

that location. Second, observed eating times were as long as 83 s and it is possible that by the time the heron finishes eating, prey occasionally are visible again in the same area; however we found no correlation between eating time and whether or not a heron moved. Third, variations in hunting motivation may influence the tendency to remain; after eating, a heron should be less hungry and thus may be less motivated to change location.

#### SUMMARY

The relationship between tendency to move to a new location and hunting success at the previous location was quantitatively investigated in Green Herons (*Butorides striatus*) and Green Kingfishers (*Chloroceryle americana*). Herons stayed in one location longer before a prey-catching attempt than when no attempt was made, moved sooner after an attempt than when no attempt was made, and stayed longer after a successful attempt than after an unsuccessful attempt. There were no significant differences in similar comparisons for the kingfishers. Herons stayed in one location longer before an attempt and moved sooner after an unsuccessful attempt than did kingfishers. Kingfishers made consecutive attempts from a location more often than herons and more often than predicted by chance. Explanations for these habits are suggested.

#### ACKNOWLEDGMENTS

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#### WEATHER-DEPENDENT FORAGING BEHAVIOR OF SOME BIRDS WINTERING IN A DECIDUOUS WOODLAND: HORIZONTAL ADJUSTMENTS

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Although avian feeding niches have been heavily studied, the influence of short-term weather variation on foraging has received scant attention. I have shown previously that birds wintering in a temperate deciduous woodland in New Jersey significantly modified several aspects of their foraging behavior in response to changing wind velocity and temperature (Grubb 1975). The birds positioned themselves closer to the ground in lower temperatures and higher winds, most likely to reduce thermal stress by moving into the area with reduced air movement near the forest floor. Such descent then significantly modified the choices available to the bird of substrate type and tree species for foraging.

The New Jersey study plot was selected in part to eliminate any complicating horizontal adjustments by the birds. Local topographical variation was negligible, and habitat edges were absent. The present

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study, in a different woodland, tests the predictions that decreased solar radiation, higher wind velocities, and lower temperatures in winter cause foraging birds to decrease their exposure to wind by: (1) capitalizing on topographical variation; and (2) using leeward sides of foraging substrates. Each weather variable is examined separately by grouping sightings so as to hold the other variables constant or within narrow ranges.

#### METHODS

From November to March 1973-75, I watched birds foraging in a 26-ha beech-maple woodlot in Bennington Township, Morrow Co., Ohio. The woodlot is rectangular, with its longer sides oriented north-south, and has a 15-m wide stream valley running its length. A 2-m wide stream meanders through the valley. Thus, the woodlot may be divided into an "east bluff" and "west bluff"; the intervening "stream valley" is separated from the bluffs by 45° slopes 5 to 15 m high. The woodlot is bordered on the north by a road, on the east by a dense old-field thicket of blackberry and hawthorne, and on the south and west by tilled fields (of winter wheat during the study).

Field methods largely duplicated those of Grubb (1975). I watched only the four most abundant species: Downy Woodpeckers (*Picoides pubescens*, ≥

TABLE 1. Influence of solar radiation, temperature and wind velocity on the use of a 26-ha deciduous woodlot by wintering birds.

Weather variable		Sightings per hour				
		Male Downy Woodpecker	Female Downy Woodpecker	White-breasted Nuthatch	Tufted Titmouse	Carolina Chickadee
Solar radiation <sup>a</sup>	Sun shining (3.8) <sup>b</sup>	7.4	1.3	5.0	10.1	5.3
	Sun occluded (12.3)	4.7	2.5	5.1	4.4	3.7
Temperature <sup>c</sup> (°C)	0.1 to 10.0 (2.9)	3.9	4.9	7.2	11.0	8.4
	-9.9 to 0.0 (10.8)	2.9	2.9	7.9	6.0	4.9
	-29.9 to -20.0 (1.4)	2.3	0.7	1.5	0.6	0
Wind velocity <sup>d</sup> (m/sec)	0.1 to 1.0 (2.9)	3.9	4.9	7.2	11.0	8.4
	3.1 to 4.0 (1.8)	3.4	2.8	4.4	3.7	2.1

<sup>a</sup> Conditions: temperature 0.1–10.0°C; wind velocity 1.1–2.0 m/sec.

<sup>b</sup> Number of sample hours.

<sup>c</sup> Conditions: wind velocity 0.1–1.0 m/sec; sun occluded.

<sup>d</sup> Conditions: temperature 0.1–10.0°C; sun occluded.

13 individuals from census data); Carolina Chickadees (*Parus carolinensis*,  $\geq 17$  individuals); Tufted Titmice (*P. bicolor*,  $\geq 22$  individuals); and White-breasted Nuthatches (*Sitta carolinensis*,  $\geq 12$  individuals). I kept separate records for the woodpecker sexes ( $\geq 7$  males,  $\geq 6$  females). In each 1- to 2-hr study session, I walked one east-bluff, one stream-valley, and one west-bluff transect in randomized order. Methods for recording bird sightings and weather conditions were those of Grubb (1975), with the following additions. Foraging birds were recorded as being: greater than or less than 25 m from the windward woodlot edge; within the east bluff, stream bottom or west bluff; and sheltered or not sheltered from the wind. Sheltered foraging was defined as being within 10 cm of any object (rock, log, trunk, branch) that blocked the wind from at least half the bird's body. To simplify matters I carried out field work only in wind directions of 225–315° (thus, the western edge of the woodlot abutting the tilled field was always windward) and avoided working in precipitation or when the ground was snow-covered.

Contemporary wind velocities were lower in the recessed stream valley than on the more exposed bluffs. To find out if the birds used the woodlot as a whole with weather-dependent intensity (see table 1), it became necessary to standardize wind velocities across both bluffs and the stream valley. Immediately after each sighting, I measured wind speed with a portable anemometer 2 m above the ground away from shrubs. For each field session, all wind velocity measurements within each section (east bluff, stream valley or west bluff) were averaged. Using the ratios among these mean values, I converted wind speeds accompanying each east bluff and stream valley sighting to the equivalent west bluff velocity. For example, if a given session's ratio of mean west-bluff to mean stream-valley wind speed were 2:1, each stream-bottom wind speed would be doubled.

In testing for the effect of solar radiation on the extent of foraging while sheltered from the wind, I confined my analysis to afternoon records when sunlight and wind both penetrated the woodlot from the west.

Relative humidity remained within such narrow limits during the study (range, 63–82%) that I lumped sightings irrespective of relative humidity when considering other weather variables. Chi-square tests were used to evaluate statistical significance and were restricted to cases where at least 80% of expected

values were five or more (Siegel 1956). Levels of significance are shown in figures.

## RESULTS

*Use of the woodlot.* The number of sightings per hour was used as an index of how intensively the birds used the woodlot. In general, when the sun was clouded over, and at low temperatures or high wind velocities, the frequency of sightings dropped for all species (table 1). The effect of worsening climatic conditions was most pronounced in the Tufted Titmouse and Carolina Chickadee, the latter abandoning the woodlot in temperatures from -20.0 to -29.9°C; they apparently moved to the bordering old-field. The only exceptions to the trend were slightly increased sightings per hour for the nuthatch and female woodpecker under cloudy skies.

*Distribution within the woodlot.* Variation in solar radiation, temperature and wind velocity all significantly influenced the distribution of birds within the woodlot (fig. 1). Under conditions of 0.1–10.0°C temperature and 1.1–2.0 m/sec wind velocity, cloudy skies significantly increased the percent of chickadee foraging in the stream valley (fig. 1A). Comparisons for the other species were non-significant but, except for the nuthatch, followed the same trend. Under the same conditions of wind and temperature, male Downy Woodpeckers and the two parids foraged significantly more within 25 m of the windward woodlot edge in sunshine than under cloud cover. The nuthatch followed the same trend (but not significantly) as did the female woodpecker (with inadequate sample size).

Temperatures also influenced distributions within the woodland (fig. 1B). Under a regime of cloudy skies and wind velocities of 1.1–2.0 m/sec, colder weather caused a significant shift toward the stream valley and away from the windward woodlot edge for the nuthatch, titmouse, and chickadee. The woodpecker sexes were not so heavily affected.

Wind velocity variation had a substantial impact on distribution. An increase of 1–2 m/sec, when the sun was clouded over and the temperature 0.1–10.0°C, significantly drove birds away from the windward edge and into the stream valley. Indeed, for the chickadee, the disparity in both windward edge and stream bottom percentages was the maximum possible (fig. 1C). Male Downy Woodpeckers appeared to be an exception, but the samples are small.

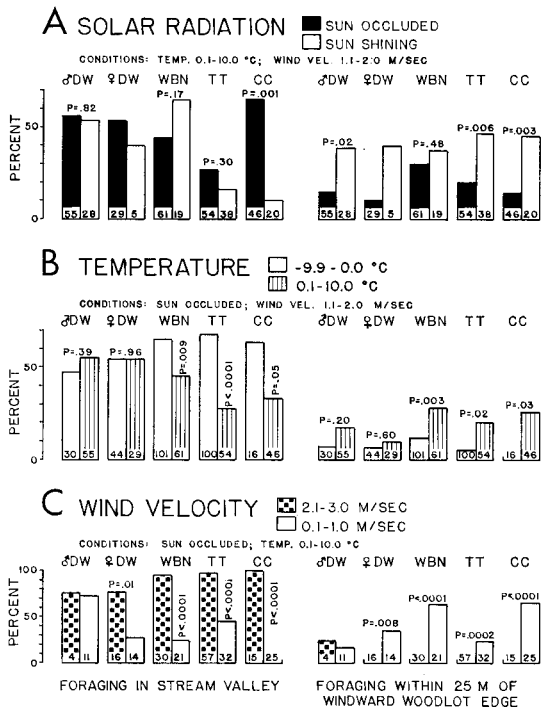


FIGURE 1. Influence of (A) solar radiation, (B) temperature, and (C) wind velocity on the distribution within a deciduous woodlot of male and female Downy Woodpeckers (DW), White-breasted Nuthatches (WBN), Tufted Titmice (TT), and Carolina Chickadees (CC) foraging in winter. Percentages are of the sample sizes shown within the bars. Chi-square test probabilities of significance are given above the bars.

*Foraging while sheltered from the wind.* Changes in solar radiation, temperature and wind velocity all significantly modified the frequency with which one or more species sought protection from the wind (fig. 2). Male woodpeckers and the titmice kept to the leeward of substrates significantly more under cloud than when the sun was shining. This trend was non-significant for the female woodpecker and absent for the nuthatch (fig. 2A). Statistical evaluation was not possible for the chickadee due to that species' overwhelming penchant for foraging on twigs under all weather conditions. By my operational definition, twigs are a substrate that cannot furnish shelter from the wind.

Lower temperatures also brought birds into the leeward of substrates; significantly so for the woodpecker sexes and the titmouse, but non-significantly for the nuthatch (fig. 2B). Although chickadees followed the same trend, the numbers of leeward foragers were again small.

Higher wind velocities also confined birds more to leeward foraging. The trend was maintained across all species in wind speeds between 0.0–1.0 and 1.1–2.0 m/sec—significantly so in all but the chickadee for which sample sizes were inadequate (fig. 2C).

DISCUSSION

All the birds surveyed varied their foraging behavior in response to changing wind velocity, temperature and solar radiation. Overall, female Downy Wood-

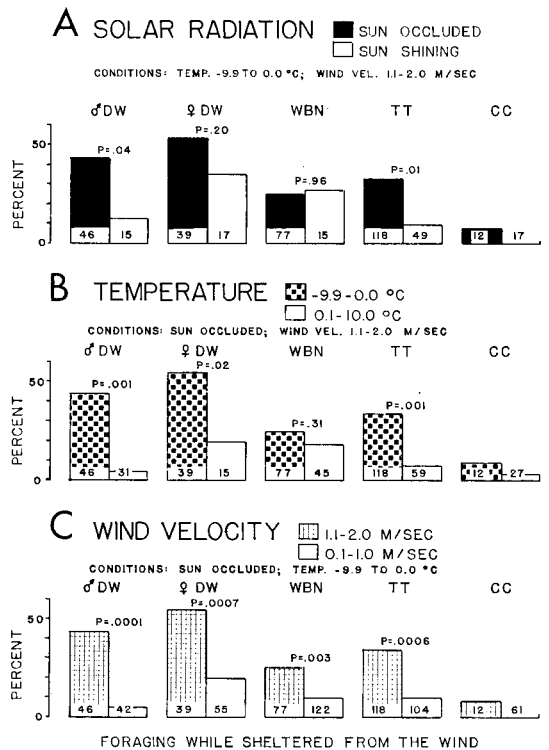


FIGURE 2. Influence of (A) solar radiation, (B) temperature, and (C) wind velocity on shelter-seeking in male and female Downy Woodpeckers (DW), White-breasted Nuthatches (WBN), Tufted Titmice (TT), and Carolina Chickadees (CC) foraging in a deciduous woodlot in winter. Percentages are of the sample sizes shown within the bars. Chi-square test probabilities of significance are given above the bars.

peckers and the nuthatches were least influenced by weather. These are large-substrate foragers (trunks and large branches, Grubb 1975) and, consequently, are less exposed to wind than are the twig and small-branch foragers (i.e., male Downy Woodpeckers and the two parids).

Laboratory studies (e.g., Lustick 1969) have demonstrated that artificial radiation lessens the energy cost of low temperatures. The present results show that the intensity of solar radiation can dictate the degree to which bird species forage in a given habitat (table 1), concentrate their foraging in parts of that habitat (fig. 1), and use only a portion of preferred foraging substrates (fig. 2).

My findings (table 1) indicate that in only slightly more severe weather conditions the woodlot as a whole would have become an unacceptable foraging area for any of the birds. Indeed, it was vacated by Carolina Chickadees under the most inhospitable conditions recorded (sun occluded, wind velocity 0.1–1.0 m/sec, temperature -20.0 to -29.9°C). I could not penetrate with the necessary stealth the blackberry-hawthorne tangle to the east of the woodlot, but I heard the four species calling there when the woodlot was essentially empty. I suspect that the dense old-field thicket served as a thermal refuge during the most stressful conditions by offering shelter from the wind.

Present evidence shows that the foraging behavior of wintering woodland birds is controlled by plant

species and substrate type (e.g., Willson 1970), by social environment (e.g., Kilham 1970, Morse 1970), and by climatic condition (Grubb 1975, present paper). We do not know how intercompensation (*sensu* Wilson 1975) among these factors might structure any given foraging niche. For example, consider a hypothetical male Downy Woodpecker hammering at a living twig in the top of a green ash. It could be foraging there because: (A) it prefers to forage on ash twigs; (B) it has been excluded from other tree species and lower substrates by its more powerful congener, the Hairy Woodpecker (*Picoides villosus*), by some other species, or even by female Downy Woodpeckers; (C) it wants to receive the thermal benefits of maximum exposure to solar radiation; or (D) some combination of the above.

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TAXONOMY AND RANGE OF *PIONUS* "SENILOIDES" IN PERÚ

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In 1961 Maria Koepeke (Am. Mus. Novit. No. 2028, 1-31) reported four specimens of the Plum-crowned Parrot (*Pionus tumultuosus*; three males, Am. Mus. Nat. Hist. nos. 235769-771, and one female, Museo de Historia Natural "Javier Prado" no. 1953), from Hacienda Taulis, Depto. Cajamarca in northwestern Perú. In 1974, J. P. Richard Thomas of the Louisiana State University Museum of Zoology collected a *Pionus* ca. 33 km NE of Ingenio on the road to Laguna Pomacochas, Depto. Amazonas, Perú. We identified this specimen (LSUMZ 77986, ad. female, collected 22 December 1974, ovary 7 × 10 mm, wt. 229 g) as a White-capped Parrot (*P. seniloides*), a species not previously reported from Perú (Meyer de Schauensee, R., A guide to the birds of South America, Livingston Publ. Co., Wynnewood, Pennsylvania, 1970). In comparing it with the one in the Museo de Historia Natural "Javier Prado" in Lima and with the three in the American Museum of Natural History, we determined that the four specimens reported by Koepeke are all representative of *seniloides* and not *tumultuosus*.

*P. seniloides* is now known in Perú south on the western slope of the western Andes to Taulis in the Depto. Cajamarca (6°54'S, 70°58'W) and south in the eastern Andes to the southern portion of the large and mainly unexplored mountain massif that is situated to the south of the Río Marañón between the Río Utcubamba and the Río Chiriaco (5°52'S, 77°56'W). The easternmost Andes in Northern Perú lie to the east of the Río Chiriaco, and thus to the east of the mountains in which the recently collected *P. seniloides* was taken. O'Neill visited this area in September 1976, and although members of the genus *Pionus* were seen, none were collected or identified.

In the LSUMZ are five unreported specimens of *P. tumultuosus* from the Carpish region (9°40'S, 76°4'W) of the Depto. Huánuco in central Perú (LSUMZ 75116 and 73808-73811) that apparently represent the northernmost records of this form. Additional field work is needed in the area intervening between the known ranges of *seniloides* and *tumultuosus* to see if they make contact with each other or not.

After careful scrutiny of the specimens available to us we have come to the conclusion that the only difference between *P. seniloides* and *P. tumultuosus* is the amount of rose or plum color present in the plumage of the head and belly. The northern birds, "*P. seniloides*," have only a wash of this color present on their otherwise whitish head plumage and have the belly with a variable amount of rosy color, but the southern birds, "*P. tumultuosus*," have the head strongly marked with this color and have solid green bellies. The older birds of either form apparently have the greatest saturation of the rosy coloration in their plumage.

Although the locality northeast of Ingenio is slightly drier than the Carpish region, both areas are covered with tall, humid cloud forest and both of the two forms of parrots inhabit the "upper sub-tropical" zone at the 1800-2100 m level.

We believe, in the absence of evidence to the contrary, that the two forms of *Pionus* under discussion do not differ enough morphologically or ecologically to warrant their being retained as separate species. Since *P. tumultuosus* was described first, the two should be known as *P. t. seniloides*, ranging from Venezuela to northern Perú, and *P. t. tumultuosus*, ranging from central Perú to Bolivia.

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