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Dietary Patterns of Bobwhite Quail on Ames Plantation

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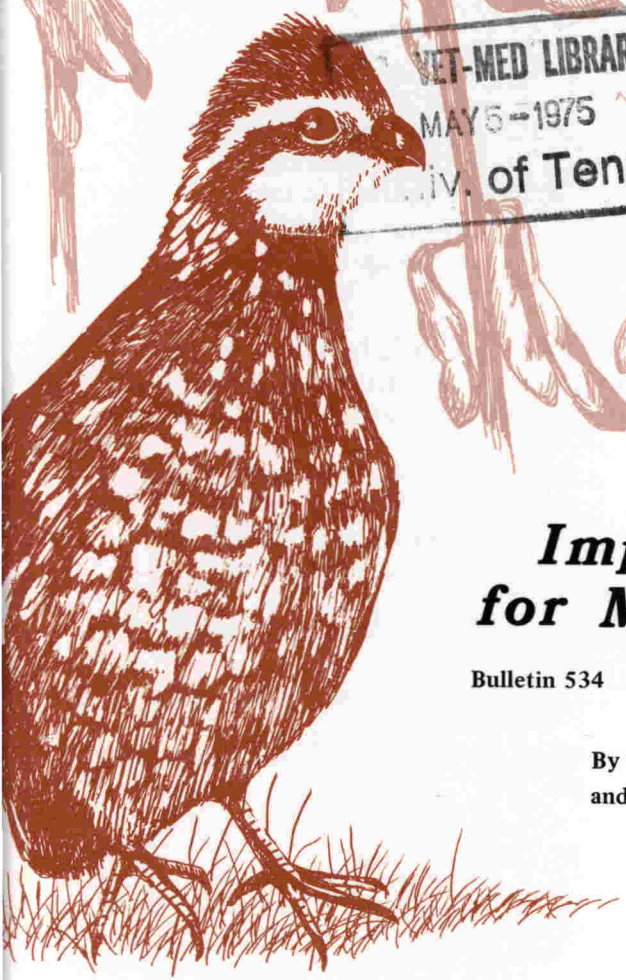

Implications for Management

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ABSTRACT

The dietary patterns of bobwhite quail were studied on the 18,600-acre Ames Plantation located near Grand Junction, Fayette-Hardeman Counties, Tennessee. A total of 672 bobwhite quail was collected for analysis of their diet. The most important foods comprising the annual diet of bobwhites on the study area were soybeans (38.1%), corn (6.0%), Johnsongrass (5.2%), grasshoppers (4.2%) and browntop millet (3.4%). Soybeans were prominent in the diet during all seasons except summer, when animals such as insects and other invertebrates predominated. Animal foods were particularly important to juvenile quail and adult hens in summer, with each of these groups consuming nearly twice as much animal food as was eaten by adult males. The diet of young quail changed markedly over the first 8 weeks of life. More than 90 percent of the diet of chicks less than 2 weeks old was comprised of small invertebrates. This proportion declined steadily through 8 weeks, stabilizing at about 40 percent for the summer period. The significance of agricultural crops in the diet of bobwhites underscores the strong relationship between this species' welfare and prevailing agricultural land use practices. Recommendations for bobwhite management in the mid-South necessarily must accommodate this relationship. Such recommendations, plus appropriate approaches for specialized food plantings and controlled burning, are presented in this report.

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Dietary Patterns of Bobwhite Quail on Ames Plantation

By Thomas R. Eubanks and Ralph W. Dimmick*

INTRODUCTION

The bobwhite quail (**Colinus virginianus**) is widely distributed in North America, occupying a variety of ecological situations throughout its range. It inhabits the southern portions of northern states such as Wisconsin, Michigan, and New York, where winter storms of ice and snow strongly influence population densities. In the arid southwestern states, quail populations fluctuate widely in response to changes in annual rainfall. In the southeastern United States, bobwhite populations remain more stable than in most other parts of its range.

In this region, close to its ecological center of distribution, bobwhites are particularly abundant in certain types of agricultural and forest lands, and also are commonly found in wet swamps and dry uplands poorly suited for farming. Their dietary patterns vary accordingly, reflecting the predominant land-use in the region occupied. Within any region their diet may be expected to change as land-use patterns change, and to respond to seasonal changes in food availability and the age structure of the population.

The objective of this study was to delineate dietary patterns of bobwhite quail on an agricultural area assumed to be representative of the more fertile farm lands of the mid-South. Seasonal variation in food selection, and feeding preferences of different age and sex groups were investigated.

Food habits of bobwhites have been reported by many workers; however, most studies were based on data obtained from birds shot

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during autumn hunting seasons, the period of greatest food abundance under most circumstances. A selection of these studies reviewed during the course of this investigation is presented in Table 1.

Table 1. Major Studies of Bobwhite Quail Food Habits in the United States.

Source	Region	No. Crops
Allen and Pearson (1945 a,b, 1949 a,b)	southeastern Alabama	1,362
Baldwin and Handley (1946)	Virginia	495
Barbour (1951)	Kentucky	331
Barnes and Klimstra (1964)	southern Illinois	195
Cady (1944)	eastern Tennessee	553
Davison (1942)	southeastern U.S.	5,189
Goodrum and Reid (1954)	south central Louisiana	3,053
Gray (1938)	central Alabama	440
Handley (1931)	southeastern U.S.	1,659
Hood (1955)	Mississippi	360
Johnson and Pearson (1948, 1949)	northern Alabama	567
Johnson (1941)	northern Mississippi	1,835
Korschgen (1948)	Missouri	5,472
Laessle and Frye (1956)	Florida	375
Larimer (1960)	southern Illinois	4,606
Lett and Pearson (1942)	Alabama	611
Martin (1935)	southeastern U.S.	2,000
McConnell (1965)	Alabama	457
Reeves (1954)	Indiana	831

It is particularly significant that all these studies except McConnell (1965) utilized quail collected prior to 1960, and most were done more than two decades ago. In the past several decades agricultural practices in the mid-South have gradually changed from tenant style patch farming to large-field, mechanized operations. Automation and mechanization are influencing land use by replacing small farms and fields with large cultivated tracts, eliminating many fence rows, corners, and woody coverts formerly utilized by wildlife. This trend has prevailed on our study area. Before the 1950's, more than 300 tenants farmed the plantation

on which this study was conducted. Today there are none, though some cooperative farming units remain for experimental purposes. Wildlife management practices such as controlled burning, food patches, and cover strips have compensated to a degree for increased field size and a strong shift to mechanization and heavy use of agricultural chemicals. Since most food habit studies on bobwhites were conducted before 1950, this study should serve to illustrate changes in the habits of quail which reflect changes in the style of farming.

THE STUDY AREA

The study was conducted on the 18,600-acre Ames Plantation located in Fayette and Hardeman Counties in West Tennessee. Ames Plantation is 60 miles east of Memphis, 10 miles north of the Mississippi state line. Quail were collected from a 4,200-acre sub-unit on which quail management is a significant factor in the land-use scheme.

Southwestern Tennessee generally has hot summers and mild winters, with a growing season of about 210 days. The maximum daily temperature averages near 90 F in summer, while the mean daily temperature in winter ranges from about 32 F to 50 F. Average annual precipitation is approximately 53 inches, with more precipitation occurring during winter and early spring than in other seasons. Snow is occasional during winter, though accumulations greater than 2 or 3 inches seldom occur and snow usually remains on the ground less than 3 or 4 days. The heaviest snowfall during the study occurred on March 22, 1968, when 12.0 inches was recorded on the study area.

The study area is gently rolling and moderately dissected. Internal and surface drainage are good to excellent. Three major types of land use were significant on the study area. Agricultural crops, including row crops, small grains, hay and pasture, and a few miscellaneous uses occupied roughly 45 percent of the area. Forests occur on 37 percent and idle lands, particularly eroded, untillable soils, comprise 18 percent. Soybean (**Glycine max**) was the main row crop but substantial acreages were planted to corn (**Zea mays**) and cotton (**Gossypium hirsutum**). Winter wheat (**Triticum aestivum**) was grown in a double-cropping system which precluded its contributing significantly to the diet of quail.

Forests are predominantly upland hardwoods comprised of many species of oaks (**Quercus** sp.), hickories (**Carya** sp.), yellow poplar (**Liriodendron tulipifera**), sweet gum (**Liquidambar styraciflua**), maples (**Acer** sp.), and ash (**Fraxinus** sp.). Loblolly pine(**Pinus taeda**) was planted on some badly-eroded sites, and shortleaf pine (**P. echinata**) occurred naturally in a few mature stands. Scattered stands and individuals of red cedar (**Juniperus virginianus**) are common.

Idle fields in early stages of succession contained buttonweed (**Diodea teres**), common ragweed (**Ambrosia artemisiifolia**), lanceleaf ragweed (**A. bidentata**), broomsedge (**Andropogon virginicus**), Johnsongrass (**Sorghum halepense**), panic grasses (**Panicum** sp.), and many others.

Fields remaining undisturbed for a few years typically become dominated by broomsedge on most sites. Once this community becomes established, fire usually will not suffice to eliminate this species.On sites with poor drainage, however, partridge pea (**Cassia fasciculata**) frequently occurs as a fire-successional species. Woody plants invade the broomsedge community soon after or during its establishment; sumac (**Rhus copelina** and **R. glabra**), sassafras (**Sassafras albidum**), winged elm (**Ulmus alata**), and persimmon (**Diospyros virginiana**) are early hardwood invaders, while loblolly pine, shortleaf pine, and red cedar are commonly-occurring conifers in old fields. Blackberry (**Rubus** sp.) and honeysuckle (**Lonicera japonica**) invade as patches, usually replacing broomsedge where they gain a foothold.

STATUS OF THE QUAIL POPULATION

Quail populations on the study area were high and relatively stable during the time this project was undertaken. Censuses were conducted twice annually, using several men walking compass lines to obtain a direct count of quail on a major portion of the study area. These censuses indicated a density of quail ranging from 1 bird/2 acres to 1 bird/1.8 acres (Dimmick and Yoho 1972). However, ongoing studies using a different census technique suggest strongly that these densities underestimate the true quail population existing on the study area by at least 50 percent. A density ranging from 1 to 2 birds per acre during late autumn is believed to more closely approximate the status of the population. High densities prevailed in summer also. Later studies (Saunders

1973) indicated that the population of adult quail in summer may approximate 1 bird per acre.

Mobility of this population is quite low, probably reflecting the high quality of the habitat. Home ranges of coveys averaged less than 17 acres during the winter period (Yoho and Dimmick 1972), somewhat smaller than reported by others (Bartholemew 1967; Roseberry 1964; Lehman 1946). During summer, the movements of adults were similarly restricted (Saunders 1973).

The population can be characterized as having high density, low mobility, and comparatively low turnover rate during the study period.

METHODS

All quail used in this study were collected by shooting. Except for those birds contributed by hunters during the legal hunting season, quail were selected systematically to provide a representative sample of birds from all sex and age groups and all major cover types. Only one or two birds were collected from any covey during any month, thus insuring a sample from a large number of coveys and cover types on the study area. This enhanced the representation of the sample, as Laessle and Fry (1956) found that crop contents of all birds of a covey were essentially similar.

Plant food items were identified to the lowest taxon possible. Most seeds could be identified to species, but leaves and stems frequently could be recognized only as vegetative matter. Animal food items were identified to Order when possible. The volume of each food item was measured by water displacement as described by Korschgen (1948). The following significant characteristics of each food were determined:

1. Relative volume- total volume of one food expressed as a percent of the total volume of all foods (grit excluded).
2. Frequency of occurrence- percent of crops in which an individual food occurred.

Relative volume was considered the more significant statistic, and most conclusions and inferences regarding the diet of quail were based upon this characteristic.

RESULTS AND DISCUSSION

A total of 672 bobwhites was collected during December, 1966, through March, 1969. Crops of 631 birds contained food; the remaining 41 were empty. Males comprised 54.1 percent of the sample, and females 45.9 percent. To evaluate the influence of age upon diet, quail were classified into two major categories, juvenile and adult. Quail 16 weeks old and older were considered adults. All others were considered juveniles (young-of-the-year). The number of adult quail collected ranged from 6 to 116 per month, averaging 24 birds per month. Juveniles were collected during June through November; the number collected per month ranged from 1 to 22, and averaged 13.

The sample size was believed adequate to evaluate dietary patterns of quail in the region studied. Davison (1940) indicated that a minimum of 50 crops and preferably 100-200 are needed to determine the importance of foods in a locality. Johnson (1941) and Korschgen (1948) stated that a minimum of 100 and preferably 200 or more crops should be obtained from an area to obtain an adequate representation of the foods quail are utilizing. Judged by these criteria, all seasons except fall were adequately represented in this study.

THE ANNUAL DIET

The diet of quail on Ames Plantation was highly varied, containing 144 plant food items and 34 animal foods (insects, snails, spiders, etc.). Despite this variety, however, the bulk of the diet (69.2 percent) was comprised of only 10 different foods (Figure 1). Soybeans were predominant, comprising 38.1 percent by volume of all foods eaten by bobwhites on the study area (Table 2). Other important foods were corn, (6.0 percent), Johnsongrass, (5.2 percent), grasshoppers (Orthoptera (4.2 percent), browntop millet (**Panicum fasciculatum**) (3.4 percent), and beetles (**Coleoptera**) (3.3 percent).

The predominance of soybeans in the diet is a most significant finding of this study, for the importance of soybeans as an agricultural crop is increasing dramatically throughout the mid-South. Since 1929, acreage devoted to this crop in 12 southeastern states has increased 1,080 percent. In Tennessee, soybean acreage more than doubled in the last decade, increasing from 492,000 acres in

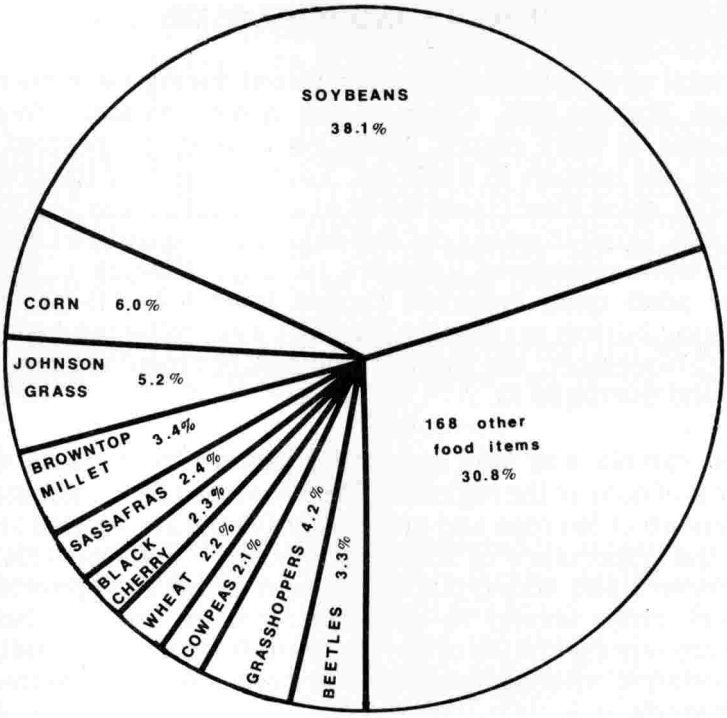

Figure 1

Important food items consumed by bobwhites on Ames Plantation during the 2-year study. Percentages represent proportion of volume of all foods eaten.

1960 to 1,293,000 in 1970. The forecast is for some continued expansion of acreage devoted to this crop. On our study area only 13 percent of the land was devoted to soybean production, yet this seed comprised more than 38 percent of all foods eaten by quail. This obvious preference for soybeans shown by quail, coupled with the expected increased in the production of soybeans as an agricultural crop, suggests that this agricultural trend may produce favorable changes in quail habitat throughout much of the region.

Corn ranked second in volume and was eaten by 8 percent of the birds. This crop has trended downward in acreage in Fayette County since 1879; it remains, however, a relatively-important food for quail where it occurs.

Table 2. Important foods of bobwhites on Ames Plantation, west Tennessee, 1968-69.

Food Items	Percent of Volume				
	Summer (235)[a]	Fall (21)	Winter (290)	Spring (126)	Total (672)
PLANT FOODS					
Soybeans	6.20	53.22	71.10	39.92	38.05
Corn	6.00	3.98	9.74	0.26	5.99
Johnsongrass	9.05	0.82	4.44		5.17
Browntop millet	7.66	7.41	0.23	0.03	3.43
Sassafras	6.10		0.03		2.43
Black cherry	4.30	0.14	1.21	0.80	2.30
Wheat	5.49			0.03	2.18
Cowpeas	3.75	4.11	0.70	0.83	2.08
Woodsorrel	0.80	0.27		6.77	1.79
Common lespedeza	0.33	1.37	3.00	2.41	1.75
Acorn	1.21	2.33	2.41	1.04	1.64
Green leafy vegetation	0.03	0.28	0.42	6.92	1.62
Violet				6.12	1.33
Smooth crabgrass	2.95	2.74	0.02		1.29
Buckwheat	2.91	0.82	0.16		1.24
Serinea	0.01			4.17	0.91
Blackberry	1.80			0.54	0.83
Sedge	0.81			1.27	0.59
Carolina geranium	0.37			1.92	0.56
Plant galls	0.30	0.69		1.79	0.55
Partridge pea	0.07		0.63	1.35	0.54
Milo	0.75		0.61		0.51
Fall panicum	0.91	0.14	0.03		0.38
Common ragweed		4.11	0.52		0.35
Flat sedge	0.11			1.30	0.32
Bicolor lespedeza			0.44	0.52	0.26
Smooth sumac	0.26		0.34	0.18	0.26
Sericea lespedeza	0.06		0.34	0.39	0.22
Sweetgum		0.27	0.60		0.22
Trailing lespedeza	0.16	2.47	0.05		0.18
Other plant foods	7.09	0.56	1.82	4.90	4.57
SUB-TOTAL	69.48	85.73	98.70	83.46	83.54

(continued)

Table 2 (continued)

Food Items	Percent of Volume				
	Summer	Fall	Winter	Spring	Total
ANIMAL FOODS					
Grasshoppers	9.44	9.46	0.06	0.29	4.21
Beetles	5.46	2.19		4.61	3.26
Snails	2.11	0.14	0.21	4.35	1.86
Insect larvae	3.56	0.14	0.02	1.24	1.71
Ants	2.51	0.69		1.50	1.35
True bugs	2.22	0.82	0.03	1.04	1.15
Bugs	2.41	0.14	0.02	0.62	1.10
Slugs	0.10	0.41	0.92	1.58	0.72
Other animal foods	2.71	0.28	0.04	1.31	1.10
SUB-TOTAL	30.52	14.27	1.30	16.54	16.64
TOTAL	100.00	100.00	100.00	100.00	100.00

[a] number of quail examined

Johnsongrass and grasshoppers, important associates of cultivated crops, were widely distributed on Ames Plantation. Johnsongrass was prevalent in soybean and corn fields, food plots, and fallow lands. Grasshoppers were abundant where green, succulent plants were available for food, such as burned areas and cultivated crops not heavily-treated with insecticides.

Food plots planted specifically for quail were an important source of food on the study area. Browntop millet, cowpeas (**Vigna sinensis**), buckwheat (**Fagopyrum esculentum**), milo (**Sorghum vulgare**), bicolor lespedeza (**Lespedeza bicolor**), and German millet (**Setaria italica**) together contributed 7.6 percent of the food consumed by bobwhites on the study area. Browntop millet was the fifth most important quail food on the study area despite a very limited distribution (0.2 percent of study area). The availability of this species was also limited in time, as it ripened early in autumn, and either was consumed or deteriorated quickly thereafter. Browntop millet appeared to be very attractive to broods and coveys in September, attracting them to the food plots during this time and providing them with adequate food until soybeans in the plot or in fields nearby became available.

SEASONAL DIETARY PATTERNS

The feeding patterns and preferences of quail during the autumn months are quite well documented, reflecting the ease of collecting

study materials from hunter-contributors during the period of year embracing the hunting season. Autumn, however, is probably the least critical season in the annual cycle of the quail. The late winter and early spring periods present the bobwhite with the greatest food shortage, and thus become critical both for survival of the adult bird and for physiological readiness for the breeding season. The summer period, generally a time of abundance, nevertheless is critical for young birds whose sustenance is a rather specialized diet of small insects. It is also important for females, some of which may be engaged in breeding and nesting activities for as long as 4 or 5 months. Consequently, we have attempted to identify those facets of the bobwhite's dietary patterns which may significantly affect its ability to survive and reproduce.

Winter. The winter period extended from December, when nearly all agricultural crops were harvested, until the end of February, at which time temperatures were warm enough to permit increased activity of invertebrates and early spring plants were beginning to provide some fresh green vegetation. During the three winter seasons, 290 quail were collected; the diet of these birds included 51 different food items. Plants predominated in the diet, comprising 98.7 percent of all foods eaten (Table 2). Particularly significant were legumes, both annuals (72.0 percent) and perennials (4.4 percent).

The importance of soybeans was pronounced; the seed from this plant contributed 71.1 percent of all foods eaten during winter, appearing in the crops of 57.2 percent of the birds. Other important winter foods were corn (9.7 percent), Johnsongrass (4.4 percent), common lespedeza (**Lespedeza striata**) (3.0 percent), and acorns (**Quercus spp.**) (2.4 percent).

Soybeans were used heavily during all 3 years, but use of the other major foods varied widely between years. Acorns, for example, comprised 22.2 percent of the diet in the winter of 1966-67. During this year a bumper crop of acorns was produced, and quail fed on them extensively. In the ensuing 2 years, the mast crop failed, and acorns were absent or insignificant in the diet. Soybean consumption increased markedly in 1968, but less so in 1969. The amount of corn consumed by quail was also variable between years, ranging from less than 1 percent to more than 14 percent, and may have substituted partly for the reduced acorn crop in 1968 and 1969.

Despite these sometimes pronounced between-year variations, the pattern of food selection during winter seems clear. When other select foods are absent or less available, bobwhites adjust their diet by increasing their consumption of soybeans and to a lesser extent, corn.

Spring. The approach of warm weather in March heralded some pronounced changes in the bobwhite's choice of food. Most noticeable was an increase in the proportion of the diet comprised of animals. Animals constituted less than 2 percent of their winter foods, increasing to more than 16 percent in spring (Table 2). The birds also began browsing on green leafy vegetation as it appeared in their habitat, and consumed significant amounts of early spring-seeding wildflowers such as woodsorrel (**Oxalis stricta**) (6.8 percent) and violets (**Viola** sp.) (6.1 percent).

Despite the trend toward a more varied diet, soybeans remained the most heavily-used food item (39.9 percent). Certain varieties of soybeans used on Ames Plantation retain some of their seeds into late spring unless harvested, and some seeds shed early remain palatable for months after falling to the ground. This continued availability was reflected in the significance of soybeans to quail until late spring. The abundance of this highly-nutritious food during the critical late winter-early spring period may be the single factor most responsible for maintaining the dense quail population on the study area.

Summer. Variety is the spice of life for quail during the months of June through September. The highly-varied diet exhibited during this period (105 different food items) probably resulted from two factors: (1) summer is the time of greatest variety of available foods; and (2) many young individuals are present in the population. The diet of these smaller individuals differs markedly from that of mature birds, as will be illustrated in a later section of this report.

The use of animals reached its highest point during summer, as 30.5 percent of all foods eaten were this general type (Table 2). Grasshoppers ranked first during this period, the only season when an animal was the most important item. Other important quail foods were Johnsongrass (9.1 percent), browntop millet (7.7 percent), and soybeans (6.2 percent). The use of soybeans during

summer was probably restricted to seeds spilled or not covered by soil during planting. As soybeans were planted as late as July, some were available until mid-summer. Certain other food items, particularly Johnsongrass and many insects, were also abundant in the growing soybean fields. Quail of all ages used these fields heavily, and their diet reflected the types of foods commonly associated with row-crop agriculture in the mid-South. The heavy use of browntop millet began in early September, as this early-ripening grass matured. This species was one of several foods planted expressly for quail in a few restricted locations on the study area. It produced copious amounts of seed which were small enough to be readily consumed by small to middle-sized young quail. Browntop millet was used during both summer and fall, but its peak use by quail was during the transition period from summer to fall when their diet was shifting toward one dominated by weed and agricultural seeds.

Autumn. During the months of October and November, quail once again shifted their attention to the increasingly abundant products of the harvest, i.e., crop seeds and associated weeds. Soybeans assumed their role as the mainstay of the diet, comprising 53.2 percent of the foods eaten, and appearing in 71.0 percent of the crops (Table 2). Grasshoppers remained important until frosts caused their disappearance from the habitat. Browntop millet, cowpeas, common ragweed, and corn all ranked high in the diet.

SEX-RELATED FEEDING PATTERNS

The diet of adult quail during summer showed certain quantitative differences between males and females (Table 3). These differences were not apparent during other seasons, thus are assumed to reflect differences in the physiological needs of the two sexes, and to a lesser extent, differences in the daily activity patterns associated with their sexual roles during the breeding season. The most pronounced difference was the variance in the proportion of animal foods consumed; this class of food constituted 36.2 percent of the female's diet, and only 19.9 percent of the diet of males.

Nestler et al. (1944) and Nestler (1949) concluded that the physiological requirements of female quail during the nesting

Table 3. Important foods of adult bobwhites during summer, Ames Plantation, 1967-68.

Food Items	Percent of Volume		
	Female (43)[a]	Male (81)	Total (124)
PLANT FOODS			
Johnsongrass	6.78	9.87	8.44
Soybeans	5.68	8.27	7.07
Browntop millet	7.33	6.21	6.70
Wheat	5.92	6.51	6.23
Corn	6.69	5.60	6.08
Black cherry	1.14	9.49	5.77
Cowpeas	4.01	5.14	4.61
Buckwheat	6.19	2.25	4.03
Smooth crabgrass	3.23	4.30	3.81
Sassafras	3.37	3.58	3.48
Blackberry	2.32	2.86	2.61
Bull paspalum		2.21	1.20
Sedge	0.27	1.90	1.16
Woodsorrel	1.59	0.80	1.16
White-haired panicum		2.10	1.14
Acorn	1.59	0.42	0.95
Kidney-bean	1.50		0.68
Other plant foods	6.19	8.58	7.51
SUB-TOTAL	63.80	80.09	72.63
ANIMAL FOODS			
Grasshoppers	11.25	6.78	8.83
Beetles	7.74	3.96	5.67
Insect larvae	2.41	3.24	2.85
Ants	3.78	1.26	2.40
Snails	4.69	0.23	2.25
True bugs	1.27	2.93	2.17
Bugs	2.69	0.53	1.51
Spiders	1.46	0.23	0.79
Other animal foods	0.55	0.75	0.90
SUB-TOTAL	36.20	19.91	27.37
TOTAL	100.00	100.00	100.00

[a] Sample size.

season demand a much greater intake of high protein foods than males. Rosene (1969: 108) noted that wild bobwhites seem to regulate their diet to include as many insects as needed to maintain higher summer protein requirements, and Nice (1910) estimated that female bobwhites consumed more insects than males. Nestler et al. (1944) also noted that as the proportion of crude protein in the diet increased, the total amount of food eaten likewise increased.

We observed that the crops of females contained roughly 60 percent more food (5.1 cc vs. 3.2 cc) than the crops of males. While the food present in a bird's crop at any single moment is not truly indicative of its total daily intake, these data suggest that during the breeding seasons females consumed both more animal food and a greater total amount of food than males. It is likely that these discrepancies relate to the female's greater needs for protein associated with egglaying rather than differences in energy requirements. Case (1972) suggested that the energy requirement for egg-laying was not judged to impose a physical strain on female bobwhites.

One minor, but interesting, variance in the diet was the male's greater use of wild black cherry (**Prunus serotina**) (9.5 percent vs 1.1 percent for females). Black cherry trees, with their open crowns, seemed to be favored as calling perches for males. Their frequent habitation of these trees was obviously reflected in the importance of the pulpy fruit in their diet.

FOOD SELECTION BY JUVENILE BOBWHITES

The first few weeks in the life of a bobwhite are probably the most hazardous (excluding, perhaps, the opening day of hunting season)! The small size and fragile constitution of the downy chicks make them particularly susceptible to a multitude of accidents, predators, and vagaries of weather. Starvation may or may not be a major cause of death; documenting the causes of mortality of juvenile birds is difficult. Nevertheless, food gathering is a highly important activity for young precocial birds, and is fraught with a variety of hazards. It seems logical that habitat which is highly productive of foods acceptable to young quail will enhance their survival by reducing the time and effort necessary for feeding. Thus, understanding the dietary needs of young quail is imperative for efficient management of the species.

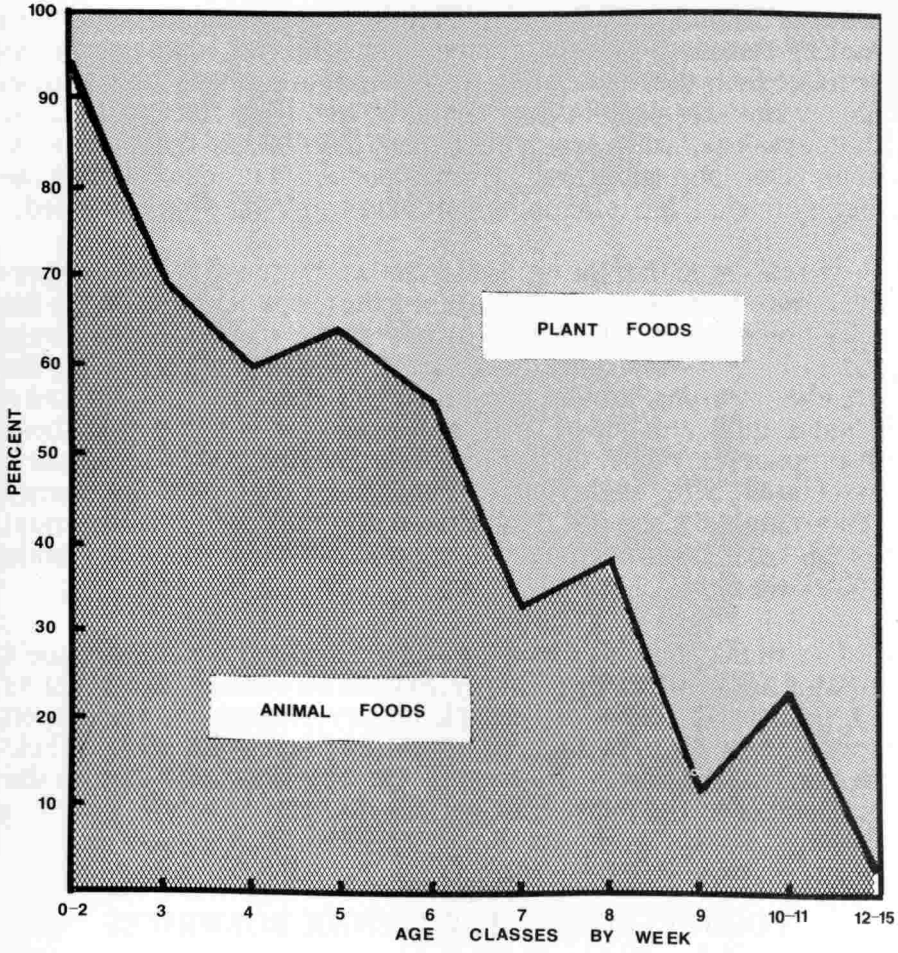

Figure 2

Relative proportions of animal and plant foods consumed by different age-classes of juvenile bobwhites.

A total of 110 juvenile birds, ranging in age from less than 1 to 15 weeks, were collected during the two summer seasons (Table 4). These birds were classified into ten sub-groups to detect trends in the diet accompanying growth from hatching to somatic maturity (Figure 2).

During the first 2 weeks of life, animal foods dominated the diet, comprising 94.1 percent of all foods eaten. Beetles, bugs, and grass-

Table 4. Important foods of juvenile bobwhites during summer, Ames Plantation, 1967-68.

Food Items	Percent of Volume 1967 (63)[a]	1968 (47)	Total (110)
PLANT FOODS			
Sassafras	17.23	6.20	11.84
Johnsongrass	0.97	20.28	10.40
Browntop millet	10.95	8.52	9.77
Corn	7.69	3.89	5.83
Soybeans		8.80	4.30
Wheat	2.91	4.91	3.89
Fall panicum	1.50	2.78	2.13
Cowpeas		3.79	1.85
Acorns	3.44		1.76
Lindheimer panicum	1.86	1.02	1.45
Black cherry	0.97	1.20	1.09
Smooth crabgrass	1.59	0.56	1.09
Milo	2.03		1.04
Smooth sumac		1.67	0.81
Common lespedeza	1.32		0.68
Other plant foods	5.32	3.67	4.43
SUB-TOTAL	57.78	67.29	62.36
ANIMAL FOODS			
Grasshoppers	9.45	12.13	10.76
Insect larvae	6.80	3.43	5.15
Beetles	5.65	4.35	5.02
Bugs	6.18	2.50	4.39
Spiders	6.71	1.67	4.25
Ants	2.03	3.52	2.76
True bugs	2.03	2.69	2.35
Snails	2.21	1.39	1.81
Other animal foods	2.03	1.57	1.81
SUB-TOTAL	42.22	32.71	37.64
TOTAL	100.00	100.00	100.00

[a] Sample size.

hoppers were particularly heavily utilized. The use of animals remained high but declined slowly through the eighth week of life, at which time the relative proportions of animals and plants compared closely with that of adult females during summer. At 9 weeks of age, quail crops contained an average volume of food comparable to that of adults. Thus, we conclude that young quail assume feeding habits similar to those of adults roughly between the ages of 7 and 9 weeks. Handley (1931: 161-62) stated that the characteristic high animal diet of young birds changed to the vegetable diet of adults during the third week of life. Examination of his data, however, suggests otherwise. Animal foods consumed during summer by adults which he examined contributed 13.9 to 23.3 percent of the diet, but the diet of 3-4 week old juveniles contained 39 percent animal matter. Our interpretation of his data is that the diet of juveniles was similar to adults at approximately 8 weeks rather than 3 weeks.

Important plant foods consumed by juvenile quail during summer included sassafras, Johnsongrass, browntop millet, corn, soybeans, and wheat (Table 4). Generally, smaller seeds such as browntop millet and Johnsongrass were more heavily used by intermediate-sized birds and larger seeds such as sassafras, soybeans, and corn were used by older, larger birds. The only seeds eaten by quail younger than 3 weeks were panic grasses (**Panicum** sp.).

THE IMPACT OF FOOD PLOTS ON DIET

Fenced food plots for quail were established at 16 locations on the study area. These plots were concentrated in pasture areas where row crops such as corn and soybeans were absent. A total of 53 acres was enclosed in these plots, but only about 60 percent of the acreage was planted; the remaining areas provided permanent woody and herbaceous cover close to the food source. The planted foods comprised approximately 0.7 percent of the study area. "Indicator" species (those planted only in fenced food plots) were browntop millet, buckwheat, German millet, and milo. Soybeans and cowpeas were also planted in fenced food plots; however, they were planted elsewhere on the study area and could not be used to determine the specific feeding sites of quail collected during this study.

The contents of crops from 443 quail were examined to evaluate the impact of food plots on the feeding patterns of the population.

Distance from the collection site to the nearest food plot was determined with the aid of aerial photographs.

Of those birds shot 50 yards or less from a fenced food plot, 71 percent had fed there. Twenty-five percent of the quail collected 51 to 300 yards distant contained "indicator" foods, and slightly less than 4 percent of those shot at distances ranging from 301 to 1,300 yards had fed in the fenced plots. Birds killed at distances greater than 1,300 yards from the plots had not utilized food from these plots. Thus, birds which "lived" within 50 yards of a food plot were strongly influenced in their diet by foods planted therein, bobwhites living within 300 yards were moderately influenced, and quail living beyond 300 yards were virtually independent of the food plots for their livelihood. During the winter season, no quail collected at distances greater than 200 yards contained food items that could be definitely identified as coming from the food plots. Robel (1969) reported similar relationships to food plots for bobwhites in Kansas: 69 percent of the birds collected within 300 meters of a food plot had fed there. The spatial relationships delineated here reflect what is known about home range dimensions and mobility of bobwhites during winter on Ames Plantation. It appears evident that when a bird's home range encompasses a food plot, the ample food supply available there will provide a substantial proportion of its sustenance. On the other hand, quail with centers of activity more than a quarter-mile away from the food plots will not make uncharacteristically long daily journeys to feed there.

IMPLICATIONS FOR MANAGEMENT

The adequacy of its basic food resource is often the factor which determines the abundance and welfare of an animal population. Intra- and interspecific competition for food likely is particularly severe for a species such as the bobwhite, which feeds largely upon the seeds of agricultural crops and weeds. Thus, understanding the dietary patterns and needs of bobwhites becomes prerequisite to implementing a satisfactory management program for the species. Gullion (1966) has succinctly criticized the failures of most food habits studies to provide certain necessary information, emphasizing their tendency to utilize birds collected only during the autumn hunts (the least critical time of year for the population), their short-term duration, and their failure to relate food habits to the status of the population. What is needed, he says, are studies that critically sample local bird populations during times of stress,

and that provide some insight into the relationship between food habits and density of the population. We "held these truths to be self-evident," designed our study accordingly, and offer several observations which may enable interested land-owners and managers to enhance their lands for quail.

AGRICULTURAL PRACTICES

Agriculture was the dominant land-use practice on our study area, and was the source of most of the food eaten by quail. The type of agriculture practiced, primarily row-crop production, is highly compatible with quail management where adequate cover is available. Soybeans were the most significant food used by quail, and where this crop is grown quail populations usually will prosper. In the mid-South, a major deviation from this compatible relationship between quail and soybeans occurs where field size is very large and woody cover is absent. This situation obtains largely in rich bottomlands along the Mississippi River and its major tributaries. The high economic potential of these lands is obvious, and diverting acres specifically to quail management is generally not feasible. In most other circumstances, however—where crops such as soybeans, corn or wheat are grown—quail populations adequate for high-quality hunting can be maintained with little additional diversion of time, land, or money.

The key to managing the food supply for bobwhites in these agricultural situations is preserving an appropriate distribution of adequate cover in relation to the food source. On our study area, roughly 60 percent of the land was in forests, idle land, or other types of non-agricultural use. This distribution of cover types produced excellent quail populations, but the amount of land not in crop production is greater than on most farm land in the region. However, on certain sub-units of our study area row-crops, including soybeans, cotton, and corn, comprised as much as 70 to 80 percent of the total. Quail densities on these units were among the highest on the study area during all seasons, clearly illustrating that moderately-intensive agriculture is not detrimental to high quail populations. Where quail are a desired product of the farm, the farm management plan should include the provisions briefly described below.

1. Field size - Crop fields 10 to 50 acres are common in the mid-South agricultural areas. Fields within this range are not exces-

sively large for quail management, particularly if their shapes are irregular or linear, and if appropriate cover strips separate them from adjacent fields (Figures 3 and 4). Smaller fields in-

Figure 3

Large soybean fields with irregular shapes bordered by good cover provide excellent feeding areas for bobwhites, yet can be planted, cultivated, and harvested efficiently with modern equipment.

Figure 4

Wide weedy cover strips between soybean field and woods improve the habitat by increasing diversity of cover types used by quail.

crease the proportion of "edge" in the habitat, however, and will usually result in higher quail densities (Figure 5). Total amount of edge is less important than the amount of suitable protective cover adjacent to attractive feeding areas.

2. Crop selection - The type of crops grown on any farm must necessarily reflect soil types and prevailing economic necessities. However, within the farm management plan, certain options may exist concerning the distribution of crops on the farm. Where possible, food-producing crops such as soybeans, wheat, and corn to be harvested as grain should be placed in fields bordered by good natural cover units. Crops such as cotton (and corn or sorghum to be harvested as silage) should be relegated to those areas where natural cover is deficient (Figure 6).
3. Maintenance of cover - In the mid-South, the most favorable protective cover for bobwhites is naturally-occurring vegetation which develops on undisturbed sites (Figure 7). Woody cover, ranging from brush to mature hardwoods, is particularly important, and is enhanced when invaded by patches of honeysuckle. This cover need not be planted, but areas where it is desired must be protected from mowing and excessive grazing. Occasional burning under controlled conditions will not be detrimental, but may be undesirable where hardwood forests are being managed for timber production.

Figure 5

Remnant of small share-cropper cabin and associated small, weedy clearing and soybean field.

Figure 6

Mechanized farming has resulted in an increase in the proportion of land in large, cleanly-cultivated fields such as this 100-acre cotton field.

Figure 7

Weedy or brushy cover will develop naturally and rapidly on undisturbed field borders.

4. Use of pesticides - Fields containing intertilled row crops are quite attractive places to young broods. Their attractiveness is a function of the openness of the cover at ground level, permitting

easy movement of small chicks, and the abundant supply of insects present in the lush-growing vegetation. Any environmental management designed to reduce the abundance of insects, such as applying insecticides, is likely to reduce the value of these areas as feeding grounds for young chicks. Use of insecticides thus should be as judicious as possible.

SPECIAL FOOD PLANTINGS

Where prevailing land use practices do not provide an abundance of food for bobwhites, the land-owner desiring to have them in sufficient numbers for hunting may provide this necessary component of their habitat by specialized planting. Agricultural systems in which livestock production is the dominant practice often are in this category (Figure 8). These plantings should utilize foods known to be attractive to quail in that region, and which will be available through the critical late winter period of food shortage. Two general types of food may be used: (1) annuals, such as soybeans and millet, which must be planted each year; and (2) perennials such as the lespedezas, which require a minimum of management after initial establishment.

Annual food plots utilizing soybeans and browntop millet or Japanese millet are particularly productive of seeds (Figure 9). Equally significant, the food plots are excellent feeding areas for

Figure 8

Pastured areas with adjacent woodlands may have adequate protective cover, but lack suitable feeding areas for bobwhites.

Figure 9

Long food strips adjacent to woods provide excellent feeding areas for quail. They will need to be adequately protected from livestock by fencing.

young chicks. Browntop millet constitutes an early fall source of nutritious foods for coveys, and the soybeans provide a source of nutritious foods from mid-autumn through the critical late winter period. The cost of planting these plots is similar to that of planting the species for agricultural production; they need not receive similar weed and insect control, however, thus reducing the total cost of maintaining them. When food plots are established in areas grazed by livestock, fencing will be an added cost. The size of these plots may range from ¼ to 1 acre or more (Figure 10). Placing them adjacent to good protective cover is essential, and where possible the food plots and coverts should be part of a system of travel lanes and protective cover.

Certain species of lespedeza, e.g. Korean, common, Kobe, and bicolor, are perennial plants or reseed themselves without aid beyond initial establishment. These plants, though not significant in the diet of quail on our study area, are the mainstay of quail in other places. Cady (1944) described their value to bobwhites in eastern Tennessee on recently-abandoned farmland. McConnell (1965) found bicolor lespedeza in great quantities in the crops of quail from Alabama, and Larimer (1960) reported Korean and Japanese lespedezas to rank third of the foods eaten by bobwhites in winter in southern Illinois. They were the most important winter food of quail in Missouri (Korschgen 1948). Most of these species and varieties can be established at relatively low cost by broadcasting with a

Figure 10

Special food planting in odd corners as small as 1/8 acre add greatly to the habitat for young quail in summer, and adult birds throughout the year.

cyclone seeder around recently-disked field borders. The specific variety chosen should be determined by local soil and climate conditions. However, one species, sericea lespedeza (**Lespedeza cuneata**) is not a good quail food, and should not be included in a quail management scheme. Some of the herbaceous lespedezas can be grazed without reducing their value as seed producers, thus can be utilized in a livestock system without detriment to quail.

CONTROLLED BURNING

The use of fire for enhancing the production of quail foods has received a great deal of attention in the southeastern United States (Figure 11). Its widely-publicized feature of increasing the proportion of legumes in the habitat is well-documented. It has some impact on the production of insects also, a factor of much importance for the nutritional welfare of young bobwhite chicks (Hurst 1972). In addition to altering the species composition of a plant community, controlled burning alters its structure as well, reducing the accumulation of litter and creating a much greater proportion of exposed mineral soil. This feature enables the young quail to move freely through the fields, facilitating their persistent feeding forays. It is relatively inexpensive, costing roughly $0.75 per acre or less.

Where the prevailing land use is the production of cash grain crops, this technique will have less impact on quail dietary patterns

Figure 11

Controlled burning, when properly done, is a valuable tool for maintaining and improving cover and food for bobwhites in the South.

than in areas where wild lands predominate. On our study area, for example, burning in idle areas often resulted in nearly pure stands of partridge pea, a plant often used heavily in the deep South. It was little used on our area by quail, probably due to the great abundance of soybeans in adjacent fields. Where agriculture is not practiced, controlled burning may well be the most significant and practical technique available to the land-owner for improving the food supplies of bobwhites. Its importance as a management tool increases as one moves south in the range of the quail.

When burning is to be used, it should be done in late winter (January, February, or early March). Until the land manager becomes familiar with the technique, he should request the advice and services of a qualified forester. Controlled burning is an art, and its effects vary widely depending upon many factors such as wind, moisture, and fuel abundance and condition.

In conclusion, we would emphasize that there exist no secret or magical formulas for managing bobwhites in the mid-South. Given ample food and properly-distributed cover, quail in this region will produce prolifically. Their most critical needs are outlined in this report, i.e., late winter food supply for adults and appropriate foods and feeding areas for young chicks during summer. If these needs are met, a quail management program can scarcely fail; without this, it cannot succeed.

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Appendix A. Scientific names of plant foods eaten by bobwhites, arranged alphabetically by Family.

Scientific Name	Common Name
Anacardiacea	
Rhus glabra	smooth sumac
Compositae	
Ambrosia artemisiifolia	common ragweed
Serinea oppositifolia	serinea
Cyperaceae	
Carex sp.	sedges
Cyperus sp.	flat sedges
Fagaceae	
Quercus sp.	oaks (acorns)
Geraniaceae	
Geranium carolinianum	Carolina geranium
Gramineae	
Digitaria ischaemum	smooth crabgrass
Panicum dichotomiflorum	fall panicum
P. fasciculatum	browntop millet
P. lindheimeri	Lindheimer panicum
P. villosissimum	white-haired panicum
Paspalum boscianum	bull paspalum
Sorghum halepense	Johnsongrass
Sorghum vulgare	milo
Triticum aestivum	wheat
Zea mays	corn
Hamamelidaceae	
Liquidambar styraciflua	sweet gum
Lauraceae	
Sassafras albidum	sassafras

continued

Scientific Name	Common Name
Leguminoseae	
Cassia fasciculata	partridge pea
Glycine max	soybeans
Lespedeza bicolor	bicolor lespedeza
L. cuneata	sericea
L. procumbens	trailing lespedeza
L. striata	common lespedeza
Phaseolus vulgaris	kidney bean
Vigna sinensis	cowpea
Oxalidaceae	
Oxalis stricta	woodsorrel
Polygonaceae	
Fagopyrum esculentum	buckwheat
Rosaceae	
Prunus serotina	black cherry
Rubus sp.	blackberry
Violaceae	
Viola sp.	violet

Appendix B. Major taxons of animals represented in the diet of bobwhites.

Taxon	Common Name
Arachnida	
Araneae	spiders
Gastropoda	
Endodontidae	snails
Helicellidae	
Philomycidae	
Polygyridae	
Pupillidae	
Succineidae	
Zonitidae	
Philomycidae	slugs
Insecta	
Coleoptera	beetles
Hemiptera	true bugs
Homoptera	bugs
Hymenoptera (Formicidae)	ants
Orthoptera	grasshoppers

(3M/1-75)