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ACORN PREFERENCE OF URBAN BLUE JAYS (*CYANOCITTA CRISTATA*) DURING FALL AND SPRING IN NORTHWESTERN ARKANSAS[1]

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Abstract. We censused 26 acorn-bearing trees of six oak species for Blue Jays (*Cyanocitta cristata*) during fall of 1985 on the University of Arkansas campus. The following spring we presented six piles, each containing 20 acorns from a different oak species, to free-ranging jays to determine acorn preference in spring. Trees censused and acorns presented were from both black oak (BO) and white oak (WO) subgenera, which differ in size, percent fat, tannin content, and germination time. In fall, Blue Jays were observed removing acorns from three species of oaks with small acorns, particularly those of willow oaks (BO, *Quercus phellos*), and were rarely observed in trees of three other oaks with large acorns. When offered a choice of acorns from six oak species in spring, Blue Jays showed a preference, based on Ivlev's electivity index, for small acorns, particularly those of pin oaks (BO, *Q. palustris*), and an avoidance of large acorns. Thus, small size appears to be an important trait associated with acorn preference in Blue Jays. Acorns of the introduced English oak (WO, *Q. robur*), which are preferred by Euorpean Jays (*Garrulus glandarius*) (Bossema 1979), also were avoided in spring by Blue Jays, suggesting that familiarity may be a general component of acorn selection by jays.

Key words: *Acorn preference; Arkansas;* Cyanocitta cristata; *jays; oaks.*

INTRODUCTION

Blue Jays cache hard mast, such as acorns, beech nuts, and pecans, in autumn (e.g., Lay and Siegler 1937, Laskey 1942, Cypert and Webster 1948, Darley-Hill and Johnson 1981, Batcheller et al. 1984, Johnson and Adkisson 1985). Blue Jays usually carry several nuts at one time, but nuts are buried singly in the same general area, usually along forest edges, fence-rows or lines of trees (Arnold 1938, Laskey 1942, Darley-Hill and Johnson 1981). Since Blue Jays cache mostly in the ground (e.g., Laskey 1942), they are important dispersal agents for oaks (*Quercus*) and beech (*Fagus*) (Harrison and Werner 1984, Johnson and Webb 1989).

Blue Jays recover items in spring that were stored by themselves or conspecifics the previous fall (Laskey 1943; J. Briggs, pers. comm.; K. Smith, pers. observ.). Recovered acorns are eaten by adults, given to mates during courtship feeding, or fed to incubating females (pers. observ.). Despite the potential importance of cached acorns to their breeding ecology, no research has addressed recovery of stored food by Blue Jays.

Very little information is available concerning the species of acorns that Blue Jays actually store and eat (Darley-Hill and Johnson 1981), other than anecdotal reports (e.g., Lay and Siegler 1937, Arnold 1938, Cypert and Webster 1948, Tacha 1981, Johnson and Adkisson 1985). Thus, we conducted this study to examine Blue Jay preference for acorns from six native species of oaks during the fall storage period and five native and one non-native species of oaks during the spring recovery period. We included acorns from English (=pedunculate) oak (*Quercus robur*) to compare acorn preference with that of the European Jay (*Garrulus glandarius*), which prefers acorns from English oaks to those of North American northern red oak (*Q. rubra*) (Bossema 1979).

STUDY AREA AND METHODS

The study was conducted on and around the University of Arkansas, Fayetteville (Washington Co.) campus during fall 1985 and spring 1986. Jays occur throughout the year on campus, where six species of oaks have been planted.

Trees and acorns were selected from both subgenera, *Erythrobalanus* (black oak group) and *Lepidobalanus* (white oak group), which differ in germination time, tannin content, and crude protein and fat content (Table 1). Species also were chosen to give a large size range independent of subgeneric differences.

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FALL TREE CENSUSES

Six species of oaks were monitored for Blue Jay activity during fall: post (*Quercus stellata*) and white (*Q. alba*) oaks (white oak subgenus); and pin (*Q. palustris*), willow (*Q. phellos*), black (*Q. velutina*), and northern red oaks (black oak subgenus). Most trees were solitary, although two willow oak trees were about 10 m apart. Twenty-six acorn-bearing trees were censused seven times between 1 October and 1 November 1985, the month of peak storing activity by jays in northwestern Arkansas (K. Smith, pers. observ.). All censuses were conducted by Scarlett between 10:30 and 12:30, the time of day when acorn removal by jays seemed highest. Number of jays present was counted upon arrival of the observer at a tree and was used as a measure of jay preference for a particular oak species. Relative acorn abundance was determined at each visit to each tree by counting as many acorns on the tree as possible for 1 min with a hand-held event recorder. Differences in number of trees censused for each species reflected the available number of trees with acorns.

SPRING ACORN CHOICE TRIALS

In spring, when Blue Jays were actively retrieving cached acorns, acorns were placed under trees that had active Blue Jay nests or trees that jays frequented. Acorns from five species of oaks (white, northern red, pin, post, and willow) used in those trials had been collected on the ground under trees censused the previous fall. Acorns from English oak (white oak group), an ornamental European species with relatively large acorns (Table 1) which Blue Jays were observed caching in fall 1985, also were included in those trials. All white oak acorns were collected under one tree; acorns of the other species were collected from underneath several different trees. Acorns from English oaks were collected at a shopping mall about 10 km from campus, so that jays in the spring trials probably were unfamiliar with them. All acorns were frozen in plastic bags until spring in an attempt to simulate winter conditions experienced by acorns cached by jays. Freezing may have reduced tannin levels of all acorns (D. Nesdill, pers. comm.).

During each of 31 trials, six piles of acorns, each pile containing 20 acorns of one species, were arranged about 30 cm apart on the ground in a circle with a diameter of about 1 m. No effort was made to standardize order or position

TABLE 1. Characteristics of acorns used in this study. Length and width measurements were made on a sample of 20 acorns of each species.

Subgenus	Common name	Time of germination	Crude protein (%)	Crude fat (%)	Tannins (%)	Tannic acid equivalents (%)	Mean length (mm) (± SD)	Mean width (mm) (± SD)
Lepidobalanus	White	Fall	4.1[d]–7.3[e]	1.2[d]–8.8[e]	3.3[e]		26.0 (1.6)	21.2 (1.2)
	Post	Fall	5.3[a]–8.3[d]	5.1[d]–6.7[c]	0.2–1.9[b]	6.5[a]	15.0 (0.7)	11.8 (0.6)
	English	Fall					31.9 (1.7)	15.6 (0.8)
Erythrobalanus	Pin	Spring	6.1[a]	11.7[a]		9.3[a]	12.4 (2.2)	14.5 (1.0)
	Willow	Spring	5.1[d]–5.5[c]	20.0[c]–21.2[d]	6.8–8.0[b]		9.5 (0.9)	11.1 (0.7)
	Black	Spring	5.7[c]–6.0[a]	13.0[a]–17.5[c]		16.5[a]	22.4 (1.4)	18.8 (0.8)
	Northern Red	Spring	4.9[c]–6.3[e]	14.0[c]–23.0[e]	13.0[e]	11.6[a]	17.3 (0.9)	18.6 (1.3)

[a] Briggs and Smith 1989.
[b] Ofcarcik and Burns 1971.
[c] Short 1976.
[d] Short and Epps 1977.
[e] Servello and Kirkpatrick 1989.

TABLE 2. Results of fall tree censuses for Blue Jays and spring acorn choice trails. Similar letters denote similar mean electivities based on multiple comparison test.

	Fall			Spring	
Oak species	Number of trees censused	Number of trees visited by jays	Number of jays tree^{-1} census^{-1}	Mean number of acorns removed/hour	Mean electivity
Pin	8	6	0.34	8.7 (0.33)	0.47 (0.03)[a]
Post	7	4	0.08	3.1 (0.17)	−0.22 (0.04)[b]
Black	5	1	0.06		
Willow	4	3	0.93	3.2 (0.24)	−0.33 (0.04)[b]
White	1	0	0.00	0.2 (0.03)	−0.91 (0.02)[c]
Northern Red	1	0	0.00	0.1 (0.01)	−0.97 (0.01)[c]
English				0.1 (0.01)	−0.95 (0.01)[c]

of each species in any circle. Trials were begun in morning, usually between 09:00 and 10:00, and acorn piles were checked approximately every hour until evening. During each check, number of acorns missing from each pile was recorded. Data were grouped into 1.5 hr intervals for analysis.

We assumed that all acorns that disappeared were removed by Blue Jays. Although squirrels (*Sciurus carolinensis* and *S. niger*) and Red-bellied (*Melanerpes carolinus*) and Red-headed (*M. erythrocephalus*) woodpeckers also cache acorns (Kilham 1958, 1963; MacRoberts 1975; Short 1976) and occurred on campus, we watched about one-third of the trials and only jays were observed removing acorns. Those woodpeckers infrequently collect acorns from the ground and the influence of squirrels was reduced by avoiding areas they frequented.

Ivlev's electivity equation (Ivlev 1961) was used to quantify preference of jays for a particular species of acorn in spring choice trials. Electivity is calculated as

$$E_i = (R_i - P_i)/(R_i + P_i),$$

where E_i is electivity of the consumer for a particular food item, i, in the available food supply, R_i is relative occurrence of that food item in the diet, and P_i is relative occurrence of that food item in the available food supply. Ivlev's electivity index ranges from −1 to 1: a negative E indicates that an item is avoided, a positive E indicates an item is selected over other items available, and $E = 0$ indicates random selection (Ivlev 1961). A Kruskal-Wallis test was performed on mean electivity values from each trial to test for differences in selection of acorns from different oak species and oak species were then grouped ($P > 0.05$) using a non-parametric multiple comparison test (Siegel and Castella 1988) to determine the acorns for which Blue Jays had similar preferences.

RESULTS

FALL TREE CENSUSES

Blue Jays were observed foraging for acorns in 14 of 26 trees censused during October (Table 2). Jays were observed mostly in pin, willow, and post oaks, which had comparable crop sizes (Fig. 1) and the smallest available acorns (Table 1). Number of jays present per tree per census was highest in willow oaks. Groups of 4–8 jays were seen in willow oak trees prior to 12 October, after which time most acorns had fallen or had been removed by jays (Fig. 1). Jays were rarely seen in trees with large acorns (Table 2), despite black oaks having the highest estimated crop of acorns (Fig. 1).

SPRING ACORN CHOICE TRIALS

In many trials we observed, Blue Jays usually started removing acorns within seconds after we left the six piles on the ground near them. Acorns from pin oaks usually were removed first. Removal rates were highest for pin oaks, followed by willow and post oaks (Table 2), which were the smallest acorns offered (Table 1). Larger acorns from white, red, and English oaks were rarely taken, making removal rates of those acorns very low.

Only pin oak acorns were actively selected by Blue Jays (Table 2). Post and willow oaks had mean E values close to zero, indicating nearly random selection. Mean E values for white, English, and red oaks were very close to −1 indicating avoidance.

Comparisons of electivity indices (Kruskal-

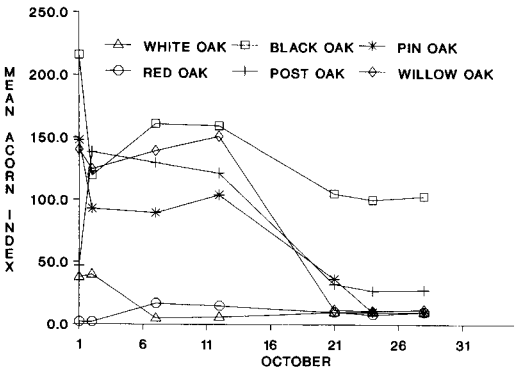

FIGURE 1. Mean number of acorns counted per tree in 1 min during the seven censuses conducted during October 1985 for six species of oaks. Samples sizes are listed in Table 1.

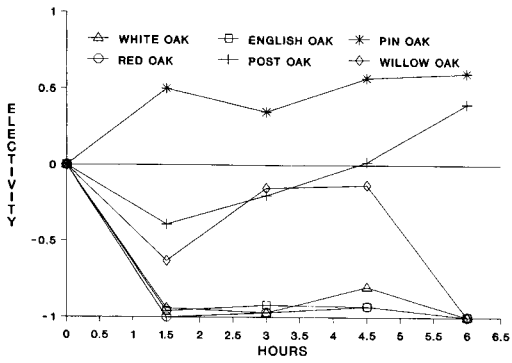

FIGURE 2. Mean electivity for acorns of the six species of oaks calculated from the 31 acorn choice trials conducted during spring 1986. Data were grouped into 1.5 hr intervals for analysis.

Wallis test) showed that acorns of the six species were not selected equally by Blue Jays (Table 2). Mean electivity for pin oak acorns was greater than those for post and willow oak acorns, which in turn were greater than those for white, red and English oak acorns.

Pin oak acorns were highly selected throughout the 6-hr trial period (Fig. 2). Post oak acorns were selected against early in trials, randomly selected in the middle, and selected positively at the end of the trials. Willow oak acorns showed a negative mean E early, a rise close to 0 and a fall to -1 at the end of trials. Acorns from white, English, and red oaks showed no sign of positive selection. All three species had mean E values that remained below -0.8 throughout the trial periods (Fig. 2).

DISCUSSION

Blue Jays demonstrated a preference for storing willow, post, and pin oak acorns in fall and a preference for consuming pin oak acorns in the spring, suggesting that small size is an important characteristic associate with acorn use by Blue Jays. Large acorns were avoided in both seasons. Darley-Hill and Johnson (1981) also concluded that Blue Jays preferred small to medium-sized nuts (*Q. palustris, Q. phellos, Q. velutina, Fagus grandifolia*) and avoided large acorns (*Q. borealis, Q. alba*).

In both fall and spring, Blue Jays preferred to store and eat acorns from the black oak group, although acorns from that group are higher in tannins than are acorns from the white oak group. Recent studies (Koenig and Heck 1988, DeGange et al. 1989) on Scrub Jays (*Aphelocoma coerulescens*) also suggest feeding behaviors of jays that are independent of tannin content of acorns (but see Servello and Kirkpatrick 1989). Although tannin content can have an adverse effect on animals eating acorns that have not been cached (e.g., Koenig and Heck 1988, Briggs and Smith 1989), high tannin content may be an important cue associated with acorn storage for some animals, if they use tannin content to determine if a food item is storable or not (Smallwood and Peters 1986). Further, tannin content of acorns may be altered after storage in the ground due to leeching (Nesdill 1988), making black oak group acorns more palatable in spring. Pin oak acorns, preferred by Blue Jays in spring in this study, have relatively low amounts of tannins to begin with for members of the black oak group (Briggs and Smith 1989), meaning that they may have few tannins left by spring. An added benefit is that acorns from the black oak group also contain much greater amounts of lipids than those from the white oak group (Table 1).

Blue Jays are scatter-hoarders that make many small caches that decrease the chance of another animal pilfering a significant portion of their stores (Stapanian and Smith 1978, 1984). Jays maximize the effect of scatter-hoarding by storing acorns separately, which would decrease olfactory cues to rodent cache robbers. By storing acorns from the black oak group, jays also decrease the chance of losing the store to germination (Vander Wall and Smith 1987), because

acorns from the black oak group germinate the following spring, whereas acorns from the white oak group germinate in the fall in which they mature.

Bossema (1979) performed choice experiments with wild European Jays by placing pairs of acorns side-by-side on nails in trees and observing which acorns were transported. In trials where English oak and red oak acorns were offered simultaneously, jays totally ignored red oak acorns, although Bossema observed other jays occasionally storing red oak acorns in fall. He concluded that red oak acorns could not be dehusked very easily because of their thicker shells compared to acorns from English oaks. However, our observations suggest that Blue Jays had the same reaction to English oak acorns as European Jays had to red oak acorns. Although some Blue Jays cached English oak acorns in fall, jays in spring that were probably unfamiliar with that species totally ignored those acorns, suggesting familiarity may be a general component of acorn selection by wild jays.

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