AN ABSTRACT OF THE THESIS OF

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Title: Comparative Ecology of Bobwhite and Scaled Quail in Southern Texas

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Abstract approved: John A. Crawford

For my research goals I addressed the theoretical importance of competition in habitat selection of 2 quails and examined the use of resources in peripheral and core areas. Methodological objectives were to determine cover and food selection of Texas bobwhite (Colinus virginianus texanus) and chestnut-bellied scaled quail (Callipepla squamata castanogastris) in southern Texas.

The Welder Refuge was the core area for bobwhites. The Chaparrosa and Experiment Ranches were peripheral areas for both quails. The core population for scaled quail was located at the Killam Ranch.

Available cover formed a gradient from Welder to Killam. The highest percentage of herbaceous material was on Welder, whereas the largest amount of bare ground and shrub cover was at Killam. Bobwhites and scaled quail used and preferred different cover types. Bobwhites selected dense herbaceous material, whereas scaled quail preferred sparse vegetation and a shrub overstory. Based on niche

breadth estimates, both quails used a narrow range of cover types in their respective core areas and a broad range in the peripheral areas.

The frequency of available food items also formed a gradient. Welder had the largest percent frequency of animal matter and of herbaceous seeds and green leaves. Killam had the highest frequency of seeds, leaves, and fleshy fruits from woody plants. Bobwhites preferred grass seeds and animal matter, whereas scaled quail selected the fruits and seeds of woody plants. Niche breadth estimates were relatively constant for each quail.

Theoretically, when intraspecific competition is most intense a species selects a broad range of habitats, whereas sympatric species occupy a narrow range of resources due to interspecific competition. However, when I used niche breadth estimates to address my first goal, neither component of the habitat (cover or food) followed the anticipated pattern. Therefore, I believe competition is not the major selective force in habitat selection of quails.

The generalization has been put forth that in the peripheral part of a range birds occupy their optimal habitat, whereas at the center of the range, optimal and suboptimal habitats are used. However, the core area contains an abundance of preferred habitat and a species is able to meet its life-history requirements whithin a narrow range of cover types. Peripheral areas supply only suboptimal habitat and in order to fulfill the species-specific needs a species must use a wide range of cover types.

Comparative Ecology of Bobwhite and
Scaled Quail in Southern Texas

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COMPARATIVE ECOLOGY OF BOBWHITE AND SCALED QUAIL IN SOUTHERN TEXAS

INTRODUCTION

The North American aridlands apparently developed from the time of the Pliocene or earlier (Hubbard 1973). During Pleistocene glaciation, the aridlands became fragmented. At this time widespread ancestors for the genera *Callipepla* and *Colinus* could have become disjoined into isolated refugia (Hubbard 1973). Scaled quail (*Callipepla squamata*) probably became differentiated as a separate species in the Chihuahuan Refugium, whereas the bobwhite (*Colinus virginianus*) became differentiated in the Flordia Refugium (Hubbard 1973). After glaciation a more continuous distribution of aridlands returned. The scaled quail expanded its distribution to encompass the present-day Chihuahuan Desert and the bobwhite extended its range westward and northward to occupy woodland and/or brush-grassland habitats (Johnsgard 1973). These 2 quails exhibit a certain amount of geographic overlap along the edge of their ranges (Fig. 1).

Along this edge, Jackson (1942), Schemnitz (1964), and Hatch (1975), found that scaled quail (*C. s. pallida*) and bobwhites (*C. v. taylori*) generally occupied different cover types within an area. In Arizona, Anderson (1974) found scaled quail and Gambel's quail (*Callipepla gambelii*) in different habitats. Likewise, Gutierrez (1977) found that California quail (*Callipepla californicus*) and mountain quail (*Oreortyx pictus*) used species-specific components of the vegetation in central California. These coexisting quails were on the margins of their distributions. According to Hilden (1965), bird

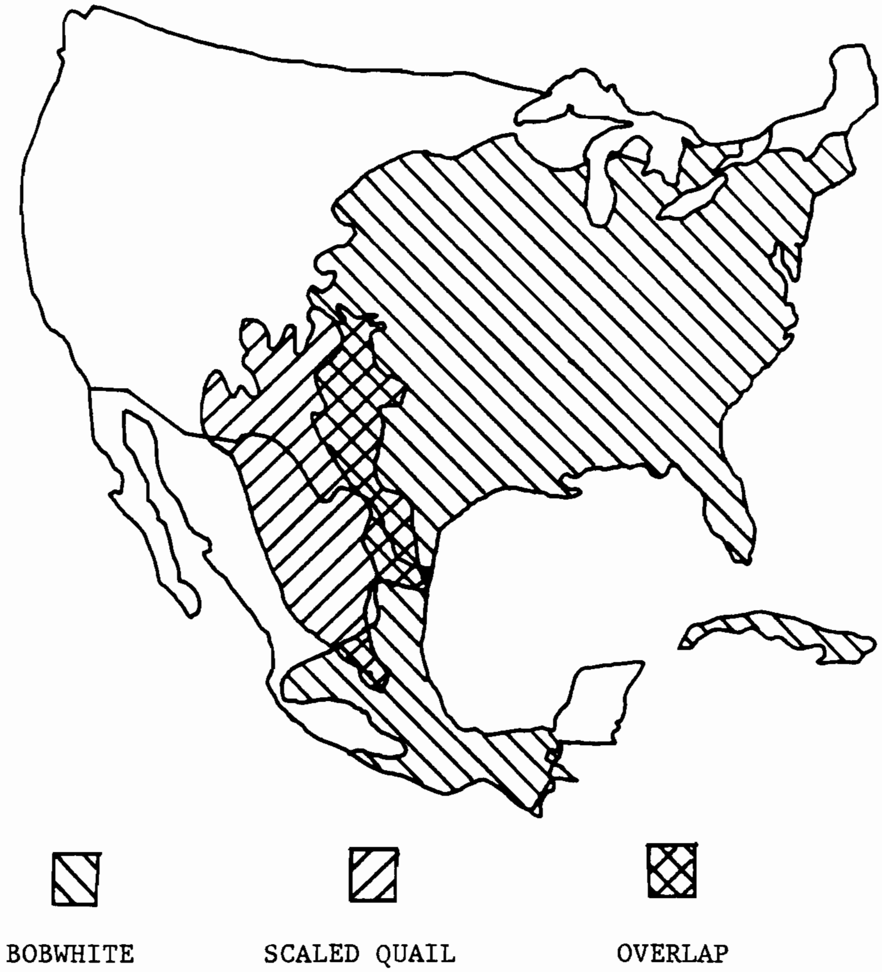

Fig. 1. Distribution of bobwhite and scaled quail throughout North America.

species are stenotopic at the periphery of their distribution and more eurytopic in the center of their breeding range. The reason Hilden (1965) made this generalization was that the range of habitat (cover, food, water, and space) exploited by a species was dependent on the density of a population. If the density were low such as on the periphery of the distribution birds occupied only the optimal habitat; with increased density less suitable habitat was also occupied.

Not only do the areas of overlap contain populations of quail on the periphery of their range, these areas also accommodate coexisting quails that are taxonomically related (Holman 1961) and ecologically similar. According to Schoener (1982), interspecific competition is the major selective force acting on similar sympatric species. Interspecific competition results in the partitioning of the habitat wherein each species uses a narrow range of resources (Diamond 1978). Schoener (1974) found that a preponderance of studies indicated that, cover, primarily, and food, secondarily, were the prevalent factors in habitat partitioning. Away from the area of overlap Svardson (1949) and Hilden (1965) proposed that each species uses a broad range of resources because of intraspecific competition. These authors seemed to understand competition as nonconditional on other factors. In contrast, other ecologists understand competition more as part of a complex of interactions. Thus, the importance of competition may be flexible and/or contingent on a variety of interrelated elements. For example, Wiens (1977) warned that the different patterns of resource use among or between coexisting species may be explained by an intermittency of competition or by other processes. Thomson (1980) maintained that mutualism or a combination of interspecific interactions may be involved in changes in population numbers and niche shifts. Connell (1975) reported that predation might lower populations below the point at which competition occurred. Based on a literature review, Jackson (1981) reported that plant ecologists, since the early 1900s, have been interested in the combined effects of competition, predation, and physical environmental disturbances on plant community composition.

Hamilton (1962) raised the issue that in order to attribute resource partitioning to the avoidance of competition, habitat requirements outside the area of sympatry must be assessed. Yet few, if any studies, have been conducted concurrently on sympatric and allopatric populations.

The goals of this study were to address the possible theoretical influence of competition on cover and food partitioning between 2 quails and to examine the use of habitats in peripheral and core (highest densities of 1 species) areas. More specifically, my methodological objectives were to determine cover and food selection of Texas bobwhite (Colinus virginianus texanus) and chestnut-bellied scaled quail (Callipepla squamata castanogastris) in core (allopatric) areas as well as peripheral (overlap) areas.

RESEARCH AREAS

I selected 4 study areas in southern Texas (Fig. 2). The allopatric/core area for bobwhites was located at the Rob and Bessie Welder Wildlife Refuge. The refuge is situated in a transitional zone between the Gulf Prairies and Marshes and the South Texas Plains (Thomas 1975). The study areas with coexisting populations of Texas bobwhites and chestnut-bellied scaled quail were located within the South Texas Plains (Thomas 1975). The peripheral sites for both species were on the Chaparrosa Ranch and the Rio Grande Plain Experiment Ranch. The Killam Ranch was the core area for the scaled quail, as well as a peripheral site for bobwhites. All the study areas were operating cattle ranches.

The Welder Refuge, located approximately 80 km northeast of Corpus Christi, occupies 3,157 ha and borders the Aransas River in San Patricio County. The annual rainfall from 1956 to 1977 was 89 cm with extreme fluctuations between years (38 cm in 1956 and 125 cm in 1973) (Drawe et al. 1978). The growing season exceeds 300 days per year with vegetative growth peaks in the spring and fall. The area is characterized by hot, humid summers and mild winters. The evaporation rate is 150 cm (Moore, pers. comm.). On the uplands, the slope gradient is less than 1%. Of the 12 range sites, the most extensive site is the Blackland (Victoria clay soil), which is level and drains poorly. Shrub-grassland dominates the uplands; the predominant shrubs include mesquite (*Prosopis glandulosa*) and blackbrush (*Acacia rigidula*). The common mid-grasses are seacoast bluestem (*Scizachyrium*

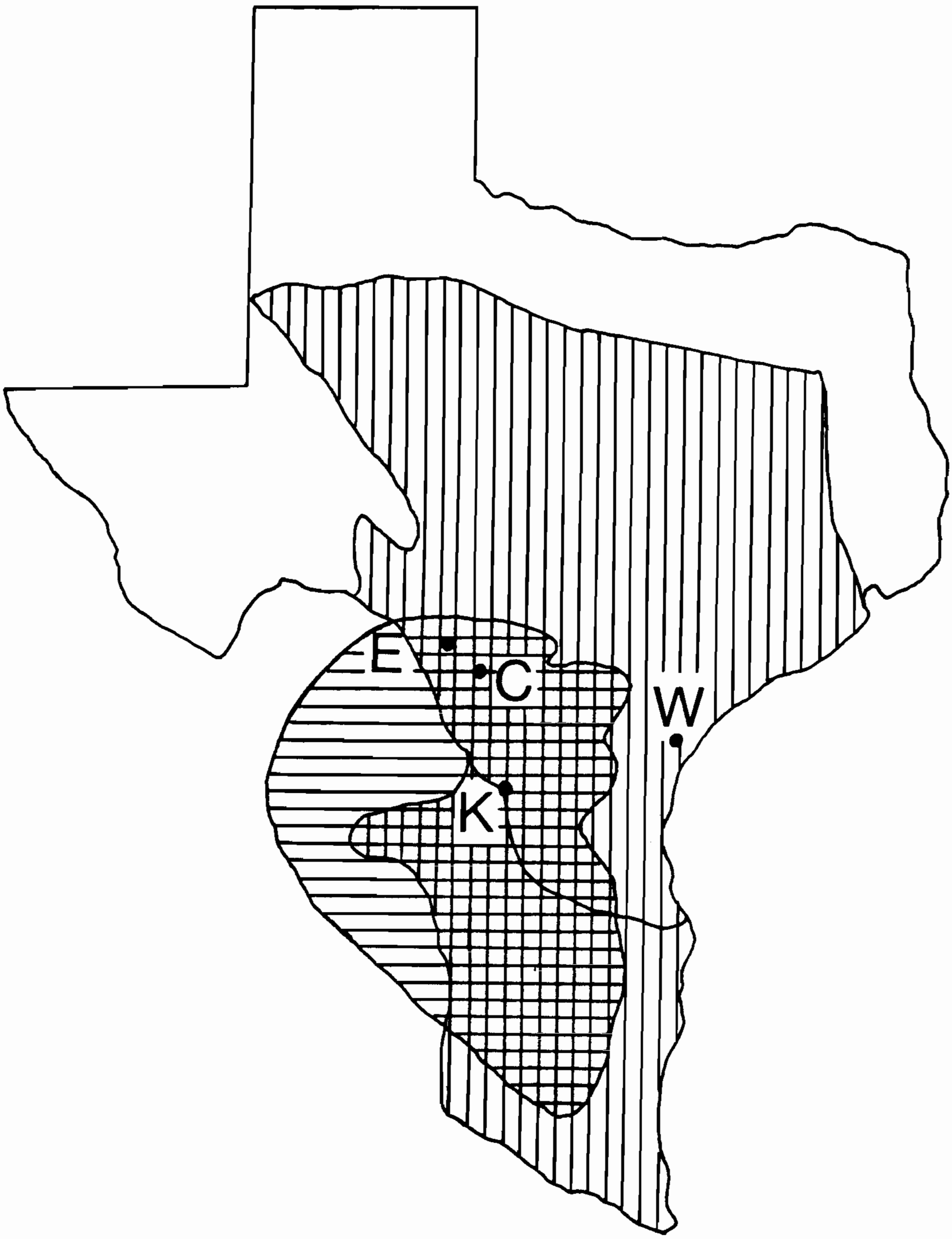

Fig. 2 Distribution of Texas bobwhites (vertical) and chestnut-bellied scaled quail (horizontal) in relation to the location of study areas Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-81.

littoralis), meadow dropseed (Sporobolas asper), and Texas wintergrass (Stipa leucotricha). After 1975, a year-round grazing system was replaced by several specialized systems. In order to control woody plants, most of the refuge has been either roller chopped, rootplowed, or sprayed with kerosene (Drawe et al. 1978).

The Chaparrosa Ranch is approximately 11 km west of La Pryor in Zavala County. Both the East and West Big Bowles pastures were selected as study sites. These pastures totaled 2,467 ha. For Zavala county the average annual precipitation is 55 cm (Escobar, pers. comm.). As in other research areas in the South Texas Plains, the Chaparrosa has the highest rainfall in May and June. This period is typically followed by a summer drought with another peak in precipitation during September (Shaw and Dodd 1976). The evaporation rate for the county is 183 cm (Escobar, pers. comm.). The topography for the ranch is primarily flat with slopes ranging from 0 to 8%. Of the 9 range sites, the most predominant are the Clay Loam (58%) and the Clay Flat (11%). Only about 2% of the pastures had Shallow Ridge and Rolling Hardland range sites, and these latter sites were around a caliche pit. The vegetation on the clay sites was characterized by the grass, curly mesquite (Hilaria belangeri), and the annual forb, bundleflower (Desmanthus sp.). The woody cover consisted of mesquite and whitebrush (Aloysia lyciodes). The Rolling Hardland site was comprised of guajillo (Acacia berlanderi) with an understory of short, sparse grasses such as threeawn (Aristida sp.) and annual forbs. Major portions of the Bowles pastures were sprayed with the herbicide 2,4,5-T between 1971 and 1976.

The Rio Grande Plain Experiment Ranch is located about 45 km southwest of Uvalde in northeastern Maverick and southeastern Kinney counties. This 4,228 ha ranch is operated by the Texas Agricultural Experiment Station. My research was conducted on pastures numbered 1 through 13. For Maverick County, rainfall from 1936 to 1968 averaged 50 cm (Clemente, pers. comm.) and ranged from 13 cm to 113 cm. The average growing season was 285 days. Nine range sites comprised the research area. As at the Chaparrosa Ranch, the most extensive site were the Clay Loam (58%) and the Clay Flat (10%). The Rolling Hardland and the Shallow Ridge sites made up about 7% of the area. Three specialized grazing systems were in use at the ranch. Parts of pastures 1, 2, 3, 8, and 9 were tame pastures and seeded with buffelgrass (Cenchrus ciliaris), an introduced warm-season bunchgrass. Other small sections of the area were chopped to control dense brush.

The Killam Ranch surrounds Laredo in Webb County. My research was restricted to the North and South Charco Pastures as well as a portion of the Middle Pasture, a total of about 4,000 ha. The study sites were located about 18 km north of Laredo. The annual precipitation for Webb County is 50 cm (Nelle, pers. comm.). The growing season exceeds 300 days annually and the average evaporation is 193 cm (Nelle, pers. comm.). Seven range sites were found on the 3 pastures. Unlike the Chaparrosa and Experiment Ranches, only 7% of the area was typified by Clay Loam and Saline Clay range sites, whereas over 40% of the area was Rolling Hardland and Gravelly Ridge sites. For the Gravelly Ridge sites the gradients averaged less than 10%. Guajillo and blackbrush are the dominant woody plants with threeawn and Texas bristle grass (*Setaria texana*) as the grass understory. Prickly pear cactus (*Opuntia sp.*) is more predominant on the Killam Ranch than any of the other research areas. The grazing system involved a 6-month rotation between the North and South Charco. On the western border of the South Charco periodic fires occurred along the railroad tracks. The Middle Pasture was chained several years ago. Portions of the Charco Pastures were rootplowed and were dominated by huisache trees (*Acacia farnesiana*), prickly pear cactus, and buffelgrass.

METHODS

Field research was conducted for 1 annual cycle from April 1980 through March of 1981. The cycle was subdivided into breeding (April through September) and nonbreeding seasons (October through March). Female bobwhites have been collected with eggs in the oviduct every month of the year (Cain, pers. comm.), but a large majority of breeding takes place from April through September. Both cover and dietary data were collected 6 times throughout the year on each of the 4 study areas.

Sampling Methods for Cover

To characterize the available cover on each research area I used 100 random points. I conducted a 1-hour flush census in both the morning and evening with the aid of a bird dog. In order to determine the cover used by quail, the initial sightings of quail such as pairs, calling males, broods, nests, roosts or coveys were marked with flags. Each random point (available cover) and sighting (cover used by quail) served as the locus of a 0.04 ha circular plot (James and Shugart 1970, James 1971). At each locus a 25-m line transect was established in a random direction. The line-intercept method was used to determine percent cover (Canfield 1941).

Presumably, birds have species-specific preferences for visual structures of the vegetation. Pitelka (1941) found no consistent relationship between the dominant plants and bird species, but he did find a constant relationship between the distribution of birds and lifeform of the vegetation. Likewise, Hamilton (1962) found that avian habitats in the Mesquite Plains of Texas reflected the structure or physiognomy of dominant vegetation, not the species composition. Thus, I used Durietz's lifeform classification as modified by Jones (1963) to characterize the vegetation of each circular plot. The lifeform categories included grass, forb, shrub, tree and cactus. The herbaceous cover was placed into height classes: under 5 cm, 10 cm, 20 cm, 40 cm, 80 cm, or over 80 cm.

The 25-m transect was divided into 5-cm intervals. For each interval if 50% or more was intercepted by a grass or forb category, it was recorded. When both grass and forb occupied an interval, this double stratum was recorded and used as an index of dense herbaceous material, otherwise, bare ground was recorded. Furthermore, I recorded the woody plants (shrub, tree, cactus) if they intercepted 50% or more of an interval.

Sampling Methods for Food

In order to avoid a common shortcoming of many food studies (Gullion 1966), dietary information was collected during each sampling period. I tried to collect 1 quail from a covey or pair because quail within a social unit tend to have similar contents in their crops (Frye 1954).

The availability of food items (percent frequency) was determined at the location where a quail was collected. After the utilized cover data were recorded, 10 ground samples were taken at equal intervals along the 25-m line. Within a 10 X 10-cm quadrat, all the ground litter to an average depth of 2 cm was collected (Glading et al. 1940). These samples provided information about the frequency of grass, forb, and woody seeds as well as the frequency of snails (Gastropoda), onion bulbs (*Allium sp.*), and termites (Isoptera). Twenty-five 10 X 10-cm quadrats were established along the transect to determine the frequency of green leaf material (grass, forb, woody), flowers, fruits, and seedheads. Also along the transect, animal matter was sampled with a sweep net at 25 stops.

Food habits were determined by examination of the crop contents. If the number of crops collected during 1 of the 6 sampling periods amounted to more than a third of the total sample of crops from 1 study area, I averaged the number of crops taken for the 5 periods. I randomly selected crops from the over-represented period to equal the average determined from the rest of the sampling periods. I froze the crops to facilitate identification of material at a later date. Food items were separated into the following categories: seeds (grass, forb or woody), leaves (grass, forb or woody), flowers (forb or woody), fleshy fruits, bulbs and animal matter (spiders (Arachnida), snails and insects). I measured the volume of each item by water displacement to the nearest 0.02 cc. Frequency of food categories was also recorded.

Selection and Niche Breadth Indices

The proportion of available resources used by each species provided an index of habitat selection. For cover selection I used Ivlev's (1961) index of electivity $E = \frac{r - p}{r + p}$; r is equal to the proportion of cover used and p is equivalent to the portion of available cover. For this index, -1 indicated avoidance and +1 suggested selection for the particular cover types. Dietary selection was estimated by the following formula: $SI = \frac{\% \text{ frequency X } \% \text{ volume}}{\% \text{ availability}}$ This index is similar to the desirability coefficient proposed by Glading et al. (1940). Availability of animal matter (except for snails and termites) was collected differently than the leaves (25 quadrats) or the seeds (10 quadrats). Therefore, selection indices among these major sampling groups could not be compared.

Pianka (1973) suggested an index that estimated the variability of resources (cover and food) used by each species. This estimate is commonly referred to as niche breadth (B). The equation, $B = \frac{1}{\text{Sum } p_i^2}$, is determined for each species and p_i is the relative proportion of a cover type or food item.

Statistical Analysis

To examine the relationships between groups (2 species, 4 locations or 2 seasons) and the simultaneous variation of all the variables (cover or diet), I used multivariate analysis (Sokol and Rohlf 1981). Each transect (cover used by quail) was recorded as either bobwhite or scaled quail regardless of the number of birds that were sighted at the location. Both data sets (cover and food) contained totals that were the sums of either height categories or plant parts. Because the totals formed singular matrices, I subdivided the data. The cover variables were separated into 2 segments: 1) the total percent of grass, forb, grass/forb, bare ground and woody cover, 2) the height categories for grass and forb and the tree, shrub, and cactus classes. The food variables were divided into 3 parts: 1) totals for seeds, leaves, fruits, flowers, bulbs and animal matter 2) seeds (grass, forb, and woody), leaves (grass, forb, and woody), spiders, snails, and insects 3) compilation of plant parts into total grass, forb or woody categories and the total animal matter.

For each division of the data, multivariate analysis of variance was performed to determine if the vectors of the means (centroids) were different between or among the groupings. Hotelling's T-square was used to test for differences among the 4 study areas (Nie et al. 1975).

If the vectors were different at the 0.05 level (or less) then each segment was subjected to discriminant analysis. I used this type of analysis as a descriptive tool. Discriminant analysis combined the variables in a linear function, which maximized the separation of the groups (Nie et al. 1975). The discriminant functions can be visualized as axes in a geometric space and thus, they provide spatial relationships between or among the groups (Gauch 1982). The number of discriminant functions is 1 less than the number of groups.

Interpretation of the function(s) was based on the correlation of each variable with the discriminant scores derived for each function (Raphael 1981). Variables with the highest correlations were used to interpret the functions (Raphael 1981). To check the adequacy of the discriminant functions a classification of the original set of cases within each group was conducted (Nie et al. 1975). Thus, a certain percentage of cases were correctly classified by the discriminating variables I selected.

RESULTS AND DISCUSSION

Quail Population Analysis

Indices to Abundance

Censuses provided indices to abundance (birds or quail sightings per hour) on each study area. I believe the scaled quail were insufficiently represented by the index of birds/hour because of the different escape behavior used by the quails. Coveys of bobwhites usually flushed as a unit, which provided a relatively accurate count. In contrast, a scaled quail covey generally separated and ran, offering glimpses of only a few birds. Therefore, I recorded coveys, pairs, or singles as 1 sighting regardless of the number of quail in the social unit, and used these sightings to estimate the ratio of bobwhites to scaled quail (Table 1).

Both indices indicated that the Welder Refuge and Killam Ranch were the allopatric and/or core areas for bobwhites and scaled quail, respectively (Table 1). The Experiment Ranch had the lowest abundance of total quail (Table 1), possibly a result of the exceptionally dry nonbreeding season (Appendix, Table A). Apparently, the amount of rainfall is important to bobwhite populations at least (Lehman 1946).

Cover Analysis

Annual Cover Availability Among Study Areas

The available cover types on the areas formed a gradient; Welder at 1 end had the most herbaceous cover and the least amount of bare

Table 1. Indices to abundance for bobwhite (BW) and scaled quail (SCQ) on 4 study areas, Texas, 1981.

	Birds/hr				Sightings/hr			
Study area	BW	SCQ	Total	BW:SCQ	BW	SCQ	Total	BW:SCQ
Welder	14.0	-	14.0	100:0	2.2	-	2.2	100:00
Chaparrosa	6.0	1.9	7.9	76:24	1.4	0.6	2.0	70:30
Experiment	1.7	1.5	3.2	53:47	0.4	0.5	0.9	44:56
Killam	0.7	4.4	5.1	14:86	0.2	1.2	1.4	14:86

ground and woody cover, whereas Killam had the smallest amount of herbaceous material but the largest amount of bare ground and woody cover (Table 2). The height classes of herbaceous vegetation also differed among areas. Welder was the area with the greatest amount of mid-level (< 20 cm, < 40 cm) and tall - (> 40 cm) herbaceous material. Killam possessed the least amount of mid- and tall herbaceous material (Table 2). In addition, the lifeforms of the woody material formed a gradient. Welder had the largest amount of tree cover, whereas Killam had the greatest amount of shrub and cactus cover (Table 2).

At the 2 ends of the gradient, the core areas were significantly different from each other and from the other areas (Hotelling's T-square, $P < 0.05$). Welder was distinctive among all the areas (Appendix, Fig. A, B, and Table B) primarily because of the large percentage of total grass (81%), forb (28%), and grass/forb (21%) (Appendix, Table C). Within these major cover types the mid-grasses and forbs under 40 cm best characterized the study area with allopatric populations of bobwhites (Appendix, Table C). Total grass cover was highly correlated with grass under 20 cm ($r = 0.70$, $P < 0.05$) and with grass under 40 cm ($r = 0.69$, $P < 0.05$). These results supported the placement of Welder in a transitional zone between the South Texas Plains and the Coastal Prairies and Marshes. Within the South Texas Plains, the Killam Ranch was the most distinct area. The cactus and dense shrub cover characterized the core area for scaled quail (Killam Ranch) (Appendix, Figure B and Table C).

Despite the smaller amount of forb cover (13%) on the Experiment

Table 2. Relative percent of available cover by cover type and height categories on the Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-1981. (N = 100 transects for each study area.)

	Percent cover by study area			
Cover type	W	C	E	K
Grass (total):	81	41	37	25
Short[a]	13	16	18	9
Mid[b]	54	21	17	12
Tall[c]	14	4	2	4
Forb (total):	28	20	13	10
Short[a]	7	13	10	8
Mid[b]	15	5	3	2
Tall[c]	6	2	0	0
Grass/forb	21	6	3	1
Bare ground	12	45	53	66
Woody (total):	31	34	36	42
Tree	11	7	7	4
Shrub	20	27	29	34
Cactus	0	0	0	4

[a]Short = height categories under 5 cm and under 10cm.

[b]Mid = height categories under 20 cm and under 40 cm.

[c]Tall = height categories under 80 cm and over 80 cm.

Ranch, the available vegetation was not significantly different from the Chaparrosa, which had 20% forb cover ($P < 0.05$). Apparently, the Experiment Ranch was better described by height classes of herbaceous material than by the total percent of cover types (Appendix, Table C).

Seasonal Cover Availability on All Study Areas Combined

I contrasted the breeding and nonbreeding seasons by consolidation of available cover on all 4 study areas. The seasons were different ($P < 0.05$) primarily because of the increase in forb cover. More specifically, the short forbs increased from 3% in the breeding season to 15% in the nonbreeding season (Appendix, Table D). Otherwise, the composition of the cover types remained relatively constant from season to season (Table 3). This consistency probably was the result of the heavy rainfall in August (Hurricane Allen) and a second vegetative growth peak (Appendix, Table A).

Annual Cover Used by Quail Among Study Areas

Examination of cover types used by quail at each study area indicated that the core areas for bobwhites (Welder) and for scaled quail (Killam) were the most different from each other in terms of all the cover classes (Fig. 3). Secondly, all of the bobwhite populations (Welder through Killam) used different percentages of grass, bare ground and woody cover than did scaled quail population (Fig. 3). The exceptions were forb cover and grass/forb cover types; forb cover was strongly correlated with grass/forb ($r = 0.80$, $P < 0.05$).

Table 3. Relative percent of available cover separated by breeding and nonbreeding season on all 4 study areas combined, Texas, 1980-81. (N = 200 for each season.)

	Percent cover by season	
Cover types	Breeding	Nonbreeding
Grass (total):	49	43
Short[a]	14	14
Mid[b]	29	23
Tall[c]	6	6
Forb (total):	12	23
Short[a]	3	15
Mid[b]	6	6
Tall[c]	3	2
Grass/forb	7	9
Bare ground	46	43
Woody (total):	37	34
Tree	9	5
Shrub	27	28
Cactus	1	1

[a]Short = height categories under 5 cm and under 10cm.

[b]Mid = height categories under 20 cm and under 40 cm.

[c]Tall = height categories under 80 cm and over 80 cm.

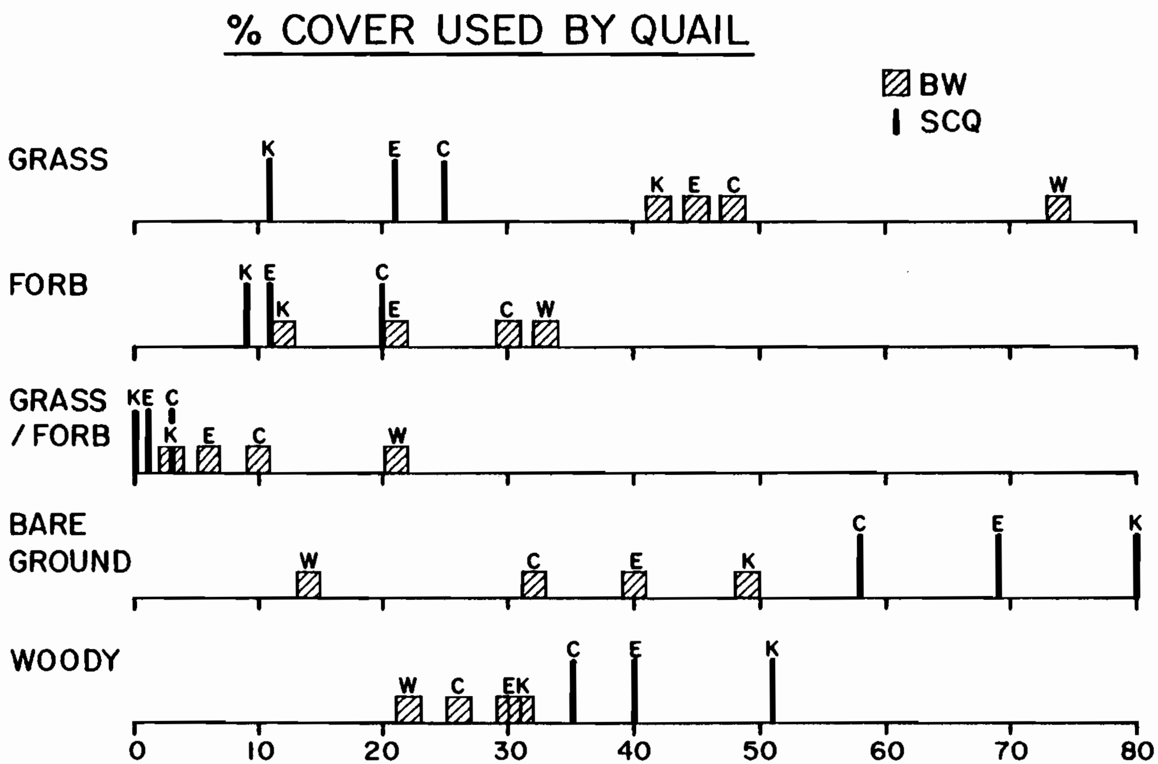

Fig. 3. Percent cover used by bobwhites (BW) and scaled quail (SCQ) on Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-1981.

Nevertheless, at each study area bobwhites occupied areas with more forb and grass/forb cover than did scaled quail (Fig. 3).

Annual Cover Used by Quail on all Study Areas Combined

I combined all the study areas and found that bobwhites used significantly different cover from scaled quail ($P < 0.05$). In addition, these 2 species were easily separated on the basis of cover types and height classes (Appendix, Table E). Bobwhites used denser herbaceous material, whereas scaled quail occupied areas with more bare ground and an overstory of woody cover (Table 4 and Appendix, Table F). Bare ground and total grass cover were negatively correlated ($r = -0.76$, $P < 0.05$). In addition, bobwhites were found in areas with taller herbaceous material, in particular mid-grasses, than were scaled quail (Appendix, Table F). Likewise, Schemnitz (1964) found in Oklahoma that scaled quail used vegetation that provided overhead protection, but was open underneath. Bobwhites used riparian areas with denser vegetation at ground level. These differences in the profile of the cover probably reflected the different escape behaviors of the 2 quails; scaled quail run and bobwhites hide or "freeze" in dense herbaceous vegetation.

Scaled quail used more shrub (37%) and cactus cover (3%) than did bobwhites (7% and 0%, respectively) (Appendix, Table F). Bobwhites were found more often in conjunction with tree cover than were scaled quail (Table 4). Similarly, Reid (1977) found that bobwhites in the South Texas Plain preferred mesquite habitats and deciduous woodlands, whereas scaled quail selected scrubland and brush habitats.

Table 4. Percent cover used by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

	Percent cover	
Cover type	Bobwhites (N = 466)	Scaled quail (N = 292)
Grass (total):	58	17
Short[a]	20	9
Mid[b]	32	8
Tall[c]	6	0
Forb (total):	28	12
Short[a]	14	9
Mid[b]	10	3
Tall[c]	4	0
Grass/forb	13	1
Bare ground	27	72
Woody (total):	26	44
Tree	19	4
Shrub	7	37
Cactus	0	3

[a]Short = height categories under 5 cm and under 10cm.

[b]Mid = height categories under 20 cm and under 40 cm.

[c]Tall = height categories under 80 cm and over 80 cm.

Furthermore, Lehman and Ward (1941) reported that prickly pear cactus was important to scaled quail in southern Texas.

Seasonal Cover Used by Quail on All Study Areas Combined

During the breeding season, bobwhites and scaled quail used different cover ($P < 0.05$). Bobwhites occupied areas with more total grass cover, especially mid-grasses, whereas scaled quail were associated with bare ground and shrub cover (Table 5 and Appendix, Table G). Lehman (1946) reported that in southwestern Texas during 1942 and 1943, 3 genera of grasses (*Andropogon*, *Aristida* and *Manisuris*) were the principal materials in 189 bobwhite nests, which amounted to 98% of the total he studied. In addition, during the 2 breeding seasons, the average heights of the grass around the nests were 23 cm and 30 cm (Lehman 1946). In contrast, Schemnitz (1964) reported only 3 of 50 scaled quail nests were located in grass. Information on the nests of chestnut-bellied scaled quail is minimal. I found 2 nests on the Experiment Ranch, both were located under shrubs. During the nonbreeding season both quails again used different cover ($P < 0.05$). Bobwhites were associated with denser herbaceous cover and scaled quail used areas with more bare ground and shrub cover (Appendix, Table H).

For each quail, the cover used was compared between breeding and nonbreeding season. During the nonbreeding season both quails occupied areas with more forb cover, especially forbs under 5 cm, than they did during the breeding season (Appendix, Tables I and J). Bobwhites used denser vegetation during the nonbreeding season (19% to

Table 5. Percent cover used by bobwhites (BW) and scaled quail (SCQ) during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

	Percent cover by season			
	Breeding		Nonbreeding	
	BW	SCQ	BW	SCQ
Cover type	(N = 233)	(N = 162)	(N = 233)	(N = 130)
Grass (total):	55	19	62	14
Short[a]	19	9	22	8
Mid[b]	32	9	32	6
Tall[c]	4	1	8	0
Forb (total):	21	9	36	17
Short[a]	7	5	22	13
Mid[b]	11	3	9	3
Tall[c]	3	1	5	1
Grass/forb	8	1	19	2
Bare ground	33	73	22	71
Woody (total):	25	39	26	49
Tree	8	4	6	2
Shrub	17	32	20	44
Cactus	0	3	0	3

[a]Short = height categories under 5 cm and under 10cm.

[b]Mid = height categories under 20 cm and under 40 cm.

[c]Tall = height categories under 80 cm and over 80 cm.

8%) and more bare ground in the breeding season (33% to 22%) (Appendix, Table I). Denser vegetation may have provided better cover for thermoregulation. Despite the minimal use of grass cover overall, scaled quail used more grass cover, in particular grass under 20 cm, during the breeding season (19%) (Appendix, Table J). Often, I found scaled quail in drainages during the breeding season, which may have reflected the dry conditions of other habitats and/or the need for brooding habitat. During the nonbreeding season scaled quail occupied denser brush than during the remainder of the year (Table 5 and Appendix, Table J).

Selection Indices for Cover Among Study Areas

All the bobwhite populations and the scaled quail populations had separate groupings of the selection indices for every cover type (Fig. 4). The coincidence of forb cover used by bobwhites at Killam and scaled quail at Chaparrosa (Fig. 3) was separated by accounting for the larger availability of forbs at the Chaparrosa (20%) than at Killam (10%).

For bobwhites, the selection for total grass cover increased from Welder to Killam (Fig. 4). In fact, the bobwhite population at Welder showed a slight avoidance of grass cover and selection for bare areas (Fig. 4). Possibly, the quantity (81%) and rankness of grass at Welder inhibited movement for bobwhites, whereas the bare areas (12% of available cover) provided a more desired surface for walking, feeding, and roosting (Scott and Klimstra 1954, Klimstra and Ziccardi 1963). By contrast, scaled quail increased the amount of avoidance

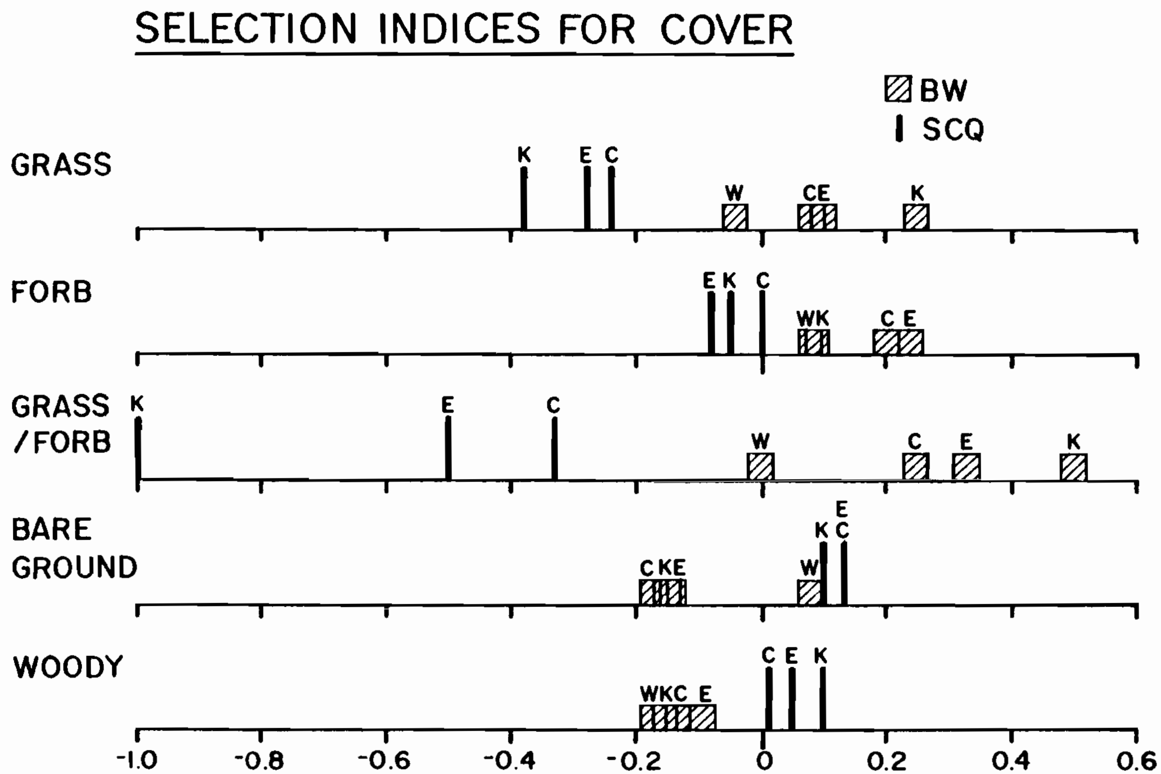

Fig. 4. Cover selection indices for bobwhites (BW) and scaled quail (SCQ) on Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-1981.

for grass cover and increased their selection for woody cover from Chaparrosa to Killam (Fig. 4). Thus, shrubs may have increasingly replaced the use of grass as overhead cover.

Selection Indices for Cover on All Study Areas Combined

Comparison of selection indices annually and seasonally indicated that bobwhites and scaled quail preferred very different cover types (Tables 6 and 7). Bobwhites preferred dense herbaceous material and avoided bare ground and wooded area, whereas scaled quail selected for bare areas and woody cover and avoided herbaceous cover, in particular grass and grass/forb areas (Tables 6 and 7).

During the nonbreeding season, bobwhites increased avoidance of bare ground and selected for dense herbaceous material (Table 7). Scaled quail increased their preference for woody cover during the nonbreeding season from 0.03 to 0.18.

Niche Breadth Indices for Cover Among Study Areas

A simple measure of niche breadth was based on the total percent cover of grass, forb, grass/forb, and the amount of bare ground used by each species (Pianka 1973). Theoretically, the size of the niche breadth should be larger at the center of the breeding range than on the periphery of the distribution (Hilden 1965). However, both quails used the narrowest range of cover types at their respective core areas and a broader range on the peripheral/overlap areas.

This seemingly contradictory statement can be best understood if the 2 core areas are viewed as sites with the largest amount of

Table 6. Selection indices for cover used by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

	Selection indices	
Cover type	Bobwhite	Scaled Quail
Grass	0.12	-0.63
Forb	0.23	-0.18
Grass/forb	0.27	-0.76
Bare ground	-0.25	0.23
Woody	-0.15	0.11

Table 7. Selection indices for cover used by bobwhite (BW) and scaled quail (SCQ) during the breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

	Selection indices by season			
	Breeding		Nonbreeding	
Cover type	BW	SCQ	BW	SCQ
Grass	0.06	-0.44	0.18	-0.51
Forb	0.27	-0.14	0.22	-0.18
Grass/forb	0.07	-0.75	0.46	-0.64
Bare ground	-0.16	0.27	-0.32	0.25
Woody	-0.19	0.03	-0.13	0.18

species-specific "optimal" cover types. In the core areas, the life-history needs of the quail can be satisfied with a narrower range of cover types. In contrast, the coexisting populations on the peripheral study areas may have less "optimal" cover types to select from. Therefore, the quail may need a greater range of cover types to fulfill their needs. This view parallels the optimal foraging theory put forth by MacArthur and Pianka (1966) if cover type is substituted for food. According to this theory as the productivity of the environment decreases (e.g. towards the periphery of the range) the amount of search time increased and the itinerary is enlarged to include less suitable habitat. I suggest the concept of productivity in optimal foraging theory should be in relation to species-specific resources. For example, the Killam study area is probably less productive than Welder, in general, but probably more productive than Welder in terms of scaled quail resources.

Niche Breadth Indices for Cover on All Study Areas Combined

Niche breadth estimates for breeding and nonbreeding seasons were similar except for the bobwhites during the breeding season (Table 8). Apparently, bobwhites are less adaptable to arid conditions than are scaled quail (Schemnitz 1964). The drought conditions during the summer of 1980 were more unsuitable for bobwhite than scaled quail, and the former species may have used a broader range of cover types to satisfy their requirements. Another possibility is that the bobwhite is more of a generalist in that it can breed in a wide variety of cover types as demonstrated by its wide distribution.

Table 8. Niche breadth indices for cover (grass, forb and bare ground) used by bobwhites and scaled quail by each study area, on all 4 study areas combined, and by season, Texas, 1980-81.

	Niche breadth indices	
Grouping	Bobwhite	Scaled quail
Welder	1.5	-
Chaparrosa	2.4	2.3
Experiment	2.5	1.9
Killam	2.3	1.5
All study areas combined	2.0	1.8
Breeding season	2.2	1.7
Nonbreeding season	1.8	1.8

Food Analysis

Annual Food Availability Among Study Areas

The percent frequency of available food items formed a gradient similar to the available cover (Table 9). The availability of food was different among the 4 study areas (Hotelling's T-square, $P < 0.05$). The major plant parts (seed, leaf, fruit, flower, bulb) and total animal matter of the 2 core areas were the most easily separated from the 4 sites (Appendix, Fig. C). The division of the major plant parts and animal matter into their finer categories improved the separation of all 4 areas (Appendix, Fig. D and Table K).

The core area for bobwhites had the highest frequency of seeds (grass and forb), green leaves (grass and forb) and animal matter (Table 9 and Appendix, Table L). The frequency of animal matter was strongly correlated with the frequency of green leaves ($r = 0.60$, $P < 0.05$). The core area for scaled quail had the largest frequency of shrub seeds (34%), leaves (43%) and fruits (3%) (Appendix, Table L).

The availability of food items on the peripheral sites of both quails were between these 2 extremes (Table 9). The major items that separated the Chaparrosa and Experiment Ranches were the larger percentage of forb seeds on the Chaparrosa (80% to 43%), and the higher frequency of snails on the Experiment Ranch (33% to 9%) (Appendix, Fig. D and Table L).

Table 9. Percent frequency of available food items on the Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-81.

	Percent frequency by study area			
	W	C	E	K
Food item	(N=40)	(N=62)	(N=45)	(N=41)
Seed (total):	97	90	78	69
Grass	88	75	60	44
Forb	82	80	43	29
Woody	8	15	13	34
Leaf (total):	99	98	95	77
Grass	94	79	75	40
Forb	82	74	56	31
Woody	15	24	24	43
Fruit	1	1	2	3
Flower	14	16	7	12
Bulb	0	2	2	1
Animal (total):	91	79	69	37
Insecta - adult				
Orthoptera	34	38	32	13
Hemiptera	17	21	15	10
Homoptera	28	18	17	8
Hymenoptera	26	22	14	7
Coleoptera	22	16	8	4
Lepidoptera	4	2	2	1
Diptera	20	10	11	4
Isoptera	0	1	2	1
Insecta larvae	12	12	4	5
Gastropoda	30	9	33	14
Arachnida	51	32	22	13
Misc.	1	1	1	0

Seasonal Food Availability on All Study Areas Combined

The availability of food items changed from the breeding to the nonbreeding season ($P < 0.05$). A slightly higher frequency of fruits and animal matter were found during the breeding season (Table 10 and Appendix, Table M). Grasshoppers (Orthoptera) also declined from 40% during the breeding season to 12% in the nonbreeding season. Similarly, Frye (1954) noted a sharp decrease in the abundance of grasshoppers from breeding to nonbreeding season.

Forb leaves and flowers were more prevalent during the nonbreeding season than during the breeding season (Table 10 and Appendix, Table M). In northern Texas, Ault (1981) reported a higher availability of new vegetative growth during the moist winter of 1980-1981 than during the previous dry year. Possibly, soil moisture was higher during the nonbreedng season than during the breeding season in southern Texas.

Annual Food Habits Among Study Areas

At Killam, 4 out of 9 crops (45%) were collected during the first sampling period. One crop was randomly selected to represent the first period. Food habits for bobwhites at the Killam Ranch were based on 6 crops (1 per sampling period).

I separated the diet into animal matter and vegetative types (grass, forb, woody). These major categories were then subdivided. Domestic grains such as corn (*Zea mays*) and wheat (*Triticum sp.*) were excluded from the calculations; they accounted for only a small percentage of the diet (< 3%).

Table 10. Percent frequency of available food items during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

	Percent frequency by season	
	Breeding	Nonbreeding
Food item	(N=125)	(N=66)
Seed (total):	85	82
Grass	68	66
Forb	59	62
Woody	17	19
Leaf (total):	91	96
Grass	75	69
Forb	53	78
Woody	26	27
Fruit	3	1
Flower	10	19
Bulb	1	2
Animal (total):	73	64
Insecta - adult		
Orthoptera	40	12
Hemiptera	22	6
Homoptera	19	16
Hymenoptera	24	6
Coleoptera	14	11
Lepidoptera	2	2
Diptera	6	19
Isoptera	1	0
Insecta larvae	11	4
Gastropoda	2	2
Arachnida	28	32
Misc.	1	1

The diets of the predominant quail at the core areas differed from populations in peripheral areas with respect to grass, forb, woody and animal matter (Table 11). Both bobwhites at Welder and scaled quail at Killam consumed a relatively larger proportion of fruits than their respective populations outside of the core areas (Table 12). These core populations also foraged on a smaller percentage of animal matter than did the peripheral populations. For an allopatric bobwhite population in southeastern United States, Stoddard (1936) reported that from 1,659 crops, 14% and 19% of the annual diet was composed of animal matter and fruits respectively. Fruits at Welder and in the southeastern part of the United States were associated with mesic riparian vegetation. In contrast, the fruits on the South Texas Plains were from more xeric scrubland. These areas lacked the herbaceous cover that bobwhites preferred. Over a 3-year period in Florida, Frye (1954) found 12% of the annual diet was composed of grass seeds (375 crops). Thus, the bobwhite diet at Welder may be typical for a core population. Also, at Welder the bobwhites ingested twice as much forb matter as did bobwhite populations on peripheral areas (Table 11). Furthermore, the percent composition of the diets (animal and vegetative types) were very similar for both quails on their respective peripheral areas (Table 11). The percent of forb material in the diet of scaled quail was the exception.

Table 11. Relative percent of diet for bobwhites (BW) and scaled quail (SCQ) on the Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches and by season, Texas, 1980-81.

Species		Percent volume of diet			
		Grass	Forb	Woody	Animal
Study area:					
Welder	BW (N=47)	11	60	15	14
Chaparrosa	BW (N=47)	23	29	7	41
	SCQ (N=29)	4	44	31	21
Experiment	BW (N=20)	16	29	1	54
	SCQ (N=19)	4	51	28	17
Killam	BW (N=6)	16	30	6	48
	SCQ (N=40)	2	37	51	10
All study areas:					
BW (N=120)		15	46	10	29
SCQ (N=88)		3	42	40	15
Breeding season:					
BW (N=66)		19	34	12	35
SCQ (N=55)		3	39	43	15
Nonbreeding season:					
BW (N=54)		8	73	5	14
SCQ (N=33)		4	48	33	15

Table 12. Relative percent of diet for bobwhites (BW) and scaled quail (SCQ) on the Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-81.

	Percent volume by study area						
	W	C		E		K	
Food item	BW	BW	SCQ	BW	SCQ	BW	SCQ
	(N=47)	(N=47)	(N=29)	(N=20)	(N=19)	(N=6)	(N=40)
Seed (total):	54	43	47	25	43	46	43
Grass	11	21	4	16	4	16	2
Forb	43	19	29	9	27	29	26
Woody	0	2	15	0	12	1	14
Leaf (total):	16	11	9	9	24	1	13
Grass	0	0	0	0	0	0	0
Forb	16	11	9	9	20	1	10
Woody	0	0	0	0	4	0	3
Fruit	14	5	18	1	13	5	33
Flower	2	0	2	1	2	0	2
Bulb	0	0	3	10	0	0	0
Animal (total):	14	41	21	54	18	48	10
Insecta - adult							
Orthoptera	5	22	8	23	6	7	1
Hemiptera	1	2	2	6	1	1	0
Homoptera	0	0	1	1	1	0	0
Hymenoptera	0	0	0	1	0	1	1
Coleoptera	2	1	0	3	1	1	0
Lepidoptera	0	0	0	0	0	0	0
Diptera	0	0	0	0	0	0	0
Isoptera	0	4	6	1	1	12	5
Insecta larvae	4	9	3	17	8	1	2
Gastropoda	2	2	1	2	0	0	0
Arachnida	0	1	0	1	0	0	0

Annual Food Habits on All Study Areas Combined

Overall, bobwhites and scaled quail had different diets ($P < 0.05$). Based on the major categories (woody, grass, forb) scaled quail consumed a larger percentage of items from woody plants (38%) than did bobwhites (9%). Bobwhites consumed a higher percentage of grass (15%) than did scaled quail (3%) (Appendix, Table N). These differences in the consumption of grass and woody food items were further demonstrated at the study area level (Table 11). For both quails a large proportion of the diet was made up of forb matter (Table 11)

When the major categories were subdivided, scaled quail foraged more heavily on fruits (24%) and woody seeds (14%) than did bobwhites (8% and 1% respectively) (Appendix, Table N). Both quails consumed the largest amount of fruits during the dry months of June and July (Table 13). The fruits of granjeno (*Celtis pallida*) and cactus fruit were the most common fruits consumed by scaled quail. Granjeno was the prevalent fruit in the diet of bobwhites on the peripheral areas, whereas bobwhites at Welder consumed mainly fruits of Texas persimmon (*Diospyros texana*) and blackberries (*Rubus sp.*). Fleshy fruits were probably a source of moisture (Frye 1954) for bobwhites during July and for scaled quail throughout the year. Bobwhites probably obtained moisture from dew, succulent vegetation, or animal matter during the remainder of the year. The major shrub seeds consumed by scaled quail were from blackbrush.

Both quails are associated with early successional stages and forb seeds are a large part of their diets (Table 14). Despite the common

Table 13. Relative percent volume of annual diet for bobwhites (BW) (N = 120) and scaled quail (SCQ) (N = 88) on all 4 study areas combined, Texas, 1980-81.

	Percent volume of diet											
	Seed		Leaf		Fruit		Flower		Bulb		Animal	
Months	BW	SCQ	BW	SCQ	BW	SCQ	BW	SCQ	BW	SCQ	BW	SCQ
April/ May	57	49	2	20	8	10	0	3	2	0	31	18
June/ July	31	26	2	4	27	48	0	0	0	3	40	19
August/ September	48	55	1	7	6	32	0	0	4	0	41	6
October/ November	58	49	7	14	0	10	0	0	0	0	35	27
December/ January	17	33	77	60	0	7	1	0	1	0	4	0
February/ March	55	55	31	8	0	21	8	9	0	0	6	7

Table 14. Percent volume of diet for bobwhites (N=120) and scaled quail (N=88) on all 4 study areas combined, Texas, 1980-81.

	Percent volume of diet	
Food item	Bobwhite	Scaled quail
Seed (total):	48	44
Grass	15	3
Forb	32	27
Woody	1	14
Leaf (total):	12	14
Grass	0	0
Forb	12	11
Woody	0	3
Fruit	8	24
Flower	1	2
Bulb	2	1
Animal (total):	29	15
Insecta - adult		
Orthoptera	14	6
Hemiptera	2	1
Homoptera	0	0
Hymenoptera	0	0
Coleoptera	2	0
Lepidoptera	0	0
Diptera	0	0
Isoptera	2	5
Insecta larvae	7	3
Gastropoda	1	0
Arachnida	1	0

consumption of forb seeds, the 2 quails (for the most part) foraged on different species. Bobwhites ate doveweed (Croton sp.), nodviolet (Hybanthus sp.) and seeds from the genera Sida on the South Texas Plains; at Welder, doveweed, snoutbean (Rhynchosia sp.), vetch (Vicia sp.), and some ragweed (Ambrosia sp.) were the predominant forbs in the diet. Scaled quail foraged on 2 major forb species along the edges of roads; one forb belonged to the genus Stellaria and the other was in the Compositae family. On the Shallow Ridge range sites, Coldenia canescens and Euphorbia sp. were the major forb seeds eaten by scaled quail. I was unable to separate forb leaves into species.

Bobwhites consumed a larger percentage of animal matter (29%) than did scaled quail (15%) (Appendix, Table N). However, Baily (1928) maintained that scaled quail foraged on animal matter more than did the other quails.

Seasonal Food Habits on All Study Areas Combined

Food habits of bobwhites differed from scaled quail during both breeding and nonbreeding seasons ($P < 0.05$). During the breeding season scaled quail consumed a larger percentage of forb leaves (11%) and a smaller portion of animal matter (15%) than did bobwhites (2% and 35%, respectively) (Appendix, Table O). However, during the same time period, Ault (1981) found that animal matter comprised the bulk of the scaled quail diet in northern Texas. Furthermore, Davis et al. (1975) reported that the average percent of animal matter in the scaled quail diet was 37% (range from 30% to 51%). I found that grasshoppers were an important part of the animal matter consumed by bobwhites during both seasons and for scaled quail in the nonbreeding season (Table 15). Bobwhites also consumed a larger percent of grass seeds (19%) than did scaled quail (3%) (Appendix, Table O). As in other studies on bobwhites (Frye 1954, Lehman 1953), panic grass (*Panicum sp.*) and paspalums (*Paspalum sp.*) were the most common grasses in the diet.

For the nonbreeding season, succulent forb leaves were more prevalent in the bobwhite diet (39%) than in the scaled quail diet (18%) (Appendix, Table P). Scaled quail supplemented their diet with shrub fruits as they came into season (Table 15 and Appendix, Table P). However, during December and January, new forb leaves made up the major portion of both quail diets (Table 13). In contrast, Lehman and Ward (1941) found only 3% of the bobwhite diet and 7% of scaled quail foods were comprised of forb leaves in January. These different results may be functions of soil moisture. Ault (1981) also reported a low percentage of greens (27% by fecal analysis) during the dry winter of 1979-80. During the nonbreeding season of 1980-81, succulent leaves were an important component of the scaled quail diet (51% by fecal analysis).

Food habits for bobwhite changed from the breeding to nonbreeding season ($P < 0.05$). During the breeding season, bobwhites consumed a larger percentage of animal matter (35%) than during the rest of the year (15%)(Appendix, Table Q). Bobwhites increased their intake of forb leaves during the nonbreeding season (from 2% to 39%) (Appendix Table Q). Contrariwise, the scaled quail diet did not change significantly from 1 season to the other.

Table 15. Relative percent of diet for bobwhites and scaled quail during the breeding (B) and nonbreeding (NB) season on all 4 study areas combined, Texas, 1980-81.

	Percent volume by season			
	Bobwhite		Scaled quail	
	B	NB	B	NB
Food item	(N=66)	(N=54)	(N=55)	(N=33)
Seed (total):	50	44	42	49
Grass	19	8	3	4
Forb	30	33	28	24
Woody	1	3	11	21
Leaf (total):	2	39	11	18
Grass	0	0	0	0
Forb	2	39	8	18
Woody	0	0	3	0
Fruit	11	0	29	14
Flower	0	3	1	4
Bulb	2	0	2	0
Animal (total):	35	14	15	15
Insecta - adult				
Orthoptera	16	8	2	8
Hemiptera	2	1	1	0
Homoptera	0	0	1	0
Hymenoptera	0	0	1	0
Coleoptera	2	1	1	0
Lepidoptera	0	0	0	0
Diptera	0	0	0	0
Isoptera	3	2	5	4
Insecta larvae	9	2	4	3
Gastropoda	2	0	0	0
Arachnida	1	0	0	0
Misc.	0	0	0	0

Based on the percent of cases correctly classified, bobwhites appeared to have a more predictable (narrow) diet annually and seasonally than did scaled quail (Appendix, Table R). This difference may reflect adaptations of each species to the specific evolutionary past. Bobwhites occupied a relatively mesic climate, had a broader range of food items available, and were able to be more selective with their food items than were scaled quail. The history of the scaled quail centered around an arid, variable environment where a more opportunistic foraging style would be advantageous.

Selection Indices for Food Among Study Areas

Food selection indices were based on the percent frequency of availability, which included both palatable and unpalatable species and parts of plants (old and germinating forb leaves). Within each food item category, relative selection was addressed. The percent frequency of certain available food items was misrepresented. For example, if the items were clumped in the habitat, such as shrub fruits and termites, the percent availability value was disproportionately low.

Selection for animal matter was generally greater for bobwhites than for scaled quail where coexistence occurred (Table 16). From Welder to Killam, bobwhites increasingly preferred animal matter, a possible reflection of the change in moisture. The bobwhite population at Welder showed the least selection for animal matter. This low index could have been a function of the high diversity and abundance of insects at Welder, combined with the possibility that

Table 16. Selection indices for food items by bobwhites (BW) and scaled quail (SCQ) on Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-81.

	Selection indices by study area						
	W	C		E		K	
Food item	BW	BW	SCQ	BW	SCQ	BW	SCQ
Seed (total):	0.52	0.35	0.51	0.27	0.52	0.45	0.55
Grass	0.06	0.14	0.03	0.16	0.03	0.12	0.02
Forb	0.45	0.16	0.33	0.12	0.56	0.50	0.73
Woody	0	0.04	0.15	0	0.59	0.01	0.22
Leaf (total):	0.10	0.05	0.06	0.04	0.19	0	0.12
Grass	0	0	0	0	0	0	0
Forb	0.12	0.06	0.07	0.07	0.26	0.01	0.21
Woody	0	0	0	0	.03	0	.02
Fruit	3.34	0.58	5.78	0.02	2.11	0.83	7.21
Flower	0.03	0	0.02	0.03	0.06	0	0.07
Bulb	0	0	0.31	1.50	0	0	0
Animal (total):	0.11	0.39	0.20	0.59	0.17	1.30	0.19
Insecta - adult							
Orthoptera	0.03	0.29	0.05	0.36	0.04	0.77	0.01
Hemiptera	0.02	0.03	0.04	0.18	0.01	0.05	0
Homoptera	0	0	0	0	0.01	0	0
Hymenoptera	0	0	0	0.01	0	0.05	0.05
Coleoptera	0.04	0.01	0	0.14	0.03	0.16	0
Lepidoptera	0	0	0	0	0	0	0
Diptera	0	0	0	0	0	0	0
Isoptera	0	0.60	1.25	0	0.23	18.01	1.46
Insecta larvae	0.06	0.25	0.08	1.28	0.42	0.02	0.05
Gastropoda	0.01	0.02	0.01	0.01	0	0	0
Arachnida	0	0	0	0.01	0	0	0

bobwhites catch and/or prefer only a few types of animal matter. Grasshoppers were a selected group of insects for bobwhite on the Chaparrosa, Experiment and Killam Raches (Table 16). Possibly the herbaceous vegetation was not as rank at these study areas and so the grasshoppers were more accessible to the quail. The index for termites ranged from 0 to 18.01. This disproportionately large range reflected the clumping of the colonies. If a quail located a colony, it generally filled its crop.

On the 3 study areas with coexisting quails, bobwhites preferred grass seeds (0.14, 0.16, 0.12) more than did scaled quail (0.03, 0.03, 0.02). On the same study areas, both woody and forb seeds were selected more frequently by scaled quail than bobwhites (Table 16). Scaled quail also selected for succulent forb leaves at Experiment and Killam, which may have indicated that these populations occupied relatively arid sites (Table 16). Apparently, bobwhites on the Experiment Ranch preferred bulbs (1.50). This relatively high value was related to the comparative rarity of bulbs in the soil samples.

For bobwhites, the largest selection index for fruits was at Welder (3.34). A large proportion of the percent use resulted from 1 quail whose crop was filled with blackberries. Where the 2 species coexisted, scaled quail preferred fruits more than did bobwhites (Table 16).

Selection Indices for Food on All Study Areas Combined

Throughout the year, scaled quail preferred shrub seeds and fruits more than did bobwhites (Table 17). Animal matter was selected more by bobwhites (0.31) than scaled quail (0.15).

Selection indices for the breeding and nonbreeding seasons indicated some changes from 1 season to the next. Bobwhites preferred animal matter more during the breeding season (0.43) than during the nonbreeding season (0.12). Insect matter may have been a source of moisture as well as protein during the dry breeding season. Fleshy fruits were another source of water. Both species selected fruits more during the breeding season than the rest of the year (Table 18).

During the nonbreeding season, scaled quail increased their preference for shrub seeds (from 0.33 to 0.60). Scaled quail also used areas with more shrub cover during this time period. Thus, this increase in preference may be due to an increased availability of shrub seeds. Both quails preferred forb leaves more during the nonbreeding than during the breeding season (Table 18).

Niche Breadth Indices for Food Among Study Areas

Despite the anticipated results that would be predicted from optimal foraging theory, no differences on niche breadth indices were estimated for the core (most productive) and peripheral (least productive) areas (Table 19). The small index for bobwhites at Killam (2.3) may have reflected the missing data for the fifth sampling period (January) and/or the small sample size.

Table 17. Selection indices for food items by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

	Selection indices	
Food item	Bobwhite	Scaled quail
Seed (total):	0.49	0.49
Grass	0.13	0.02
Forb	0.48	0.44
Woody	0.02	0.67
Leaf (total):	0.06	0.10
Grass	0	0
Forb	0.10	0.11
Woody	0	0.02
Fruit	0.64	6.72
Flower	0.01	0.05
Bulb	0.22	0.08
Animal (total):	0.31	0.15
Insecta - adult		
Orthoptera	0.18	0.04
Hemiptera	0.04	0.01
Homoptera	0	0
Hymenoptera	0	0
Coleoptera	0.05	0
Lepidoptera	0	0
Diptera	0	0
Isoptera	0.24	1.30
Insecta larvae	0.18	0.08
Gastropoda	0.01	0
Arachnida	0.01	0

Table 18. Selection indices for food items by bobwhites and scaled quail during the breeding (B) and nonbreeding (NB) season on all 4 study areas combined, Texas, 1980-81.

	Selection indices by season			
	Bobwhite		Scaled quail	
Food item	B	NB	B	NB
Seed (total):	0.53	0.43	0.48	0.52
Grass	0.18	0.04	0.02	0.02
Forb	0.40	0.34	0.42	0.30
Woody	0.01	0.05	0.33	0.60
Leaf (total):	0.01	0.32	0.08	0.15
Grass	0	0	0	0
Forb	0.01	0.37	0.08	0.18
Woody	0	0	0.03	0
Fruit	2.97	0	17.40	9.70
Flower	0	0.04	0.03	0.07
Bulb	0.13	0	0.06	0
Animal (total):	0.43	0.12	0.17	0.13
Insecta - adult				
Orthoptera	0.18	0.16	0.01	0.18
Hemiptera	0.05	0.02	0.01	0
Homoptera	0	0	0	0
Hymenoptera	0	0	0.01	0
Coleoptera	0.06	0.02	0.01	0
Lepidoptera	0	0	0	0
Diptera	0	0	0	0
Isoptera	0.37	0.35	1.19	3.64
Insecta larvae	0.29	0.06	0.07	0.10
Gastropoda	0.18	0	0	0
Arachnida	0.01	0	0	0

Table 19. Niche breadth indices for the diet (seed, leaf, fruit, flower, blub, animal) of bobwhite and scaled quail by each study area, on all 4 study areas combined, and by season, Texas, 1980-81.

	Niche breadth indices	
Grouping	Bobwhite	Scaled quail
Welder	2.8	-
Chaparrosa	2.7	3.3
Experiment	2.7	3.4
Killam	2.3	3.2
All study areas combined	3.0	3.4
Breeding season	2.6	3.4
Nonbreeding season	2.7	3.2

The contrast between cover and food indices may indicate that quail select habitat primarily on the basis of structure. As Hilden (1965) suggested, most birds are not specialized in their diet and will tend to forage on whatever food they can obtain within their species-specific habitat.

Niche Breadth Indices for Food on All Study Areas Combined

Overall, bobwhites seemed to forage on a narrower range of plant parts than did scaled quail on all the study areas and during both seasons (Table 19). The overall differences between the 2 quails may be indicative of the past adaptations of each species to their specific environments. As Gullion (1966) pointed out, Gambel's quail concentrated on 3 genera of forbs in a wet year when a wide selection of foods was available. By contrast, during a dry year, the birds foraged on a wide variety of foods. The findings of Gullion (1966) followed the prediction of foraging theory i.e. the lower the density of food the greater the range of food items a species should consume (Schoener 1971, MacArthur and Pianka 1966). Thus, bobwhites that occupy more mesic sites have developed more selectivity with their food items. Scaled quail, an arid-adapted species, probably forage on many different plant parts as they are encountered.

CONCLUSION

Bobwhite and scaled quail occupied different habitats in general (when all study areas were combined) and where the quails coexisted. This difference was noted on both annual and seasonal bases. In general, bobwhites preferred denser, herbaceous vegetation with some shrub and tree cover, whereas scaled quail selected sparser vegetation and bare areas with more of a shrub and/or cactus overstory. To a certain extent, differences in food preferences reflected the different cover types used by the 2 quail. Bobwhites tended to prefer more grass seeds and animal matter than did scaled quail. The latter species selected seeds, leaves, and fruits from woody plant species. Forbs were a large part of the diet of both quails. Nevertheless, based on species composition of the seeds, the 2 quails foraged largely on different forbs.

Even though Schoener (1982) cautioned against explaining nature on the basis of 1 interaction, many researchers over the last 2 decades would have inferred that the observed differences in resource use where bobwhite and scaled quail coexisted were evidence for and the result of interspecific competition. However, occupation of separate preferred habitats could also suggest that these sympatric quails had little opportunity to compete.

Given that the 2 quails do have different habitat preferences, I would still expect to find species-specific preferences to be intensified by interspecific competition (Hilden 1965). In other words, coexisting species occupy a more narrow optimal habitat than they would in an allopatric situation.

In order to address the potential importance of competition in habitat partitioning, I used simple niche breadth estimates. Neither indices for cover or food followed the expected pattern as defined by Hilden (1965) or Emmel (1976). Indices for cover were narrow where intraspecific competition should have been most intense (i.e. where bobwhites were allopatric and scaled quail predominated), and broad where the quails overlapped. Niche breadth indices for food were fairly constant for each quail on all their respective areas. Thus, it is likely that intra- and interspecific competition were not the only factors involved in the habitat selection of these 2 quails.

Several explanations may shed some light on this apparently anomalous conclusion. Both Brown (1981) and Hamilton (1962) have stressed the important influence of historical events on some present-day communities. Within the evolutionary history of bobwhites and scaled quail, their species-specific habitat requirements probably evolved during geographic isolation (Lack 1940). A secondary or even primary contact may be a recent phenomenon, and so these 2 quails may not have coevolved. In fact, this recent contact could be human induced. According to Edminster (1954), grazing and land-use practices increased the shrub cover on grasslands and this encouraged the spread of bobwhites southwestwardly. Therefore, these quails may have developed specialization in isolation and with subsequent contact demonstrate "resource partitioning" rather than interspecific competition giving rise to habitat specialization (Bloom 1981).

Quails in general tend to have r-selected life history strategies. As Emmel (1976) stated, intra- and interspecific competition may be lax under these circumstances. Furthermore, much of the competition research with birds has been done with migrant species (a mobile group). My research was conducted with sedentary resident species that may be much more dependent on changing environmental conditions rather than competition as the major selective force.

My secondary goal was to examine traditional theory concerning core and peripheral populations of a species. First, both core areas were significantly different from the peripheral areas based on available cover and food items. Correspondingly, both core populations used different habitats than the respective populations on the peripheral areas. In addition, these latter populations were very similar in their use of cover type and food items.

Based on the generalization proposed by Hilden (1965), bird species occupy a narrow range of habitats at the periphery of their distribution and a wide range at the core of their breeding distribution. The underlying premise is that the range of habitats is dependent on population density. At the center of the range a species with a high density will disperse into suboptimal habitat. When the density is low such as on the periphery of the distribution only the optimal habitat is exploited. From my research with a resident species, the niche breadth estimates indicated the possibility of a different outcome. At least for cover, this outcome was more in line with optimal foraging theory (MacArthur and Pianka 1966).

The geographical generalization proposed by Hilden (1965) may explain short-term observations for a migrant species that returns to the center of its breeding range with a larger population than the optimal habitat can support. Good winter survival or habitat deterioration on breeding grounds could cause this imbalance.

However, the explanation by Hilden (1965) of core and peripheral populations seems inadequate for a resident species (and possibly for some migrant species as well). I believe that in the core area an abundance of preferred habitat supports a high density (over time). Within this "optimal" habitat, a species is able to meet its life-history requirements with a narrow range of cover types.

A peripheral area does not contain all the features characteristic of an "optimal" environment. Thus, the density is correspondingly low (over time). In a suboptimal area a species may require a wide range of cover types to fulfill their specific needs.

Examination of ecological literature often leaves one with the impression that 1 theory (such as competition or geographical) explains the interrelatedness of a community. Yet, in order to more fully understand natural systems, I recommend that the evolutionary past, life-history strategy, human activities as well as the biological interactions (predation, mutualism, and competition) should be considered.

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APPENDICES

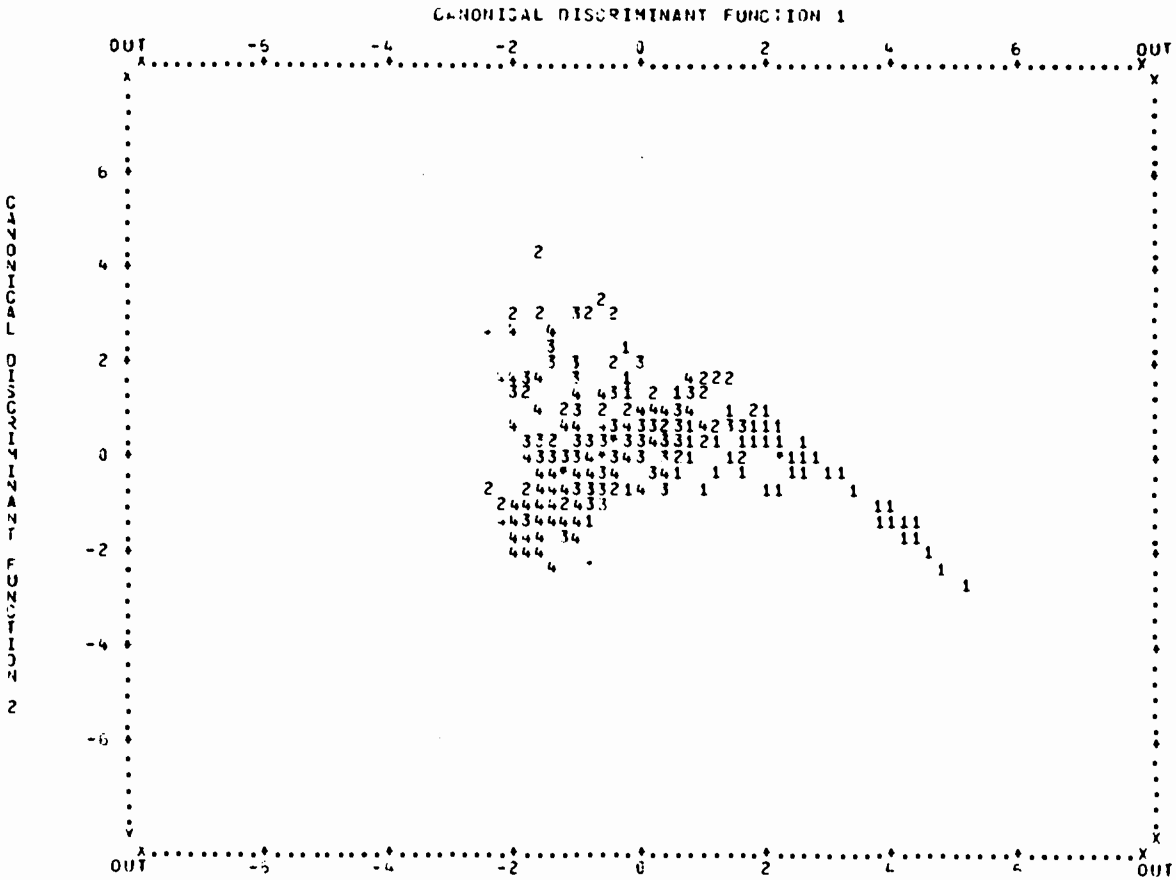

Fig. A. Scatterplot of the first and second functions derived from discriminant analysis for the percent cover of grass, forb, grass/forb, woody and bare ground available on Welder (1), Chaparrosa (2), Experiment (3), and Killam (4) Ranches, Texas, 1980-81.

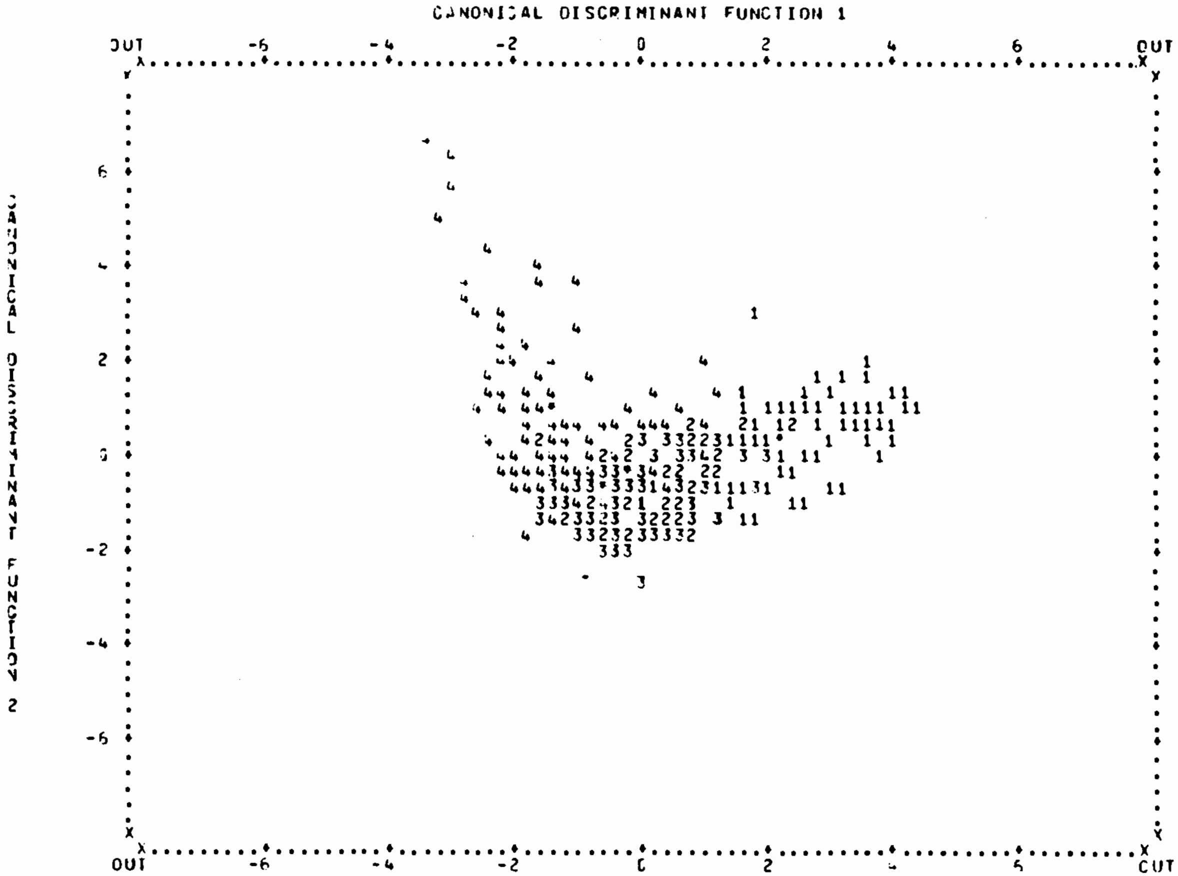

Fig. B. Scatterplot of the first and second functions derived from discriminant analysis for the percent cover of grass and forb height categories plus the life-forms of woody cover available on Welder (1), Chaparrosa (2), Experiment (3), and Killam (4) Ranches, Texas, 1980-81.

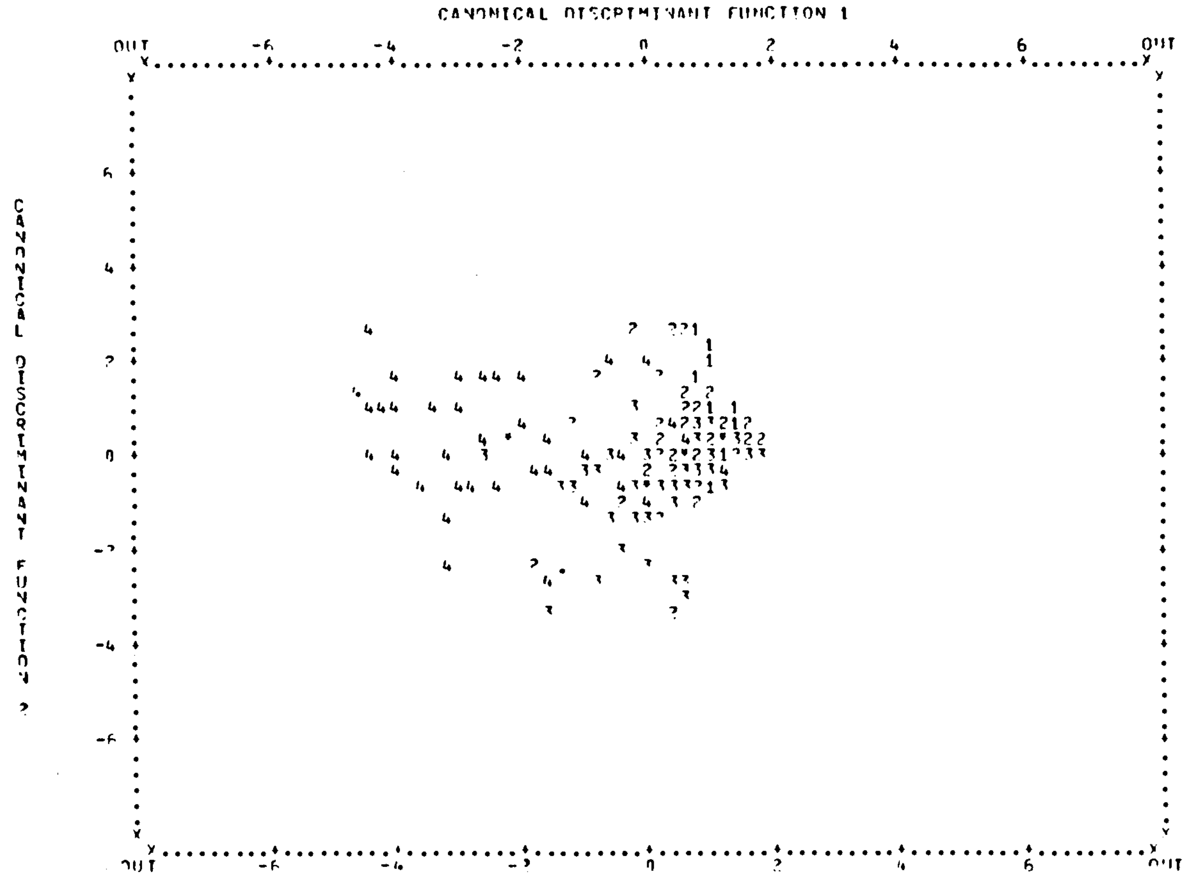

Fig. C. Scatterplot of the first and second functions derived from discriminant analysis for the percent frequency of seeds, leaves fruits, flowers, bulbs, and animal matter on Welder (1), Chaparrosa (2), Experiment (3), and Killam (4) Ranches, Texas 1980-81.

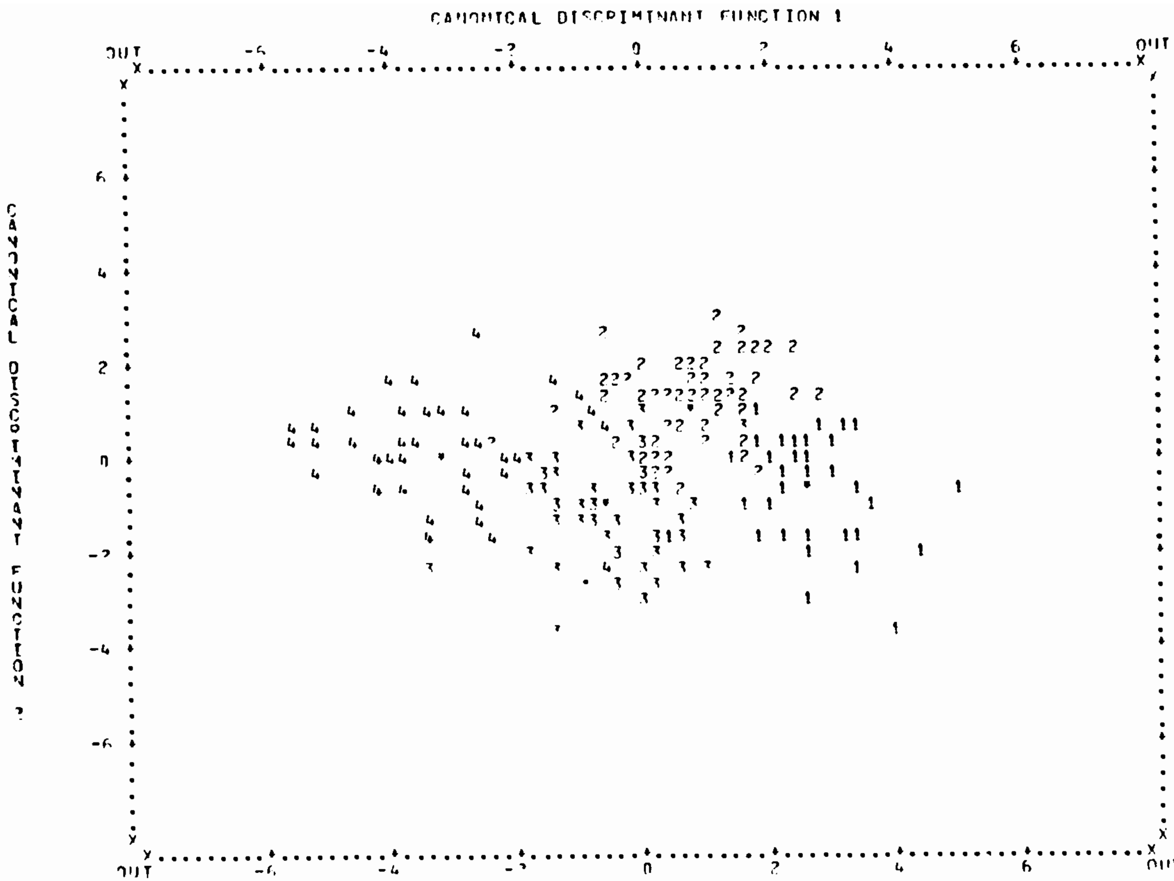

Fig. D. Scatterplot of the first and second functions derived from discriminant analysis for the partitioned seeds, leaves, and animal matter categories on Welder (1), Chaparrosa (2), Experiment (3), and Killam (4) Ranches, Texas, 1980-81.

Table A. Seasonal rainfall for Welder (W), Experiment (E), and Killam (K) Ranches, Texas, 1979-81. (Data for Chaparrosa were available only during breeding season.)

Season	Rainfall (cm) by study area			Total rainfall (cm) by study area		
	W	E	K	W	E	K
Nonbreeding 1979-80:						
Oct/Nov	2.5	2.4	0.4			
Dec/Jan	16.0	1.4	3.8	24.7	5.1	7.0
Feb/Mar	6.2	1.3	2.8			
Breeding 1980:						
Apr/May	9.4	17.7	12.1			
June/July	6.8	2.3	0	59.8	34.7	29.1
Aug/Sept	43.6	14.7	17.0		(39.1)[a]	
Nonbreeding 1980-81:						
Oct/Nov	7.6	7.3	10.9			
Dec/Jan	9.4	4.2	6.3	26.2	12.4[b]	24.8
Feb/Mar	9.2	0.9	7.6			

[a]Total rainfall for Chaparrosa Ranch for the breeding season of 1980.

[b]Data available through second week of March.

Table B. Classification results for available vegetation on Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-1981.

Segment 1:

	Predicted group membership			
Actual group	W	C	E	K
W	81	16	0	3
C	8	50	17	26
E	2	41	16	41
K	0	26	15	59

Percent of grouped cases correctly classified 51%

Segment 2:

	Predicted group membership			
Actual group	W	C	E	K
W	85	12	3	0
C	9	48	37	7
E	5	21	67	7
K	5	12	21	63

Percent of grouped cases correctly classified 65%

Table C. Pooled-within-group correlations between the discriminant functions (DF) and discriminating variables for the available vegetation on Welder, Chaparrosa, Experiment, and Killam Ranches, Texas, 1980-81.

	Correlation coefficients		
Variable	DF1	DF2	DF3
Segment 1:			
Grass	0.77	0.28	0.45
Grass/forb	0.74	-0.08	-0.28
Bare ground	-0.71	-0.61	0.18
Woody	-0.12	-0.40	-0.24
Forb	0.30	0.42	-0.55
Segment 2:			
Grass under 40 cm	0.66	0.33	0.06
Grass under 20 cm	0.53	-0.13	0.11
Forb under 40 cm	0.51	0.10	0.05
Forb under 20 cm	0.37	0.06	-0.23
Forb under 80 cm	0.34	0.16	-0.06
Shrub	-0.21	0.09	0.13
Forb over 80 cm	0.20	0.08	-0.12
Tree	0.14	-0.05	0.05
Cactus	-0.27	0.76	0.14
Grass under 10 cm	0.14	-0.49	0.16
Grass under 5 cm	-0.12	-0.35	0.01
Grass under 80 cm	0.26	0.26	-0.13
Grass over 80 cm	0.12	0.21	0.08
Forb under 10 cm	0.07	-0.05	-0.84
Forb under 5 cm	-0.08	-0.21	-0.27

Table D. Pooled within-group correlations between discriminant function and discriminating variables for the available vegetation and during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Forb	-0.83[a]
Grass	0.26
Grass/forb	-0.26
Woody	0.20
Bare ground	0.15
Segment 2:	
Forb under 5 cm	0.79[b]
Forb under 10 cm	0.65
Grass under 20 cm	-0.38
Tree	-0.25
Grass under 5 cm	0.16
Forb under 80 cm	-0.15
Forb under 40 cm	-0.15
Grass under 40 cm	-0.14
Grass over 80 cm	0.12
Forb under 20 cm	0.09
Grass under 10 cm	-0.07
Cactus	0.06
Grass under 80 cm	-0.06
Forb over 80 cm	-0.02
Shrub	0.02

[a]For segment 1, positive and negative correlation coefficients are associated with breeding and nonbreeding seasons respectively.

[b]For segment 2, positive and negative correlation coefficients are associated with nonbreeding and breeding seasons respectively.

Table E. Classification results for cover used by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

Segment 1:

	Predicted group membership	
Actual group	Bobwhite	Scaled quail
Bobwhite	88	12
Scaled quail	12	88

Percent of grouped cases correctly classified 88%

Segment 2:

	Predicted group membership	
Actual group	Bobwhite	Scaled quail
Bobwhite	86	14
Scaled quail	10	90

Percent of grouped cases correctly classified 87%

Table F. Pooled within-group correlations between discriminant function and discriminating variables for cover used by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Bare ground	0.98[a]
Grass	-0.84
Grass/forb	-0.47
Forb	-0.40
Woody	0.37
Segment 2:	
Grass under 20 cm	0.63[b]
Grass under 40 cm	0.52
Grass under 10 cm	0.51
Shrub	-0.45
Forb under 40 cm	0.31
Forb under 20 cm	0.28
Grass under 80 cm	0.28
Cactus	-0.23
Forb under 80 cm	0.23
Grass under 5 cm	0.23
Forb under 10 cm	0.19
Grass over 80 cm	0.16
Tree	0.14
Forb under 5 cm	0.14
Forb over 80 cm	0.11

[a]For segment 1, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

[b]For segment 2, positive and negative correlation coefficients are associated with bobwhites and scaled quail respectively.

Table G. Pooled within-group correlation between the discriminant function and discriminating variables for cover used by bobwhites and scaled quail during the breeding season on all 4 study areas combined, Texas, 1980-81.

	Correlation coefficients
Variable	Discriminant function 1
Segment 1:	
Bare ground	0.98[a]
Grass	-0.90
Forb	-0.39
Grass/forb	-0.38
Woody	0.31
Segment 2:	
Grass under 20 cm	0.69[b]
Grass under 10 cm	0.50
Grass under 40 cm	0.50
Forb under 20 cm	0.39
Shrub	-0.39
Forb under 40 cm	0.35
Forb under 10 cm	0.24
Grass under 80 cm	0.22
Cactus	-0.21
Forb under 80 cm	0.20
Grass under 5 cm	0.14
Tree	0.14
Grass over 80 cm	0.12
Forb over 80 cm	0.05
Forb under 5 cm	0.03

[a]For segment 1, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

[b]For segment 2, positive and negative correlation coefficients are associated with bobwhites and scaled quail respectively.

Table H. Pooled within-group correlations between the discriminant function and discriminating variables for cover used by bobwhites and scaled quail during the nonbreeding season on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Bare ground	0.98[a]
Grass	-0.75
Grass/forb	-0.55
Woody	0.41
Forb	-0.40
Segment 2:	
Grass under 20 cm	0.56[b]
Grass under 40 cm	0.51
Shrub	-0.50
Grass under 10 cm	0.47
Grass under 80 cm	0.30
Grass under 5 cm	0.26
Forb under 40 cm	0.26
Cactus	-0.25
Forb under 80 cm	0.22
Forb under 20 cm	0.18
Grass over 80 cm	0.17
Forb under 5 cm	0.16
Forb under 10 cm	0.15
Tree	0.15
Forb over 80 cm	0.14

[a] For segment 1, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

[b] For segment 2, positive and negative correlation coefficients are associated with bobwhites and scaled quail respectively.

Table I. Pooled within-group correlations between the discriminant function and discriminating variables for cover used by bobwhites during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

Variables	Correlation coefficient Discriminant function 1
Segment 1:	
Grass/forb	0.88[a]
Forb	0.88
Bare ground	-0.60
Grass	0.31
Woody	0.02
Segment2:	
Forb under 5 cm	0.71[a]
Forb under 20 cm	-0.24
Grass under 5 cm	0.21
Forb under 10 cm	0.18
Grass over 80 cm	0.18
Grass under 80 cm	0.15
Grass under 20 cm	-0.14
Forb under 80 cm	0.14
Grass under 40 cm	0.12
Forb over 80 cm	0.10
Tree	-0.06
Shrub	0.06
Grass under 10 cm	0.05
Cactus	-0.05
Forb under 40 cm	-0.00

[a]For both segments, positive and negative correlation coefficients are associated with nonbreeding and breeding seasons respectively.

Table J. Pooled within-group correlations between the discriminant function and discriminating variables for cover used by scaled quail during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Forb	0.65[a]
Woody	0.53
Grass	-0.37
Grass/forb	0.31
Bare ground	0.07
Segment 2:	
Forb under 5 cm	0.71[a]
Shrub	0.48
Grass under 20 cm	-0.26
Forb under 10 cm	0.18
Tree	-0.17
Grass under 10 cm	-0.17
Grass under 40 cm	-0.16
Forb over 80 cm	-0.16
Forb under 20 cm	-0.11
Grass under 80 cm	-0.10
Grass over 80 cm	-0.10
Grass under 5 cm	-0.09
Forb under 40 cm	-0.07
Forb under 80 cm	0.02
Cactus	-0.01

[a]For both segments, positive and negative correlation coefficients are associated with nonbreeding and breeding seasons respectively.

Table K. Classification results for available food items on Welder (W), Chaparrosa (C), Experiment (E), and Killam (K) Ranches, Texas, 1980-1981.

Segment 1:

Actual group	Predicted group membership W	C	E	K
W	<u>75</u>	15	10	0
C	32	<u>45</u>	18	5
E	11	31	<u>49</u>	9
K	7	5	17	<u>71</u>

Percent of grouped cases correctly classified 58%

Segment 2:

Actual group	Predicted group membership W	C	E	K
W	<u>90</u>	8	2	0
C	8	<u>81</u>	9	2
E	0	11	<u>87</u>	2
K	0	7	5	<u>88</u>

Percent of grouped cases correctly classified 86%

Table L. Pooled-within-group correlations between discriminant functions (DF) and discriminating variables for available food items on Welder, Chaparrosa, Experiment, and Killam Ranches, Texas, 1980-81.

	Correlation coefficients		
Variable	DF1	DF2	DF3
Segment 1:			
Leaf	0.74	-0.36	0.39
Animal	0.71	0.14	-0.26
Seed	0.45	0.60	-0.21
Fruit	-0.18	-0.20	0.06
Flower	0.03	0.34	0.57
Bulb	0.05	-0.22	0.52
Segment 2:			
Forb seed	0.53	0.52	0.00
Grass leaf	0.49	-0.13	-0.30
Forb leaf	0.39	0.13	-0.15
Grass seed	0.33	0.08	0.08
Woody leaf	-0.30	0.13	0.18
Coleoptera	0.26	0.10	0.22
Homoptera	0.20	-0.10	0.07
Diptera	0.19	-0.16	0.14
Hymenoptera	0.19	0.10	0.01
Lepidoptera	0.14	-0.11	0.12
Woody beans	-0.11	0.04	0.03
Gastropoda	0.07	-0.55	-0.06
Forb seedhead	0.15	0.34	-0.06
Insecta larvae	0.09	0.16	0.07
Seedheads	0.11	0.23	-0.36
Isoptera	-0.05	0.01	-0.34
Arachnida	0.33	-0.01	0.34
Grass seedhead	0.09	0.08	-0.33
Orthoptera	0.16	0.08	-0.33
Woody seed	-0.25	0.16	0.30
Hemiptera	0.08	0.12	-0.14

Table M. Pooled within-group correlations between the discriminant function and discriminating variables for available food items during breeding and nonbreeding seasons on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Flower	0.38[a]
Fruit	-0.35
Leaf	0.29
Animal	-0.24
Seed	-0.10
Bulb	0.10
Segment 2:	
Orthoptera	0.45[b]
Hymenoptera	0.42
Forb leaf	-0.32
Hemiptera	0.31
Seedhead	0.26
Grass seedhead	0.22
Insecta larvae	0.20
Isoptera	0.16
Woody bean	0.12
Forb seedhead	0.10
Grass leaf	0.09
Coleoptera	0.08
Lepidoptera	-0.08
Homoptera	0.08
Arachnida	-0.07
Forb seed	-0.04
Woody seed	-0.04
Grass seed	0.03
Woody leaf	-0.01

[a]For segment 1, positive and negative correlation coefficients are associated with nonbreeding and breeding seasons respectively.

[b]For segment 2, positive and negative correlation coefficients are associated with breeding and nonbreeding seasons respectively.

Table N. Pooled within-group correlations between discriminant function and discriminating variables for food items consumed by bobwhites and scaled quail on all 4 study areas combined, Texas, 1980-81.

	Correlation coefficient
Variable	Discriminant function 1
Segment 1:	
Fruit	0.78[a]
Leaf	0.31
Seed	0.29
Animal	-0.28
Flower	0.29
Bulb	0.02
Segment 2:	
Woody seed	0.63[a]
Woody leaf	0.39
Coleoptera	-0.36
Grass seed	-0.31
Orthoptera	-0.22
Arachnida	-0.22
Hymenoptera	0.21
Isoptera	0.20
Grass leaf	-0.18
Gastropoda	-0.15
Diptera	-0.13
Homoptera	0.13
Hemiptera	-0.12
Insecta larvae	-0.09
Forb leaf	0.08
Forb seed	0.08
Segment 3:	
Woody	0.85[a]
Grass	-0.45
Forb	0.21
Animal	-0.20

[a]For all segments, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

Table 0. Pooled within-group correlations between discriminant function and discriminating variables for food items consumed by bobwhites and scaled quail during the breeding season on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Leaf	0.77[a]
Fruit	0.46
Animal	-0.43
Flower	0.33
Seed	-0.03
Bulb	-0.01
Segment 2:	
Woody seed	0.52[a]
Forb leaf	0.42
Woody leaf	0.39
Grass seed	-0.38
Coleoptera	-0.36
Orthoptera	-0.35
Hymenoptera	0.24
Arachnida	-0.23
Gastropoda	-0.18
Insecta larvae	-0.16
Hemiptera	-0.16
Isoptera	0.14
Homoptera	0.13
Diptera	-0.11
Forb seed	0.33
Segment 3:	
Woody	0.70[a]
Grass	-0.60
Animal	-0.45
Forb	0.21

[a]For all segments, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

Table P. Pooled within-group correlations between discriminant function and discriminating variables for food items consumed by bobwhites and scaled quail during the nonbreeding season on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Fruit	0.90[a]
Seed	0.50
Animal	0.36
Flower	0.18
Leaf	-0.13
Bulb	0.01
Segment 2:	
Woody seed	0.61[a]
Coleoptera	-0.28
Woody leaf	0.25
Grass leaf	-0.24
Isoptera	0.18
Insecta larvae	0.18
Orthoptera	0.15
Arachnid	-0.15
Diptera	-0.13
Homoptera	-0.11
Forb seed	0.10
Hemiptera	-0.09
Forb leaf	-0.09
Hymenoptera	-0.06
Gastropoda	-0.02
Grass seed	-0.01
Segment 3:	
Woody	0.98[a]
Animal	0.30
Forb	0.14
Grass	-0.03

[a]For all segments, positive and negative correlation coefficients are associated with scaled quail and bobwhites respectively.

Table Q. Pooled within-group correlations between discriminant function and discriminating variables for food items consumed by bobwhites during the breeding and nonbreeding season on all 4 study areas combined, Texas, 1980-81.

Variable	Correlation coefficient Discriminant function 1
Segment 1:	
Leaf	-0.66[a]
Animal	0.53
Seed	0.39
Fruit	0.27
Flower	-0.24
Bulb	0.21
Segment 2:	
Forb leaf	-0.59[a]
Hemiptera	0.40
Grass seed	0.33
Orthoptera	0.29
Insecta larvae	0.28
Coleoptera	0.27
Woody seed	-0.25
Arachnida	0.24
Gastropoda	0.23
Forb seed	0.21
Isoptera	0.19
Woody leaf	0.13
Hymenoptera	0.07
Homoptera	0.05
Diptera	0.03
Segment 3:	
Animal	0.83[a]
Grass	0.59
Wood	0.33
Forb	-0.07

[a]For all segments, positive and negative correlation coeeficients are associated with the breeding and nonbreeding seasons respectively.

Table R. Classification results for food items consumed by bobwhites (BW) and scaled quail (SCQ) during 2 seasons and throughout the year on all 4 study areas combined, Texas, 1980-81.

	Percent predicted group membership					
	Segment 1		Segment 2		Segment 3	
Time period	BW	SCQ	BW	SCQ	BW	SCQ
Breeding season	88	53	84	73	71	73
Nonbreeding season	94	39	87	58	94	48
Throughout the year	81	50	86	58	82	54