FOODS OF SCALED QUAIL (*CALLIPEPLA SQUAMATA*) IN SOUTHEASTERN NEW MEXICO

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Abstract.—In late summer and autumn 1981-1988, 563 scaled quail (*Callipepla squamata*) were collected in southeastern New Mexico to determine amounts and kinds of food items ingested and to evaluate variation in feeding habits by sex, age, time of day, month and year. Grasshoppers and seeds of *Helianthus*, *Euphorbia* and *Croton* were dominant food items. Diet did not differ between sexes or age groups. Scaled quail consumed more grasshoppers and other insects in morning, and more seeds in afternoon. Composition of diet differed by month and year; these differences may be due to annual variation in rainfall and may be related to population fluctuations.

The scaled quail (*Callipepla squamata*) is one of the most popular game birds of the southwestern United States and has been the subject of numerous studies of food habits (Lehman & Ward 1941; Schemnitz 1961; Ault 1981; Rollins 1981; Ault & Stormer 1983; Campbell-Kissock et al. 1985; Medina 1988), including several that have been conducted in southeastern New Mexico (Davis & Banks 1973; Davis et al. 1975; Best & Smartt 1985). Each of these studies covered one to two years; none examined long-term variation in diet of scaled quail. Only Best & Smartt (1985) examined dietary differences between sexes. No study has examined dietary differences between age classes. A more complete understanding of food habits of the scaled quail is desirable for land managers and those who wish to understand population declines by scaled quail (Brennan 1994). For example, much of the geographic range of scaled quail in New Mexico has been subjected to treatments intended to control shinnery oak (*Quercus havardii*) (cf. Peterson & Boyd 1998). If shinnery oak acorns are utilized as a food source by scaled quail, destruction of shinnery oaks might have a deleterious effect on populations of scaled quail. This study examines variation in diet by sex, age, time of day and season over an eight year period.

MATERIALS AND METHODS

The study was conducted on the Los Medaños Waste Isolation Pilot Plant site in southeastern New Mexico in conjunction with a study of lead poisoning in game birds (Best et al. 1992a; 1992b). The study area was centered at the southeast corner of section 20 (T22S, R31E), extended outward to 8 km, and covered ≈ 20,000 ha in eastern Eddy County and extreme western Lea County. Studies of the feeding ecology of mourning doves, *Zenaida macroura* (cf. Davis 1974; Best & Smartt 1986; Hunt 1999) and northern bobwhites, *Colinus virginianus* (cf. Hunt & Best 2001) have been conducted on this site. All scaled quail were collected in uncultivated, shinnery oak-mesquite (*Quercus havardii*/*Prosopis glandulosa*) habitat. Extensive analyses of vegetation have been conducted on the site (Best & Jackson 1982; Cockman 1987; 1988). The study site was heavily grazed by cattle, and several man-made stock tanks are located on the site.

In late summer and autumn 1981-1988, 563 scaled quail were collected by shooting as encountered. Equal effort was made in each year to collect quail. Specimens were immediately placed on ice to minimize effects of post-mortem digestion (Farner 1960; Dillery 1965; Sedinger 1986). No effects of digestion were observed in crop contents in this study. For each bird, time and date of collection, body mass, and sex and age as determined from plumage were recorded. Crops were removed, placed into plastic vials and frozen. Crops were later thawed and contents separated by type of food and placed into envelopes for drying. Each crop was analyzed separately. Food items were dried for 48 hours at 60°C to standardize masses.

Food items were identified by comparison with samples of plants collected at the study site and by identification manuals (Martin & Barkley 1961; Borror & White 1970; Davis 1993). Seeds were identified to genus and insects were identified to order or family. Leafy plant material, which accounted for ≈ 5% of the total mass of crop contents, was classified as miscellaneous plant material and was included in analyses so that results might be compared with other analyses.

Discriminant-function analyses were used to evaluate sexual, age-related and temporal variation in food habits; categories of food were used as variables and total masses of each food item contained in individual crops served as characters. All statistical analyses were conducted using SPSS 8.0 for Windows (Green et al. 1997); discriminant-function analyses were cross-verified using the leave-one-out protocol. Empty crops (n = 13) were not included in analyses of crop contents.

RESULTS AND DISCUSSION

Contents of crops.—Frequency, total mass and percentage of total mass for each food item are presented in Table 1. Seeds of prairie sunflower (*Helianthus petiolaris*) accounted for 14.3% of total mass of food and were present in 37% of crops. *Euphorbia* was the most common food item; it occurred in 60% of crops and accounted for 10.9% of total mass. Acridid grasshoppers were in 32% of crops and made up 13.6% of total mass of food. Five other food items were found in 37-57% of crops; miscellaneous plant material, *Croton*, *Panicum*, ants (Formicidae) and *Heterotheca*. These five food categories accounted for 22% of total mass. Of 79 food items detected, 60 were present in amounts < 1% of total mass. Overall, plant material accounted for 79.4% of total mass, and animal material accounted for the remaining 19.6%. The overall results from this study differ from those obtained by Best & Smartt (1985) on the same site; however, they collected scaled quail only in November 1979. Results from November 1981 of this study (the only November collected) produced similar results to those of Best & Smartt (1985).

Sexual differences.—The sample consisted of 277 males and 274 females, with 12 specimens of unknown sex. The sex ratio in this population was 101.1 males:100 females; this is not significantly different from 1:1 (χ^2 = 0.016, P = 0.898). The sex ratios for individual years also did not differ significantly from 1:1 ($P < 0.05$). Discriminant-function analysis of crop contents in this sample indicated no significant difference in feeding habits of males and females (Wilks' λ = 0.838, P = 0.262). These results differ from results obtained for scaled quail in 1979 on the same study site (Best & Smartt 1985), in that slight differences between diets of males and females were found in quail collected only in November. A discriminant-function analysis of birds in this study collected in November 1981 indicated no significant difference in feeding habits of males and females (Wilks' λ = 0.409, P = 0.565). These conflicting findings may be due to differences in interpretation of statistical results; in any case, differences between sexes in the previous study were minor (Best & Smartt 1985).

Differences by age.—Quail were categorized as adult or subadult. The sample consisted of 118 adults and 423 subadults; nine birds were of undetermined age. Discriminant-function analysis of crop contents indicated no significant difference in feeding habits of adults and subadults (Wilks' λ = 0.826, P = 0.118).

Table 1. Frequency, total mass and percentage of food items in crops (n = 563) of scaled quail in southeastern New Mexico.

Item	Frequency	Percentage	Mass (g)	Percentage
Plant material				
Amaranthaceae				
Amaranthus	197	35.0	35.765	5.3
Anacardiaceae				
Rhus	27	4.8	11.467	1.7
Boraginaceae				
Lithospermum	42	7.5	1.305	0.2
Brassicaceae				
Arabis	44	7.8	1.260	0.2
Cactaceae				
Opuntia	24	4.3	10.553	1.6
Caesalpinaceae				
Caesalpinia	28	5.0	1.805	0.3
Chenopodiaceae				
Chenopodium	145	25.8	24.061	3.5
Cycloloma	87	15.5	6.171	0.9
Salsola	1	0.2	1.504	0.2
Commelinaceae				
Commelina	52	9.2	2.458	0.4
Compositae				
Ambrosia	21	3.7	4.300	0.6
Artemesia	16	2.8	4.256	0.6
Helianthus	208	36.9	97.052	14.3
Heterotheca	211	37.5	38.061	5.6
Verbesina	43	7.6	2.153	0.3
Euphorbiaceae				
Croton	241	42.8	44.880	6.6
Euphorbia	336	59.7	74.357	10.9
Fagaceae				
Quercus	72	12.8	32.070	4.7
Gramineae				
Andropogon	91	16.2	4.284	0.6
Panicum	222	39.4	22.537	3.3
Paspalum	162	28.8	6.973	1.0
Labiatae				
Monarda	30	5.3	2.317	0.3
Leguminosae				
Astragalus	156	27.8	6.470	1.0
Prosopis	173	30.7	44.000	6.5
Linaceae				
Linum	47	8.3	11.240	1.7
Loasaceae				
Mentzelia	28	5.0	0.739	0.1
Molluginaceae				
Mollugo	41	7.3	7.113	1.0

Table 1 cont.

Item	Frequency	Percentage	Mass (g)	Percentage
Nyctaginaceae				
Oxybaphus	13	2.3	0.864	0.1
Plantaginaceae				
Plantago	1	0.2	0.007	<0.1
Polygonaceae				
Erigonum	8	1.4	2.116	0.3
Verbenaceae				
Verbena	12	2.1	1.034	0.2
Other seeds*	54	9.6	1.597	0.2
Miscellaneous plant material	321	57.0	34.350	5.1
Total plant	548	97.3	539.110	79.4
Animal material				
Acrididae	179	31.8	92.314	13.6
Aphididae	1	0.2	0.692	0.1
Chrysomelidae	82	14.6	2.198	0.3
Cicadellidae	69	12.3	0.978	0.1
Cicadidae	5	0.9	0.522	0.1
Coccinellidae	57	10.1	2.256	0.3
Coreidae	3	0.5	0.743	0.1
Curculionidae	59	10.5	2.899	0.4
Diptera	22	3.9	2.891	0.4
Formicidae	215	38.2	8.124	1.2
Hymenoptera	10	1.8	0.362	0.1
Kermidae	45	8.0	12.453	1.8
Lygeidae	40	7.1	1.473	0.2
Mantidae	3	0.5	0.663	0.1
Margarodidae	49	8.7	3.027	0.4
Scarabaeidae	35	6.2	3.464	0.5
Tenebrionidae	20	3.6	0.994	0.1
Other insects**	108	19.2	2.072	0.3
Insect eggs	39	6.9	0.160	<0.1
Insect larvae	35	6.2	0.855	0.1
Aranae	49	8.7	0.719	0.1
Other invertebrates	5	0.8	0.078	<0.1
Bone	1	0.2	0.190	<0.1
Total animal	389	69.1	140.126	20.6
Total food	550	97.7	679.235	100.0
Empty crops	13	2.3		

* Includes *Atriplex, Cyperus, Digitaria, Eragrostris, Kallstroemia, Leptoloma, Plantago, Sida, Solanum* and unidentified seeds.

** Includes Acanaloniidae, Asilidae, Bruchidae, Carabidae, Cerambycidae, Cicindelidae, Elateridae, Miridae, Myrmeleontidae, Nabidae, Pentatomidae, Psyllidae, Rhopalidae, Scutellaridae and unidentified insect parts.

Diel differences.—Although collecting began at dawn and continued until sundown each collecting day, most birds were encountered early in the morning (before 1000 hr) or late in the afternoon (after 1600 hr). Discriminant-function analysis of crop contents based on separation at 1200 hr into morning (n = 389) and afternoon (n = 161) groups indicated a significant difference in diet in morning and afternoon (Wilks' $\lambda = 0.766$, $P < 0.001$). Based upon crop contents, 77% of individuals were correctly classified as to time of collection. Of the most important food items that exhibited a significant difference between mean masses found in morning and afternoon, grasshoppers and ants were more common in morning and *Helianthus* and miscellaneous plant material were more common in afternoon (t-tests, all $P < 0.05$). These differences probably are due to cooler temperatures in morning, which make insects sluggish and easier to catch (Chapman 1969); birds may concentrate on seeds when insects are more active. These findings are similar to those for a study of northern bobwhites (*Colinus virginianus*) conducted on the same site (Hunt & Best 2001), which showed that more grasshoppers were taken in morning than in afternoon.

Seasonal and annual differences.—Scaled quail were collected in August (n = 137), October (n = 330), November (n = 58) and December (n = 38). Discriminant-function analysis of crop contents indicated a significant difference in diet of quail in these four months (Wilks' $\lambda = 0.088$, $P < 0.001$). Eighty-four percent of birds were correctly classified as to month of collection. Total mean masses of all major food items differed significantly between months (*ANOVA*, all $P < 0.05$). Monthly differences were probably due to changing availability of food items as each year progressed. For example, mean mass of grasshoppers in each crop decreased from 0.545 g in August to 0.052 g in October, then to 0.019 g in December. Animal material was 44% of the total mass of food items in August, 13% in October, and < 2% in November and December. Mean mass of *Helianthus* and *Heterotheca* in each crop increased as the year progressed, while that of *Croton* and *Panicum* decreased. These changes probably are due to differences in time of seed maturation.

Discriminant-function analyses also were performed separately for each month because differences were detected in analyses of diets by month. Crops from November and December were excluded from analyses because birds were collected only in November 1981 and December 1987. Quail from August 1988 were also deleted from analysis because only two quail were collected during that month. Significant differences were present in the diet of scaled quail for 1982-1988 (August, Wilks' λ = 0.003, $P < 0.001$; October, Wilks' λ = 0.087, $P < 0.001$). For birds collected in August, 90% were correctly classified to year of collection. For birds collected in October, 63% were correctly classified to year of collection.

Annual variation in diet may be due to differences in availability of food items associated with annual differences in precipitation. Rainfall at the study site ranged from 24.77 cm in 1983 to 58.42 cm in 1986 (NOAA 1981-1988). In October, scaled quail ate a lower percentage of animal material in years with greater rainfall (linear regression, R^2 = 0.616, F = 8.013, P = 0.037); in August, there was a similar, but non-significant, trend (R^2 = 0.442, F = 3.958, P = 0.103). Ault (1981) reported a similar trend in scaled quail in the Texas Panhandle. Scaled quail may eat greater amounts of insects in drier years to obtain water (Giuliano et al. 1995).

Miscellaneous plant material accounted for 5.1% of total mass of crop contents; levels of miscellaneous plant material taken remained 1-4% during each August and October sampled. Vorhies (1928) suggested that quail may eat leafy vegetation to obtain water. There was no relationship in this study between annual precipitation and percentage of miscellaneous plant material taken (linear regression, August R^2 = 0.218, F = 1.39, P = 0.291; October R^2 = 0.036, F = 0.189, P = 0.682). However, percentage of total food mass accounted for by miscellaneous plant material was greater in November and December, months that are extremely dry on the study site. This is not simply a function of lower mass of food consumed during these months; in fact, total intake of food expressed as a percentage of body weight was higher in December than in October (*ANOVA*, F = 30.281, $P < 0.001$).

Variation in precipitation may affect overall availability of food, may lower reproductive success, and may directly contribute to fluctuation in population levels of scaled quail (Campbell 1968; Giuliano et al. 1995; 1999). Although equal amounts of collection effort were expended each year, numbers of quail collected varied widely. A strong relationship existed between the number of scaled quail collected each year and the total precipitation for the previous year (linear regression, R^2 = 0.648, F = 13.59, P = 0.010). Lower population levels after dry years may be due to lower availability of food items in addition to increased competitive pressure from other medium-sized, ground-feeding birds, such as mourning doves and northern bobwhites; further studies to investigate possible competition are needed.

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