WINTER FOOD-HABITS OF THE BOBWHITE QUAIL (*COLINUS VIRGINIANUS*) ON THE GENE HOWE WILDLIFE MANAGEMENT AREA, HEMPHILL COUNTY, TEXAS, DECEMBER 1955 AND JANUARY 1956

By

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INTRODUCTION

Successful, efficient and economical management of a game species is dependent upon a practicable working knowledge of its ecology. One important phase of animal ecology is the study of food habits; therefore an understanding of this phase is necessary for successful management. Bobwhite quail (Colinus virginianus) food habits have been studied throughout most of its range (Judd, 1905; Stoddard, 1931; Martin, 1935; Lehman, 1937; Errington, 1939; Davison, 1940, 1942; Baumgartner, 1946; Korschgen, 1948; Lee, 1948; Wagner, 1949; Jackson, 1951; Baumgartner et al., 1952; Hanson, 1953; Parmalee, 1953, 1955; Hood, 1955; Laessle and Frye, 1956; Robinson, 1957). However, data are not available for the region within which the Gene Howe Wildlife Management Area is located.

The study of bobwhite foods reported here was initiated as part of a broad, long-range project concerned with the relationships between wildlife, rodents, cattle and range, and the development of sound, practical wildlife management compatible with good land-use practices.

The objectives of the study were: (1) to ascertain the principal winter foods of the bobwhite, (2) to correlate the winter use of seeds with their availability, and (3) to establish a starting point for determining trends in food use by bobwhite on this area.

The relationship between availability of foods and actual food use by game birds is little known or understood. Few investigators have

attempted to gain information on this relationship. Most attempts have been casual observations of the animal's habitat. Glading, Biswell and Smith's (1940) study of the foods of California quail was one of the first attempts to correlate availability and utilization of wildlife foods. Both plants and seeds available on the ground were measured by these investigators. More recent studies of availability and utilization of game bird foods are those by Bookhout (1954) on availability of foods for bobwhite quail in several habitat types in Illinois, and by Hungerford (1957), who sampled the availability of ruffed grouse foods on an area in Idaho.

The data concerning seed availability gathered by Mr. Jack Inglis, when compared with the crop analyses, provide information about food selection by the bobwhite quail in general and, more specifically, in the region of the study.

The crops analyzed in this study were collected on the Howe Area during the 1955-56 hunting season by personnel of the Texas Game and Fish Commission. The analysis was initiated during the summer of 1956 while the writer was employed by the Texas Game and Fish Commission, and was completed during the fall of 1956 at Oklahoma State University.

METHODS OF INVESTIGATION

The quail crops used were collected from the hunters' bag by personnel of the Texas Game and Fish Commission during four public hunts (December 3, and 17, 1955, and January 1, and 14, 1956). The management area was divided into ten blocks to distribute hunting more evenly and to insure accuracy of the food-habits' investigation in regard to information on type of habitat and seed availability. Crop analysis was completed and data summarized for each of the ten hunt blocks, but due to study limitations only the overall summary (composite of the ten blocks) and the four blocks needed for comparison with seed availability information are presented.

Technicians prepared the crops for future analysis by (1) placing each in a muslin bag; (2) tagging with information telling sex, age, date killed, and block (where killed); and (3) preserving in a formalin solution.

Each crop was individually separated in the following manner: (1) removed from the formalin and air dried, (2) opened and the contents placed in a standard set of soil screens for initial separation, and (3) the contents of each screen were placed in a white enamel pan where the final separation was completed. The tedious job of final separation was appreciably hastened by the use of a miniature vacuum cleaner. The cleaner was a simple apparatus involving a small wide-mouth bottle, a rubber hose, assorted sizes of glass nozzles, and a source of vacuum.

Where possible, the seed portions of the crops were identified to species. Identification was made possible by extensive aid given the writer by the wildlife area personnel and by the use of their seed collection and herbarium. Dr. A. C. Martin of the Patuxent Research Refuge identified many of the unknown items. The scientific nomenclature of the plant food items and range vegetation were taken from Gray's Manual of Botany (Fernald, 1950). No attempt was made to identify the green vegetation (leaves, stems, etc.) or animal portions in the crops and they were listed only as such. Grit and soil were excluded from the analyses as suggested by Martin (1949).

After separation, each food component from each crop was volumetrically measured, weighed, counted and the data recorded on 3 x 5 cards bearing crop number, date killed, block and age information. The volumetric measurement was obtained by liquid displacement using an apparatus designed by Mr. Jack Inglis, Biologist, Texas Agricultural Experiment Station, and the writer (Inglis and Barstow, 1960). The significant difference between this method and other liquid displacement techniques is that a correction can be made for absorption of the liquid medium by the material which is measured. Since the method was rather tedious and time consuming, a mathematical index was computed by averaging the volumes obtained from a large sample of seeds of each species represented in the analysis. Thus the volumes of the food items then could be rapidly figured mathematically for the remaining crops.

Volumes were measured to 0.1 cubic centimeter, with lesser items listed as traces. The food items were weighed to the nearest milligram on a chain-O-matic balance. Weights were recorded in order to have a

direct method of comparing the food-habits data with the information of seed availability which was computed by weight and frequency per acre.

Per cent volume (per cent of aggregate volume), per cent occurrence (per cent of number of crops in which the food items occurred), per cent weight (per cent of aggregate weight), and an index involving the volume and occurrence factors were determined for each of the food items and are presented in tabular form.

The validity of the size of the sample available for the study was tested through the use of methods presented by Hanson and Graybill (1956). The results of the test indicated that the analyzed sample of 411 crops was approximately 3 per cent in excess of the suggested minimum sample size of 400 at the 95 per cent confidence level and within 5 per cent permissable deviation.

A brief resume of the test is as follows: $N = \frac{4p\ (100-p)}{d^2}$. Where N equals sample size, d equals permissible deviation from true value of p, and p equals the proportion of the animals of a population which eat the major foods. "The material which comes nearest to being eaten by 50 per cent of the animals will require the largest sample. Therefore, the major food which has p most nearly approaching 50 per cent can set the minimum sample size for all major foods." The food in this study most nearly approaching this value (50 per cent) is Amaranthus retroflexus (50.12 per cent occurrence).

$$N = \frac{4p\ (100-p)}{d^2}$$

$$N = \frac{4\ (50.12)\ (100-50.12)}{5^2}$$

$$N = \frac{(200.48)\ (49.88)}{25}$$

$N = 399.99$ or 400 crops (minimum sample size)

DESCRIPTION OF STUDY AREA

Location

The 6,000-acre Gene Howe Wildlife Management Area is located on the north side of the Canadian River, in Hemphill County, in the northeast corner of the Texas Panhandle. This area is operated by the Texas Game and Fish Commission for public hunting, wildlife research, and demonstration purposes.

Climate

The climate of the Texas Panhandle and particularly Hemphill County is classified by the United States Weather Bureau as continental. Throughout the region, the length of the frost-free period is approximately 201 days. Temperature averages for the Canadian, Texas station are: January, 36.4 degrees; July, 81.3 degrees; annual minimum, 14 degrees; and annual maximum, 112 degrees (United States Department of Agriculture, 1941).

According to Jackson (1955) the rainfall for 1955 on the Howe Area was 13.82 inches (area rain gauge), a drop of 7.21 inches from the norm of 21.03 inches (31-year average, Canadian, Texas, weather station). This decrease in moisture followed a pattern of several successive years of below normal precipitation. Heavy snows which furnish an important amount of the annual moisture had been lacking for several winters. The

prolonged drouth had serious effects upon both the physical and biotic components of the area, and is, therefore, mentioned repeatedly throughout the report.

Physiography

The dominant physiographical characteristic of the area is the sand hills. These rolling deposits of sand are found along the north side of the main streams which flow in a southeasterly direction and are the result of the prevailing southerly winds blowing across the sandy rivers. The predominating sand hills of the Howe Area can be sub-divided into six rather distinct physiographic types: (1) creek bench situation, (2) roughlands of stabilized dunes, (3) rolling dune situation on the level terrain above the slope of the river valley. (4) an area of level terrain just above the valley slope that has scattered dunes, (5) the steep eroded slope from the upland to the river terraces, and (6) river bench (the old terraces) just above the bottomland. In addition to the sandy lands mentioned above, a small margin of bottomland which lies in the river flood plain is an important part of the area. These physical types are illustrated in Figure 1.

The soils of the area are predominately of deep sand, therefore water penetrates readily and there is little runoff. Wind erosion is often severe. Because of these factors, the soil is not suitable for cultivation; however, the vegetation on the sand hills can furnish excellent forage for grazing animals. Cattle ranching is, therefore, the main land-use industry of the region.

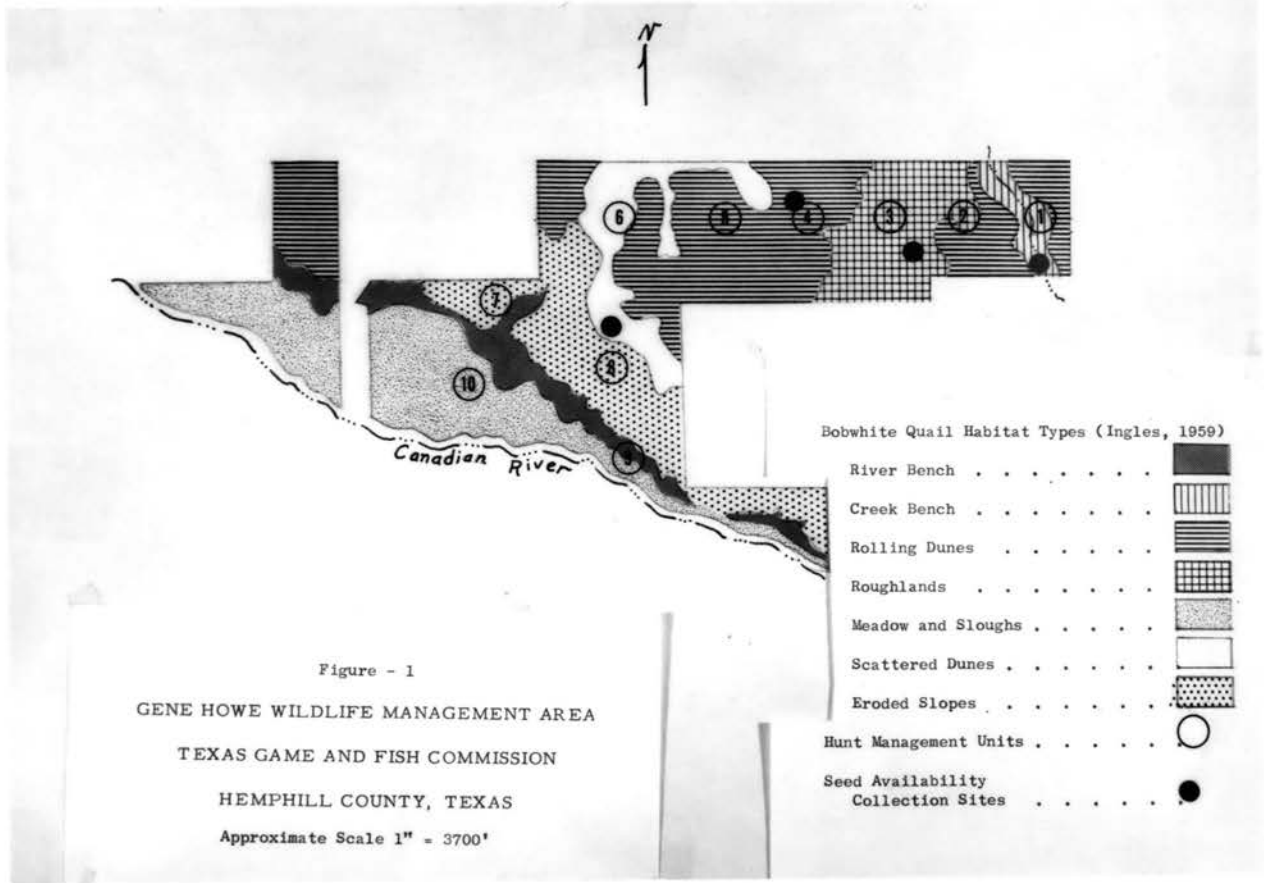

Figure - 1

GENE HOWE WILDLIFE MANAGEMENT AREA

TEXAS GAME AND FISH COMMISSION

HEMPHILL COUNTY, TEXAS

Approximate Scale 1" = 3700'

Vegetation

Weaver and Albertson (1956) have characterized the vegetation of the sand hills as the bunch-grass type, and originally of tall, mid and some short grasses. However, after years of abuse, primarily severe overgrazing and prolonged drouth, the original and more palatable grasses and forbs are relatively sparse and have been replaced by increaser type species of grasses, forbs and brush. The range has improved little even with ten years of no grazing. Sandsage (Artemesia filifolia) and sand dropseed (Sporobolus cryptandrus) were the dominant species on the Howe Area (Jackson, 1955).

The dominating sandsage gives the area a rather monotonous and barren aspect, however, stools of tall grasses, predominately sand bluestem (Andropogon hallii) and giant sand reed (Calamovilfa gigantea), and small motts of woody species, primarily Chickasaw plum (Prunus angustifolia) and sumacs (Rhus aromatica and Rhus glabra), are found scattered with varying abundance over the area. Russian thistle (Salsola pestifer) of considerable importance as wildlife food and cover is found distributed over the range, especially in the depressions and lower elevations along the river bench. Cottonwood (Populus spp.), hackberry (Celtis reticulata), elm (Ulmus pumila), and black locust (Robinia Pseudo-Acacia) are common trees found along the river and creek drainages. The small margin of rich bottomland is sub-irrigated and produces a rather luxuriant growth of grasses, predominately switch grass (Panicum virgatum), Indian grass (Sorghastrum nutans) and bluestems (Andropogon spp.).

The area's landscape presents a generally barren aspect which is rather misleading as 276 plant species representing 64 families have been collected and identified on the Howe Area (Rowell, 1955). This list is not regarded as being complete. Owing to the number of important food species and the distribution and abundance of brushy cover (Chickasaw plum, sumac, sage, and Russian thistle), the sand hills have a relatively high carrying capacity for bobwhite quail. The more than 60 plant species used as food by quail as found in this study (Table II) indicates further the quality of this quail habitat. Baumgartner et al. (1952) noted that the sandy lands of western Oklahoma (similar to those of the study area) consistently produced the best quail hunting in that state.

There are seven rather generalized bobwhite quail habitat types on the Gene Howe Area which conform to the physiographic divisions recognized above. These, to a degree, differ in vegetative cover. The most apparent and important characteristic differentiating these types is the distribution and abundance of woody cover. A detailed analysis of these types is presented by Inglis (1959). Brief descriptions taken from his publication are presented in Table I.

TABLE I

QUAIL HABITAT TYPES ON THE CHEE HONE WILDLIFE MANAGEMENT AREA, COVER QUALITY, FOOD SUPPLY DYNAMICS AND QUAIL POPULATION CHARACTERISTICS (INGLIS, 1959)

Type	Cover Quality	Food Supply Dynamics	Quail Population Dynamics
Creek Bench	generally good; ground cover not well developed	moderately productive; some variation due to climatic fluctuations	stable, fairly high; some annual variation
Roughlands	excellent shrubby cover (plum and skunk-bush thickets) ground cover highly variable due to xeric site	high to low; production depending on annual climatic extremes on xeric site	highly dynamic; high to very low depending on variations of food and cover and effective reproductive potential of population
Rolling Dunes	scattered plum and skunkbush thickets, large clumps of sage; ground cover variable as to season	productive to fairly so; variable due to climatic extremes and xeric site	dynamic; high to low depending on annual (secondary) variations in food and cover and effective reproductive potential of population
Scattered Dunes	shrubby coverts scattered, sage low though widely distributed; ground cover poorly developed, variable due to annual climatic variations	moderate to low production, depending upon annual climatic variations on xeric site	dynamic; moderately high in best years to very low in worst years due to variations in food and cover and effective reproduction potential of population

TABLE I (Continued)

Type	Cover Quality	Food Supply Dynamics	Quail Population Dynamics
Eroded Slopes	little shrubby cover, sage common but low and ineffective; ground cover poorly developed	moderate to low depending upon annual climatic variations on xeric site	low; some coveys found in draws where cover and food supplies are more abundant
River Bench	generally good; shrubby with good ground cover	productive; some variation due to climatic extremes	stable, high; some annual variation
Meadows and Sloughs	coverts scattered (sloughs and tree rows) ground cover often too dense, variable due to annual mowing	fairly high to low production depending upon grass competition and whether mowed; good around sloughs locally dependable due to subirrigation	stable; moderately low except around coverts

RESULTS

Results of the analysis of 411 bobwhite quail crops collected on the Gene Howe Wildlife Management Area during December, 1955, and January, 1956, are presented in Tables II, III, and IV. A total of 72 different food items were identified, however, only 10 items constituted 1.0 per cent or more of the gross volume. Foods of vegetable origin constituted 98.9 per cent by volume of the total diet. Of this percentage, 38 per cent were annuals, 41 per cent were perennials, 17 per cent were annual or perennials, and 3 per cent were annual or biennial plants. The plant portion of the diet was represented by 28 families and 69 genera or species, or approximately 25 per cent of the known flora of the Howe Area. Seeds and fruits, primarily the former, made up 94.7 per cent by volume of the total diet, and greens 2.3 per cent. Animal matter composed 1.1 per cent of the foods eaten. Inorganic material, in most cases very fine sand, comprised 1.9 per cent by volume of the total. The first 11 foods, ranked by index number, made up approximately 90 per cent by volume of the total foods eaten. These foods, in order of their importance, are; Texas Croton (Croton texensis), stickleaf Mentzelia (Mentzelia stricta), erect dayflower (Commelina erecta), glandular Croton (Croton glandulosus), greens, western ragweed (Ambrosia psilostachya), redroot Amaranth (Amaranthus retroflexus), sixangle Euphorbia (Euphorbia hexagona), animal matter, fringeleaf Paspalum (Paspalum ciliatifolium), and Russian thistle (Salsola pestifer). Texas Croton was by far the most important food.

DISCUSSION

It is evident from the data presented in Table II that the bobwhite of the Howe Area, as in most parts of its geographic range, fed upon a rather large variety of foods, and further, that only a small number of foods comprised the bulk of the diet. Because of the limited scope of the study and the rapidly changing environmental conditions due to the prevailing drouth, no attempt was made to assign strict values to the various components of the diet (i.e. preferred, staple, stuffing, etc.), as this would necessitate several years of crop analysis plus detailed nutritional and availability studies. Therefore, the first eleven food items (ranked by the volume-frequency index developed by Baumgartner et al., 1952) are arbitrarily designated as being the principal foods of the bobwhite. This in no way infers that the other food species are not of some significance to the welfare of the bobwhite, but rather that they were not as readily acceptable or available during the period. It is quite probable that some of the foods of lesser rank, even those eaten in small quantities, are of some importance to the diet and also that under differing ecological conditions they might have greater or lesser importance. Some significance is added to this when it is considered that several of the lesser utilized species are of important food value in other sections of the bobwhite range (examples being wild bean, tickclover, goosefoot, sunflower, fall witchgrass, hackberry, panic grass, green bristle grass, etc.).

In the following discussion, the statements about the relative status of and response to land-use and drought conditions of specific plant species are taken from Engleman and Nelson (1948), Weaver (1954), and Jackson (1955) unless otherwise stated.

TABLE II

SUMMARY OF THE ANALYSIS OF 411 BOBWHITE QUAIL CROPS COLLECTED ON THE GENE HOWE WILDLIFE MANAGEMENT AREA, HEMPHILL COUNTY, TEXAS, DURING THE 1955-1956 HUNTING SEASON

Food Item	*Volume-Frequency Index	Per cent Volume	Per cent Occurrence
Texas Croton (Croton texensis)	1.0	69.92	88.08
Stickleaf Mentzelia (Mentzelia stricta)	2.5	3.79	76.16
Erect Dayflower (Commelina erecta)	4.0	2.41	61.00
Glandular Croton (Croton glandulosus)	5.5	2.56	44.30
Greens (leaves, stems, etc.)	6.0	2.30	49.14
Western Ragweed (Ambrosia psilostachya)	6.5	3.90	31.63
Redroot Amaranth (Amaranthus retroflexus)	6.5	1.34	50.12
Sixangle Euphorbia (Euphorbia hexagona)	9.5	1.80	27.01
Animal Matter	9.5	1.12	32.60
Fringeleaf Paspalum (Paspalum ciliatifolium)	12.0	.81	34.31
Russian Thistle (Salsola pestifer)	12.5	1.03	17.80
Prickly Poppy (Argemone intermedia)	14.0	.88	17.30
Purple Sandgrass (Triplasis purpurea)	14.5	.57	26.03
Sand Dropseed (Sporobolus cryptandrus)	16.0	.04	57.18
Small Wildbean (Strophostyles pauciflora)	16.5	.81	12.90
Woolly Indianwheat (Plantago Purshii)	17.5	.31	18.50
Euphorbia (Euphorbia spp.)	18.5	.51	10.71
Prairie Sunflower (Helianthus petiolaris)	18.5	.45	12.17
Goosefoot (Chenopodium desiccatum)	18.5	T	36.00
Green Bristlegrass (Setaria viridis)	19.0	.85	6.33
Western Indigo (Indigofera leptosepala)	21.0	.90	4.62
Fall Witchgrass (Leptoloma cognatum)	21.0	.40	9.50
Queensdelight Stillingia (Stillingia sylvatica)	23.5	.84	4.14
Smut (Sphacelotheca spp.)	24.0	.25	6.10
Annual Eriogonum (Eriogonum annuum)	24.0	T	15.60

TABLE II (Continued)

Food Item	*Volume-Frequency Index	Per cent Volume	Per cent Occurrence
Flatsedge (Cyperus spp.)	26.0	T	10.22
Cristatella (Cristatella Jamesii)	26.5	.12	6.08
Sand Lovegrass (Eragrostis trichodes)	26.5	.01	8.27
Giant Ragweed (Ambrosia trifida)	27.0	.81	1.95
Big Sandreed (Calamovilfa gigantea)	27.5	T	6.60
Grape (Vitis acerifolia)	29.0	.13	4.14
Tumble Ringwing (Cycloloma atriplicifolium)	29.0	T	6.10
Spotted Euphorbia (Chamaesyce maculata)	29.5	.01	5.83
Carolina Gromwell (Lithospermum carolinense)	30.5	T	5.60
Mat Sandbur (Cenchrus pauciflorus)	31.0	T	4.38
Wedelia (Allionia spp.)	31.0	T	4.38
Snow-on-the-Mountain Euphorbia (Euphorbia marginata)	32.0	.43	.24
Falsemallow (Malvastrum spp.)	32.5	.25	1.21
Netleaf Hackberry (Celtis reticulata)	32.5	.04	2.43
Grama (Bouteloua spp.)	32.5	T	4.14
Tickseed (Coriospermum spp.)	33.0	.01	2.67
Unidentified	33.0	T	3.41
Caltrop (Kallstroemia spp.)	33.5	.07	1.46
Yerbadetajo (Eclipta alba)	33.5	.06	1.70
Common Sunflower (Helianthus annuus)	33.5	.03	2.19
Azure Sage (Salvia azurea)	34.5	.01	1.95
Bundleflower (Desmanthus spp.)	34.5	.01	1.95
Senna (Cassia fasciculata)	35.0	.01	1.70
Tickclover (Desmodium spp.)	35.0	T	1.95
Pokeberry (Phytolacca spp.)	35.5	.04	.73
Switchgrass (Panicum virgatum)	35.5	T	1.70
Buffalogourd (Cucurbita foetidissimal)	36.0	.04	.49
Rushpea (Hoffmanseggia Jamesii)	36.0	.01	1.22

TABLE II (Continued)

Food Item	*Volume-Frequency Index	Per cent Volume	Per cent Occurrence
Spikesedge (Eleocharis spp.)	36.0	T	1.46
Common Persimmon (Diospyros virginiana)	36.5	.04	.24
Smooth Sumac (Rhus glabra)	36.5	.04	.24
Morning Glory (Ipomea spp.)	36.5	.03	.49
Virginia Tephrosia (Tephrosia virginiana)	36.5	T	1.22
Common Witchgrass (Panicum capillare)	36.5	T	1.22
Goldenweed (Prionopsis ciliatus)	36.5	T	1.22
Lippia (Lippia spp.)	37.0	T	.73
Bluestem (Andropogon spp.)	37.0	T	.73
Fragrant Sumac (Rhus aromatica)	37.5	.01	.24
Prickly Pear (Opuntia spp.)	37.5	T	.49
Golden Aster (Chrysopsis spp.)	38.0	T	.24
Sumpweed (Iva spp.)	38.0	T	.24
Smallspike Falsenettle (Boehmeria cylindrica)	38.0	T	.24
Vine-Mesquite (Panicum obtusum)	38.0	T	.24
Dock (Rumex spp.)	38.0	T	.24
Sensitive Brier (Schrankia Nuttallii)	38.0	T	.24
Nightshade (Solanum spp.)	38.0	T	.24
Rosering Gaillardia (Gaillardia pulchella)	38.0	T	.24

* Volume-Frequency Index = $\frac{\text{Rank of volume plus rank of frequency}}{2}$

Principal Foods

Texas Croton (*Croton texensis*) was by far the most important food based on utilization, ranking first in the index, comprising almost 70 per cent by volume and occurring in over 88 per cent of the 411 crops. It is believed that the importance of this species was due to the fact it is first of all a very acceptable food; further it is drought hardy both in vegetative growth and seed production, and it increases readily with disturbance of the soil. It was found to be abundant and widely distributed over most of the area. Texas Croton is reported to be an important food in other parts of the bobwhite's range; however only in north central Texas (Parmalee, 1953) has it been reported used to the extent found in this study.

Stickleaf Mentzelia (*Mentzelia stricta*) was also eaten very extensively. The forb, a perennial, is a common and typical member of the sand hills flora, and was found abundantly and well distributed over the study area with the exception of the bottomland section. The species increases with overstocking of livestock and other soil disturbances and is believed to be exceptionally drought resistant. For example, it was one of the few plants to fruit during the extremely dry 1954 growing season. The value of Mentzelia as shown in this study substantiates Baumgartner's statement (1952) that it had local value in western Oklahoma, and that further study might prove it to be a major food.

Erect dayflower (Commelina erecta) ranked third; its importance strengthened by its rather high frequency of occurrence (61.0 per cent). The species is a perennial with a good root system; however it is believed to be quite sensitive to drought conditions. It is a palatable range plant, thereby decreasing with overstocking; however it was a common and widespread plant on the Howe Area. It has been noted to be an important quail food, but in no other known study has it been found to attain the high usage as shown in this investigation.

Glandular Croton (Croton glandulosa), a large seeded, sandy soil annual, ranked fourth. The species was common on the area, and increases with disturbance. Like Texas Croton, it is thought to be a good seed producer, even under drouth conditions.

Green vegetation (greens) composed of flower parts, leaves, stems, etc., ranked fifth. The value of green stuffs as a source of vitamin A has been indicated by Nestler (1949). Also, it has been generally suggested that this type of food is a source of carbohydrates, minerals, vitamins and moisture (Stoddard, 1931). It is possible that during dry periods green vegetation becomes much more important as both a source of moisture and food if seed production is reduced.

Western ragweed (Ambrosia psilostachya) ranked sixth in usage along with redroot Amaranth (Amaranthus retroflexus); however it had the second highest percentage by volume (3.90 per cent) of all the foods eaten, and occurred in approximately 31.0 per cent of the crops. The species was not evenly distributed over the area, but was found spottedly in small aggregations or clumps. This might be at least a partial answer to the lower frequency of usage as compared to the other principal foods.

The little ragweeds (Ambrosia psilostachya and Ambrosia artemisiifolia) are among the most important foods of the bobwhite over most of its range. They are usually associated with disturbed soils, occur abundantly on overgrazed pastures, and normally produce a good seed crop. However, Inglis (1959) indicated that western ragweed is dependent on early summer rains for good seed production. Since the crops analyzed in this study were taken during a period of severe drouth, it would seem possible that the importance of ragweed was minimized during the period of this investigation by a seed crop failure.

Redroot Amaranth (Amaranthus retroflexus) occurred in approximately 50 per cent of the samples. A total of almost 40 thousand of these small, shiny seeds were found in the 411 crops. The plant, normally considered an agricultural pest, was common on the area, particularly on the disturbed sites of the heavier soils between sand dunes and along the creek and river bottom. It was considered to be one of the most abundant forbs. Although it is readily established following land disturbance, it is considered a palatable livestock food and could be expected to decline with normal stocking.

Sixangle Euphorbia (Euphorbia hexagona) ranked seventh along with the animal portion of the diet. The distribution and relative abundance of this annual species on the area is not known. The plant is normally non-palatable and increases with overstocking and other types of soil disturbance.

Animal matter, although not found in large quantities, occurred in almost one-third of the crops. No attempt was made to classify the various items comprising this group of foods; however, insects, primarily

those of the orders Hemiptera, Coleoptera and Orthroptera, comprised the major items. Hemiptera were by far the most frequently used.

Fringeleaf Paspalum (Paspalum ciliatifolium), the only member of the Graminae to be found in quantity and frequency, ranked eighth. This palatable range species was very common and well distributed over the sand hills. Its status as an increaser or decreaser is unknown. Seed production is thought to be dependent upon good moisture conditions.

Russian thistle (Salsola pestifor), a serious range pest, ranked ninth among foods eaten. The forb was widely distributed over the Howe Area and was found abundantly in low areas and along the river bench just above the bottomland. A study by Lee (1948) indicated that it was utilized by bobwhite but not in significant amounts. Other investigations of bobwhite foods in Oklahoma and in south-central Kansas did not mention Russian thistle as an important food (Baumgartner et al., 1952; Hanson, 1953; and Robinson, 1957). The species has been found, however, to constitute a major portion of the diet of two other upland game bird species (Scaled quail in northwest Oklahoma, Schemnitz, 1961; and Chuker partridge in California, Harper, 1958). The actual value of the seeds as a quail food is not known. If future studies reveal that the food is readily accepted, it would seem justified to analyze its nutritional value in order to fully understand its actual significance, especially since the plant is considered to be continually spreading throughout the region. If it should prove to be of value as a food, then it would have value in bobwhite management both as an important source of cover and a source of food.

Plant Foods by Taxonomic Groups

An analysis of the major broad vegetable groups of foods, i.e. forbs, legumes, grasses, smuts, and woody plants presented in Table III may assist in gaining some degree of understanding as to relative food values of the floral components of the bobwhite's habitat during the period of the study. For the purpose of discussion, legumes were separated from the other forbs because of the significance placed on them in many studies of wildlife foods. Green vegetation was omitted from this section as it has been covered under the discussion of principal foods.

Forbs made up by far the most important class of food (number of species, quantity and frequency of occurrence). A total of 48 forbs were identified representing 23 families, comprising almost 92 per cent by volume of all foods eaten. As previously indicated, the Crotons and spurges were the main groups involved. The majority of these forbs are annual and perennial species which are known to increase with soil disturbance and overstocking of livestock.

A total of 13 species of Graminae were identified making up almost 3 per cent by volume of all foods eaten and with only 3 species occurring in over 25 per cent of the crops. One species, fringeleaf Paspalum, ranked high enough to be considered a principal food. Also of particular note, sand dropseed, a hardy perennial invading species, was the most abundant grass found on the study area and occurred in almost 60 per

cent of the crops. The usage of these two grasses by bobwhite in western Oklahoma has been pointed out by Hanson (1953). However, as a group the grasses did not provide a major quantity of food in the overall diet.

Seven legumes, totalling 1.73 per cent by volume of the total diet, were found in the crops. Two species, small wildbean (Strophostyles pauciflora) and western indigo (Indigofera leptosepala), made up almost the whole of the volume found, 1.71 per cent. The low usage of legumes agrees with the results indicated by Hanson (1953) for similar habitats in western Oklahoma. Woody plants (shrubs, trees and woody vines), although of prime importance as a source of cover, offered little in the way of food to the bobwhite during the period of the study. Seed or fruit of the following were found in small amounts in the crops: grape (Vitis acerifolia), hackberry (Celtis reticulata) persimmon (Diospyros virginiana), and sumacs (Rhus glabra and Rhus aromatica). Narrow-leafed sage (Artemesia filifolia), one of the most abundant and typical components of the flora of this range, did not occur in any of the crops taken during the study.

Common smuts, Sphacelotheca spp., were found in small quantities in 6 per cent of the crops. The fungi occur readily on sorghum species and other grasses. The genus is not known to have any direct harmful effects on animal life. Dr. Imy V. Holt, formerly of the Department of Botany and Plant Pathology, Oklahoma State University, identified and supplied information on this item.

TABLE III

MAJOR FOODS BY TAXONOMIC GROUPS PRESENTED BY PER CENT OF VOLUME

Food Groups	Per cent Volume
Plant	
Forbs (other than legumes)	91.5
Grasses	2.7
Green Vegetation	2.3
Legumes	1.8
Shrubs, Trees and Woody Vines	.3
Smut	.3
Animal	1.1
Total	100.0

Food Selection

Seed availability data were gathered on the Howe Area by Mr. Jack Inglis, then associated with the Texas Agricultural Experiment Station, as one phase of an extensive ecological research project. Full details of the methods involved in obtaining, handling, and analyzing the data are presented by Inglis (1959). The procedure was as follows: (1) collection of samples of surface soil within 5-acre quadrats located within four bobwhite habitat types (1 quadrat within each of the four types), (2) separation of seeds and ground litter, (3) identification, counting and weighing sound seeds, and (4) expansion of the extracted data to estimate frequency and weight per acre.

It was hoped that a good measure of food selection or order of preference could be obtained by comparing the results of the crop analysis from these four habitats with that of the food availability study. This would have assisted in gaining a better understanding of bobwhite food relationships. However, a comparison of the availability data with that of the quail diets is restricted for the two following reasons: (1) ground samples were taken on 5-acre quadrats designed primarily for rodent studies, while crops were collected from a much larger and varied area, and (2) mechanical separation through the use of a seed cleaner resulted in the loss of the smaller seeds. Only two of these smaller seeds, Amaranthus retroflexus and Euphorbia hexagona, were found in even moderate amounts in the quail diet; however the importance of this loss is shown when it is considered that Inglis (1959) through a complete separation of one collection found that the non-screenable smaller seeds made up more than half of the total weight of all seeds available.

Because of these limitations, the availability data from the four quadrats (totalling a sample of approximately 502 square feet) were combined as were the crop analyses from the corresponding four general areas within which the availability quadrats were located. The data were separated into screenable and non-screenable portions and presented by per cent by weight in Table IV.

Discussion of this material is limited primarily to the relationships involving the screenable portion of the sample. Even considering the limitations, the following general inferences pertaining to food selection can be drawn from the data. Seeds of 16 species of plants making 9.5 per cent of the total weight of seeds available were not

eaten by any of the bobwhite examined. Three species totalling approximately 50.2 per cent of the seed available occurred in only trace amounts in the crops. One species, rosering Gaillardia (Gaillardia pulchella), comprised the largest single amount of seed available (33 per cent), yet was found in only 10 crops in trace amounts. Eight foods, each comprising 1.0 per cent or more and totalling 88 per cent of the diet, composed but 38 per cent of the total quantity of seed available. These eight species, with but one exception, appear to be utilized in direct relation to their abundance.

These factors indicate a selection of foods by bobwhite, and further that the more readily accepted species seem to be eaten generally in order of their availability. The tendency of definite food selection in bobwhite feeding habits has been inferred by other investigators; however it has been substantially indicated through field availability research (Bookhout, 1954) and through pen studies (Michael and Beckwith, 1955).

TABLE IV

A COMPARISON OF THE ANALYSIS OF 161 BOBWHITE QUAIL CROPS COLLECTED DURING THE PERIOD DECEMBER 1955-JANUARY 1956 WITH AN ESTIMATE OF SEED AVAILABILITY FROM A TOTAL OF 502 SQUARE FEET OF GROUND SAMPLES TAKEN DURING DECEMBER 1955, GENE HOWE WILDLIFE MANAGEMENT AREA, HEMPHILL COUNTY, TEXAS

Seed Species	Crop Analysis Per cent of Total Weight	Seed Availability Per cent of Total Weight
Screenable Seeds		
Croton texensis	51.99	15.58
Commelina erecta	9.94	5.38
Stillingia sylvatica	7.05	1.57
Mentzelia stricta	5.59	3.94
Croton glandulosus	4.74	1.16
Paspalum ciliatifolium	3.60	9.83
Ambrosia psilostachya	3.55	.65
Strophostyles pauciflora	2.73	.20
Helianthus petiolaris	.51	.03
Salsola pestifer	.51	.06
Argemone intermedia	.46	.40
Malvastrum spp.	.33	-
Calamovilfa gigantea	.11	.55
Desmanthus spp.	.04	.06
Allionia spp.	.03	-
Celtis reticulata	.03	3.63
Cristatella Jamesii	.03	.19
Lithospermum carolinense	.02	.04
Indigofera leptosepala	.02	-
Hoffmanseggia Jamesii	.01	-
Plantago Purshii	.01	-
Tephrosia virginiana	.01	.95
Desmodium spp.	T	-
Cassia fasciculata	T	-
Prionopsis ciliatus	T	-
Solanum spp.	T	2.32
Cenchrus pauciflorus	T	10.27
Gaillardia pulchella	T	37.60
Rhus aromatica	-	5.31
Ipomea spp.	-	.88
Froelichia spp.	-	.65
Vitis acerifolia	-	.56
Opuntia spp.	-	.46
Corispermum spp.	-	.44
Dithyraea wislizeni	-	.34
Palafoxia sphacelata	-	.33
Gaura villosa	-	.24

TABLE IV (Continued)

Seed Species	Crop Analysis Per cent of Total Weight	Seed Availability Per cent of Total Weight
Screenable Seeds		
Prunus angustifolia	-	.14
Meriabilis exalata	-	.08
Cornus Drummondi	-	.06
Liatris glabrata	-	.03
Unidentified	-	.02
Callirhoe involucrata	-	.02
Tradescantia occidentalis	-	.01
Non-Screenable Seeds		
Euphorbia hexagona	2.57	-
Leptoloma cognatum	2.45	-
Amaranthus retroflexus	1.82	T
Setaria viridis	.76	-
Triplasis purpurea	.57	T
Eragrostis trichodes	.40	T
Sporobolus cryptandrus	.22	T
Cyperus spp.	.15	T
Chamaesyce maculata	.10	-
Chenopodium desiccatum	.09	T
Bouteloua spp.	.04	T
Euphorbia spp.	.03	T
Cycloloma atriplicifolium	.02	T
Panicum virgatum	.01	T
Chrysopsis spp.	.01	T
Eriogonum annuum	.01	T
Andropogon spp.	T	T
Cryptantha minima	-	T
Physalis longifolia	-	T

Management Implications

As shown above, annual and perennial forbs which increase with soil disturbance and heavy grazing comprised the primary source of winter foods of the bobwhite. Generally poor range conditions on the area due to severe overgrazing, drought, and wind erosion provided favorable conditions for an abundance of these increaser species.

Although this stage of succession provided good supplies of quail food, the long term well-being of the land would require continued prohibition of grazing until the range has recovered. The degree of recovery will depend upon the Texas Game and Fish Commission's long-range plans for the use of the area.

The improved range conditions should provide better, more permanent ground cover conditions and perhaps a more stable basic quail habitat. Upon recovery, the information obtained from continuing studies of food habits and food availability relationships in regard to changing range conditions should provide a firm basis for extensive bobwhite management, particularly that phase having to do with food production.

SUMMARY

1. Information on winter foods utilized by the bobwhite quail (Colinus virginianus) on the Gene Howe Wildlife Management Area, Hemphill County, Texas, was obtained through the analyses of 411 crops collected during the 1955-56 hunting season.
2. A total of 72 food items were identified; however only 10 constituted 1.0 per cent or more of the gross volume.
3. Foods of vegetable origin, primarily seeds of increaser type, annual and perennial species, constituted 97.0 per cent by volume of the total diet. The remaining portion was comprised of animal matter (1.1 per cent) and inorganic materials, primarily fine sand, (1.9 per cent).
4. The 11 principal foods, ranked in order of their importance by an index number that considered both volume and frequency, are as follows: Texas Croton, stickleaf Mentzelia, erect dayflower, glandular Croton, greens, western ragweed, redroot Amaranth, sixangle Euphorbia, animal matter, fringeleaf Paspalum, and Russian thistle. Texas Croton, comprising almost 70 per cent by volume, and occurring in over 88 per cent of the crops, was utilized to a much greater extent than any other food. These 11 food species made up approximately 90 per cent of the volume of the total.
5. Forbs were by far the most significant food group identified. Species in this catagory made up almost 92 per cent by volume of all foods utilized.

6. Comparison of food habits and seed availability data suggested definite selection of certain foods by bobwhite. The more readily accepted species were eaten generally in order of their availability.
7. Although the primary sources of food found in this study are the result of the generally poor range conditions, the overall condition of the land necessitates the continued prohibition of grazing. The resulting increased vegetative cover should provide a more stable basic quail habitat. Continuing studies of food habits, food availability, and range conditions should provide an excellent foundation for future management of the bobwhite.

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