8 March 1990 during the non-breeding season using point counts. Census points were located in 2 pine forest habitats. Longleaf pine dominates much of the southern portion of the ANF. This pine habitat is generally very open and when maintained with prescribed fire possesses a well-developed herbaceous ground cover. The second pine habitat is dominated by 1 or a mixture of loblolly pine and shortleaf pine and typically contains a relatively dense stratum of midstory vegetation due in part to less frequent and less effective prescribed burning.

Point counts were conducted at least 30 minutes apart in both pine habitats while following red-cockaded woodpeckers during studies of foraging behavior. We also counted birds at random points separated by at least 0.8 km in similar habitat in the absence of red-cockaded woodpeckers. Each count period lasted 5 minutes. All species and individuals detected visually or aurally within 75 m were recorded. Individuals detected as they flew over the canopy were not recorded.

We opportunistically recorded behavioral interactions between red-cockaded woodpeckers and other species. These included the tendency of red-cockaded woodpeckers to follow or lead another species from one foraging point to another, incidents of foraging site displacement, and the role of red-cockaded woodpeckers within the flock as a whole.

Comparisons of number of species (species richness), number of individuals, and species diversity were made for longleaf pine versus loblolly-shortleaf pine habitats at random points and at red-cockaded woodpecker points, and for random points versus red-cockaded woodpecker points within longleaf pine and loblolly-shortleaf pine habitats using Wilcoxon rank-sum tests with a Bonferroni correction ($P = 0.0125$) for multiple tests. The Shannon-Weaver diversity index was used to calculate species diversity (Shannon and Weaver 1949). The probability that a species was more likely to be present at red-cockaded woodpecker points versus random points was examined within each pine habitat using Wilcoxon rank-sum tests. Within each pine habitat, we pooled the number of species detected and used chi-square analyses to determine any differences in the proportion of species present at random points versus red-cockaded woodpecker points. We used similar analyses to determine any differences in the proportion of times the mean number of a given species was greater at random points versus red-cockaded woodpecker points within each pine habitat. An alpha level of 0.05 was used in statistical tests for which the Bonferroni correction was not used.

Table 1. Means (± SD) for number of species, number of individuals, and species diversity for longleaf pine and loblolly-shortleaf pine habitats at random points and red-cockaded woodpecker points in eastern Texas.

	Random Points		Z^b	P^b
	Longleaf (n = 107)	Lob-short[a] (n = 140)		
Number of Species	0.54 ± 0.9	0.91 ± 1.3	- 2.45	0.014
Number of Individuals	0.85 ± 2.0	1.38 ± 2.7	- 2.48	0.013
Species Diversity[c]	0.10 ± 0.3	0.20 ± 0.4	- 2.21	0.027
	Red-cockaded Woodpecker Points			
	Longleaf (n = 94)	Lob-short[a] (n = 94)		
Number of Species	3.33 ± 1.8	3.44 ± 1.9	- 0.58	0.562
Number of Individuals	11.87 ± 10.6	8.34 ± 6.4	2.17	0.030
Species Diversity[c]	0.86 ± 0.5	0.93 ± 0.6	- 1.33	0.182

[a]Loblolly-shortleaf.
[b]Wilcoxon rank-sum tests. A Bonferroni correction was calculated and $P = 0.0125$ is needed for statistical significance.
[c]Shannon-Weaver diversity index was used to calculate species diversity.

Table 2. Means (± SD) for number of species, number of individuals, and species diversity for random points and red-cockaded woodpecker (RCW) points in longleaf pine and loblolly-shortleaf pine habitats in eastern Texas.

	Random (n = 107)	RCW (n = 94)	Z^a	P^a
Longleaf pine habitat				
Number of species	0.54 ± 0.9	3.33 ± 1.8	10.87	< 0.001
Number of individuals	0.85 ± 2.0	11.87 ± 10.6	11.34	< 0.001
Species diversity[b]	0.10 ± 0.3	0.86 ± 0.5	10.19	< 0.001
	Random (n = 140)	RCW (n = 94)	Z^a	P^a
Loblolly-shortleaf pine habitat				
Number of species	0.91 ± 1.3	3.44 ± 1.9	9.77	< 0.001
Number of individuals	1.38 ± 2.7	8.34 ± 6.4	10.57	< 0.001
Species diversity[b]	0.20 ± 0.4	0.93 ± 0.6	9.15	< 0.001

[a] Wilcoxon rank-sum tests. A Bonferroni correction was calculated and $P = 0.0125$ is needed for statistical significance.

[b] Shannon-Weaver diversity index was used to calculate species diversity.

Table 3. Mean (± SD) number of individuals of each species detected at random points and red-cockaded woodpecker (RCW) points in longleaf pine habitat in eastern Texas.

	Random points (n = 107)		RCW points (n = 94)			
Species	% of points where detected	$\bar{x}$ ± SD[a]	% of points where detected	$\bar{x}$ ± SD[a]	Z^b	P^b
American kestrel	0.0		1.1	0.02 ± 1.2		
Red-bellied woodpecker	0.0		19.1	0.21 ± 0.5		
Yellow-bellied sapsucker	0.0		11.7	0.17 ± 0.5		
Downy woodpecker	0.0		1.1	0.03 ± 0.3		
Hairy woodpecker	0.0		1.1	0.01 ± 0.1		
Northern flicker[c]	0.0		1.1	0.01 ± 0.1		
Pileated woodpecker	0.9	0.01 ± 0.1	2.1	0.03 ± 0.2	0.69	0.488
Eastern wood-pewee[c]	0.9	0.01 ± 0.1	0.0			
Eastern phoebe	0.0		2.1	0.02 ± 0.1		
Blue-headed vireo	0.0		1.1	0.01 ± 0.1		
Blue jay[c]	0.9	0.02 ± 0.2	4.3	0.04 ± 0.2	1.48	0.138
Carolina chickadee	2.8	0.06 ± 0.4	16.0	0.27 ± 0.7	3.22	0.001
Tufted titmouse	0.9	0.01 ± 0.1	4.3	0.06 ± 0.3	1.51	0.131
Red-breasted nuthatch[c]	2.8	0.04 ± 0.2	12.8	0.15 ± 0.4	2.66	0.008
Brown-headed nuthatch	3.7	0.05 ± 0.3	71.3	1.60 ± 1.5	9.89	< 0.001
Carolina wren	3.7	0.04 ± 0.2	10.6	0.14 ± 0.4	1.94	0.052
Golden-crowned kinglet	0.0		1.1	0.01 ± 0.1		
Ruby-crowned kinglet[c]	0.0		13.8	0.18 ± 0.5		
Eastern bluebird[c]	0.9	0.06 ± 0.6	18.1	0.91 ± 3.0	4.21	< 0.001
Hermit thrush	0.0		2.1	0.02 ± 0.1		
American robin	0.0		3.2	0.57 ± 5.2		
Yellow-rumped warbler[c]	3.7	0.09 ± 0.5	12.8	0.37 ± 1.1	2.37	0.018
Pine warbler	26.2	0.41 ± 0.9	89.4	5.50 ± 5.0	10.46	< 0.001
Summer tanager	0.9	0.01 ± 0.1	0.0			
Chipping sparrow	0.0		4.3	0.14 ± 0.7		
Field sparrow[c]	2.8	0.03 ± 0.2	0.0			
White-throated sparrow	0.0		4.3	0.15 ± 0.8		
Dark-eyed junco	0.0		8.5	0.59 ± 2.3		
Northern cardinal	2.8	0.03 ± 0.2	7.4	0.14 ± 0.5	1.54	0.123
American goldfinch	0.0		5.3	0.23 ± 1.2		
Unidentified	0.0		2.1	0.27 ± 1.9		

[a] All 107 random points and 94 red-cockaded woodpecker points were used in calculating the mean number of each species detected per point.

[b] Wilcoxon rank-sum tests.

[c] Scientific names for species not already listed in text: northern flicker (*Colaptes auratus*), eastern wood-pewee (*Contopus virens*), blue jay (*Cyanocitta cristata*), red-breasted nuthatch (*Sitta canadensis*), ruby-crowned kinglet (*Regulus calendula*), eastern bluebird (*Sialia sialis*), yellow-rumped warbler (*Dendroica coronata*), field sparrow (*Spizella pusilla*).

RESULTS

There were no significant differences in number of species, number of individuals, and species diversity when comparing longleaf pine versus loblolly-shortleaf pine habitats at random points and red-cockaded woodpecker points using a Bonferroni correction (Table 1). However, number of species, number of individuals, and species diversity were all significantly greater at red-cockaded woodpecker points than at random points in both pine habitats (Table 2).

A total of 30 species was recorded in longleaf pine habitat (Table 3). Fourteen species (46.7%) were recorded at random points and 27 (90.0%) species at red-cockaded woodpecker points. Eleven (36.7%) species were detected at both random and red-cockaded woodpecker points in longleaf pine habitat. Six (20.0 %) species were detected in significantly greater numbers at red-cockaded woodpecker points than at random points. Sixteen (53.3%) species were detected only at red-cockaded woodpecker points and 3 (10.0%) species were detected only at random points in longleaf pine habitat. A significantly greater proportion of all species found in longleaf pine habitat was present at red-cockaded woodpecker points than at random points ($\chi^2 = 13.0, P < 0.001$). The mean number of a given species was higher at red-cockaded woodpecker points a significantly greater proportion of the time than at random points ($\chi^2 = 38.4, P < 0.001$).

A total of 31 species was recorded in loblolly-shortleaf pine habitat (Table 4). Twenty-two (71.0%) species were recorded at random points and 28 (90.3%) species at red-cockaded woodpecker points. Nineteen (61.3%) species were detected at both random and red-cockaded woodpecker points in loblolly-shortleaf pine habitat. Eleven (35.5%) species were detected in significantly greater numbers at red-cockaded woodpecker points than at random points. Nine (29.0%) species were detected only at red-cockaded woodpecker points and 3 (9.7%) species were detected only at random points in loblolly-shortleaf pine habitat. The proportion of species present at red-cockaded woodpecker points was greater than at random points in loblolly-shortleaf pine habitat but was only marginally significant ($\chi^2 = 3.7, P = 0.054$). The mean number of a given species was higher at red-cockaded woodpecker points a significantly greater proportion of the time than at random points ($\chi^2 = 34.3, P < 0.001$).

We observed other species closely following red-cockaded woodpeckers from one foraging point to another on 18 occasions: pine warbler (*Dendroica pinus*) 14 times, brown-headed nuthatch (*Sitta pusilla*) 3 times, and summer tanager (*Piranga rubra*) 1 time. We never observed a red-cockaded woodpecker following another species in this manner.

Red-cockaded woodpeckers were displaced from a foraging site by another species on 14 occasions: red-bellied woodpecker (*Melanerpes carolinus*) 6 times, hairy woodpecker (*Picoides villosus*) 3 times, pileated woodpecker (*Dryocopus pileatus*) 3 times, and summer tanager 2 times. Red-cockaded woodpeckers displaced another species from a foraging site on 26 occasions: yellow-bellied sapsucker (*Sphyrapicus varius*) 11 times, red-bellied woodpecker 9 times, downy woodpecker (*Picoides pubescens*) 5 times, and hairy woodpecker 1 time.

DISCUSSION

Red-cockaded woodpecker populations have declined drastically over the past 130 years or so (Conner et al. 2001*a*), making this species a much less significant foraging flock associate throughout most of its former range. However, this woodpecker can be a very conspicuous flock member where it does occur due to its generally vocal nature. Morse (1970) reported red-cockaded woodpeckers in 43.9% of mixed-species flocks in longleaf pine forests in southeastern Louisiana. A number of species commonly associate with red-cockaded woodpeckers in mixed-species flocks. The pine warbler was by far the most commonly encountered species in terms of both occurrence within flocks and total individuals. This was true for random and red-cockaded woodpecker points in both pine habitats.

Relatively few mixed-species flocks were encountered at random points compared to red-cockaded woodpecker points. Number of species, number of individuals, and species diversity were all much greater at red-cockaded woodpecker points than at random points in both pine habitats indicating that red-cockaded woodpeckers have a strong tendency to be associated with mixed-species flocks.

Hardwood midstory and canopy trees were much more prevalent in loblolly-shortleaf pine than in longleaf pine habitat, creating a more diverse woody flora in the former. This increased plant diversity perhaps contributed to a trend for greater number of bird species, greater number of individuals, and greater species diversity at random points in loblolly-shortleaf pine habitat. Morse (1970) found a greater density of

birds in mixed forest (tree cover = 50% pine, 50% hardwood; 229.2 birds per 40 ha) than in coniferous forest (pure longleaf pine overstory; 65.9 birds per 40 ha). Interestingly, this pattern was not maintained at red-cockaded woodpecker points where number of species and species diversity were not very different between the 2 pine habitats, and the number of individuals detected was marginally greater in longleaf pine than in loblolly-shortleaf pine habitat. This may indicate a greater tendency for birds to form flocks in the relatively open longleaf pine habitat than in the less open loblolly-shortleaf pine habitat. Morse (1970) reported greater means for individuals per flock in longleaf pine habitat (22.8) versus mixed pine-deciduous habitat (12.1) in Louisiana. Birds may seek safety in numbers in more open forest habitats where increased visibility may result in greater vulnerability to predators.

Table 4. Mean (± SD) number of individuals of each species detected at random points and red-cockaded woodpecker (RCW) points in loblolly-shortleaf pine habitat in eastern Texas.

	Random points (n = 140)		RCW points (n = 94)			
Species	% of points where detected	$\bar{x}$ ± SD[a]	% of points where detected	$\bar{x}$ ± SD[a]	Z[b]	P[b]
Red-headed woodpecker[c]	0.7	0.01 ± 0.1	1.1	0.03 ± 0.3	0.28	0.776
Red-bellied woodpecker	0.7	0.01 ± 0.1	25.5	0.36 ± 0.7	6.02	< 0.001
Yellow-bellied sapsucker	0.7	0.01 ± 0.1	18.1	0.22 ± 0.5	4.88	< 0.001
Downy woodpecker	2.9	0.03 ± 0.2	23.4	0.31 ± 0.7	4.92	< 0.001
Hairy woodpecker	0.7	0.01 ± 0.1	7.4	0.07 ± 0.3	2.75	0.006
Northern flicker[c]	1.4	0.01 ± 0.1	1.1	0.01 ± 0.1	- 0.24	0.812
Pileated woodpecker	0.7	0.01 ± 0.1	2.1	0.02 ± 0.1	0.94	0.350
Eastern wood-pewee[c]	0.7	0.01 ± 0.1	1.1	0.01 ± 0.1	0.28	0.781
Eastern phoebe	0.0		3.2	0.03 ± 0.2		
Blue-headed vireo	0.0		1.1	0.05 ± 0.5		
Blue jay[c]	1.4	0.01 ± 0.1	1.1	0.02 ± 0.2	- 0.23	0.820
Carolina chickadee	12.9	0.21 ± 0.6	38.3	0.66 ± 1.0	4.54	< 0.001
Tufted titmouse	0.7	0.01 ± 0.1	8.5	0.14 ± 0.5	3.04	0.002
Red-breasted nuthatch[c]	0.7	0.01 ± 0.1	0.0			
Brown-headed nuthatch	1.4	0.02 ± 0.2	29.8	0.52 ± 0.9	6.35	< 0.001
Brown creeper[c]	2.1	0.02 ± 0.1	7.4	0.09 ± 0.3	1.97	0.049
Carolina wren	7.1	0.08 ± 0.3	11.7	0.13 ± 0.4	1.19	0.234
Winter wren[c]	0.7	0.01 ± 0.1	0.0			
Golden-crowned kinglet	0.0		5.3	0.05 ± 0.2		
Ruby-crowned kinglet[c]	5.7	0.07 ± 0.3	21.3	0.27 ± 0.6	3.61	< 0.001
Blue-gray gnatcatcher	0.0		2.1	0.03 ± 0.2		
Eastern bluebird[c]	0.7	0.01 ± 0.2	3.2	0.07 ± 0.5	1.43	0.154
American robin	0.0		1.1	0.02 ± 0.2		
Brown thrasher[c]	0.7	0.01 ± 0.1	0.0			
Yellow-rumped warbler[c]	8.6	0.19 ± 0.8	18.1	0.56 ± 1.4	2.26	0.024
Pine warbler	30.0	0.53 ± 1.2	85.1	3.87 ± 3.5	10.02	< 0.001
Summer tanager	0.0		4.3	0.10 ± 0.5		
Chipping sparrow	0.0		3.2	0.10 ± 0.7		
Dark-eyed junco	0.0		1.1	0.11 ± 1.0		
Northern cardinal	9.3	0.10 ± 0.3	10.6	0.15 ± 0.5	0.40	0.693
American goldfinch	0.0		1.1	0.01 ± 0.10		
Unidentified	0.7	0.01 ± 0.1	6.4	0.32 ± 1.5	2.50	0.012

[a] All 140 random points and 94 red-cockaded woodpecker points were used in calculating the mean number of each species detected per point.

[b] Wilcoxon rank-sum tests.

[c] Scientific names for species not already listed in text: red-headed woodpecker (*Melanerpes erythrocephalus*), northern flicker (*Colaptes auratus*), eastern wood-pewee (*Contopus virens*), blue jay (*Cyanocitta cristata*), red-breasted nuthatch (*Sitta canadensis*), brown creeper (*Certhia americana*), winter wren (*Troglodytes troglodytes*), ruby-crowned kinglet (*Regulus calendula*), eastern bluebird (*Sialia sialis*), brown thrasher (*Toxostoma rufum*), yellow-rumped warbler (*Dendroica coronata*).

A number of species were very regularly associated with red-cockaded woodpeckers and others were much less common. Species detected only at red-cockaded woodpecker points in both pine habitats include eastern phoebe (*Sayornis phoebe*), blue-headed vireo (*Vireo solitarius*), golden-crowned kinglet (*Regulus satrapa*), American robin (*Turdus migratorius*), dark-eyed junco (*Junco hyemalis*), and American goldfinch (*Carduelis tristis*). Species detected only at red-cockaded woodpecker points in longleaf pine habitat include hermit thrush (*Catharus guttatus*), chipping sparrow (*Spizella passerina*), and white-throated sparrow (*Zonotrichia albicollis*). Blue-gray gnatcatcher (*Polioptila caerulea*) was the only species to be detected solely at red-cockaded woodpecker points in loblolly-shortleaf pine habitat.

Some species detected were not as prone to joining mixed-species foraging flocks in the canopy. These include species that are typically understory dwellers such as the Carolina wren (*Thryothorus ludovicianus*), and northern cardinal (*Cardinalis cardinalis*). Both of these species were detected more often at red-cockaded woodpecker points, though not significantly so. Perhaps the activity of the canopy flock induced increased movement of these understory species, thus causing their increased detectability at red-cockaded woodpecker points. Two American kestrels (*Falco sparverius*) were detected on 1 occasion at a red-cockaded woodpecker point in longleaf pine habitat, but they were certainly not flock members.

Several authors have defined members of mixed-species foraging flocks according to the role they play within the flock. Morse (1970) categorized species in mixed-species flocks in Louisiana as "true leaders," "secondary leaders," "usual followers," or "absolute followers" based on the number of times a species led or followed another. He described the Carolina chickadee (*Poecile carolinensis*) and tufted titmouse (*Baeolophus bicolor*) as the only true leaders and red-cockaded woodpeckers as absolute followers. Since we focused our observations solely on the activities of the red-cockaded woodpeckers, we cannot infer interspecific interactions not involving them. However, we recorded several observations of red-cockaded woodpeckers being closely followed by another species from one foraging site to another. We did not observe red-cockaded woodpeckers following other species in the same manner. Using Morse's (1970) categories, we believe the role of red-cockaded woodpeckers in the mixed-species flocks we observed was that of secondary leader if not a true leader.

The terms "nuclear species" and "attendant species" have been used in a larger sense to describe roles of members in mixed-species flocks. Nuclear species are those that are instrumental in flock formation and appear to direct the flock's movements, and attendant species are flock followers. Our foraging observations always began at a cluster of red-cockaded woodpecker cavity trees. The woodpeckers typically did not exit the cavities until well after most other species had become active. Prior to the emergence of the red-cockaded woodpeckers, we regularly noticed an aggregation of other species form around the cavity trees. When the woodpeckers emerged, the flock appeared to join them and move with them. Conversely, the woodpeckers could have joined the flock and moved with it. However, when a foraging flock made its way to the edge of a large opening such as a clearcut, the red-cockaded woodpeckers appeared to initiate movement across the opening with other species following.

Red-cockaded woodpeckers fit most of the characteristics of a nuclear species as stated by Hutto (1994) with the exception of those pertaining to absolute abundance. They appear to be "joined and followed more often than they themselves join and follow others," they are "intraspecifically gregarious," conspicuous in plumage and vocalization, and they are permanent residents. However, due to their current rarity they are not present in most flocks, and are not always numerically dominant due to their social biology.

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LITERATURE CITED

Audubon, J. J. 1839. *Piculus querulus*, Wils. Red-cockaded woodpecker. Pages 180-181 *in* A synopsis of the birds of North America. Adam and Charles Black, Edinburgh, England.

Bowman, R., D. L. Leonard Jr., L. K. Backus, and A. R. Mains. 1999. Interspecific interactions with foraging red-cockaded woodpeckers in south-central Florida. Wilson Bull. 111:346-353.

Conner, R. N., D. C. Rudolph, and J. R. Walters. 2001. The red-cockaded woodpecker: surviving in a fire-maintained ecosystem. University of Texas Press, Austin, Texas, USA.

Davis, D. E. 1946. A seasonal analysis of mixed flocks of birds in Brazil. Ecology 27:168-181.

Diamond, J. M. 1981. Mixed-species foraging groups. Nature 292:408-409.

Gradwohl, J., and R. Greenberg. 1980. The formation of antwren flocks on Barro Colorado Island, Panama. Auk 97:385-395.

Hutto, R. L. 1988. Foraging behavior patterns suggest a possible cost associated with participation in mixed-species bird flocks. Oikos 51:79-83.

Hutto, R. L. 1994. The composition and social organization of mixed-species flocks in a tropical deciduous forest in western Mexico. Condor 96:105-118.

Morse, D. H. 1970. Ecological aspects of some mixed-species foraging flocks of birds. Ecol. Monog. 40:119-168.

Morse, D. H. 1977. Feeding behavior and predator avoidance in heterospecific groups. BioScience 27:332-339.

Moynihan, M. 1962. The organization and probable evolution of some mixed species flocks of neotropical birds. Smithsonian Misc. Collect. 143:1-140.

Munn, C. A., and J. W. Terborgh. 1979. Multi-species territoriality in neotropical foraging flocks. Condor 81:338-347.

Powell, G. V. N. 1974. Experimental analysis of the social value of flocking by starlings (*Sturnus vulgaris*) in relation to predation and foraging. Anim. Behav. 22:501-505.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. University Illinois Press, Urbana.

Sullivan, K. A. 1984. The advantages of social foraging in downy woodpeckers. Anim. Behav. 32:16-22.

Woodruff, E. S. 1907. Some interesting records from southern Missouri. Auk 24:348-349.