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Gambel and Scaled Quail Diets on the Santa Rita Experimental Range

Abstract: Diets of Gambel (*Lophortyx gambelii* Gambel) and scaled quail (*Callipepla squamata* Vigors) from 1982 to 1984 were examined on the Santa Rita Experimental Range in southern Arizona. Quail selected some foods yearlong and others on a seasonal basis, but exhibited a preference for the seeds and leaves of forbs and insects. Seeds of bristlegrasses were selected primarily during winter. Gonadal development was strongly associated with the availability of spring forbs. Forbs were most common in areas frequented by cattle in native range pastures, and nearly absent from Lehmann lovegrass (*Eragrostis lehmanniana* Nees) habitats. Gambel quail exhibited an affinity for desert hackberry (*Celtis pallida*) as resting cover, while scaled quail were most often associated with grassland habitats with bunchgrasses. The management implications of cattle, quail, and Lehmann's lovegrass interactions are discussed.

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Introduction

Diets of Gambel (*Lophortyx gambelii* Gambel) and scaled quail (*Callipepla squamata* Vigors) have been described for portions of Texas (Ault and Stormer 1983; Campbell-Kissock and others 1985), Oklahoma (Schemnitz 1961), New Mexico (Best and Smartt 1985; Campbell and others 1973; Davis and Banks 1973; Davis and others 1975; Schemnitz and others 1997), Arizona (Kelso 1937), and the Santa Rita Experimental Range (Hungerford 1960). These studies were seasonal, typically only fall and winter, or were conducted in habitats different from those available to scaled quail on SRER. Continuous study of quail diets across seasons and years were first reported by Medina (1988) for scaled quail.

The objective of this research was to compare the amounts and kinds of foods consumed by Gambel and scaled quail in southern Arizona across seasons for 2 successive years. Additional information on the gonadal cycle and endoparasites was also collected. The importance of maintaining diverse plant communities as it relates to quail habitats and livestock grazing is discussed.

Study Area

The study was conducted on the Santa Rita Experimental Range (SRER) in Pima County, Arizona. The study area was described in detail by Martin and Reynolds (1973), but considerable changes in herbaceous vegetation have occurred in the last 40 years. Lehmann's lovegrass (*Eragrostis lehmanniana* Nees) was sown as a reseeding treatment in the 1950s. Spread by seed, it has become the dominant graminoid in areas of mid to high elevation (Cox and Ruyle 1986; Medina 1986). Vegetation on the range is dominated by stands of velvet mesquite (*Prosopis juliflora*), cholla cactus (*Opuntia fulgida, O. spinosior*, and *O. versicolor*), prickly pear cactus (*O. engelmanni*), burroweed (*Haplopappus tenuisectus*), acacia (*Acacia* spp.), and mimosa (*Mimosa* spp.). Various native grass species including three-awn (*Aristida* spp.), grama (*Bouteloua* spp.), bush muhly (*Muhlenbergia porteri*), and Arizona cottontop (*Trichachne californica*) persist (Medina 1988). Plant nomenclature follow USDA, NRCS (2002).

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The Santa Rita Experimental Rane is situated on a broad sloping bajada interspersed by numerous dry washes. Elevations range from 885 to 1,370 m. Average rainfall ranges from 25 cm at 885 m to approximately 51 cm at 1,370 m. Precipitation for the study period 1982 to 1984 was similar to the 43-year mean. The frost-free period is approximately 8 months, but growth of herbaceous plants is limited by drought during May and June. Sixty percent of annual rainfall occurs between 1 July and 30 September (Medina 1988).

Methods

Detailed crop analyses were described in Medina (1988). Quail were collected each month with a shotgun from September 1982 through December 1984. Some quail were collected by hunters during quail hunting seasons and their attributes were noted. Individual quail were identified by sex, age, and species, and their total body weights recorded. Diets (table 1) were assessed by analysis of crop contents that were ovendried.

Table 1—List of principal plants comprising the diets of Gambel and scaled quail on the Santa Rita Experimental Range.

Scientific name	Plant code	Scientific name	Plant code
Abutilon berlandieri Gray ex S. Wats.	ABBE	*Lotus wrightii* (Gray) Greene	LOWR
Acacia angustissima (P. Mill.) Kuntze	ACAN	*Lupinus sparsiflorus* Benth.	LUSP2
Acacia constricta Benth.	ACCO2	*Lygodesmia grandiflora* (Nutt.) Torr. & Gray	LYGR
Acacia greggii Gray	ACGR	*Machaeranthera tanacetifolia* (Kunth) Nees	MATA2
Acalypha neomexicana Muell.-Arg.	ACLO2	*Menodora scabra* Gray	MESC
Acleisanthes longiflora Gray	ACNE	*Mimosa dysocarpa* Benth.	MIDY
Amsinckia douglasiana A. DC.	AMDO	*Mollugo verticillata* L.	MOVE
Argemone pleiacantha Greene	ARPL3	*Monolepis nuttalliana* (J.A. Schultes) Greene	MONU
Aristolochia watsonii Woot. & Standl.	ARWA	*Opuntia engelmannii* Salm-Dyck	OPEN3
Astragalus allochrous Gray var. playanus Isely	ASALP	*Panicum capillare* L.	PACA6
Astragalus nuttallianus DC.	ASNU4	*Panicum hallii* Vasey var. hallii	PAHAH
Astragalus tephrodes Gray	ASTE8	*Panicum hirticaule* J. Presl	PAHI5
Baileya multiradiata Harvey & Gray ex Gray	BAMU	*Parkinsonia microphylla* Torr.	PAMI5
Boerhavia intermedia M.E. Jones	BOIN	*Penstemon pseudospectabilis* M.E. Jones	PEPS
Boerhavia spicata Choisy	BOSP	*Phaseolus ritensis* M.E. Jones	PHRI
Calliandra eriophylla Benth.	CAER	*Physalis crassifolia* Benth.	PHCR4
Carlowrightia arizonica Gray	CAAR7	*Plagiobothrys arizonicus* (Gray) Greene ex Gray	PLAR
Celtis pallida Torr.	CEPA8	*Plagiobothrys pringlei* Greene	PLPR3
Cerastium brachypodum (Engelm. ex Gray) B.L. Robins.	CEBR	*Polanisia dodecandra* (L.) DC. ssp. *trachysperma* (Torr. & Gray) Iltis	PODOT
Cerastium glomeratum Thuill.	CEGL2	*Portulaca oleracea* L.	POOL
Cerastium nutans Raf.	CENU2	*Portulaca pilosa* L.	POPI3
Chamaesyce maculata (L.) Small	CHMA15	*Proboscidea parviflora* (Woot.) Woot. & Standl.	PRPA2
Chamaesyce melanadenia (Torr.) Millsp.	CHME5	*Prosopis juliflora* (Sw.) DC.	PRJU3
Chamaesyce prostrata (Ait.) Small	CHPR	*Rumex hymenosepalus* Torr.	RUHY
Chamaesyce serrula (Engelm.) Woot. & Standl.	CHSE7	*Salsola tragus* L.	SATR12
Chenopodium album L.	CHAL7	*Salvia columbariae* Benth.	SACO6
Croton glandulosus L.	CRGL	*Setaria grisebachii* Fourn.	SEGR6
Cryptantha nevadensis A. Nels. & Kennedy	CRNE	*Setaria viridis* (L.) Beauv.	SEVI4
Dalea aurea Nutt. ex Pursh	DAAU	*Sida spinosa* L.	SISP
Daucus carota L.	DACA6	*Silene antirrhina* L.	SIAN2
Daucus pusillus Michx.	DAPU3	*Solanum douglasii* Dunal	SODO
Descurainia pinnata (Walt.) Britt.	DEPI	*Solanum heterodoxum* Dunal var. *setigeroides* M.D. Whalen	SOHES
Digitaria sanguinalis (L.) Scop.	DISA	*Stephanomeria spinosa* (Nutt.) S. Tomb	STSP6
Erodium botrys (Cav.) Bertol.	ERBO	*Talinum paniculatum* (Jacq.) Gaertn.	TAPA2
Eschscholzia californica Cham.	ESCA2	*Tetramerium nervosum* Nees	TENE
Eschscholzia californica Cham. ssp. mexicana (Greene) C. Clark	ESCAM	*Torilis nodosa* (L.) Gaertn.	TONO
Euphorbia marginata Pursh	EUMA8	*Tragopogon porrifolius* L.	TRPO
Ferocactus wislizeni (Engelm.) Britt. & Rose	FEWI	*Urochloa arizonica* (Scribn. & Merr.) O. Morrone & F. Zuloaga	URAR
Galactia wrightii Gray	GAWR	*Verbesina encelioides* (Cav.) Benth. & Hook. f. ex Gray	VEEN
Ipomoea capillacea (Kunth) G. Don	IPCA2	*Vicia hassei* S. Wats.	VIHA3
Ipomoea coccinea L.	IPCO3	*Yeatesia platystegia* (Torr.) Hilsenb.	YEPL
Ipomoea eriocarpa R. Br.	IPER	*Ziziphus obtusifolia* (Hook. ex Torr. & Gray) Gray var. *obtusifolia*	ZIOB
Ipomoea plummerae Gray	IPPL		
Kallstroemia grandiflora Torr. ex Gray	KAGR		
Lotus humistratus Greene	LOHU2		
Lotus rigidus (Benth.) Greene	LORI3		
Lotus salsuginosus Greene	LOSA		
Lotus strigosus (Nutt.) Greene var. tomentellus (Greene) Isely	LOST4		

Individual foods were weighed and measured volumetrically by water displacement to nearest 0.1 ml. Seed identification was facilitated by an extensive seed collection (589 species) from the area, use of manuals (Martin 1946; Martin and Barkley 1961; Musil 1963; USDA Forest Service 1974), and identification of plants germinated from seeds found in samples. Herbage and insect material were treated separately. Data were initially expressed by the aggregate volume method (Martin and others 1946) and then summarized in terms of frequency of occurrence (table 2). Results were summarized on a seasonal basis (winter = December through February, spring = March through May, summer = June through August, fall = September through November). Diets are presented as percent of occurrence across seasons and years. Simple measures of statistics were used to illustrate diet selection between quail species. Means and their standard deviations are provided to illustrate diet variability. Constancy was used as a measure of the relative occurrence of an individual food across the sample period. Foods selected in all seasons have high constancy.

Seasonal condition of quail gonads were recorded by measuring the length, width, and volume of testes. Birds were refrigerated and processed within 6 hours of collection. It is well established that testis size is proportional to testicular activity in birds. In females, the size (volume) of enlarging follicles was used as a measure of ovarian activity. Ovary and testis color were also determined. Observations of general health conditions, for example, endoparasites, were also noted.

Results

Over the 2-year period, 512 crops were analyzed: 61 adult-scaled females, 15 immature (less than 1-year-old) females, 60 adult males, and 26 immature males; 104 Gambel adult females, 46 immature, 161 adult males, and 39 immature males. Seeds of 88 plant taxa (table 1) were identified in the crops: 18 woody plants, 64 herbaceous plants, and 6 grasses. Seeds averaged the highest mean frequency of occurrence (67 percent) of all food categories followed by green herbage (6.7 percent), insects (5 percent), gravel (3.4 percent), and miscellaneous.

Forb seeds were selected with 2.7 and 4.5 times greater frequency than woody and grass seeds, respectively (table 2). Consumption of forb seeds exceeded woody plant seeds during most collection periods. Grass seeds were selected with greater frequency by both quails over forb seeds during the fall seasons, and Gambel selected them about 3 times more than scaled (table 3). Gambel quail generally selected seeds of woody plant more than scaled.

Seeds that averaged high constancy and high mean frequency across seasons included smallflowered milkvetch (*Astragalus nuttallianus*), spiny hackberry (*Celtis pallida*), spotted sandmat (*Chamaesyce maculata*), morningglory (*Ipomoea eriocarpa*), foothill deervetch (*Lotus humistratus*), lupine (*Lupinus sparsiflorus*), spiny sida (*Sida spinosa*), velvet mesquite, Grisebach's bristlegrass (*Setaria grisebachii*), and green bristlegrass (*Setaria viridis*) (table 2) . Other plant seeds that averaged high constancy (greater than 87 percent) across seasons but with lower mean frequency of occurrence or lower constancy but higher mean frequency of occurrence included crested pricklypoppy (*Argemone platyceras*), spiderling (*Boerhaavia intermedia*), lambquarters (*Chenopodium album*), Arizona carlowrightia (*Carlowrightia arizonica*), Strigose bird-foot trefoil (*Lotus strigosus*), pinnate tansymustard (*Descurainia pinnata*), carpetweed (*Mollugo verticillata*), desert penstemon (*Penstemon pseudospectabilis*), sleepy silene (*Silene antirrhina*), tetramerium (*Tetramerium nervosum*), panicum (*Panicum hirticaule*), and yellow nightshade groundcherry (*Physalis crassifolia*). Mesquite seeds were the dominant woody species selected. Morningglory seeds were selected more than any other forb. Bristlegrasses were the most important grasses yearlong.

Seasonal differences in quail diets were highly variable (table 2) for many species. Seeds of some plants (for example, *Acacia constricta*, *Tragopogon porrifolius*) became important in summer and fall, while others (for example, *Baileya multiradiata*, *Euphorbia marginata*) were more important in winter or spring. Green herbage and insects were important yearlong, and green herbage was especially important in late winter. Both green herbage and insects were represented in 67 percent of all crops across all seasons. Ants, beetles, and grasshoppers composed the bulk of insects eaten.

Differences in diets between Gambel and scaled quail were not apparent within or across seasons for individual plants, but were evident across major food groups (tables 2 and 3). Foods may or may not be selected in any one season. Individual foods with high constancy across seasons were used in relatively the similar proportions within seasons. However, some seasonal differences were evident at the group level primarily for seeds of forbs and grasses (table 3). Scaled quail selected seeds of forbs, grasses, and woody plants 1.5 to 4 times less than Gambel quail in the summer and fall. These differences were less apparent during the winter and spring.

Differences in body weights between species, sex, and age were unremarkable (table 4). Examination of seasonal body weights also were unremarkable. Differences in body weights of juveniles during the fall were noted and attributed to collection times. The body weight of juveniles collected early in the summer were less than those collected during the first month of the fall season. This was verified from examination of body weights across months for this group (table 5).

Male gonadal development initiated in early March with onset of cool season herbage (primarily *Erodium* spp.), peaked in late April to early May, remained active through mid-July, decreased in September, and slightly increased in October and November during hunting season (table 6). Teste size and color ranged from small and white-gray during periods of low activity to large and black during developmental periods. Testes began to shrink in August, attaining a stable volumetric size near 0.1 cc through the winter. Ovary development in female quail initiated about 1 month earlier than teste development in males. Eggs were laid primarily in May to June. Hatching of chicks occurred primarily in June to July, but occasional eggs and chicks were observed into August.

Nematodes were observed in 8.4 percent of all quail examined, with a 3.7 percent occurrence in Gambel and 4.7 percent in scaled quail. Tapeworms (*Gastrotaenia* spp.) were observed in 9 percent of all quail examined, with a 7 percent occurrence in Gambel and 2 percent in scaled quail.

Table 2—Frequency of food plants occurring in the diets of Gambel (G) and scaled (S) quail on the Santa Rita Experimental Range by season and study period. Constancy refers to the occurrence of individual plants across seasons over the study period by quail species; average is the mean frequency in percent across the period of study for all birds.

Plant	Fall		Winter		Spring		Summer		Constancy		
code	G	S	G	S	G	S	G	S	G	S	Average
									- - - - - - - *percent*-	- - - - - - - - -	
ABBE	0.43			0.88			0.13		50	50	12.86
	.60										
ACAN	.17							0.53	25	25	0.35
ACCO2	.86						.13	.67	50	50	.44
	.09										
ACGR	.52			.88		.18	.40	.40	50	75	.48
ACLO2						.54			0	25	.54
ACNE							.27		25	0	.27
AMDO	.26						.53	.67	50	25	.49
ARPL3	.35		.29		.18	.36	.40	.40	100	75	.32
	.26										
ARWA	.09			.29		.18			25	50	.20
	.26										
ASALP								.27	0	25	.27
ASNU4	1.81		2.06	2.65	.89	1.25	1.74	.53	100	100	1.51
	1.12										
ASTE8	.60								25	0	.60
BAMU			.29			.18			25	25	.24
BOIN	3.37		.29				3.34	.40	75	50	1.55
	.35										
BOSP	.60			.29		.18			25	50	.33
	.26										
CAAR7	.09				.36	.89		.13	50	75	.33
	.17										
CAER					.72	.36	.27		50	25	.45
CEPA8	2.59			.88	.54	.54	2.54	1.20	75	100	1.28
	.69										
CEBR				.29					0	25	.29
CENU2	.09								25	25	.09
	.09										
CEGL2	.09								25	0	.09
CHAL7					1.97				25	0	1.97
CHMA15	2.94		.88	.59	.18	1.25	2.40	.27	100	100	1.16
	.78										
CHME5	.09								0	25	.09
CHPR	.17	.			.18				50	25	.32
	.60										
CHSE7	.09					.18			25	25	.14
CRGL							.13	.40	25	25	.26
CRNE							.13		25	0	.13
DAAU				.29					0	25	.29
DACA6				.29					0	25	.29
DAPU3						.18	.27		25	25	.22
DEPI	.09		1.77	2.06	3.58	3.04			25	75	2.11
DISA	.09								25	0	.09
ERBO							.13	.13	25	25	.13
ESCA2						.18	.40	.40	25	50	.33
ESCAM	.17				.18	.54			25	50	.30
EUMA8			.29	.59	.36	.89			50	50	.53
FEWI	.69		.29	.29		.36			50	50	.41
GAWR	.09		.59						25	25	.34
IPCA2	.09						.13		50	0	.11
IPCO3	.09						.13		50	0	.11
IPER	2.68		2.95	3.54	.54	.54	1.07		100	75	1.85
	1.64										
IPPL	.86							.18	25	25	.83
KAGR	.26						.67	.40	50	50	.42
	.35										
LOHU2	3.71		1.18	2.95	2.33	4.65	2.54	1.47	100	100	2.53
	1.38										
LORI3	.26				.18	.18	.27	.27	75	75	.24
	.26										
LOSA	.26		.59	.29	.89	1.25		.27	50	75	.59
LOST4	1.38		.88	1.18	1.07	1.79	.80	.27	100	100	.98
LOWR	.26		.29		.72	.54		.40	50	75	.44

(Con.)

Table 2—(Con.)

Plant code	Fall G	Fall S	Winter G	Winter S	Spring G	Spring S	Summer G	Summer S	Constancy G	Constancy S	Average
									- - - - - - - *percent*	- - - - - - - - - -	
LUSP2	2.42		1.47	.88	2.86	3.22	3.20	.67	100	100	1.93
	.69										
LYGR	.95						1.60	.27	50	50	.73
	.09										
MATA2					.18				25	0	.18
MESC	.26								25	0	.26
MIDY							.27		25	0	.27
MONU	.17		.59				.13	.27	50	50	.29
MOVE	.69					.18	1.20	.53	50	50	.65
OPEN3	.09						.27	.27	50	25	.21
PACA6	1.04						2.40	.40	50	50	1.05
	.35										
PAHAH					.18				25	0	.18
PAHI5	1.04			.59	.18	.72	1.34	.80	75	100	.72
	.35										
PAMI5					.36	1.25	.13	.13	50	50	.47
PEPS	.35		2.06	1.18	.18	1.07		.13	75	100	.75
	.26										
PHCR4	.09		.29	.29	.36	.36	.27		100	75	.27
	.26										
PHRI							.13		25	0	.1
PLAR						.36			0	25	.36
PLPR3	.18		.59				.13		50	50	.25
	.09										
PODOT					.18		1.07		50	0	.62
POOL					.36		.27		50	0	.32
POPI3	.09						1.47	.53	50	50	.54
	.09										
PRJU3	4.40		6.78	1.18	3.04	2.86	4.67	1.87	100	100	3.23
	1.04										
PRPA2						.18			0	25	.18
RUHY	.26								0	25	.26
SACO6	.09					.18	.13		50	25	.13
SATR12			.29						25	0	.29
SEGR6	3.63		.59	.59	.54	.36	3.74	.53	100	100	1.37
	.95										
SEVI4	6.13			1.18	.36	.54	4.81	2.14	75	100	2.36
	1.38										
SIAN2	.09		.59		.18	1.25		.27	50	75	.48
SISP	4.06		2.06	2.06	1.25	2.33	2.14	1.20	100	100	2.09
	1.64										
SODO						.18			0	25	.18
SOHES			.29						25	0	.29
STSP6	.69								25	0	.69
TAPA2	.09		.29				.27		75	0	.22
TENE	2.07		.29	.59	.54	1.07	.67	.67	100	100	.86
	.95										
TONO	.17				.36	1.25		.40	50	50	.55
TRPO	.17						.53	1.20	50	50	.58
	.43										
URAR							.13		25	0	.13
VEEN							.13		25	0	.13
VIHA3	.43							.13	50	25	.22
	.09										
YEPL	.09		.29	.29				.27	50	50	.24
ZIOB	.09						.53		50	0	.31
Bone	.51		.88		1.07		.80	.13	100	75	.58
	.09										
Gravel	5.51		4.13	3.24	3.58	3.04	4.94	1.47	100	100	3.44
	1.64										
GreenVeg	7.34		14.16	7.56	7.12	6.80	6.01	2.27	100	100	6.7
	2.32										
Insect	5.11		5.90	5.13	6.03	7.16	5.47	3.34	100	100	5.05
	2.25										
DryVeg	.60		1.18	1.18	1.07	.54	1.34	.80	100	100	.91
	.60										
Unknown	.01		.18	.29	.01	.01	.01	.01	100	100	.07
	.01										
Total	73.7		55.5	44.5	44.9	55.1	69.2	30.8			

Table 3—Frequency (percent) of seeds selected as foods for quail on the Santa Rita Experimental Range by life form. The total number of plants selected by individual quail species are indicated by "N."

	Fall		Winter		Spring		Summer	
Seeds	Gambel	Scaled	Gambel	Scaled	Gambel	Scaled	Gambel	Scaled
Foods N	58	47	34	32	39	46	56	46
Forbs total percent	29.39	12.47	18.50	17.35	19.52	29.52	28.28	12.69
Grass total percent	11.84	3.03	0.59	2.36	1.26	1.62	12.42	3.87
Woody total percent	13.39	3.89	10.02	7.35	5.20	6.45	9.88	6.27
Seed total percent	54.19	18.79	29.11	26.18	25.98	37.59	50.45	22.83

Table 4—Comparison of average body weights (g) by species, sex, and age.

Class	Gambel	Scaled
Female, juvenile	123.3 ± 42.4	123.7 ± 51.4
Female, immature	159.4 ± 21.1	175.8 ± 23.6
Female, mature	169.7 ± 17.6	173.4 ± 22.4
Male, juvenile	121.0 ± 46.8	71.2 ± 59.3
Male, immature	164.9 ± 18.9	183.0 ± 9.8
Male, mature	169.8 ± 13.7	186.7 ± 13.2

Table 5—Mean body weights (g) with standard deviations indicated of Gambel and scaled quail sampled on SRER by age class, season, and species. Sample sizes are given within parenthesis.

Season	Juvenile	Immature	Mature
Fall			
Gambel	154.9 ± 16.8 (37)	168.8 ± 11.7 (31)	169.9 ± 9.4 (40)
Scaled	152.7 ± 43.6 (11)	181.1 ± 12.9 (12)	169.2 ± 36.2 (15)
Winter			
Gambel	—	179.0 ± 7.1 (2)	172.6 ± 14.1 (45)
Scaled	—	—	178.4 ± 14.1 (32)
Spring			
Gambel	—	165.2 ± 23.4 (30)	175.3 ± 16.9 (52)
Scaled	—	185.3 ± 20.0 (20)	185.1 ± 9.6 (27)
Summer			
Gambel	93.4 ± 40.9 (42)	155.8 ± 20.4 (38)	155.9 ± 13.3 (30)
Scaled	63.4 ± 36.3 (14)	170.2 ± 13.5 (13)	184.9 ± 15.5 (21)

Table 6—Monthly progression in teste and ovary development of Gambel and scaled quail on the Santa Rita Experimental Range. Values are volume (cc) determinations.

Month	Teste	Ovary/egg
January	<0.1	0.1
February	<0.1	.7
March	.7	1.8
April	.9	1.7
May	.8	6.2
June	.5	.6
July	.5	.2
August	.2	.2
September	.1	.2
October	.2	.4
November	.3	.4
December	<0.1	.2

Discussion and Management Implications

Diets of both Gambel and scaled quail were similar to those described by Campbell and others (1973), Davis and others (1975), and Schemnitz and others (1997) in southern New Mexico, Ault and Stormer (1983) in west Texas, and Campbell-Kissock and others (1985) in southwest Texas. Similarities included high selection of seeds of forbs, bristle grass seeds, and woody plants. Selection of these species over others perhaps resulted from conspicuous size of the seeds (Davis and others 1975), high protein content (Earle and Jones 1962; Jones and Earle 1966), and abundance (Medina 1988). Differences between this study and those from other states are attributed to differences in vegetation composition, site influences, and climatic factors. Schemnitz and others (1997) found Russian thistle and snakeweed seed were highly preferred by both Gambel and scaled. Medina (1988) attributed selection of succulent foods during drier seasons is perhaps an adaptive strategy developed by scaled quail in arid environments, as was observed by Wilson and Crawford (1987). Differences in diets were most evident in the relative greater quantities of forb and woody plant seeds consumed by quail in Arizona and New Mexico than in some areas in Texas. Differences in selection of various foods by quail could also be attributed to methodology of food determination, plant species composition, availability, climatic factors, individual preferences, sample size, or sampling period (Medina 1988). Greater similarities in diets of scaled quail were found between studies with similar methodologies and sampling periods. Seasonal studies tended to amplify the relative importance of individual species or group of plants (for example, grasses).

Differences in diets between quail species could be attributed to differences in habitat selection. Scaled quail were most abundant in habitats with low perennial grass cover but high forb cover. Wash and disturbed habitats had lowest perennial plant cover, highest annual plant cover, and low effort ratios. In contrast, Lehmann's lovegrass habitats had highest perennial plant cover and lowest annual plant cover (Medina 1988). Goodwin and Hungerford (1977), Campbell and others (1973), and Campbell-Kissock and others (1985) also reported avoidance of densely vegetated habitats by scaled quail and preference for habitats that exhibited diversity in plant composition, structure, and density. Apparent differences in selection of individual foods within a season were attributed to local abundance of such foods within the home range of respective coveys.

Results of this study revealed that seeds of forb plants were consumed in higher proportions than any other food item. This suggests that habitats that exhibit diverse plant composition are selected by quail. Observations indicated that scaled quail were most abundant on habitats with low perennial grass cover and high forb cover (Medina 1988). Gambel quail were most abundant on mesquite-shrub/grassland habitats. Lehmann's lovegrass habitats were seemly the least desirable habitat for both quail, given the high percent grass cover and low forb cover. Goodwin and Hungerford (1977), Campbell-Kissock and others (1985), and Wilson and Crawford (1987) also reported avoidance of densely vegetated habitats by scaled quail. Campbell and others (1973), Davis and others (1975), and Campbell-Kissock and others (1985) concluded that a moderately high degree of diversity in plant composition and community structure were conditions required for optimum scaled quail habitat.

The reproductive periods of the gonadal cycle were consistent with studies by Wallmo (1956). The quiescent period of testicular activity was evident in September through February. Increase in size of testes was coincident with cool-season herbage (March), which provides vitamins and other nutrients necessary for gonadal development (Hungerford 1964). The quiescent period for ovarian activity was similar to testicular activity but marked with a general decline (table 6) as early as July (September in Texas; Wallmo 1956). A similar increase in testicular activity was noted during the hunting season (October to November). This increase could be a hormonal response to nutrient intake from green herbage produced during late warm-season growth or increased activity due to hunting.

The investigation of endoparasites on SRER's quail population were incidental to dietary and habitat studies. The information is presented here to alert managers of their incidence of occurrence. The prevalence and importance of parasitic organisms (such as nematodes and tapeworms) in southwestern quail has not been studied, rather most works have dealt with bobwhite quail in areas of Southeastern and Northeastern United States (Kocan and others 1979). Other studies have also focused on Japanese quail, a species of commercial significance. Kocan and others (1979) reported the prevalence of nematodes and cestodes in Oklahoma bobwhite quail to approximate 27 and 6 percent Statewide, respectively. Boggs and others (1990) reported an incidence of physalopterid nematodes in 5 of 64 bobwhite quail examined in Oklahoma. Heavy burdens of tapeworms may reduce the vigor of the bird, occlude the intestines, and serve as a predisposing factor for other diseases (Friend and Franson 1999). Nematode infection has been suggested as a factor that may reduce fecundity within populations as well direct chick mortality (Friend and Franson 1999).

The management implications of this work for quail populations suggest that rangelands should be managed to produce a diverse vegetative composition. It is also important to note that key staple foods were those typically known as weeds, invaders, or generally undesirable species. These species typically establish on disturbed sites. On SRER these microsites are mostly sustained by cattle grazing on upland habitats. Hence, there appears to be a positive interaction between cattle grazing and good quail habitats. No evidence exists from cattle dietary studies (Galt and others 1966; Medina, unpublished data) on SRER that competition for foods is an issue. Galt and others (1982) reported cattle diets on SRER as 67 to 97 percent grasses and 0 to 4 percent forbs. Very little dietary overlap was noted for the principal food group—forbs. Secondly, range management goals have traditionally strived to achieve excellent range conditions.

This study suggests that attainment of the latter conditions may not be desirable for sustaining quail populations. Schemnitz and others (1997) concluded that moderate livestock grazing may be beneficial to desert quail by enhancing the variety and abundance of forb plants. Smith and others (1996) noted that sightings of scaled quail and other important game species were higher on rangelands classified as good than on excellent. They also recommend moderate grazing practices. Livestock grazing on SRER over the past century has included various grazing designs, including the Santa Rita Grazing System, continuous, and high intensity-low duration. Here, livestock grazing could be used as a tool for maintaining low seral plant communities and quail habitat diversity.

Burning, intensive grazing, and other management practices that could provide a higher proportion of food plants and perhaps a more diverse environment in lovegrass stands are alternatives that should benefit scaled quail populations in the area (Medina 1988). Furthermore, reseeding of native rangelands with Lehmann's lovegrass should be re-evaluated with respect to potential long-term impacts on native flora and fauna. Scaled quail were most prevalent in areas with early plant successional stages and open habitats; hence, range management efforts that promote high successional plant communities should include provisions for wildlife species associated with low seral habitats. Vegetation treatments (for example, mesquite removal, fire, grazing) on SRER have demonstrated that Gambel and scaled quail habitat can be improved (Germano 1978; McCormick 1975).

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