

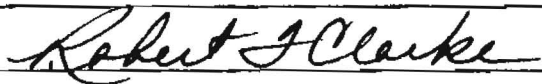
AN ABSTRACT OF THE THESIS OF

Hassan M. Felemban for the Master of Science

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Abstract approved:



A comparative study of five woodpecker species was conducted on a four hectare riparian woodland in Lyon County, Kansas, during the winter of 1980-81. Six major comparisons were made. Differences among woodpeckers in this study were found to be most affected by the vegetation available and the physical factors. Four other comparisons: vertical distribution, DBH measurements, interspecific associations, and movement activities indicated different trends among woodpeckers in their winter behaviors and ranges. These differences among the five species in their winter niche dimensions allowed a successful coexistence.

A COMPARATIVE NICHE STUDY OF WINTERING WOODPECKERS

A Thesis
Submitted to
the Division of Biological Sciences
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Hassan M. Felemban
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Robert J. Clarke
Approved for Major Department

Harold E. Dunst
Approved for Graduate Council

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INTRODUCTION

The purpose of this study was to determine the role of behavior and other ecological aspects in the winter coexistence of five woodpecker species:

Downy Woodpecker, Picoides pubescens

Hairy Woodpecker, Picoides villosus

Red-bellied Woodpecker, Melanerpes carolinus

Common Flicker, Colaptes auratus

Yellow-bellied Sapsucker, Sphyrapicus varius

These five species belong to Order Piciformes, Family Picidae, and are mainly found in wooded areas. They possess strong and sharply pointed bills, stiff tails which are used as props, and males have some red color on the head.

The study area was located in the city of Emporia, Kansas, 38° 27' N 96° 05' W, (Fig. 1) on a wooded tract, bordered on three sides by the Neosho River (Fig. 2), at the north edge of Emporia State University Campus.

Field observations were made from November 8th, 1980, through mid-April, 1981. About 200 hours of observations were made during a total of sixty days. The Red-headed Woodpecker was intended to be included in this study, but none was observed during the study period.

General considerations of the study were the geographical distribution of woodpecker species within the winter range, composition of wooded land or forested area, presence or absence of other avian members in the communities, effects of physical factors, vertical distribution of the woodpeckers, and the interspecific ecological relationships among members of the woodpecker family.

Fig. 1. Map of Kansas, showing location of Emporia.

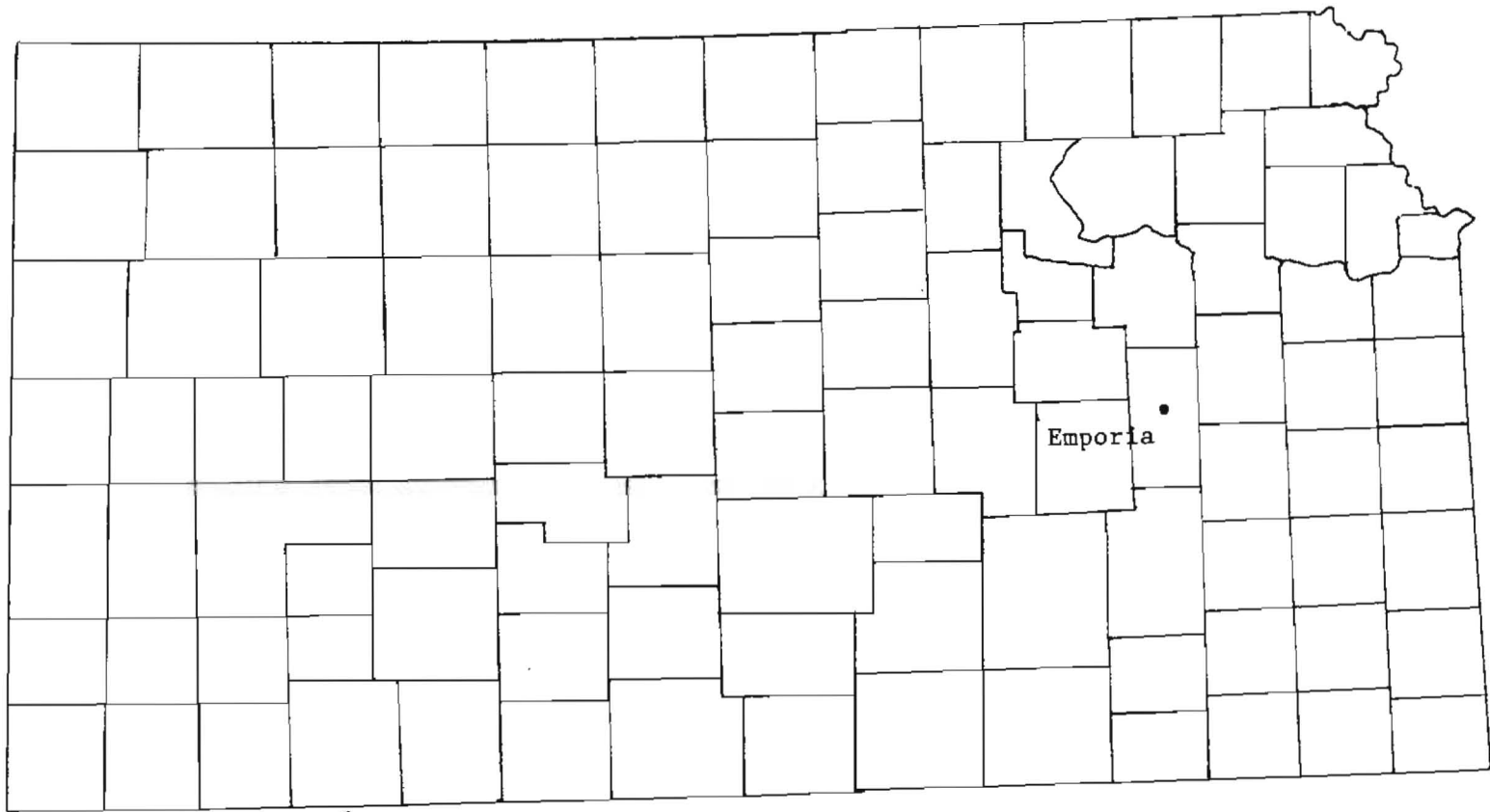
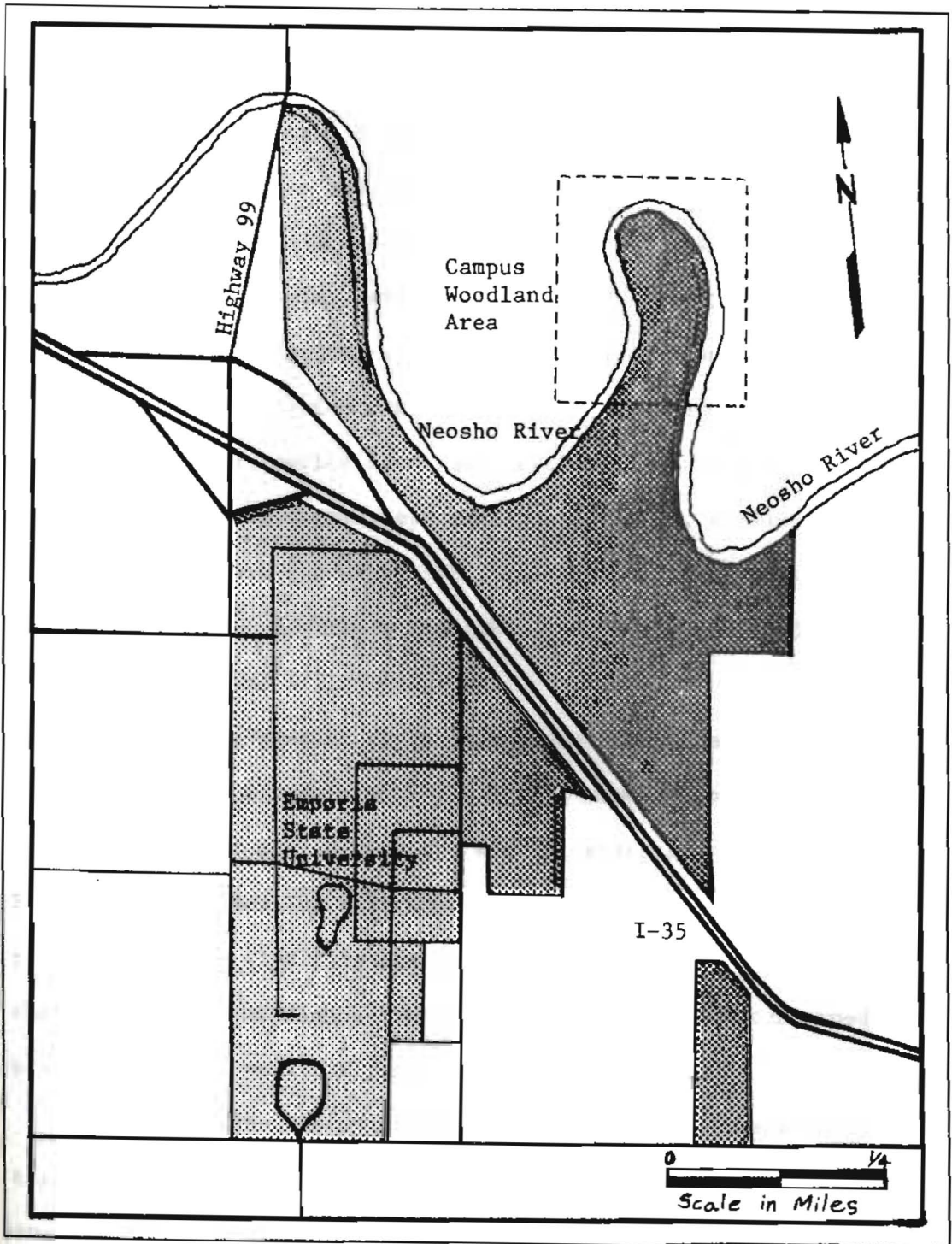


Fig. 2. Map of city of Emporia, showing location of
Emporia State University Campus Woodland
area.



The ecological aspects of the five woodpecker species have received much attention in various parts of the United States where woodlands occur, especially in the East. Kilham (1956, 1960, 1963, 1964, 1965, 1970), studied various ecological aspects of several woodpecker species. Conner (1980, 1981) discussed the foraging habitats of six woodpecker species and the foraging patterns of three species in different seasons, and Kisiel (1972) reported a comparison between Downy and Hairy Woodpeckers in their foraging behaviors. Also, many authors in midwestern and central North America have been involved in studying the ecological behavior of many woodpecker species: In Illinois, Williams (1975, 1980), Williams and Batzli (1979a, 1979b), Reller (1972), Stickel (1965), and Willson (1970); in Kansas, Boone (1963), and Jackson (1970); and in Texas, Selander and Giller (1959).

Although the present study is somewhat like the works of others in different areas, it deals with the family members that occur together in one particular area during the winter, which has been little studied. Similar studies dealing with several woodpecker species have been reported by Conner (1980) in West Virginia and by Williams (1975) in a central Illinois woodland, whereas most other studies concerned the behavior of only one particular woodpecker species.

Therefore, studies which deal with those woodpeckers associated together in a specific habitat during a specific season are much in order.

METHODS AND MATERIALS

Observations of five woodpecker species were made from November 8th, 1980, through April 15th, 1981. A total of 60 trips was made to the study area. They were made mostly every other day, and, occasionally, two days per week in three-hour blocks, for a total of about two hundred hours.

In most cases, observations extended during daylight from early morning to mid-day, and occasionally from mid-day to about two hours before sundown. Morning to mid-day observations were the most valuable. The woodpeckers were observed from a distance of twelve to thirteen meters in order not to disturb their wild behavior and natural movements.

Equipment (Fig. 3) included a pair of 10x50 binoculars, a stop watch, an air thermometer, a tape recorder, data sheets, an Olympus OM-10 35mm SLR camera equipped with a 200mm telephoto lens and a tripod, Peterson's "A Field Guide to the Birds East of the Rockies" (1980), Robbins et al. "A Guide to Field Identification Birds of North America" (1966), Stephens' "Trees, Shrubs, and Woody Vines in Kansas" (1969), Brockman's "A Guide to Field Identification Trees of North America" (1979), and Martin et al. "A Golden Guide, Weeds" (1972).

The common and scientific names of all avian species were based on Peterson (1980). Tree species identification and taxonomy were based on Stephens (1969) and Brockman (1979), and for weeds on Martin et al. (1972).

Daily information recorded on the data sheet (Appendix I) were the day and date, starting time and ending time, the sky conditions (rainy,

Fig. 3. Equipment used for field observation.



cloudy, partly cloudy, and sunny or clear), temperature, wind direction, and the condition of the ground surface (wet, snow, or uncovered).

Observational categories for woodpecker behavior in the field were: time (whenever a single woodpecker was observed); woodpecker species and sex; specific location of each woodpecker (ground, trunk, or branch); other avian or woodpecker species that occurred on the same tree and at the same time; species of tree; diameter at breast height (DBH) of tree in centimeters; height of bird on tree in meters at beginning and end of observation in meters; the relation of wind direction to woodpecker location (either in or out of wind); the position of each bird with respect to the sun (in shade or out of shade); duration of observation of an individual woodpecker on a tree in minutes and seconds; and the distance that woodpecker moved to the next tree or location in meters. Usually one data sheet was used for each day's observations.

Observation methods varied from winter to very early spring. During winter, individual woodpeckers were observed and followed as long as possible at different locations, but during early spring, March and April, pairs of woodpeckers were observed because courtship was taking place.

During major weather change periods, especially snow with calm wind, or cold and dry weather with wind speed of more than 20 miles per hour, an extra effort was made for observations in order to determine the effects of these physical factors on woodpecker activities.

A student t-test was utilized to determine the significant differences as $P=.05$ between various types of information that were recorded during the study. The X^2 test at $P=.05$ level of significance was used

on one occasion. Expected values were considered to be 50-50. Also, Dice-Leraas diagrams were applied to statistical descriptions, such as the range, the mean, the standard deviation, and the standard error.

DESCRIPTION AND LOCATION OF STUDY AREA

This study was confined to a four hectare woodland area (Fig. 4), which is part of the Emporia State University campus bordering the Neosho River. The river is normally about ten to twelve meters wide, and from three-fourths to one meter deep. The opposite river bank was edged by a strip of vegetation similar to that which covered the study area.

The study area was dominated by a mature deciduous forest with moderate undergrowth (Fig. 5). A Total of forty-six standing dead trees of various sizes was counted. Also, a great variety of fallen timber occurred within the study area. The density of mature deciduous trees has been estimated at approximately 340 trees per hectare.

In addition to the main deciduous forest, there existed in the most southern part of the study area a total of 126 pine trees. Half of them were Ponderosa Pines, Pinus ponderosa; the rest was a mixture of Scotch Pine, Pinus sylvestris, and Western White Pine, Pinus monticola.

Dominant plants of this area utilized by woodpecker species were:

Weeds: Stinging nettle, Urtica urens

Trees: Hackberry, Celtis occidentalis

Green Ash, Fraxinus pennsylvanica

Oak, Quercus spp.

Cottonwood, Populus deltoides

Elm, Ulmus spp.

Kentucky Coffee tree, Gymnocladus dioica

Boxelder, Acer negundo

Fig. 4. Aerial view of study area.



Fig. 5. View of study area during early winter.



Sycamore, Platanus occidentalis

Bitternut Hickory, Carya cordiformis

Red Mulberry, Morus rubra

Osage Orange, Maclura pomifera

Ponderosa Pine, Pinus ponderosa

Scotch Pine, Pinus sylvestris

DISTRIBUTION OF THE FIVE WOODPECKER SPECIES

The geographical distributions of the five woodpecker species in North America, as reported by the A.O.U. Check-list (1957), are as follows:

Downy Woodpecker, Dendrocopos pubescens

"From southwestern Alaska, southwestern Mackenzie, northern Alberta, central Saskatchewan, northern Manitoba, James Bay, southern Quebec, Anticosti Island, and Newfoundland south to southern California, central Arizona, northern New Mexico, south-central Texas, and the Gulf coast from Louisiana to Florida."

Hairy Woodpecker, Dendrocopos villosus

"Central Alaska, middle Yukon, central Mackenzie, northern Manitoba, James Bay, south-central Quebec, and Newfoundland south to northern Baja California, Mexico, central Texas, the Gulf coast, southern Florida, the Bahama Islands, and through the mountains of Central America to western Panama."

Red-bellied Woodpecker, Centurus carolinus

"Southeastern Minnesota, southern Wisconsin, southern Michigan, extreme southern Ontario, western New York, and Delaware south to southern Texas, the Gulf coast, and the Florida Keys West. Local in distribution in the more northern areas."

Yellow-bellied Sapsucker, Sphyrapicus varius

"From southeastern Alaska, southern Mackenzie, northern Manitoba, northern Ontario, southern Quebec, southern Labrador, Anticosti Island, and Newfoundland to the mountains of southern California, central Arizona, northern New Mexico, southeastern South Dakota,

eastern Missouri, central Illinois, northwestern Indiana, northern Ohio, western Pennsylvania, northern New York, and central New England southward in the Alleghenias to Tennessee. North Carolina, and northern Georgia."

Yellow-shafted Flicker, Colaptes auratus

"North America from limit of trees in central Alaska, northwestern Mackenzie, northern Manitoba, James Bay, central Quebec, southern Labrador, and Newfoundland south (east of the Rocky Mountains) to southern Texas, the Gulf coast, the Florida Keys, Cuba, and Grand Cayman."

Johnston (1965) reported the occurrence of the five woodpecker species within the state of Kansas. The Downy and the Hairy Woodpeckers are common residents in woodlands in Kansas. The Yellow-shafted Flicker is a common resident in the east, while the Red-bellied Woodpecker is a common resident in the east with scattered records in west, in woodland. The Yellow-bellied Sapsucker is only a winter resident in woodlands, arriving September 28 - November 14 and departing April 6-24.

Peterson (1980) employed range maps in an appendix which showed that: Downy Woodpecker, Hairy Woodpecker, and Common Flicker (Yellow-shafted races) are residents year-round; Red-bellied Woodpecker is only present in half the state (east section) of Kansas as a resident year-round; and Yellow-bellied Sapsucker inhabits the south and south-eastern parts of Kansas only in winter range, which includes Emporia area.

Peterson's common and scientific names were used in this study. Some differences have been found between Peterson's (1980) and both the A.O.U. Check-list (1957) and Johnston's (1965) in the genus names of

Downy, Hairy, and Red-bellied Woodpeckers. Also, the Common ("Yellow-shafted") Flicker, Colaptes auratus, (in part) has been used by the A.O.U. (1957) and Johnston (1965) as Yellow-shafted Flicker, Colaptes auratus.

RESULTS

Vertical Distribution

Because woodpecker species are adapted to wooded habitats, most feeding and winter activities occur on tree parts. Obviously, the vertical distribution of woodpecker species is a very important aspect of winter niches.

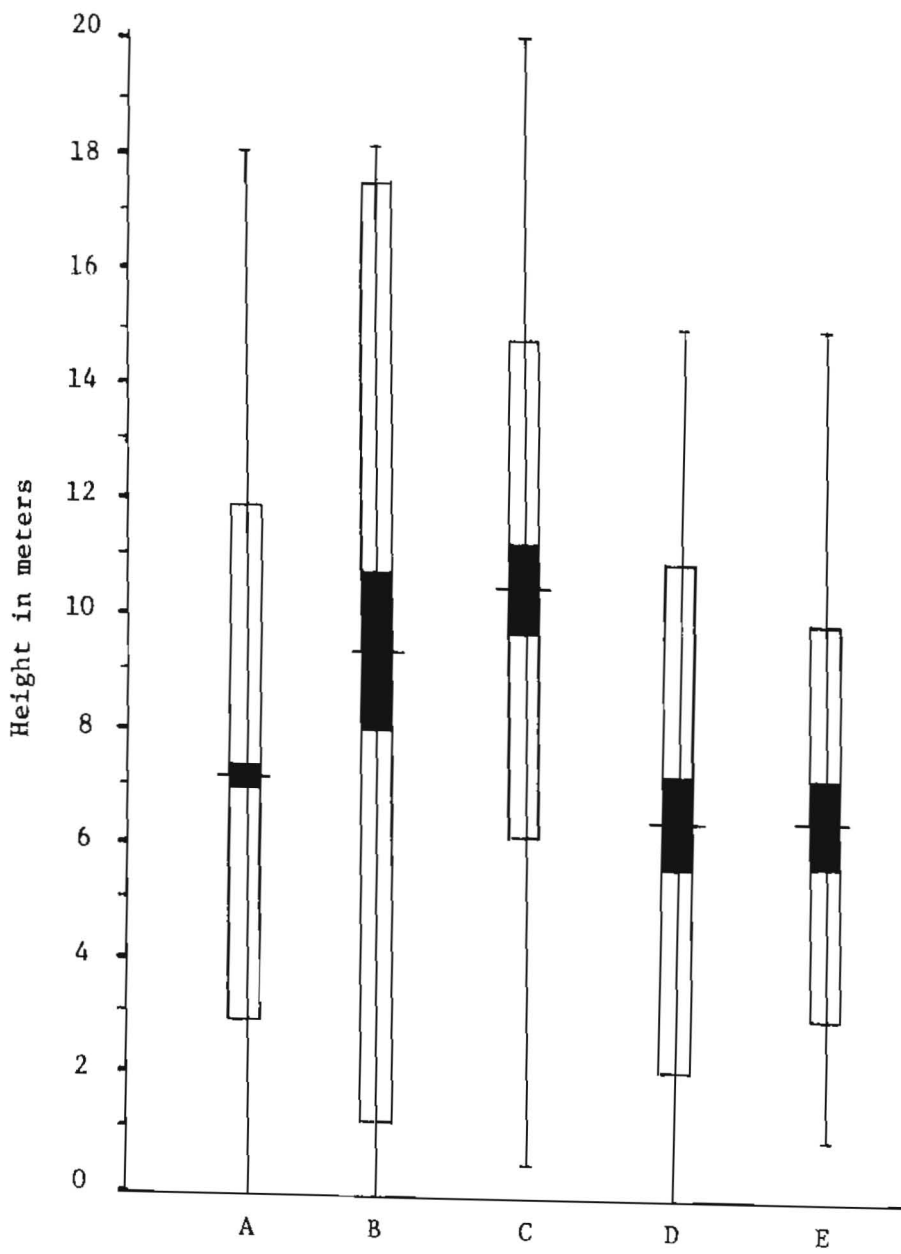
The Red-bellied Woodpecker, a moderate-size bird, and the Downy Woodpecker, the smallest woodpecker in this investigation, used the same vertical range from the ground surface to 18 meters (Fig. 6). However, the means were different: the Downy Woodpecker averaged 7.04 meters whereas, the Red-bellied Woodpecker averaged 9.24 meters. Boone (1963) also reported a similar vertical range for the Red-bellied Woodpecker of 0.00 to 17.2 meters. Both Willson (1970) and Williams (1975) indicated that the Red-bellied Woodpecker exploited the higher height classes whereas the Downy Woodpecker used the lower ranges.

Average heights of Common Flickers and Yellow-bellied Sapsuckers were very similar, 6.58 and 6.64 meters, respectively. They utilized the lower ranges most frequently, but their vertical ranges were slightly different. The Common Flicker ranged from the ground surface to 15 meters, whereas the Yellow-bellied Sapsucker ranged from one meter above the ground surface to 15 meters high.

In one of 38 sightings, the Hairy Woodpecker was observed at a height of 20 meters. This observation produced a vertical range between 0.5 and 20 meters high. The Hairy Woodpecker, thus, had the highest maximum range utilized by the five woodpecker species studied (Fig. 6).

The vertical range refers to the area that occurs between the highest

Fig. 6. Vertical distribution of five woodpecker species. Ranges (vertical lines); means (horizontal lines); \pm two standard errors (black rectangles); \pm two standard deviations (open rectangles). A = Downy Woodpecker (N=106); B = Red-bellied Woodpecker (N=98); C = Hairy Woodpecker (N=38); D = Common Flicker (N=32); E = Yellow-bellied Sapsucker (N=27).



and the lowest bird sightings.

Vertical range of activities refers to the maximum activities (up to 70%) that occur within the normal vertical ranges. These values are obtained from the values of \pm two standard deviations from the mean (Fig. 6). The Red-bellied Woodpecker exhibited the widest vertical range of activities from 0.86 to 17.62 meters, which indicates that the Red-bellied Woodpecker was the most versatile woodpecker species through the vertical distribution of trees. The Common Flicker showed the next widest vertical range of activities from 2.23 to 10.93 meters high. The Yellow-bellied Sapsucker had the smallest range of activities from 2.96 to 10.32 meters.

DBH Measurements

The diameter of trees selected by the five woodpecker species studied was highly variable. The Hairy Woodpecker displayed the greatest versatility in choosing trees which ranged between 15 and 130 centimeters in diameter. This dimension DBH (diameter at the breast height of the observer) range, appeared to be rather species-specific. The Yellow-bellied Sapsucker consistently selected the smallest trees, with a DBH range of 10 to 50 centimeters (Fig. 7).

The small DBH range of the Yellow-bellied Sapsucker arises largely due to the affinity of this species for the small coniferous trees within the study area. The Yellow-bellied Sapsucker was observed on pine trees 40 percent of the time. Figure 7 illustrates that most Yellow-bellied Sapsucker activity occurred on tree parts the diameter of which ranged between 17.66 and 42.26 centimeters.

The Downy Woodpecker was frequently found not only on small trees but also on large trees and branches. Williams (1975) and Kisiel (1972)

Fig. 7. Tree diameter at breast height (DBH) measurements in centimeters used by each woodpecker species. Ranges (basal lines); means (vertical lines); \pm two standard errors (black rectangles); \pm two standard deviations (open rectangles).

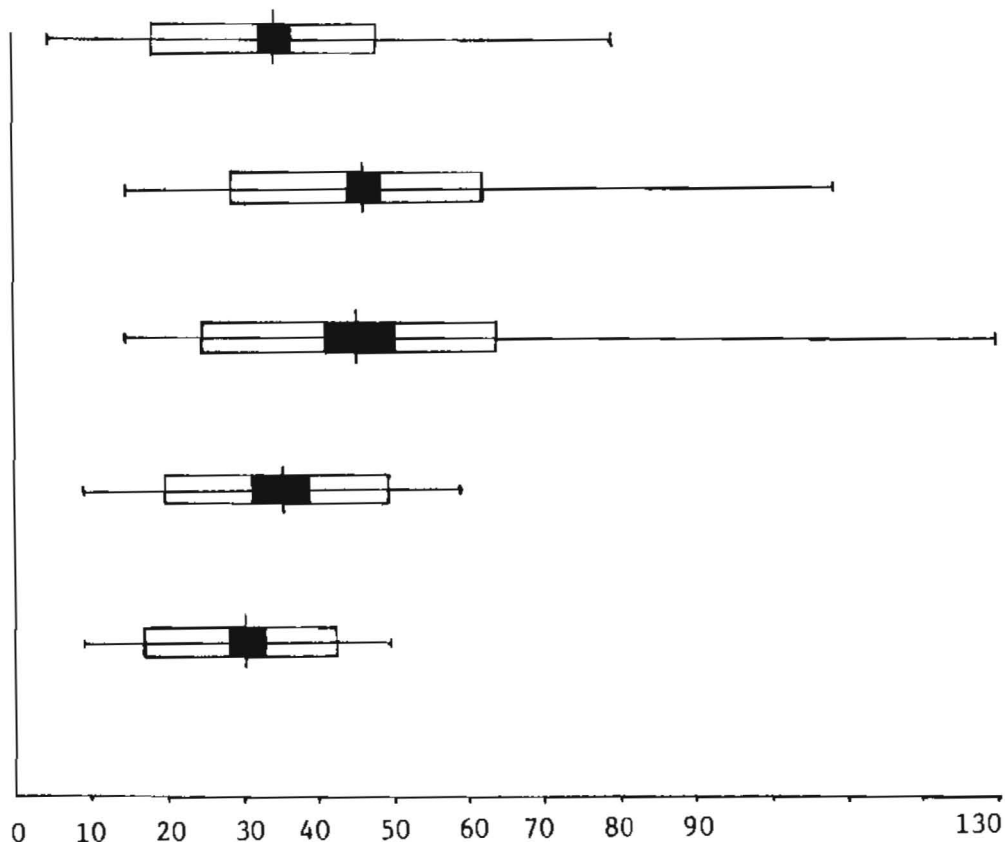
Downy
Woodpecker
(N=104)

Red-bellied
Woodpecker
(N=98)

Hairy
Woodpecker
(N=38)

Common
Flicker
(N=27)

Yellow-
bellied
Sapsucker
(N=27)



DBH in centimeters

reported similar results. Also, the Downy Woodpecker was the only species that used weeds. Therefore, its greatest activity as a function of specific plant stem diameters occurred within a small to large diameter range, (19.84 to 48.62 cm). There appeared to be very little difference between the Downy Woodpecker and the Common Flicker in their specific diameter range preference. Williams (1975) reported a similar phenomenon.

The Red-bellied and the Hairy Woodpeckers are birds of approximately the same size, and their selections of tree diameters ranged about the same. However, their restricted activities were different (see open rectangles in Fig. 7). The Hairy Woodpecker tended to concentrate upon trees with larger diameters than those used by the Red-bellied Woodpeckers.

Interspecific Associations

Interspecific associations of the five woodpecker species with other winter bird species were difficult to observe in an entire tree. However, the data of this study represent the interspecific and intraspecific associations within a range of one meter around an individual woodpecker site. Throughout the study, no conflict was observed.

The Downy Woodpecker was associated with many other winter bird species at its feeding sites (Group I, Table I). The Downy Woodpecker was followed closely by the Common Flicker, which was observed on six occasions associated with the Cedar Waxwing. In other words, they showed more association with non-woodpeckers (Group I) than intraspecific association (Group II).

The Red-bellied Woodpecker was most frequently found with other woodpecker species, but sometimes found with non-woodpecker species

Table 1. Interspecific associations among the five woodpecker species and other winter bird species.

GROUP	Bird Species	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
I	American Robin <u>Turdus migratorius</u>	3	1	-	3	-
	Black-capped Chickadee <u>Parus atricapillus</u>	7	1	2	-	1
	Brown Creeper <u>Certhia familiaris</u>	3	-	-	-	-
	Northern Cardinal <u>Cardinalis cardinalis</u>	1	-	-	1	1
	Cedar Waxwing <u>Bombycilla cedrorum</u>	1	-	-	6	-
	Northern Junco <u>Junco hyemalis</u>	1	-	-	-	-
	Red-breasted Nuthatch <u>Sitta canadensis</u>	4	-	1	-	1
	Tufted Titmouse <u>Parus bicolor</u>	-	1	-	-	1
II	Downy Woodpecker <u>Picoides pubescens</u>	(2)*	2	1	-	-
	Red-bellied Woodpecker <u>Melanerpes carolinus</u>	2	(11)*	1	1	3
	Hairy Woodpecker <u>Picoides villosus</u>	1	1	(2)*	-	-

Table 1. Interspecific associations among the five woodpecker species and other winter bird species.
(Continued)

GROUP	Bird Species	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
Common Flicker	<u>Colaptes auratus</u>	-	1	-	(2)*	-
Yellow-bellied Sapsucker	<u>Sphyrapicus varius</u>	-	3	-	-	(1)*

()* = indicates intraspecific associations with the same woodpecker species of the opposite sex.

(Group I). Among the non-woodpecker species were the American Robin, the Black-capped Chickadee, and the Tufted Titmouse.

There appeared to be no difference in group preference in both the Hairy Woodpecker and the Yellow-bellied Sapsucker.

The most frequently observed non-woodpecker species found in association with woodpecker species was the Black-capped Chickadee.

Movement Activities

Tree to tree movement of each woodpecker species was recorded as the horizontal "next flight distance" and measured in meters. The importance of these movement activities was to support the information on tree species selection used by the woodpeckers, that is to show both the behavior of avoiding certain tree species or moving to the next direct tree, and to illustrate the possible activity breadth of the woodpeckers.

In most cases, the least next flight distance indicates the most variety in tree selections used by a woodpecker species, unless there is only one type of tree that cover the area. Three distinct types of next flight distance were utilized throughout the study period: within the study area, out of the study area, and unknown, as the next sighting was impossible to see.

The Red-bellied Woodpecker consistently ranked as the species with the greatest next flight distance average of 17.4 meters (Table 2).

Many times the Red-bellied Woodpecker flew for a next flight distance of 50 to 70 meters. During this study, the Red-bellied Woodpecker flew from deciduous trees to other deciduous trees at different locations without stopping at the pine trees.

The Red-bellied Woodpecker was followed closely by the Hairy Woodpecker with an average next flight distance of 13 meters. The Hairy Woodpecker had a preference for Oak more than any other tree. The Oak

Table 2. Percentages of next flight distance observed in meters.

Next flight distance	Downy Woodpecker N=106	Red-bellied Woodpecker N=98	Hairy Woodpecker N=38	Common Flicker N=32	Yellow-bellied Sapsucker N=27
In study area	45.28	45.92	50.0	37.50	62.96
(Avg. in meter)	(8.71)	(17.4)	(13)	(9)	(7.59)
Out study area	13.21	33.67	18.42	43.75	3.7
Unknown	41.51	20.41	31.58	18.75	33.34

was not the most dominant tree in the study area; thus a great next flight distance was required by the Hairy Woodpecker. Both the Hairy and the Red-bellied Woodpeckers spent a considerable amount of time upon a tree at each stop.

The Downy Woodpecker had an average next flight distance of 8.71 meters, which was completely different from the two previous woodpeckers. Its next flight distance movement was short, which accounted for the large variety in the trees selected. It was also the woodpecker that used the upside down movements most often in its feeding.

The high density of the pine tree area made the distance between two pine trees short. The average was 4.5 meters. Since the Yellow-bellied Sapsucker was primarily using the coniferous habitat, it had the least next flight distance average of 7.59 m.

The study area was relatively small and was contained by a clearly defined natural border, since it was surrounded on three sides by the Neosho River. Species which rarely crossed the river to and from the area were considered to have most of their activities within the study area. From the "out of study area" next flight distance figures, the Yellow-bellied Sapsucker and the Downy Woodpecker were observed crossing the river least. Therefore, they were considered to be active primarily within the study area. This degree of activity breadth was followed by the Hairy Woodpecker, which crossed the river during 18.42% of the total recording sightings, the Red-bellied Woodpecker with 33.67%, and the Common Flicker with 43.75%.

The percentage of unknown next flight distance figures indicated that the woodpecker species was observed and the information was recorded,

except for next flight distance measurements. The unknown referred to loosing sight of a woodpecker that was being observed for next flight distance.

During this study, the Red-bellied Woodpecker was observed utilizing Sycamore trees as resting sites, whereas the Common Flicker used Pine and Green Ash trees. The other species were not observed utilizing a specific rest site.

Food Resources Used by Each Species

This study did not include an analysis of woodpecker stomach contents. However, a review of the known information is necessary in order to correlate the data on foraging sites and duration of feeding.

On the basis of stomach analysis, Beal (1911) estimated that the Downy Woodpecker fed on 76.05% animal matter, which consisted of beetles, ants, caterpillars, bugs, and eggs of insects and spiders, and 23.95% vegetable matter. He discovered that eight of eleven stomachs collected from Kansas in December contained an average of 10% grasshopper eggs. Williams and Batzli (1979a) found in stomach analysis of winter birds that the Downy Woodpecker fed on 61.1% animal matter, which was mostly ants, adult beetles, and small homopterans; and 38.9% of all stomach contents was vegetable material.

According to Williams and Batzli (1979a), the winter diet of Red-bellied Woodpecker was composed of 94% vegetable materials, 70.9% of which were acorns; with the animal portion mostly adult beetles. Beal (1911) reported that Red-bellied Woodpeckers fed on 30.94% animal matter, which was mostly insects and spiders, and 69.06% vegetable material (grain, fruit, and mast). Boone (1963) studied the food habitats of this

woodpecker in Kansas and found that 74.5% of gizzard volume was occupied by plant items, mostly corn and 25.5% animal items. Beal (1911) also reported that the Hairy Woodpecker obtained 77.67% of its food from animal matter and 22.33% from vegetable matter, whereas the Common Flicker's food consisted of 60.92% vegetable matter, corn being the main item. Acorn and other mast were not favorites of Common Flickers. Cruz and Johnston (1979) indicated that 98% of the total animal matter which was taken by Grand Cayman Island Flickers was ants, whereas 65.3% was taken by Florida Flickers.

The Yellow-bellied Sapsucker feeds on 41.31% animal matter (ants, weevils, dung and click beetles, with a few Cerambycid larvae, a few miscellaneous insects, and spiders) and 50.69% vegetable matter, mostly cambium and sap of trees (Beal, 1911). Burt (1930) stated that the Yellow-bellied Sapsucker obtains 27% of its food by pecking, 16% of which is cambium, 38% on the surface of tree trunks, and 35% from other places. Tate (1973) indicated two types of food sources utilized by the Sapsucker, which were labeled as soft food and solid food. Solid foods include matter that would be available in a stomach analysis and the soft foods are sap, cambium, and phloem.

Foraging Sites and Durations

Differences in the foraging sites of the five woodpeckers were noted. The favorite foraging tree within the study area was the Hackberry. This tree was utilized frequently by all five species, and it was significantly different from other tree species used by woodpeckers (t -test $P \leq 0.05$). The Common Flicker proved to be a notable exception in its preference for Green Ash (Table 3).

Table 3. Frequency and percentage of tree species used by foraging woodpeckers.

Tree Species	Downy Woodpecker		Red-bellied Woodpecker		Hairy Woodpecker		Common Flicker		Yellow-bellied Sapsucker	
	N	%	N	%	N	%	N	%	N	%
	Hackberry	30	30.61	33	36.67	9	26.47	3	11.54	11
Green Ash	18	18.38	11	12.22	3	8.82	6	23.08	4	14.81
Oak	8	8.16	13	14.44	6	17.65	3	11.54	-	-
Cottonwood	3	3.06	14	15.56	7	20.56	3	11.54	1	3.7
Elm	19	19.39	9	10.0	3	8.82	5	19.23	-	-
Kentucky Coffee Tree	9	9.18	6	6.77	3	8.82	2	7.69	2	7.41
Sycamore	-	-	2	2.22	-	-	-	-	-	-
Boxelder	4	4.08	1	1.11	1	2.94	3	11.54	-	-
Bitternut Hickory	3	3.06	1	1.11	-	-	-	-	-	-
Mulberry	1	1.02	-	-	-	-	-	-	-	-
Osage Orange	1	1.02	-	-	-	-	-	-	-	-
Pine	2	2.04	-	-	2	5.88	1	3.85	9	33.33

The Downy Woodpecker showed the most diverse selection of tree species. A similar phenomenon was reported by Williams and Batzli (1979a). It was also the only woodpecker which foraged upon the Stinging Nettle. This weed grew near the edge of the river on gradual slopes (Fig. 8), and it was also often visited by the Northern Junco.

Two tree species, Mulberry and Osage Orange, were foraged only by the Downy Woodpecker. The Sycamore tree was utilized only by the Red-bellied Woodpecker, especially as a resting site.

With the exception of the Yellow-bellied Sapsucker, all species used the Oak-Elm-Boxelder group as their second choice, following the Hackberry, as the first. However, the Yellow-bellied Sapsucker used pine trees for 33.33% of its foraging selection. Tate (1973) reported that, unlike most woodpeckers, the Yellow-bellied Sapsucker feeds upon sap, adult insects, and fruit. In this study, the Yellow-bellied Sapsucker concentrated upon the Hackberry for its insects and fruit, and shared this foraging site with the Downy, Red-bellied, and Hairy Woodpeckers.

Drill holes are the major evidence that the Yellow-bellied Sapsucker feeds on sap and cambium (Townsend, 1932), (Howell, 1952), (Kilham, 1956, 1964), and (Tate, 1973). During this study, drill holes were most commonly found in the bark of Ponderosa Pine and Scotch Pine, but none on Western White Pine (Fig. 9).

There was a single circle of drill holes observed in the bark of a Bitternut Hickory. This tree was visited by a Downy Woodpecker (Fig. 10), but Townsend's study (1932), however, suggested that these well known circles are made by Yellow-bellied Sapsuckers. Williams (1975) stated that the Yellow-bellied Sapsucker exploited sap from Hickory trees

Fig. 8. Downy Woodpecker Feeding in Weed Area.



Fig. 9. Scotch Pine, showing drill holes made by Yellow-bellied Sapsuckers.

Fig. 10. Downy Woodpecker sapping and feeding around a ring of holes in a bitternut Hickory.



while in migration. This circle or ring of holes was not seen until the area was covered by snow in late December, 1980, and also after the arrival of the Yellow-bellied Sapsuckers in the study area. The ring of holes at this site are assumed to have been made by a Yellow-bellied Sapsucker.

Although tree species selection indicated the number of times each woodpecker had stopped at a particular tree, the percentage of foraging time varied from species to species. The Hairy Woodpecker spent 41.36% of its time during six stops at Oak trees (Table 4); it was also observed making nine stops with less foraging time on Hackberry trees (Table 3).

The Common Flicker spent almost half of its foraging time either on Green Ash trees or the ground surface. It was the only woodpecker observed spending a large percentage of foraging time in the ground (22.17%). It spent less than 7% of the observed time on Oak and Cottonwood trees.

The differences in the condition of the trees utilized by woodpeckers were evident (Table 5). All five woodpeckers foraged mainly (more than 80%) on living trees during this study. The Yellow-bellied Sapsucker was the only woodpecker which was not observed on a dead tree.

The small percentage of dead tree utilization in this study probably results from the small proportion of dead trees to living trees within the study area. Other studies have reported different results. Jackson (1970) stated that the Downy Woodpecker utilized dead and living trees with equal frequency during the colder months, and Conner (1980) stated, "Downy and Hairy Woodpeckers foraged mainly on live wood (70% and 56%, respectively).....when not foraging on the ground, Flickers foraged about the same amount of time in dead trees as in living."

Table 6 illustrates the foraging preference of woodpecker species

Table 4. Comparison of percentages of foraging time.

Feeding Site	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
Total Observations in Sec.	(16290)	(11460)	(6480)	(6505)	(4519)
Hackberry	19.23	27.72	12.12	8.33	44.13
Green Ash	11.66	10.64	5.01	21.68	9.47
Oak	12.87	9.89	41.36	4.20	-
Cottonwood	4.11	16.92	17.29	2.29	0.44
Elm	17.47	8.20	6.94	12.00	-
Kentucky Coffee tree	14.07	9.49	4.63	7.60	8.65
Boxelder	3.38	2.26	2.31	11.02	-
Sycamore	-	4.09	-	-	-
Bitternut Hickory	2.86	0.17	-	-	-
Mulberry	1.09	-	-	-	-
Osage Orange	3.87	-	-	-	-
Stinging Nettle	3.69	-	-	-	-
Pine tree	0.30	-	6.65	2.29	37.30
Dead tree	3.87	10.18	3.70	8.41	-
Ground or Fallen timber	1.09	0.44	-	22.17	-

Table 5. Frequency of foraging by woodpecker in relation to tree condition.

Tree Condition	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
Living tree	100	90	34	26	27
Dead tree	4	7	4	3	0
Fallen timber	2	1	0	3	0
Total	106	98	38	29	27

Table 6. Frequency of location sites selected by foraging woodpeckers.

Location Site	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
Branches	46	29	17	16	3
Trunks	69	75	24	12	25
Total	115	104	41	28	28

for either branches or trunks.

The Common Flicker appeared to prefer branches to trunks as foraging sites, whereas other woodpeckers utilized trunks more frequently. The frequency of site selected by the Common Flicker was significantly different than the frequencies of other woodpeckers ($X^2 P \leq .05$). Cruz and Johnston (1979) found that the Common Flicker in Grand Cayman Island, West Indies, foraged primarily in trees, and used mainly branches (76%). However, this study showed about 57% of the total sightings of Common Flickers on branches.

The Effect of Physical Factors

Weather conditions were recorded in four categories: temperature, wind, sun position, and major snow falls. The data of daily temperature, the wind direction and speed (Appendix II) indicated that the winter of 1980-81 was not unusually cold nor windy.

The wind was recorded as one of three categories: below 10 mph, between 10-20 mph, and more than 20 mph. These categories represented approximately 30%, 50%, and 20%, respectively, of the wind conditions during the total trips to the study area. The Red-bellied Woodpecker, despite its large size, was most affected with increased wind speed. Wind speed also caused the Red-bellied Woodpecker to change its average foraging height from 10 meters in light wind to 7.1 meters in high wind (Fig. 11).

On the other hand, both the Downy Woodpecker and the Yellow-bellied Sapsucker showed resistance against increasing wind speed. Both species increased their foraging height average with higher wind speeds. On windy days, the Hairy Woodpecker exploited the maximum average height of 14 meters, which was approximately double that of the other species.

Fig. 11. The relationship between wind speed and the average height of each woodpecker species on trees. A = Downy Woodpecker (N=114); B = Red-bellied Woodpecker (N=99); C = Hairy Woodpecker (N=38); D = Common Flicker (N=34); and E = Yellow-bellied Sapsucker (N=27)

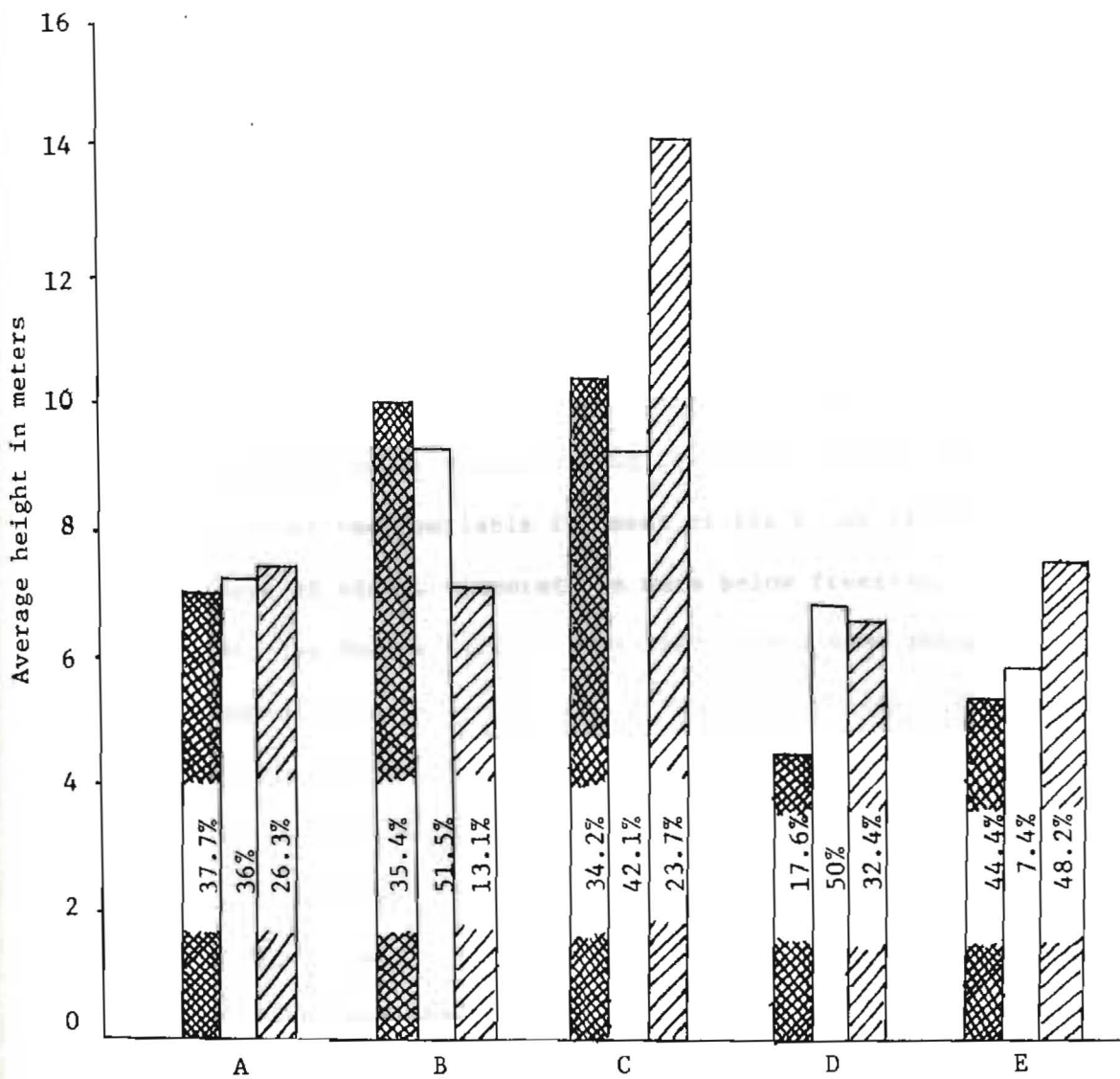


Wind speed below 10 mph.

Wind speed between 10 and 20 mph.

Wind speed over 20 mph.

Percentage of total sighting
of each woodpecker species.



During the study period, the area received five major snow falls. The heaviest was February 9th, 1981, with an accumulation of 5 inches of blowing snow. On the next day, activities were normal for the Downy, Hairy, and Red-bellied Woodpeckers. The other two woodpeckers were not observed.

The accumulation for each of the other four snow falls was two inches or less (Fig. 12). All woodpeckers showed normal activities during these times.

Since observations were made during the daylight hours, temperature was not an extreme variable for most of the study period. Except for 10 days of study, temperatures were below freezing. During those ten days, the Yellow-bellied Sapsucker showed some change from pine to deciduous trees, by using the deciduous about two-thirds of the total ten days as foraging sites. The proportion was about equal during the rest of the study period sightings. The change may have been due to the freezing of sap, and searching for solid food matter on deciduous tree bark. Also, in 64% of the sightings the Yellow-bellied Sapsuckers were positioned in the sun and 36% in the shade. It appeared that they preferred the sun position when temperatures were below freezing.

Tate (1973) indicated that the northern-wintering Sapsuckers subsist on a diet of arthropods obtained from tree bark, frozen fruit, and little sap. He then added that "during warm winter days, Sapsuckers in the middle latitude feed on local sap flow from many tree species." Tate's statement supported the hypothesis that the Sapsucker utilizes deciduous trees when temperature reaches the freezing point.

Table 7 illustrates the position of each woodpecker in response

Table 7. Woodpecker positions in relationship to wind and sun.

Sun and Wind Position	Downy Woodpecker	Red-bellied Woodpecker	Hairy Woodpecker	Common Flicker	Yellow-bellied Sapsucker
Shade + out wind	56	38	20	20	12
Shade + in wind	14	14	5	1	3
Sun + out wind	43	38	11	8	9
Sun + in wind	15	16	6	4	4

to wind and sun. Four categories were employed: shade and out wind; shade and in wind; sun and out wind; and sun and in wind. Each category is a combination of two factors at the same time. Among these four categories, shade and out of wind was significantly different from both shade and sun in wind situations (t-test $P \leq 0.05$). It indicates that wind factor appeared to be more independent than those of shade and sun factors, and obviously the out of wind situation was favorable for woodpeckers since all woodpeckers showed more than 70% of the total observations in out of wind. The Common Flicker was in shade and out of wind in 60% of sightings.

Among the five woodpeckers, although their responses to the four categories were similar from each other, there was a significant difference only between the Red-bellied Woodpecker and the Yellow-bellied Sapsucker (t-test $P \leq 0.05$).

Fig. 12. View of study area with accumulation of less than two inches of snow.



DISCUSSION

Differences in winter niche selection among the five woodpecker species in a riparian woodland was likely affected by the type of vegetation available and weather conditions.

Behavioral differences between sexes were not examined in this study. Therefore, the comparison of niche study among the five species dealt with the female and male woodpeckers as one unit.

The Yellow-bellied Sapsucker differed from other woodpecker species in its foraging habits. The frequency with which they used pine trees to obtain their sap needs was 33.33%; whereas other woodpeckers utilized pine trees less than 6%. Howell (1952) indicated that the feeding habits differed because, "Sapsuckers rarely if ever dig into infested trees for woodboring insects and larvae but feed to a considerable extent on the cambium and softer parts under the bark of trees and shrubs and on the sap as well."

In this study, woodpeckers utilized Hackberry more frequent than other tree species. According to Reller (1972), and Williams and Batzli (1979a, 1979b), in separate regions in the East, deciduous Oak was the major habitat used by woodpeckers; Selander and Giller (1959) indicated that the deciduous Oak was most often used in Texas.

Vertical distribution, which is one dimension of niche definition for woodpeckers, has been studied by several authors.

In a comparative study among four woodpecker species, Williams (1975) reported similar results to this study, except for the Downy Woodpecker. However, Williams and Batzli (1979b) indicated that with the absence of Red-headed Woodpeckers in 1973-74, Red-bellied and Downy Woodpeckers used the higher height classes in Hart Memorial Woods

Upland, Illinois. In other words, the Red-headed dominated the highest height over the other two species. The results of this study were similar to that of Williams and Batzli since no Red-headed Woodpecker was observed.

Dickson and Noble (1978) studied the vertical distribution of common birds in Louisiana. Among these were: Common Flickers, which were more oriented to the ground with 21% of sightings; Yellow-bellied Sapsuckers were primarily mid-story occupants, with 58% of all sightings; and Red-bellied Woodpeckers were often top canopy occupants, or above 7.6 meters. The vertical distributions of the present study showed a similarity to the results of Dickson and Noble.

The role of winter behavior for each woodpecker species differed, although there were some common preferences for the average tree diameter used among the five woodpecker species. The woodpeckers' vertical distributional use differed.

The average heights of the Hairy, the Red-bellied, and the Downy Woodpeckers were different. The Yellow-bellied Sapsuckers and the Common Flickers were close in their average heights, but the Common Flicker utilized branches more frequently than Yellow-bellied Sapsuckers, which appeared to use trunks most. These differences caused the vertical utilization of each species to be limited to a certain part within the area available.

Kisiel (1972), in his study of two woodpecker species, reported that he never observed two or more Hairy Woodpeckers feeding on the same tree; however, the Downy Woodpecker was found feeding together often. The present study agreed with Kisiel's findings in that both the Downy and the Hairy Woodpeckers had intraspecific associations, but not as often.

Kisiel also indicated that both the Downy and the Hairy Woodpeckers fed in mixed flocks of Chickadees, Brown Creepers, and Nuthatches. This was often the case with the Downy Woodpecker and occasionally with the Hairy Woodpecker in this study.

A male Downy Woodpecker had an interesting interspecific association with a Brown Creeper on December 24, 1980. The ground surface was covered by snow and the temperature was 15°F. The Downy Woodpecker was followed by the Brown Creeper from tree to tree without any conflicts.

Several studies indicated the interspecific association of Downy Woodpeckers with Brown Creepers within their vertical ranges. Willson (1970) found that the vertical distribution of winter foraging of Downy Woodpecker was in the lower range and Brown Creepers and Nuthatches in the low and middle heights. Also Williams and Batzli (1979b) reported that the height patterns of both Downy Woodpeckers and Brown Creepers were in the lower zones in 1974-75 in Illinois study.

The movement activities of both the Yellow-bellied Sapsucker and the Downy Woodpecker were similar, yet quite different from other woodpeckers. The Yellow-bellied Sapsucker was observed moving among three White Pine trees for more than five minutes and revisited the same tree several times. The same technique was exhibited by a female Downy Woodpecker that stayed for eight minutes foraging on a Kentucky Coffee tree, then moved to a Green Ash tree, and utilized only these two tree species. This particular behavior was used only by these two woodpeckers during the study period.

The diversity of vegetation and structure within a habitat, and the source of foods that woodpeckers use in their feeding allow variety in their avian niche selections.

In Seneca, Maryland, Red-bellied Woodpeckers appear to have stored acorns and berries for their food during the fall season (Kilham, 1963), but the Hairy Woodpeckers were most apparently fed on the elms (Kilham, 1965). According to Boone's study in Kansas (1963), "Corn was the major food source, present in 63 per cent of the gizzards." Thus the situation for Red-bellied Woodpeckers in Kansas is somehow different than that of the East. Boone did not describe the vegetation type, but in the present study area, which is not far removed from Boone's, Hackberry trees were the most dominant. The Red-bellied Woodpecker was observed crossing the river 33.67% of the total next flight distance sightings. A reason for this might be that the Red-bellied Woodpecker fed upon corn in the fields that were located adjacent to the study area.

In this study, the Common Flicker was observed with 22.17% of its total foraging time on the ground. Cruz and Johnston (1979) indicated that Flickers in Florida spent about 75% of all foraging observations on the ground, whereas other woodpecker members (among them were Hairy and Downy Woodpeckers) foraged mainly by using arboreal pecking and probing. Also, they indicated that 65.3% of the total animal matter which was taken by Flickers was ants. The considerable amount of time spent on the ground by Common Flickers in this study may be due for searching for animal matter.

The Downy Woodpecker was the only bird feeding in a weedy area, and spent about 4% of the total foraging time there. Beal (1911) discovered, in his study of stomach analysis of the Downy Woodpecker in Kansas, that 10% of stomach contents were grasshopper eggs. Foraging in relatively open weedy area might be related to probing for grasshopper eggs on the ground.

The statistical results of tree species selection and the amount of foraging time on the same trees that were used by woodpeckers differed. Although the Hackberry was significantly different from other tree species used by woodpeckers (Table 3), birds spent a considerable amount of time on five other feeding sites (Green Ash, Oak, Cottonwood, Pine, and Ground sites), (Table 4). Thus, there was no significant difference between Hackberry utilized by woodpeckers and the other five feeding sites (t -test $P \leq 0.05$).

The effect of weather changes on woodpecker behavior has been little studied. Reller (1972) was one of the few authors who related weather conditions to the nesting part of his study on woodpeckers.

Great attention was given to the effect of weather changes in the present study. Woodpecker winter behavior was affected by wind factor more than any other physical factor. The relationship of wind and woodpecker behavior was observed in two ways: (1) The distribution of birds during three categories of wind speed, with respect to the vertical height of each woodpecker species, and without attention to whether or not the bird encountered the wind in its position. (2) The distribution of woodpecker positions with respect to wind direction, sun, and shade.

Woodpeckers' height was affected by different categories of wind speed. The Red-bellied displayed a different preference from the other woodpeckers, as it decreased its average height in high winds. Wind direction was an independent factor from other physical factors. All woodpeckers appeared to be out of wind in more than 70% of the total observations.

SUMMARY

Five woodpecker species were simultaneously compared for their winter niche dimension in an attempt to identify any significant differences.

Six major comparisons were made; (1) vertical distribution, (2) DBH measurements, (3) Interspecific associations, (4) movement activities, (5) foraging sites and durations, (6) and the effect of physical factors.

Vertical distribution: The Red-bellied Woodpecker spread its vertical range distribution over the higher and lower zones. It was also the dominant bird throughout the vertical distribution, whereas the Yellow-bellied Sapsucker's and the Common Flicker's ranges were mostly in the lower zones.

DBH measurements: The Hairy Woodpecker was significantly different from other woodpeckers in DBH selection. It was more often on large diameter trees as compared to the other woodpecker species. On the other hand, the Yellow-bellied Sapsucker was observed at small trunks most of the time.

Interspecific associations: During the study period only eight bird species were associated with woodpecker species in their feeding sites. The Downy Woodpecker showed the most association with other avian species, whereas the Red-bellied Woodpeckers were observed in intraspecific associations most frequently.

Movement activities: The Red-bellied Woodpecker averaged the longest tree to tree distance. The Yellow-bellied Sapsucker and the Downy Woodpecker moved directly to the next tree without tree species preference. The similarity of the Sapsucker to the Downy in least flight distance

traveled occurred because the Sapsucker preferred the concentrated group of pine trees and the Downy Woodpecker was not selective and chose any tree.

Foraging sites and duration: All species preferred the Hackberry for their feeding sites, except the Common Flicker, that preferred the Green Ash. The Downy Woodpecker showed most diversity in its tree selection.

It was followed by the Red-bellied Woodpecker, both species were significantly different from the other three species. Selection of tree species by each of the woodpecker species differed from the duration of feeding on the same tree. For instance, the Hackberry was visited by the five woodpeckers most often, but the percentage of time spent was less than the percentage of visits. However, the Yellow-bellied Sapsucker's tree preference was Hackberry in both cases (number of visits and duration). Foraging time on Green Ash, Oak, Cottonwood, Pine, and the ground was significantly different from other feeding sites. These second choice sites produced less competition among the woodpeckers for feeding sites.

The effects of physical factors: Wind speed and direction, and temperature affected the woodpeckers in their winter niches. The Red-bellied Woodpecker decreased its foraging height in high winds. All woodpecker species appeared to stay in position, out of the wind direction in more than 70% of the total observations. The activity of the Common Flicker and the Yellow-bellied Sapsucker was hampered by temperatures below the freezing point.

North America
United States, N. Y.
New York
1914.

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APPENDIX I

During the winter season of 1955-56
 the temperature was recorded at Vitoria, Spain.

Wind	High	Low	Time
SE 10	24	18.30	
	23	18.30	
	24	5.20-30	
	23	18-21	
		18.30-21	

APPENDIX II

					18.30
					18.30
				18	18.30
				21	18.30-21
		Dec. 23	24	18	18.30
23	SE 12	Dec. 24	17	18	18.30-21
18	Variable	Dec. 25	21	18	18.30
18	Variable	Dec. 26	21	18	18.30
25	Variable	Dec. 27	21	18	18.30
27	SE 10-20	Dec. 28	21	18	18.30
32	SE 10	Dec. 29	21	18	18.30
		Dec. 30	21	18	18.30-21
		Dec. 31	21	18	18.30

Weather records during the winter season of 1980-81
obtained from The Emporia Gazette, Emporia, Kansas.

Date	High	Low	Wind	Date	High	Low	Wind
Nov. 1	64	39	NE 10	Dec. 1	57	24	N 14
Nov. 2	76	36	-----	Dec. 2	27	10	NE 10
Nov. 3	70	49	NW 18	Dec. 3	47	16	S 20-30
Nov. 4	67	39	NW 15	Dec. 4	63	33	SW 18-27
Nov. 5	69	39	-----	Dec. 5	70	57	SW 20-30
Nov. 6	83	38	SW 15	Dec. 6	56	37	N 7
Nov. 7	78	58	N 15	Dec. 7	39	34	-----
Nov. 8	84	48	SW 12	Dec. 8	32	28	NE 13
Nov. 9	75	42	-----	Dec. 9	34	24	SW 8
Nov. 10	69	40	SE 17	Dec. 10	43	22	SW 11
Nov. 11	73	50	-----	Dec. 11	56	30	W 11
Nov. 12	72	55	S 18-27	Dec. 12	61	39	N 12
Nov. 13	65	38	N-NW 15	Dec. 13	50	34	NE 11
Nov. 14	37	35	N 12	Dec. 14	55	30	-----
Nov. 15	43	32	N 11	Dec. 15	55	31	NW 18
Nov. 16	36	27	-----	Dec. 16	50	41	N 16
Nov. 17	41	29	N 14	Dec. 17	63	32	SW 15-22
Nov. 18	46	21	Variable	Dec. 18	37	32	NE 17
Nov. 19	55	23	SW 10	Dec. 19	30	11	NE 15
Nov. 20	52	27	N 16	Dec. 20	20	8	NE 7
Nov. 21	56	22	SW 17	Dec. 21	31	10	-----
Nov. 22	53	30	S-SW 17-23	Dec. 22	39	21	SW 13-25
Nov. 23	45	36	-----	Dec. 23	46	24	SW 8
Nov. 24	42	23	NE 12	Dec. 24	17	0	N 20-30
Nov. 25	40	18	Variable	Dec. 25	21	-1	-----
Nov. 26	39	18	Variable	Dec. 26	42	21	N 9
Nov. 27	44	26	-----	Dec. 27	43	24	S 16
Nov. 28	50	22	N 17-25	Dec. 28	53	33	-----
Nov. 29	59	32	NW 15	Dec. 29	49	31	N 11
Nov. 30	63	42	-----	Dec. 30	56	29	SW 18-27
				Dec. 31	56	32	-----

Date	High	Low	Wind	Date	High	Low	Wind
Jan. 1	43	25	-----	Feb. 1	28	11	-----
Jan. 2	51	23	SW 15-22	Feb. 2	21	8	NW 17-24
Jan. 3	59	17	NE 17-26	Feb. 3	35	11	SW 10
Jan. 4	30	14	-----	Feb. 4	27	14	N 6
Jan. 5	39	17	S 15	Feb. 5	45	21	SW 14
Jan. 6	45	26	N-NW 20-30	Feb. 6	43	20	S 10
Jan. 7	48	18	SW 18	Feb. 7	44	22	NW 6
Jan. 8	43	23	N 15	Feb. 8	31	22	-----
Jan. 9	40	18	N 12	Feb. 9	27	19	E 11
Jan. 10	32	11	SE 6	Feb. 10	22	-3	N 28-44
Jan. 11	26	13	-----	Feb. 11	19	-10	SW 15
Jan. 12	48	15	SW 17-25	Feb. 12	34	8	S 18-25
Jan. 13	47	26	NW 7	Feb. 13	44	19	SW 12
Jan. 14	44	26	N 20	Feb. 14	54	25	SW 13-20
Jan. 15	36	18	N 11	Feb. 15	56	33	-----
Jan. 16	28	10	N 15	Feb. 16	65	34	S 10
Jan. 17	40	8	W 10	Feb. 17	68	33	SW 15-22
Jan. 18	51	19	-----	Feb. 18	67	41	NE 8
Jan. 19	39	34	SW 14	Feb. 19	70	39	NW 13
Jan. 20	41	33	N 12	Feb. 20	80	35	S 14-22
Jan. 21	47	24	N 9	Feb. 21	59	43	N 10
Jan. 22	58	25	NW 10	Feb. 22	51	38	-----
Jan. 23	65	25	W 10	Feb. 23	62	34	NW 14
Jan. 24	72	34	Calm	Feb. 24	75	30	S 14
Jan. 25	61	38	-----	Feb. 25	77	46	S 12
Jan. 26	44	26	NW 5	Feb. 26	66	54	S 10
Jan. 27	50	25	NW 7	Feb. 27	68	48	NW 13
Jan. 28	58	25	NW 4	Feb. 28	55	35	N 10
Jan. 29	48	23	E-NE 17-26				
Jan. 30	37	16	SE 8				
Jan. 31	31	21	SE 17				

Date	High	Low	Wind	Date	High	Low	Wind
Mar. 1	52	26	N 10	Apr. 1	76	39	SW 10
Mar. 2	52	32	NE 8	Apr. 2	83	51	SW 22-37
Mar. 3	46	36	S 7	Apr. 3	74	51	S 21-30
Mar. 4	46	36	NE 12	Apr. 4	56	40	N 20
Mar. 5	47	30	N 12	Apr. 5	64	35	-----
Mar. 6	57	28	E 12	Apr. 6	72	36	SW 22-31
Mar. 7	42	28	E 15	Apr. 7	79	50	SW 20-30
Mar. 8	47	22	-----	Apr. 8	75	49	NW 15-23
Mar. 9	60	26	W 20	Apr. 9	75	44	SE 13
Mar. 10	58	26	NW 13	Apr. 10	84	62	SW 24-38
Mar. 11	57	32	NE 15	Apr. 11	81	60	S 18
Mar. 12	65	35	W 15-23	Apr. 12	87	60	-----
Mar. 13	62	37	NE 14	Apr. 13	84	52	SW 17
Mar. 14	62	29	S 13	Apr. 14	65	40	N-NE 15-25
Mar. 15	67	40	-----	Apr. 15	64	35	SE 14
Mar. 16	64	29	NW 12	Apr. 16	74	50	SW 22-32
Mar. 17	73	40	S 15				
Mar. 18	45	26	N 18-28				
Mar. 19	55	26	N-NW 16-23				
Mar. 20	54	32	SE 15				
Mar. 21	60	42	SE 22-35				
Mar. 22	49	35	-----				
Mar. 23	62	30	SW 7				
Mar. 24	69	39	SW 13-25				
Mar. 25	59	44	SE 10				
Mar. 26	66	42	SE 15-25				
Mar. 27	69	48	S-SE 15				
Mar. 28	69	56	S 18-30				
Mar. 29	59	41	-----				
Mar. 30	77	40	SW 16				
Mar. 31	67	43	W 20-33				

Case 1:13-cv-00001
Case 1:13-cv-00001

APPENDIX III

Some equivalents of the Metric System and
U. S. Units of measurement used in this study

Length: 1 centimeter (cm) = 0.394 inch (in.)

1 Meter (m) = 3.281 feet (ft.)

Area: 1 hectare (ha) = 2.471 acres