

Food Preferences of Captive Wild Raccoons, *Procyon lotor*, from East Texas

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Taulman, James F., and James H. Williamson. 1994. Food preferences of captive wild Raccoons, *Procyon lotor*, from east Texas. *Canadian Field-Naturalist* 108(2): 170–175.

We offered a random assortment of six foods to nine captive Raccoons (*Procyon lotor*) during 10 days in February 1991 and to 10 Raccoons during 9 days in January 1992: Persimmon, (*Diospyros virginiana*); Southern Red Oak acorn, (*Quercus falcata*); chicken egg; crayfish (*Cambarus bartoni*); corn (*Zea mays*); and Earthworm (*Lumbricus terrestris*). Foods were given preference ranks 1 - 6 corresponding to feeding sequence; we assumed that the item eaten first was most preferred. We calculated the mean of each Raccoon's preference ranks for each food item over the days of the trial period. Persimmon was the most highly favored food both years, followed by acorn. Earthworm was the least preferred of the six foods. Testing the mean rank totals for each food separately showed that the 1992 group favored egg significantly more than the 1991 group. Males showed a preference for corn more frequently than females did. The results of this study are discussed with implications for enhancing habitat and reducing crop damage.

Key Words: Raccoon, *Procyon lotor*, food habits, food preferences, feeding trials.

Reports of Raccoon (*Procyon lotor*) feeding habits have listed food items identified from the stomachs and intestines of carcasses (Greenwood 1982; Hendricks 1975; Smith et al. 1987; Tabatabai and Kennedy 1988), from analysis of scats (Greenwood 1981; Lehman 1977; Rivest and Bergeron 1981; Schoonover and Marshall 1951), from a combination of stomach and fecal samples (Baker et al. 1945; Harman and Stains 1979; Sonenshine and Winslow 1972), and also from direct observation of Raccoons and their available foods in the wild (Mech et al. 1968; Rue III 1964; Urban 1970). Seasonal analysis of Raccoon stomachs and scats reveals a few food items taken in abundance at certain times of the year in particular habitats. Kaufman (1982) summarized the current literature with regard to foods taken by Raccoons at all seasons.

Averaged over the year, the ratio of plant to animal food taken by Raccoons is about 60% to 40%, respectively (Baker et al. 1945; Hendricks 1975; Smith et al. 1987). Fleshy fruits and nuts (acorns [*Quercus* spp.], in particular) are the most important plant foods (Baker et al. 1945; Hendricks 1975; Kaufman 1982; Tabatabai and Kennedy 1988); corn is a staple in agricultural areas (Greenwood 1982; Rivest and Bergeron 1981). Crayfish is the most frequently consumed animal food (Kaufman 1982). While Raccoons are omnivorous and reportedly opportunistic (Kaufman 1982), they are selective when a variety of foods are available (Tabatabai and Kennedy 1988), favoring items high in sugar (Fleming 1983; Johnson 1970; Smith et al. 1987).

No results have been published describing systematic feeding trials on live Raccoons. The purpose of this experiment was to investigate the relative preferences of Raccoons for a selection of commonly reported natural foods. An interesting novelty in the present experimental design was the opportunity to observe the preferences of Raccoons for food items whose disjunct seasonal availability precludes comparative determinations from examination of carcasses. Smallwood and Peters (1986) suggested that food preference experiments which concurrently offer test animals a selection of foods are "flawed in their basic assumptions" that the normal foraging behavior of free-ranging animals involves similar choices from an array of available food items. We made no assumption that the present experiment simulated field conditions encountered by free-ranging Raccoons. Nevertheless, it is certainly possible that free-ranging Raccoons could be faced with a choice between potential food items, and preferences demonstrated under test conditions provide a basis for prediction of behavior in the wild. This experimental design permitted investigation of aspects of Raccoon behavior that are not easily addressed through trials on free-ranging animals. The null "opportunistic" hypothesis was that no preference would exist for any of the test foods and that selection sequence would be random.

Methods and Materials

Our sample consisted of seven males and two females in 1991 and seven males and three females

in 1992. Though two Raccoons captured in 1992 appeared to be recaptured members of the 1991 group, positive identification from ear notches was not possible, and all animals were considered unique for purposes of statistical analyses. Animals used in the trials were collected under Texas Parks and Wildlife permit # SPR-0192475 to the junior author from three counties in Texas: Nacogdoches, Houston, and Cherokee (31° 20' – 40' N, 94° 20' – 95° 10' W). Collection sites described the boundaries of a geographical area of over 2000 square km. Raccoons were housed indoors in wire cage traps 36 x 48 x 91 cm (15 x 20 x 36 in). During the 3 – 4 weeks in captivity in 1991 and 3 – 7 days in 1992 before the feeding trials began, Raccoons were provided a commercial dry cat food containing 40% carbohydrate, 30% protein, 8% fat, 12% moisture, 4.0% fiber, 1% calcium, 1% phosphorus, 1.5% salt, and 0.1% magnesium. Each animal was also given a minimum of 1 liter of water each day. Dry food was withheld one day prior to the start of the trials in 1991; in 1992 Raccoons were given dry food up to the day that the experiment began. A partition was placed between cages during feeding to provide some privacy and to prevent interactions between Raccoons. These conditions of captivity and treatment are in accordance with the Animal Welfare Act of 1970 (7 U.S. Code Service § 2131).

Six food items were apportioned to the subject Raccoons on each of 10 consecutive trial nights in February 1991 and 9 nights in January 1992. We repeated trials over a 9 – 10 day period using a different randomized assortment of the food items each night in order to gain a higher confidence mean of a Raccoon's preference scores for each food item. Test foods were selected from the most abundant reported dietary constituents of Raccoons from the United States during all seasons. In addition, an effort was made to include a representative sample of the plant and animal diversity encountered by free-ranging Raccoons. Corn was the only cultivated food item offered. The other five food items were live earthworms; fresh (dead) crayfish; small chicken eggs (as a substitute for wildfowl eggs); ripe persimmon fruit; and Southern Red Oak acorns. Portions of each food were as follows:

corn — 3 to 5 cm of a cob

crayfish — 1 (or 2 if very small), with about 5 ml water

acorns — 4 to 6

earthworms — 2 or 3, with about 5 ml water

egg — 1

Persimmon — 1 or 2

Food items were placed in six baking cups mounted to a board in a single row and wired to the back of the cage. Water was included with the crayfish to make the presentation as similar as possible to a natural occurrence. Earthworms were placed in a small

amount of water to prevent desiccation before the Raccoon arose to eat (sometimes three or four hours after serving).

The presentation of the foods was intended to approximate as nearly as possible the appearance and texture of the same items as encountered in the field. All items were either refrigerated or frozen until needed to preserve freshness. As needed, foods were thawed or taken from refrigeration and served at ambient temperature. Our main priorities in determining the quantity and form of food servings were: (1) to provide Raccoons with enough nutrition so that they did not physically decline during the trials, (2) to provide small enough servings to ensure that Raccoons would be hungry enough to eat at least five of the items each night, (3) to provide approximately equal mass servings of each item, and (4) to present the foods in such a way as to give the Raccoon equal access to each item in the array.

The use of whole items, in the form in which they are available to the foraging Raccoon, precluded serving each item in exactly equal mass quantities. We decided that serving foods in a consistent texture, such as powdered, in order to give exactly equal portions of each, would not produce easily interpreted information on which foods Raccoons would choose relative to others in nature. Indeed, the purpose of the experiment was to observe the selection sequence of live Raccoons for natural foods, some of which are not normally available simultaneously. The underlying causes of the selections were not investigated and are discussed only in reference to possibilities suggested by our results and available literature on Raccoon food habits.

Water was placed in the center of the cage away from the food tray. Food order was randomized each night, and each Raccoon in the group received the same selection. The data sheet consisted of a randomized block matrix with Raccoons as blocks and foods representing treatments. Cells were filled with numbers (1 – 6) corresponding to the order in which food items were eaten. An item was considered to be eaten, and a preference rank assigned, if all or part of the serving was consumed. For the purposes of this experiment, we assume that a Raccoon indicated a preference for one food item over another by selection sequence, i.e., the first food eaten was the most preferred, the last taken was the least preferred. An item was only ranked once. Therefore, instances in which an animal went back to a previously selected item were not recorded. Raccoon feeding behavior was viewed by three video cameras covering 3 – 4 cages each. Two or three observers watched monitors in an adjacent room and recorded feeding data.

We calculated each Raccoon's mean rank preference score for every food item over the trial period and used those values in comparisons of groups between years, of males with females, and in calcu-

lating combined mean preference ranks for both years. On the basis of the individual Raccoon mean rank scores we assigned pooled ranks (1 – 6) to be used in analysis of variance. We define a trial Raccoon/day as a day in which a Raccoon chose among all six food items (at least five were eaten). Incomplete trials in which two or more items were left uneaten were not included in the analyses. The pooled rank scores were totaled across years and analyzed with the Friedman two-way ANOVA by ranks (a nonparametric parallel to the repeated measures ANOVA) (McClave and Dietrich 1988) to test the hypothesis that none of the treatment totals differed from any others. After confirming that at least two preference scores differed, we tested all pairs with the multiple comparisons test (Siegel and Castellan 1988). We used the Mann-Whitney U test (McClave and Dietrich 1988) to compare groups between years and to compare mean preferences between males and females across both years (14 males and 5 females). All statistical tests, with the exception of multiple comparisons, were performed using CSS:Statistica (Statsoft c1991). An $\alpha = 0.05$ level was used for all tests.

Results

Raccoon #1 died on the ninth day of the trial in 1991; it appeared emaciated, though it ate all food items until the day of its death. All remaining Raccoons in 1991 and 1992 seemed vigorous when released at the end of the experiment. There were 88 trial Raccoon/days in 1991, 9 Raccoons tested for 8 days and 8 Raccoons for 2 days. The 10 Raccoons tested for 9 days in 1992 yielded a total of 76 Raccoon/days on which data were complete. Upon approaching the food array, as well as after consuming an item, individuals commonly sniffed over uneaten foods before selecting one. Table 1 shows the mean preference ranks for each Raccoon averaged over the trial periods in 1991 and 1992, using days in which an individual selected at least five foods.

The Friedman ANOVA showed that at least one of the treatment totals differed from the others (ANOVA chi-square = 50.66, $P = 0.0000$, $N = 19$, d.f. = 5). The multiple comparisons test of differences in mean preference rank totals for all Raccoons combined across both years showed that scores for persimmon were significantly lower (more preferred) than those for corn and earthworm, and scores for acorn were significantly lower than those for earthworm (Critical difference = 33.85; persimmon – corn = 43.80, persimmon – earthworm = 53.49, acorn – earthworm = 42.31). The mean preference ranks for each food item combined for all 19 Raccoons across both years are shown in Figure 1.

The 1992 group exhibited a greater selection preference for egg than did the 1991 group ($U = 21$, $z =$

-1.96 , $P = 0.05$, $N_1 = 9$, $N_2 = 10$). The mean ranks for other food items were not significantly different between years. Males showed a greater preference for corn than did females ($\delta \bar{x} = 3.82$, $SE = 0.32$; $\bar{y} = 5.46$, $SE = 0.20$; $U = 11.0$, $z = -2.22$, $P = 0.03$, $N_m = 14$, $N_f = 5$). Mean preference scores for other food items were not different between sexes.

Discussion

The dry cat food which Raccoons were allowed to consume ad libitum prior to the start of trials included substantial protein, fat, carbohydrate, and mineral components. Therefore, we do not believe that Raccoons were starved for any essential nutrient at the onset of the experiment. As a result, we believe that these preference results may be indicative of choices that would be made by free-ranging Raccoons in East Texas.

Based on the multiple comparisons tests of differences in mean rank totals, we may reject our null hypothesis and conclude that these groups of Raccoons favored persimmon over corn and persimmon and Southern Red Oak acorns over earthworm. The similarity in the rank totals for egg, corn, and crayfish, preclude a clear distinction between test animals' preferences for those items.

While the remains of earthworms in Raccoon feces may be determined indirectly by soil volume (Greenwood 1981), the lack of durable structures makes an estimation of the importance of earthworms in Raccoon diet problematic (Yeager and Rennels 1943). These results showing Earthworm to be ranked significantly higher (eaten later) than both persimmon and Southern Red Oak acorns give the first indication of the relative preference of Raccoons for earthworms in comparison to at least these two other common foods.

The preference scores for persimmon and acorn shown by test animals compliment other studies reporting foods frequently taken by Raccoons. Fleshy fruits and acorns are similar in nutrient and digestibility values (Short and Epps 1976), both containing high levels of carbohydrates important in the formation of needed fat reserves (Goodrum et al. 1971; Harman and Stains 1979). In addition, Short and Epps (1976) found that acorns and fleshy fruits had "greater usefulness" to wildlife than seeds and dried fruit due to a combination of their nutrition, digestibility, palatability, and seasonal abundance.

It might be argued that the high preference scores received by acorns in this study were related to seasonal habituation, since acorns are a staple of the winter Raccoon diet (Baker et al. 1945; Harman and Stains 1979; Hendricks 1975; Tabatabai and Kennedy 1988). We doubt that season exerted a significant influence on Raccoon preferences, however, since persimmon was the most favored food item but had been unavailable in the woods of East Texas for four

TABLE 1. Mean and [SE] of rank preference scores for each Raccoon for each offered food item during the trial periods in 1991 and 1992, averaged over the number of days in which Raccoons chose among at least five foods. Treatment rank totals used in multiple comparison tests shown at bottom of table. A total score is significantly different from others which are not followed by at least one common letter.

Year	Raccoon	Food						Trial Days
		Persimmon	Acorn	Egg	Crayfish	Corn	Worm	
1991	1	3.00 [0.66]	2.88 [0.67]	4.88 [0.58]	3.13 [0.58]	3.88 [0.55]	3.25 [0.49]	8
1991	2	2.20 [0.49]	2.60 [0.48]	4.40 [0.31]	3.20 [0.53]	3.30 [0.39]	5.60 [0.22]	10
1991	3	1.60 [0.31]	2.50 [0.40]	4.30 [0.21]	4.00 [0.60]	3.10 [0.35]	5.50 [0.31]	10
1991	4	1.50 [0.31]	2.00 [0.26]	3.70 [0.45]	4.30 [0.40]	5.00 [0.37]	4.50 [0.40]	10
1991	5	1.60 [0.43]	3.10 [0.38]	2.50 [0.27]	3.10 [0.35]	5.90 [0.10]	4.80 [0.20]	10
1991	6	1.60 [0.50]	3.30 [0.30]	3.50 [0.27]	4.80 [0.47]	2.30 [0.26]	5.50 [0.22]	10
1991	7	1.40 [0.16]	1.70 [0.21]	4.30 [0.21]	3.90 [0.35]	3.70 [0.26]	6.00 [0.00]	10
1991	8	3.40 [0.58]	2.20 [0.55]	5.10 [0.38]	4.00 [0.47]	3.70 [0.30]	2.60 [0.50]	10
1991	9	2.30 [0.52]	2.00 [0.30]	4.70 [0.26]	2.80 [0.47]	3.40 [0.27]	5.80 [0.13]	10
1992	10	1.14 [0.14]	2.86 [0.40]	2.86 [0.26]	5.00 [0.00]	3.14 [0.54]	6.00 [0.00]	7
1992	11	2.10 [0.59]	2.80 [0.29]	4.80 [0.29]	4.30 [0.45]	2.30 [0.37]	4.70 [0.50]	10
1992	12	1.63 [0.42]	2.50 [0.33]	4.00 [0.68]	3.63 [0.53]	5.00 [0.27]	4.25 [0.56]	8
1992	13	1.71 [0.42]	2.71 [0.61]	2.43 [0.53]	3.71 [0.18]	5.86 [0.14]	4.57 [0.30]	7
1992	14	1.00 [0.00]	2.83 [0.17]	2.17 [0.17]	4.67 [0.53]	5.33 [0.33]	5.00 [0.26]	6
1992	15	1.78 [0.47]	3.33 [0.50]	4.78 [0.40]	2.78 [0.57]	3.22 [0.32]	5.11 [0.39]	9
1992	16	1.44 [0.29]	2.89 [0.31]	3.11 [0.31]	4.00 [0.47]	5.22 [0.43]	4.33 [0.65]	9
1992	17	2.44 [0.29]	2.56 [0.38]	1.56 [0.34]	4.56 [0.38]	5.22 [0.28]	4.67 [0.47]	9
1992	18	4.00 [1.00]	2.50 [1.50]	2.00 [0.00]	2.00 [1.00]	6.00 [0.00]	4.50 [0.50]	2
1992	19	2.00 [0.50]	1.89 [0.26]	3.33 [0.41]	3.33 [0.29]	5.56 [0.18]	4.89 [0.46]	9
Totals		37.94 A	49.12 AB	68.62 ABC	71.11 ABC	80.74 BC	91.43 C	164 $\bar{x}$ = 8.63 SE = 0.47

months prior to our experiment. It would be interesting to repeat this experiment in agricultural areas where corn replaces oaks in the Raccoon's range in order to see if local animals would show an acquired preference for corn on the basis of its availability or if persimmons and acorns would still be favored.

Our results showing a greater male preference for corn than that shown by females support data on the frequency and volume of food items collected from Raccoon carcasses by Tabatabai and Kennedy (1988). Examination of 111 male and 96 female Raccoons from three regions in Tennessee revealed

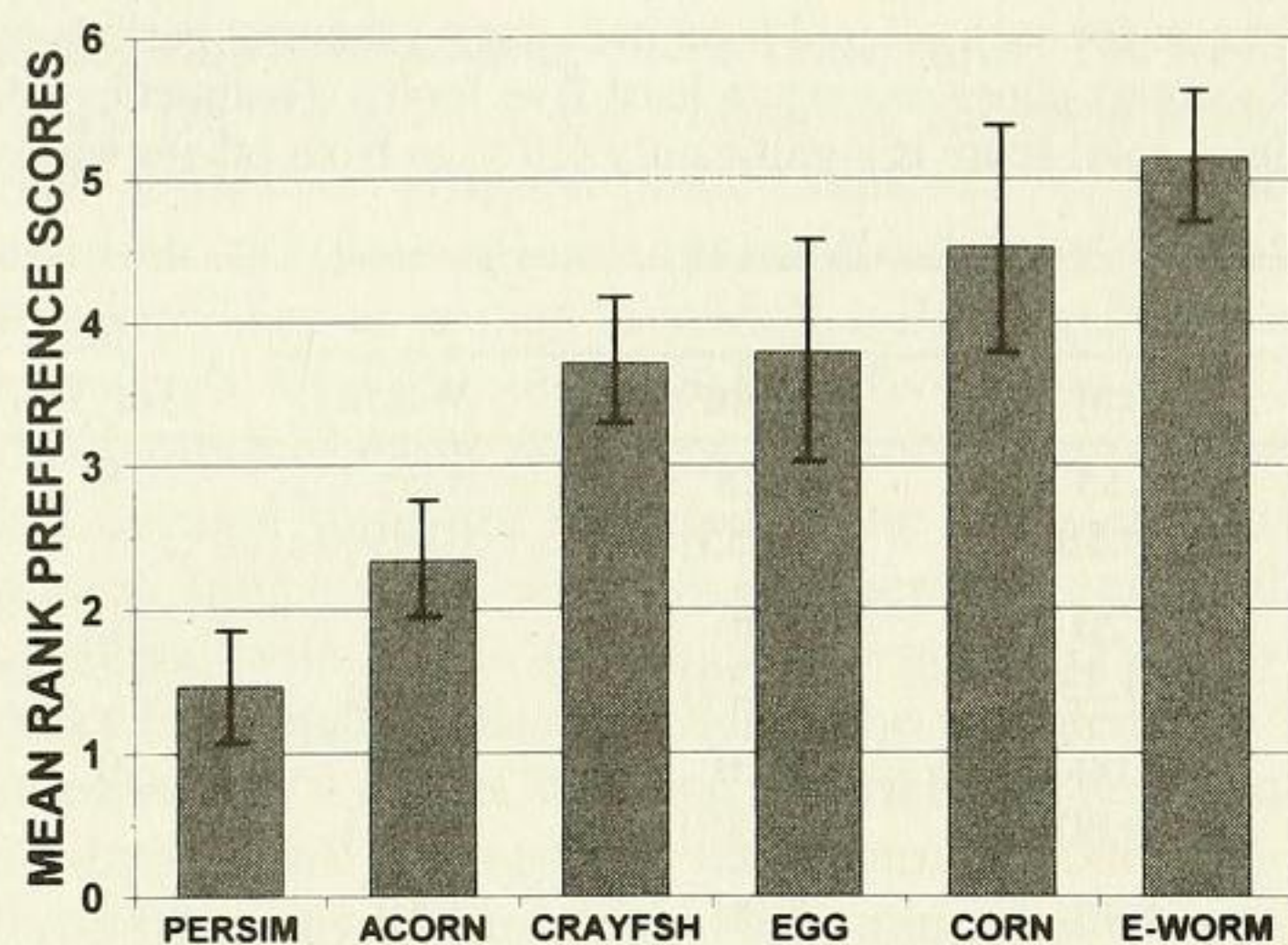


FIGURE 1. Mean rank preference scores for all Raccoons combined for both years (88 Raccoon/days, 1991; 76 Raccoon/days, 1992). Lower scores indicate more preferred items. Whiskers overlain onto bars represent ± 2 standard errors.

corn in males more often than in females in all regions. While the differences we observed in food preferences between the sexes are interesting, the small sample size in this experiment (particularly females) precludes definitive conclusions.

We recommend the elimination of incomplete trials in experiments such as this one in order to ensure that results from different studies measure the same degree of choice made by test animals. Experiments in which incomplete feeding trials are filled out with assigned ties (1) presume food choices not actually demonstrated by test animals and (2) hide possible deficiencies in procedures that make comparisons with this and other similar experiments invalid.

Tests of the optimal diet theory normally rank foods based on calorie or mass units, associated handling time, and searching effort. The optimum diet is then determined by listing ranked foods in order from the highest down, until the ratio of a subsequent food's value to its handling time becomes less than the net rate of consumption for all previously listed foods (Pyke et al. 1977). However, in addition to energy content, the currency used in dietary analyses should also include consideration of important constraints such as protein, mineral, and cellulose composition, as well as the presence of toxins and digestive inhibitors (Robbins 1983). While it would be interesting to calculate a predictive rank order for the foods used in this experiment based on optimal diet theory and compare that with observed results, nutritional assays of food items were beyond the scope of this investigation.

Results presented here suggest that Raccoons are not purely opportunistic foragers when a variety of foods is available. An understanding of seasonal food habits, together with a knowledge of preferred food items, can be useful in managing Raccoon pop-

ulations and their habitat. For example, Rivest and Bergeron (1981) found that Raccoons foraged in fields of sweet corn, bypassing adjacent stands of field corn. They recommended that farmers sustaining crop damage in sweet corn fields plant small patches of sweet corn near wood margins or along streams in order to provide Raccoons with a preferred food source nearer their nesting sites. McComb (1981) also advocated using a knowledge of Raccoon food preferences as a tool in management. He suggested that by preserving oaks and fruit trees and removing den trees near corn fields, crop damage by Raccoons might be reduced. Our results reinforce these management strategies and support Goodrum's (1971) assertion of the importance of forests with mast-producing hardwoods to Raccoon populations.

Acknowledgments

This research was partially funded by a grant to the senior author from the Max McGraw Wildlife Foundation, Dundee, Illinois. We thank D. C. Rudolph, J. G. Williamson, S. J. Burgdorf, and R. R. Schaefer for help with behavioral observations. N. Colson assisted with field work. R. E. Thill, W. P. Smith, B. Parresol, D. C. Rudolph, W. Clark, S. R. Humphrey, K. M. Andres, and two anonymous reviewers offered many useful suggestions on earlier versions of this manuscript.

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Received 14 April 1993

Accepted 28 February 1994