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FOOD HABITS OF THE CHIRICAHUA FOX SQUIRREL (*SCIURUS NAYARITENSIS CHIRICAHUAE*)

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ABSTRACT—The Chiricahua fox squirrel (*Sciurus nayaritensis chiricahuae*) is restricted to montane forests of the Chiricahua Mountains of southeastern Arizona. We used observations of focal animals to determine the diet of squirrels during summer and winter. Chiricahua fox squirrels feed heavily on seeds of trees, berries of mistletoe, and hypogeous fungi. Diets were most diverse in summer for males, whereas females did not demonstrate significant seasonality of diet. Daily diets were more diverse than reported for other tree squirrels. As in other tree squirrels, Chiricahua fox squirrels appear to be highly dependent on mature forest trees for food.

RESUMEN—La ardilla *Sciurus nayaritensis chiricahuae* está restringida a los bosques montañosos de las Chiricahua Mountains del sureste de Arizona. Hicimos observaciones focales de animales para detallar la dieta dé las ardillas durante el verano y el invierno. *Sciurus nayaritensis chiricahuae* se alimenta principalmentede semillas de árboles, así como de bayas de muérdago y hongos hipogeos. Las dietas fueron más diversas en el verano para los machos, mientras que la hembras no demostraron un temporalidad de deita significativa; las dietas diarias fueron más diversas que las reportadas para otras ardillas. Como en las otras ardillas, *Sciurus nayaritensis chiricahuae* parece ser altamente dependiente de árboles maduros de bosques para su manutención.

Tree squirrels (Family Sciuridae, Tribe Sciurini) rely heavily on mature forests for nesting locations and food (Gurnell, 1987). Survivorship and reproduction of tree squirrels often are positively correlated with tree-seed productivity (Barkalow et al., 1970; Gurnell, 1987; Koprowski, 1991). This dependence on mature, seed-producing forests is likely one reason that several species of tree squirrels are considered to be threatened or endangered in all or part of their ranges including *Sciurus arizonensis, S. griseus, S. niger,* and *S. vulgaris* (Koprowski and Steele, 1998).

The Chiricahua fox squirrel (*Sciurus nayaritensis chiricahuae*) is a subspecies of the poorly known Mexican fox squirrel and is restricted to the forested mountains and canyons of the Chiricahua Mountains of southeastern Arizona (Cahalane, 1939; Hoffmeister, 1986). Due in part to a restricted range and a paucity of life-history information, Chiricahua fox squirrels were recently listed as a Category II species by the United States Fish and Wildlife Service (Drewry, 1991). No ecological studies have focused on *S. nayaritensis* in any portion of its range (Best, 1995). Anecdotal information suggests that Chiricahua fox squirrels feed on tree seeds, buds, bulbs, and roots (Cahalane, 1939; Brown, 1984; Hoffmeister, 1986). Herein, we quantify the food habits of Chiricahua fox squirrels during summer and winter.

MATERIALS AND METHODS—Chiricahua fox squirrels were observed in Chiricahua National Monument, Cochise Co., Arizona, which is located on the western slope of the Chiricahua Mountains. Squirrels are found primarily in canyon bottoms dominated by pines (*Pinus engelmanni, P. leiophylla*), oaks (principally *Quercus emoryi, Q. arizonica, Q. hypoleucoides*), alligator junipers (*Juniperus deppeana*), and Arizona cypress (*Cupressus arizonica*; Cahalane, 1939; Brown, 1984; Hoffmeister, 1986); our observations were focused in the two major canyons, Bonita and Rhyolite.

To assess food habits, we took advantage of the remarkable tolerance of *S. n. chiricahuae* for human presence (Cahalane, 1939; Kneeland et al., 1995)

TABLE 1—Sex-specific diets in minutes (proportion of total time feeding) and diversity index values for *Sciurus nayaritensis chiricahuae* during summer and winter, Chiricahua National Monument, Cochise Co., Arizona.

Food	Female		Male		Sexes combined	
	Summer	Winter	Summer	Winter	Summer	Winter
Cupressus arizonica (nuts)	791 (0.497)	408 (0.668)	768 (0.657)	576 (0.758)	1,559 (0.565)	984 (0.718)
Quercus emoryi (acorns)	251 (0.158)	5 (0.008)	173 (0.147)	1 (0.001)	424 (0.154)	6 (0.004)
Juniperus deppeana (seeds)	219 (0.138)	7 (0.016)	33 (0.028)		252 (0.091)	7 (0.005)
Phoradendron (berries)		121 (0.198)		79 (0.104)		200 (0.146)
Pinus leiophylla (seeds)	66 (0.042)	3 (0.005)	116 (0.099)	2 (0.003)	182 (0.066)	5 (0.004)
Hypogeous fungi	89 (0.055)	56 (0.092)	6 (0.005)	45 (0.059)	95 (0.034)	101 (0.074)
Juglans major (nuts)	84 (0.053)				84 (0.030)	
Quercus arizonica (acorns)	24 (0.015)	1 (0.002)	20 (0.017)		44 (0.016)	1 (0.001)
Pinus engelmanni (seeds)	16 (0.010)		15 (0.013)	57 (0.075)	31 (0.011)	57 (0.042)
Pseudotsuga menziesii (seeds)	1 (0.001)		26 (0.022)		27 (0.010)	
Arctostaphylos (seeds)		10 (0.016)				10 (0.007)
Hymenoptera (ants)	6 (0.004)				6 (0.002)	
Hymenoptera (gall larvae)		10 (0.016)				10 (0.007)
Platanus wrightii (leaves)			5 (0.004)		5 (0.002)	
Quercus emoryi (bark)			3 (0.003)		3 (0.001)	
Quercus hypoleucoides (acorns)			3 (0.003)		3 (0.001)	
Lichen	2 (0.001)				2 (0.001)	
Arbutus arizonica (seeds)			1 (0.001)		1 (0.001)	
Platanus wrightii (bark)	1 (0.001)				1 (0.001)	
Populus fremontii (leaves)	1 (0.001)				1 (0.001)	
Diversity measures						
Species richness	16	8	12	6	20	9
Simpson's diversity	3.341	2.202	2.150	1.683	2.791	1.839
Simpson's equitability	0.209	0.253	0.179	0.280	0.140	0.204

that enabled us to follow 28 individuals at a distance of about 20 m during June (male = 5,633 min, female = 7,328 min), August (male = 5,454 min, female = 4,122 min), and December 1994–January 1995 (male = 1,831 min, female = 3,667 min). Squirrels often were followed from the morning exit of the nest until the evening entrance into the nest, and behaviors were recorded at 1-min intervals. We identified items eaten by squirrels whenever possible with the use of binoculars or by examination of food remains. We tallied the number of minutes that individuals actually spent feeding on food items and do not include time spent searching for or processing food. To compare diet patterns between seasons and sexes, Simpson diversity and equitability measures were calculated (Begon et al., 1990). The number of different foods ingested by each sex was compared using Mann-Whitney *U*-tests and frequencies were tested using χ^2 goodness-of-fit techniques.

RESULTS AND DISCUSSION—The diet of Chiricahua fox squirrels is more varied than previously reported (Best, 1995). During 4,130 min of observations on feeding squirrels of both sexes, 22 different food items were recorded (Table 1). Summer diet is more diverse than winter diet with more than twice as many species used. As in other tree squirrels (Gurnell, 1987), the diet was dominated by seeds of trees that comprised 95.9% of summer foods and 77.3% of winter foods in concordance with observations of others (Cahalane, 1939; Brown, 1984; Hoffmeister, 1986). However, hypogeous mycorrhizal fungi were relatively important foods during both summer (fifth most common food) and winter (third most common food). In winter, berries of mistletoe (*Phoradendron*) were the second most important food after cypress nuts. Animal foods often are used at least in small amounts by other species of tree squirrels (Koprowski, 1994*a*, 1994*b*). Ants (Hymenoptera: Formicidae), however, were eaten only rarely (0.2%) in summer and larvae of an unidentified parasitoid wasp (Hymenoptera) on twigs of Palmer oak (*Q. dunnii*) were ingested infrequently in winter (0.7%).

Diets of both sexes consisted predominantly (>65% of food items) of two species during both summer and winter (Table 1). During each season, diets of females generally were more diverse than diets of males as indicated by diversity values; the difference was more pronounced in summer when females were pregnant or nursing young (Best, 1995). Diets are known to become more diverse during seasons of pregnancy and lactation in other *Sciurus* (Nixon et al., 1968; Thompson and Thompson, 1980; Korschgen, 1981; Weigl et al., 1989). Furthermore, food consumption in fox squirrels (*S. niger*) and gray squirrels (*S. carolinensis*) is greater in summer with a voluntary decrease during winter (Havera, 1979; Knee, 1983); females tend to consume greater amounts of food than males during all seasons (Short and Duke, 1971) suggesting females could have a more diverse diet simply because they eat more food. Such dietary differences are not likely related to differences in use of space between sexes, for male tree squirrels typically have home ranges ≥1.4 times larger than females (Koprowski, 1998), and this difference appears to hold for Chiricahua fox squirrels (J. L. Koprowski et al., in litt.). The mean number of foods (±1 *SE*) use by male and female Chiricahua fox squirrels declined in winter, but only significantly so for males (females: 5.86 ± 1.30 in summer, 3.60 ± 0.87 in winter, $W = 25.0$, $P = 0.22$; males: 5.57 ± 0.90 in summer, 2.60 ± 0.68 in winter, $W = 30.0$, $P = 0.04$).

Equitability indices indicate that the diet of each sex was more even during winter than summer (Table 1). Gray squirrels and fox squirrels more than 60% of the time have only a single food item in their stomachs (Korschgen, 1981); however, Chiricahua fox squirrels only occasionally (20.8% of 24 squirrels) were observed to feed on a single type of food over the course of a day ($\chi^2 = 15.33$, $P < 0.05$ assuming a 60:40 distribution of single food types:multiple food types as found for other tree squirrels). For individuals that had food items identified for ≥60 min over the course of a day, individual females and males used similar numbers (±1 *SE*) of food types on a single day in summer (7 females, 5.86 ± 1.30 foods; 7 males, 5.57 ± 0.90 food; $W = 24.0$, $P = 0.95$) and in winter (5 females, 3.60 ± 0.87 foods; five males, 2.60 ± 0.68 foods; $W = 9.0$, $P = 0.46$).

Chiricahua fox squirrels appear to consume a diet that is similar to other tree squirrels (Gurnell, 1987). Tissues of trees including seeds, bark, leaves, and buds dominate food items used; however, the diet is balanced by use of fungi, fruits, and occasional animal matter. Similar to other species of tree squirrels found in the mountains of the western United States such as *S. griseus* (Carraway and Verts, 1994), *S. arizonensis* (Brown, 1984), and *S. aberti* (Keith, 1965; Kotter and Farentinos, 1984), *S. n. chiricahuae* appears to make significant use of fungi. The diverse diet is likely a response to spatial and temporal variation in seed crops of trees, especially in the drought-prone mountains inhabited by Chiricahua fox squirrels.

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