FORAGING BEHAVIOR OF THE PYGMY NUTHATCH IN COLORADO PONDEROSA PINE FORESTS

HEATHER EWELL and ALEXANDER CRUZ, Environmental, Population, and Organismic Biology Department, University of Colorado, Boulder, Colorado 80309-0334

The Pygmy Nuthatch (*Sitta pygmaea*) is a permanent resident of montane habitats in the Rocky Mountain region, occurring most commonly in forests of Ponderosa Pine (*Pinus ponderosa*). In Colorado, the center of its distribution is in the lower montane region (1660 to 2425 m) (Bailey and Niedrach 1965, Andrews and Righter 1992). The breeding season (egg laying through fledgling stage) in Colorado lasts from early May to August (Bent 1964, Bailey and Niedrach 1965).

The diet of the Pygmy Nuthatch consists of both insect and vegetable matter. In Monterey County, California, Beal (1907) found that during late spring and early summer the diet consisted of 83% animal matter and 17% conifer seeds. Beal found that the insect diet is dominated by Hymenoptera (38%), Homoptera (23%) and Coleoptera (12%). Norris (1958) found that in Marin County, California, in winter nuthatches ate an average of 85 to 95% vegetable matter (pine seeds) while from April-September, they ate an average of 40 to 60% vegetable matter. In Larimer County, Colorado, McEllin (1979) noted that the nuthatches' diet shifted from primarily insects in the summer to primarily pine seeds in the winter.

We observed the foraging behavior of Pygmy Nuthatches during the breeding (10 June–31 August 1995 and 15 June–31 August 1996) and non-breeding season (1 March–30 April, 1995, 15 January–30 April 1996, and 1 September 1996–1 March 1997) in the Ponderosa Pine foothills of Colorado, focusing on foraging technique, position during foraging, and foraging location. Our goal was to increase understanding of how the Pygmy Nuthatch uses the Ponderosa Pine forests.

STUDY AREAS AND METHODS

The study areas were open woodlands (Betasso Preserve, Mount Sanitas Open Space, Flagstaff Mountain, and Shanahan Ridge) consisting mainly of stands of ponderosa pines mixed with Douglas Fir (*Pseudotsuga menziesii*) and Common Juniper (*Juniperus communis*) trees in Boulder County, Colorado (elev. 1550 to 2150 m).

Every bird that was encountered while foraging was recorded. Each bird was watched until it ceased a single foraging attempt. Thus, no observations were made in succession on the same birds. We estimate that a minimum 30 individuals were observed. In total 259 observations were made, 131 during the breeding season and 128 during the nonbreeding season.

Foraging behaviors were divided into three categories (Cruz 1987). One category, foraging technique, consisted of probing (removal of a food item by penetrating of the surface), gleaning (removal of a food item from the surface), pecking (removal of prey item by tapping and then penetrating surface), sallying (prey caught in flight), or cracking seeds/pounding (repeated pounding of the bird's beak on a seed). Another category, position

during foraging, consisted of stationary facing up, stationary facing down, vertical movement upward (usually on a trunk), vertical movement downward, lateral movement toward the trunk, lateral movement away from the trunk (resulting from a bird starting near the trunk and moving usually on branches toward the outer margins of the tree), movement among cone/needle clusters, and sallying. The final category was foraging location, consisting of top of branch, bottom of branch, top and bottom of branch, cone/needle cluster, trunk, base of branch, ground, and air. All statistical comparisons were done using the one-way chi-square test for independence and significance was determined if $P < 0.05$.

RESULTS

Nonbreeding Season

Probing was used significantly more often than all three other foraging techniques, namely, pecking/flaking bark ($\chi^2 = 11.8$, df = 1, $P < 0.05$), cracking seeds/pounding ($\chi^2 = 23.5$, df = 1, $P < 0.05$), and sallying ($\chi^2 = 27.3$, df = 1, $P < 0.05$). Pecking/flaking bark was only used significantly more than sallying ($\chi^2 = 5.8$, df = 1, $P < 0.05$). Gleaning was preferred over both cracking seeds/pounding ($\chi^2 = 11.2$, df = 1, $P < 0.05$), and sallying ($\chi^2 = 14.5$, df = 1, $P < 0.05$) (Table 1).

Pygmy Nuthatches were observed significantly more often in the stationary-facing-up, lateral-movement-away-from-the-trunk, and cone/needle-cluster positions than in the stationary-facing-down position ($\chi^2 = 8.0, 5.4, 8.4$, df = 1, $P < 0.05$). Stationary facing up was also used significantly more frequently than vertical movement upward ($\chi^2 = 5.7$, df = 1, $P < 0.05$) and lateral movement toward the trunk ($\chi^2 = 5.0$, df = 1, $P < 0.05$). Likewise, movement among cone/needle clusters was also performed more frequently than vertical movement upward ($\chi^2 = 6.1$, df = 1, $P < 0.05$) and lateral movement toward the trunk ($\chi^2 = 5.4$, df = 1, $P < 0.05$) (Table 2).

Nuthatches were observed significantly more often on the upper side of branches ($\chi^2 = 11.2$, df = 1, $P < 0.05$) and cone/needle clusters ($\chi^2 = 9.3$, df = 1, $P < 0.05$) than on the under side of branches (Table 3). Likewise, these foraging locations were both used significantly more frequently than the upper and under sides of branches ($\chi^2 = 11.2, 9.3$, df = 1, $P < 0.05$), bases of branches ($\chi^2 = 7.8, 6.2$, df = 1, $P < 0.05$), ground ($\chi^2 = 12.2, 10.3$ df = 1, $P < 0.05$), air ($\chi^2 = 14.5, 12.5$, df = 1, $P < 0.05$), and twigs ($\chi^2 = 8.5, 6.9$ df = 1, $P < 0.05$). In addition, the trunk was preferred significantly more than both the ground ($\chi^2 = 4.5$, df = 1, $P < 0.05$) and air ($\chi^2 = 6.3$, df = 1, $P < 0.05$) (Table 3).

Breeding Season

The nuthatches showed a preference for three of the foraging techniques (Table 1). Probing ($\chi^2 = 16.9$, df = 1, $P < 0.01$), pecking/flaking bark ($\chi^2 = 17.9$, df = 1, $P < 0.05$), and gleaning ($\chi^2 = 15.4$, df = 1, $P < 0.05$) were all used significantly more than either cracking seeds/pounding or sallying (Table 1).

With respect to position during foraging, stationary facing up was found to be used significantly more than stationary facing down ($\chi^2 = 4.5$, df = 1, $P < 0.05$), vertical movement downward ($\chi^2 = 4.5$, df = 1, $P < 0.05$), lateral

Table 1 Pygmy Nuthatch Foraging Technique in the Colorado Front Range, 1995–1997

Technique	Breeding Season (n = 131)	Nonbreeding Season (n = 128)
Probing	32.0% (42)	49.2% (63)
Pecking/flaking bark	33.6% (44)	14.8% (19)
Gleaning	29.8% (39)	28.9% (37)
Cracking seeds/pounding	2.3% (3)	4.7% (6)
Sallying	2.3% (3)	2.4% (3)

movement toward trunk (χ^2 = 8.9, df = 1, $P < 0.05$), and sallying (χ^2 = 12.0, df = 1, $P < 0.05$) (Table 2).

The nuthatches foraged in the cone/needle clusters significantly more than in all other locations except upper side of branch (Table 3). These other subcategories included under side of branch (χ^2 = 8.5, df = 1, $P < 0.05$), upper and under sides of branch (χ^2 = 11.3 df = 1, $P < 0.05$), trunk (χ^2 = 6.9, df = 1, $P < 0.05$), base of branch (χ^2 = 5.0, df = 1, $P < 0.05$), ground (χ^2 = 11,3, df = 1, $P < 0.05$), air (χ^2 = 13.5, df = 1, $P < 0.05$), and twigs (χ^2 = 7.7, df = 1, $P < 0.05$). The other location that was preferred significantly more by the nuthatches was upper side of branch (Table 3). This was used significantly more frequently than under side of branch (χ^2 = 4.4, df = 1, $P < 0.05$), upper and under sides of branch (χ^2 = 6.7, df = 1, $P < 0.05$), ground (χ^2 = 7.7, df = 1, $P < 0.05$), and air (χ^2 = 7.7, df = 1, $P < 0.05$).

Breeding Season vs. Nonbreeding Season

Of the various foraging categories, only foraging technique was found to differ significantly between the two seasons. Probing (χ^2 = 9.39, df = 1, $P < 0.05$) and pecking/flaking bark (χ^2 = 9.39, df = 1, $P < 0.05$) were used significantly more in the nonbreeding than in the breeding season (Table 1). Although there were numerical differences in frequency between other foraging behaviors in the two seasons, none was found to be significant.

Table 2 Pygmy Nuthatch Positions during Foraging in the Colorado Front Range, 1995–1997

Position	Breeding Season (n = 131)	Nonbreeding Season (n = 128)
Stationary facing up	24.4% (32)	23.4% (30)
Stationary facing down	9.2% (6)	4.7% (6)
Moving vertically upward	10.7% (14)	7.0% (9)
Moving vertically downward	9.2% (12)	11.7% (15)
Lateral toward trunk	4.6% (6)	7.8% (10)
Lateral away from trunk	19.1% (25)	19.0% (24)
Among cone/needle clusters	20.6% (27)	19.0% (24)
Sallying	2.3% (3)	2.3% (3)

Table 3 Pygmy Nuthatch Foraging Location in the Colorado Front Range, 1995–1997

Location	Breeding Season (n = 131)	Nonbreeding Season (n = 128)
Upper side of branch	19.1% (25)	28.9% (37)
Under side of branch	6.1% (8)	4.7% (6)
Upper and under sides of branch	3.8% (5)	4.7% (6)
Trunk	7.6% (10)	15.6% (20)
Base of branch	10.0% (13)	7.8% (10)
Ground	3.8% (5)	3.9% (5)
Air	2.3% (3)	2.3% (3)
Cone/needle clusters	26.7% (35)	25.8% (33)
Twigs	6.9% (9)	7.8% (9)

DISCUSSION

The diversity of positions and substrates used during foraging suggest that nuthatches are generalists in these variables. These findings are supported by McEllin (1979), who said Pygmy Nuthatches are "generalists in location and specialists in prey strategy." However, the prevalence of several subcategories demonstrates a preference for certain behaviors.

The nuthatches made greatest use of the upper sides of branches and cone/needle clusters. This is in agreement with findings of Norris (1958) in California and Bock (1969) and McEllin (1979) in Colorado. Ground foraging, however, was found by Richardson (1942) in California and Stallcup (1968) in Colorado, whereas we observed it infrequently.

The frequent use of the stationary-facing-up position and lateral movements away from the trunk are associated with the use of the upper side of branches. Likewise, movement among cone/needle clusters clearly suggests foraging attempts within cone/needle clusters, the second major foraging location.

Although nuthatches are generalized in foraging location and positions, they appear to be exploiting fairly specific resources. This is suggested by the high frequencies of probing, pecking/flaking bark, and gleaning, paralleling the findings of Richardson (1942), Hay (1977) in Riverside County, California, and McEllin (1979). All three of these foraging techniques demonstrate use of resources and prey that are present on or in the bark of trees. Since this is a small subset of the resources available, this suggests that nuthatches are technique and prey specialists.

During our study, we rarely observed ground feeding. In contrast, Stallcup (1968) found that during the nonbreeding season nuthatches in Larimer County, Colorado, frequently (19.3%) fed on the ground. The ground was used mainly for extracting seeds from fallen pine cones.

Our data support cone/needle clusters and the upper sides of branches as the Pygmy Nuthatch's primary foraging areas. Past findings also supported high use of cone/needle clusters (Norris 1958, Bock 1968, McEllin 1979). This is relevant to management since only healthy adult pines produce cone

crops. As a result, healthy mature Ponderosa Pines appear to offer the Pygmy Nuthatch the best foraging habitat.

The lack of difference in the main foraging behaviors observed between seasons was surprising. Differences in foraging behaviors across seasons have been reported in Colorado by Stallcup (1968), who found that the nuthatches used more foraging zones during the breeding season than during the rest of the year. Similarly, Manolis (1977) found in Lassen County, California, that the most frequent foraging locations in summer and winter differed. McEllin (1979), however, found no seasonal difference in foraging technique in Colorado.

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LITERATURE CITED

Andrews, R., and Righter, R. L. 1992. Colorado Birds: A Reference to Their Distribution and Habitat. Denver Mus. Nat. Hist., Denver.

Bailey, A. M., and Niedrach, R. J. 1965. Birds of Colorado. Denver Mus. Nat. Hist., Denver.

Beal, F. E. L. 1907. Birds of California in relation to the fruit industry. Part I. U.S. Dept. Agric. Biol. Surv. Bull. 30:1–100.

Bent, A. C. 1964. Life Histories of North American Nuthatches, Wrens, Thrashers, and Their Allies. Dover, New York.

Bock, C. E. 1968. Intra- vs. interspecific aggression in Pygmy Nuthatch flocks. Ecology 50:903–905.

Cruz, A. 1987. Avian community organization in a mahogany plantation on a neotropical island. Carib. J. Sci. 23:286–296.

Hay, D. B. 1977. Seasonal fluctuations in the foraging and flocking behavior of nuthatches and chickadees. Master's thesis, Calif. State Univ., Long Beach.

Manolis, T. 1977. Foraging relationships of Mountain Chickadees and Pygmy Nuthatches. W. Birds 8:13–20.

McEllin, S. M. 1979. Population demographies, spacing, and foraging behaviors of White-breasted and Pygmy Nuthatches in ponderosa pine habitats, in The Role of Insectivorous Birds in Forest Ecosystems (J. G. Dickson, R. N. Conner, R. R. Fleet, J. A. Jackson, and J. C. Kroll, eds.), pp. 301–329. Academic Press, New York.

Norris, R. A. 1958. Comparative biosystematics and life history of the nuthatches *Sitta pygmaea* and *Sitta pusilla*. Univ. Calif. Publ. Zool. 56:119–300.

Richardson, F. 1942. Adaptive modifications for tree-trunk foraging birds. Univ. Calif. Publ. Zool. 46:317–368.

Stallcup, L. 1968. Spatio-temporal relationships of nuthatches and woodpeckers in ponderosa pine forests of Colorado. Ecology 49:831–843.

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