BOBWHITE QUAIL FOODS AND POPULATIONS ON PINE PLANTATIONS IN THE GEORGIA PIEDMONT DURING THE FIRST SEVEN YEARS FOLLOWING SITE PREPARATION

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ABSTRACT

Thirty-five loblolly pine plantations in the Georgia Piedmont, ages one to seven years since site preparation, were sampled by line transects for bobwhite quail food plants, and plantations four years old and under were systematically hunted to obtain data on relative abundance of quail, distribution of coveys, and food habits. Plantations in the second and third growing seasons after site preparation and planting produced the most total quail food plants. Annual quail food plants were most prevalent on plantations aged three years or less. They were at their maximum on two-year-old plantations, and declined drastically after the third year. Perennials reached their greatest line occupancy in the third season and declined gradually thereafter. Census data indicated that quail populations were highest two seasons after site preparation. Plantations over three years of age were generally too densely vegetated and supported too few quail for good hunting.

INTRODUCTION

Forest industries own about 40,000,000 acres of forest land in the South (Wheeler 1970). Most of this land and much of the 17,000,000 acres of commercial forest land in public ownership (Wheeler 1970) are managed under the even-aged system of silviculture. Data reported by Arner (1972) indicate that forest land in the Southeast is being cleared and planted to pines at an average rate of about 1,000,000 acres per year.

It is generally known that pine plantations often provide good hunting for bobwhite quail *(Colinus virginianus)* in the years immediately following site preparation and planting. However, no estimates of density of quail or the persistence of huntable populations on such areas have been reported, and the only published data relating to quail foods in newly established pine plantations are those of Cushwa and Jones (1969) comparing ground story plants on two areas clear-cut and chopped with those on an uncut area. Their plots were not replicated and their data were restricted to the first two years after chopping. The apparent lack of detailed information on the quail-hunting potential of areas clear-cut and subjected to intensive site-preparation prompted us to make this study. We sought to determine the stages of succession in newly established pine stands that are most productive of quail, to determine the plant species that dominate each stage and to evaluate the significance of these areas in providing increased opportunities for hunting quail.

Changes in abundance of quail and their foods were studied in the Georgia Piedmont on 35 plantations ranging in age from one to seven years since site preparation and planting. These age classes were selected because seven years is the average age at which crown closure occurs and because it coincides with the beginning of this type of land treatment in the Piedmont.

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METHODS

General Procedure and Description of Study Areas

During spring and early summer of 1971, we made extensive observations in the eastern Piedmont of Georgia on areas that had been clear-cut, subjected to intensive site preparation and planted to loblolly pine *(Pinus taeda).* We met with foresters of a number of paper companies owning land in the area; they provided us with information on their methods of site preparation, planting and other management procedures. Each forester spent one or more days with us in the field, showed us many of the company plantations and provided us with detailed data on the plantations. Ultimately we selected 35 plantations in two adjoining counties (Oglethorpe and Wilkes) for more intensive study. These plantations were all owned by two companies that used similar methods of site preparation.

Plants providing food for quail on the study areas were sampled by line transects during August and September 1971, and the areas were systematically hunted from October 1971 through March 1972 to obtain information on population densities, covey distribution and food habits of quail.

The plantations selected for detailed study ranged in age from one to seven years from the date of final site preparation. The oldest stands were planted in 1965 and the youngest in 1971. Five plantations were selected in each of the seven age classes. The plantations varied in size from 28 to 262 acres, with a mean of 102 acres. However, in some areas clear-cutting of contiguous areas in successive years created blocks of young plantations consisting of 2000 acres or more.

All of the study areas were located on upland soils typical of the Piedmont (Iredell-Mecklinburg, Cecil-Madison-Lloyd, and Georgeville-Herndon-Goldston associations). The greatest distance between any two of the plantations was 20 miles. All of the areas had supported stands of merchantable pines before harvest and site preparation. Care was taken to avoid including stands planted on recently abandoned agricultural fields because early succession on these types can differ significantly from that on areas previously supporting forest vegetation.

Following is a typical sequence of treatments to which the study areas were subjected in establishing plantations following harvest by clear-cutting. Nonmerchantable trees were felled with a Rome K/G clearing blade mounted on a bulldozer, and roots were excavated with a root rake which was also mounted on a bulldozer. The slash, stems and roots were pushed into windrows or piles and burned. Disking with large harrows, the last step in site preparation, usually was done from July to September. Loblolly pine seedlings were mechanically planted during winter, except that inaccessible parts of some areas were planted by hand. The most commonly prescribed spacing was 10 feet between rows and 6 feet between trees in a row, yielding about 720 trees per acre. But there was much variation both within and between stands.

These site preparation procedures are used by a number of forest industries in the Piedmont although, depending on site condition before treatment, one or more steps may be omitted. This form of site preparation, involving severe soil disturbance, is the most intensive of those commonly used by forest industries in the Piedmont. Land receiving such treatment is virtually devoid of vegetation until the first growing season.

Plant Sampling

Ground story plants known to produce seed used as food by quail (hereafter referred to as quail food plants) were sampled during August and September 1971. Only plants known from the literature to occur frequently and abundantly in quail crops were recorded during sampling. These included all legumes (Legume species that produce seed which are known not to be quail foods did not occur on the study areas), *Ambrosia* spp., *Digitaria* spp., and all large-seeded members of *Panicum, Paspalum* and *Setaria*. Only ground story plants were recorded, it being assumed that these would produce the bulk of the quail food and determine the ability of these young plantations to support quail. Inclusion of the few woody vines and shrubs that may be eaten to a minor extent by quail on these areas (*e.g. Lonicera, Rhus, Rubus*) would have necessitated modifications in sampling technique that would have reduced sampling intensity.

Quail food plants were sampled along seventy 100-foot line transects: two on each plantation, 10 for each of the seven age groups. By sampling more plantations less intensively, we sought to encompass more area-to-area variation, thus reducing the influence of peculiarities of individual areas.

Sampling order was determined systematically so that the effects of seasonal progression were, as nearly as possible, evenly distributed across age classes. The 35 plantations were divided into five sets, each containing one plantation in each of the seven age classes. One complete set of areas was sampled beginning with the youngest stand and proceeding to the oldest. This sampling order was repeated for each set of areas until all had been sampled.

Transect lines were randomly located on the tracts. Numbered plastic grids were placed over the maps of each area, and numbers were drawn from a table of random numbers to select points of origin for the lines. Points were rejected if they occurred within 100 feet of the edge of the tract, within 50 feet of a woods road or in a swamp or creek bottom. Each point was located on a map by bearing and distance to a distinct landmark. A staff compass and a 100-foot steel tape were used to chain to the sample points on the land. Once the point was located, the zero end of the tape was anchored over it. Then the tape was pulled up the steepest slope, anchored, and stretched approximately two feet off the ground. Transects were run perpendicular to contour lines so as to reduce variation between lines due to position on slopes.

After locating the sample site and stretching the tape, we recorded general observations on site characteristics, paying particular attention to the appearance of the soil surface, degree of erosion, percentage of the ground covered by vegetation, and species composition of vegetation. Notes on species composition were important as our sampling procedure involved recording only selected plant species. Any ususual characteristics of the site were also recorded. The compass direction, per cent slope, and position on the slope of each line were also recorded. Positions on slopes were recorded as either upper, upper middle, middle, lower middle, or lower.

Species on the line were identified and their frequency of occurrence and linear occupancy were recorded. All quail food plants (as previously defined) that intercepted an imaginary plane perpendicular to the transect line were recorded on data sheets consisting of 100 numbered spaces corresponding to one-foot intervals on the line. For each one-foot interval, occupancy by quail food plants was recorded to the nearest .05 foot. The length of the one-foot sample unit not occupied by vegetation was also measured. Each one-foot interval was treated as a distinct sample unit, thus permitting calculations of the percentage of the total line occupied by a species (per cent occupancy) and the percentage of sample units in which a plant occurred (frequency). Every one-foot unit was totally occupied by either quail food plants, herbaceous plants not eaten by quail, or nonherbaceous material (including bare soil).

Quail Census and Crop Analysis

From October 1, 1971 through March 15, 1972, using bird dogs, we systematically hunted the study areas to obtain indexes to relative abundance of quail on the different areas. Food habits data were collected from birds that were killed and detailed records were kept on coveys. Because many of the older stands were so densely vegetated that hunting in them was virtually impossible, quail census and collection were limited to plantations in the youngest four age groups, with the majority of the hunting effort being devoted to plantations three years old and younger.

Each area was systematically hunted in its entirety three to five times. An effort was made to cover all portions of each tract, including places that were poor prospects for a covey find. Number of birds and locations of coveys on the area were noted. Distance of coveys from windrows, brush piles, creek bottoms, or woods edges were also recorded. In an effort to determine the importance of these features for cover, we plotted all covey locations on study area maps. Details of each day's hunt were kept in a log. From the hours hunted on each area and the coveys and total birds found, relative population indices were calculated.

Crop contents were analyzed to determine if the plants sampled by the line transects were significant in the diet of birds on the area and were thus determining the ability of the area to support quail.

RESULTS AND DISCUSSION

Successsion of Quail Food Plants

Plant data were grouped by plantation age. Occupancy and frequency figures are mean values derived from the 10 transects for each age group. Frequency and line occupancy of quail food plants are shown by species and plantation age in Table 1. Trends in production of quail foods on plantations during the first seven years are apparent from Figure 1. Quail food plants occurred with greatest frequency on two-year-old plantations but occupied a greater percentage of the lines on the three-year-old areas. Line occupancy by quail food plants was markedly lower in four-year-old plantations than in three-year-old plantations. Annual plants occurred with the greatest frequency and occupancy in plantations aged one to three years with a peak on two-year-old areas. Perennials had their greatest occupancy on three-year-old plantations and dominated thereafter. (Fig. 2).

Table 1. Occupancy and frequency of quail food plants on pine plantations of ages one through seven years.

	Ages in Years													
	1-year		2-years		3-years		4-years		5-years		6-years		7-years	
	Occ.	Freq.	Occ.	Freq.	Occ.	Freq.	Occ.	Freq.	Occ.	Freq.	Occ.	Freq.	Occ.	Freq.
Annuals														
Ragweed	9.6	20.4	11.1	29.9	5.4	13.7	0.1	0.8	0.3	2.8	0.1	1.1	tr.	0.3
Small partridge pea	1.8	7.3	0.8	3.9	6.1	20.8	2.1	13.7	3.7	19.0	0.4	2.2	1.2	8.3
Common lespedeza	0.7	3.1	5.9	15.1	4.6	9.2	0.7	3.3	-	-	-	-	-	-
Crab grass	1.6	3.8	0.2	0.5	-	-	-	-	-	-	-	-	-	-
Large partridge pea	0.2	0.7	-	-	0.5	0.7	0.1	0.6	tr.	0.1	-	-	-	-
Total	13.9		18.0		16.6		3.0		4.0		0.5		1.2	
Perennials														
Perennial lespedezas	1.3	7.4	5.5	19.7	10.8	25.2	9.5	38.2	4.0	13.4	2.2	9.9	8.3	30.1
Beggarweeds	0.4	1.7	2.7	10.1	2.9	11.5	1.6	9.2	2.7	12.8	0.4	1.4	1.6	7.1
Milk pea	0.3	1.3	0.1	1.0	0.1	0.7	0.2	1.6	0.4	3.4	0.1	1.0	0.5	3.9
Wild bean	tr.	0.2	0.2	1.0	0.1	0.5	tr.	0.3	0.3	1.6	-	-	0.2	1.2
Goat's rue	-	-	tr.	0.2	tr.	0.1	tr.	0.1	0.2	1.0	0.1	0.6	0.1	0.4
Rhynchosia spp.	-	-	-	-	-	-	-	-	0.3	1.3	tr.	0.3	0.2	0.6
Butterfly pea	0.1	0.3	tr.	0.1	-	-	0.2	1.3	0.2	1.6	-	-	tr.	0.2
Total	2.1		8.5		13.9		11.5		8.1		2.8		10.9	
Grand Total	16.0		26.5		30.5		14.5		12.1		3.3		12.1	

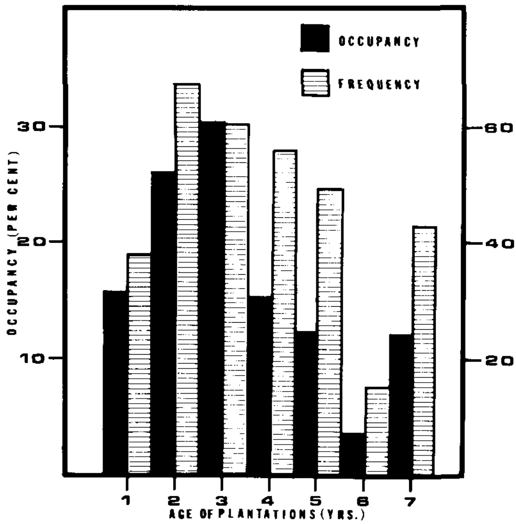

Figure 1. Occupancy and frequency of quail food plants on pine plantations of ages one through seven years.

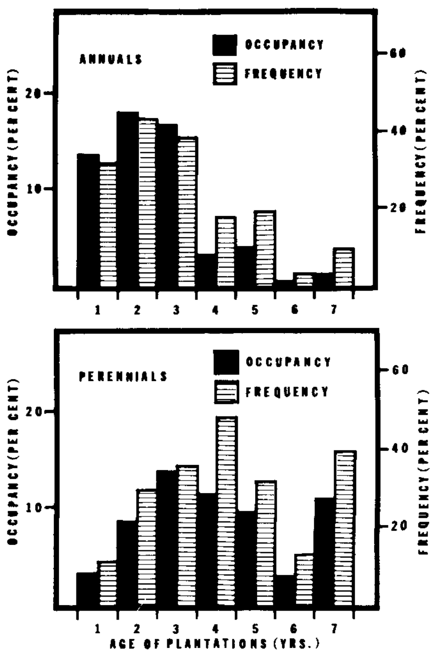

Figure 2. Occupancy and frequency of annual and perennial quail food plants on pine plantations of ages one through three years.

Quail food plants occurring with the greatest frequency and the greatest occupancy were ragweed *(Ambrosia artemisiifolia)*, common lespedeza *(Lespedeza striata)*, perennial lespedezas *(Lespedeza* spp.), beggarweeds *(Desmodium* spp.) and small partridge pea (*Cassia nictitans*). Trends in the occurrence of these species will be discussed specifically in the following sections. Other species were of much less importance. Crab grass (*Digitaria* spp.) did not occur on plantations older than two years. Large partridge pea (*Cassia fasciculata*) increased through the third year after site preparation, occurred in insignificant amounts on fourth- and fifth-year plantations and did not occur in the six- and seven-year-old areas. Butterfly pea (*Centrosema virginianum*), milk pea (*Galactia* spp.), wild bean (*Strophostyles* spp.), and goat's rue (*Tephrosia virginiana*) occurred sporadically and occupied very small percentages of the lines on all age groups. Our data did not show a relationship between the abundance of these plants and plantation age. *Rhynchosia* appeared on our lines only in plantations five years old and older and it occurred infrequently there.

One-year-old plantations.—The large quail food value for one-year-old areas was primarily a result of the annual plants (Fig. 2). These rapid invaders made up 13.9 per cent of the total line, as compared with only 2.1 per cent for the perennials. Ragweed led the annuals in occupancy (9.6 per cent), followed by small partridge pea (1.8 per cent) and crab grass (1.6 per cent). Perennial lespedezas, occupying 1.3 per cent of the line, were the only abundant perennial quail food plants on the one-year-old plantations.

Two-year-old plantations.—Annual plants, occupying 18.0 per cent of the total line, continued to predominate over perennials, which occupied 8.5 per cent of the lines on the second-year areas. Annual quail foods attained maximum occupancy during this stage, declining in older areas. Ragweed (11.1 per cent occupancy) again led all annuals, followed by common lespedeza (5.9 per cent). Both of these plants attained their maximum occupancy and frequency on areas of this age group. The line occupancy by ragweed on two-year-old areas was the greatest occupancy by any one plant on any single age group. Crab grass and small partridge pea decreased in line occupancy on two-year-old areas.

Perennials, particularly perennial lespedezas with 5.5 per cent of the line and beggarweeds with 2.7 per cent, showed a great increase on two-year-old areas as compared with one-year-old areas.

The two-year-old areas were much more well vegetated than the one-year-old areas. The rate of erosion was lower and most of the eroded and silted areas had developed good stands of plants.

Planted pines on two-year-old areas are small and have little effect on surrounding vegetation. Broomsedge (*Andropogon* spp.) is an invader in the second-year stands but appears too sparse to have much effect on neighboring plants.

Three-year-old plantations.—Line occupancy by quail foods was at its maximum on plantations in the third growing season following site preparation and planting. Annuals, occupying 16.6 per cent of the line, still exceeded perennials with 13.9 per cent coverage. Occupancy by annuals on plantations of this year was only slightly less than its maximum of 18.0 per cent on year class two, and occupancy by perennials was at maximum.

Small partridge pea (6.1 per cent occupancy) was the most abundant annual (Table 1). Crab grass disappeared after the second year and did not occur again on older plantations. The only other annual to increase from the second to the third year was large partridge pea which attained its maximum occupancy, 0.5 per cent. Other important annuals, ragweed and common lespedeza, decreased in abundance in the third year to 5.4 and 4.6 per cent respectively. Perennial lespedezas (10.8 per cent) and beggarweeds (2.9 per cent) attained their maximum occupancy.

Pine trees and broomsedge were significant vegetative components on three-year-old areas and were competing with quail foods and other herbaceous plants. Blackberry (*Rubus* spp.) and hardwood sprouts of various species, though not yet competing strongly, were also much more abundant on three-year-old plantations.

Older plantations.--From the fourth to the sixth years, most quail food species declined steadily in occupancy and frequency (Table 1 and Fig. 1). Perennial lespedezas, the most abundant quail food plants on the older areas, decreased from 9.5 per cent on four-year-old plantations to 4.0 per cent on five-year-old areas and to 2.2 per cent on six-year-old areas. A single species, *Lespedeza procumbens*, accounted for much of the quail food in older plantations. This plant persisted after most quail food plants, including the other perennial lespedezas, had virtually disappeared. Small partridge pea was the only annual to persist in significant numbers beyond the fourth growing season (Table1).

Canopy closure, and increasing competition from hardwood sprouts, blackberries, and broomsedge were important factors reducing quail food plants on older areas. In five- through seven-year-old plantations, shading and increased accumulations of pine needles replaced blackberry and broomsedge as dominant factors limiting quail food plants.

Quail food plants recorded on the oldest areas were usually in small openings where tree survival was poor. Where trees were planted on good sites at the prescribed spacing, and survival and growth were good there were virtually no quail food plants in plantations older than five years of age. Where site index was lower, as on open hilltops, and pine growth was slower and survival rates lower, crown closure was delayed, and a small number of quail food plants lingered on in older stands.

Figure 1 indicates that quail food plants were more abundant on seven-year-old areas than on six-year-old areas. This greater than expected production of quail food plants on our areas was readily apparent from observation and did not result from sampling error. However, evidence indicates that this is not generally characteristic of pine plantations of that age. Low rainfall may have caused increased seedling mortality in 1965, leaving many plantations dating from that year poorly stocked. At the time of plant sampling on three seven-year-old areas on dry sites, patchy tree success and a relatively dense herbaceous understory were noted. Two seven-year-old plantations on more moist sites were fully stocked and supported almost no quail food plants. Rainfall records obtained from the Georgia Forestry Commission revealed that total rainfall for 1965 in the two counties containing the study areas was 14.8 inches below the mean for 1963, 1964, 1966, and 1967. Ranger Robert Wright of the Georgia Forestry Commission and industrial foresters Lewis Brown and Austin Pruitt, all headquartered in Wilkes County, confirmed drought conditions and more forest fires than usual in 1965.

Crop Contents of Quail Collected on the Study Areas

Contents of the crops of 44 quail collected from plantations one, two and three years old were examined to determine the extent to which quail on the study areas were subsisting on seed produced by the plants that we sampled, and to determine the extent to which they obtained food from areas off the plantations. Results of crop analysis are presented in Table 2.

Seed produced by plants measured on the transect lines comprised 53.3 per cent of the total volume in quail crops. Fruit and seeds of trees, shrubs and woody vines not occurring on the area made up 12.3 per cent, and foods that could not be sampled (e.g. insects and other invertebrates and green leaves) comprised another 8.5 percent. Of the remaining 25.9 per cent, pokeweed (*Phytolacca americana*) accounted for 18.2 per cent. It occurred in only four

Table 2. Per cent volume and per cent occurrence of food items found in the crops of 44 quail collected during the fall and winter on plantations of ages one through three years

Species	% Vol	% Occ.
Animal Material		
Insects	5.5	45.5
Slugs (Gastropoda)	2.4	4.6
Plant Material		
Common lespedeza (*Lespedeza striata*)	21.8	45.5
Pokeweed (*Phytolacca americana*)	18.2	9.1
Partridge pea (*Cassia* spp.)	8.4	40.9
Acorns (*Quercus* spp.)	7.9	9.1
Ragweed (*Ambrosia* spp.)	6.8	47.7
Beggarweed (*Desmodium* spp.)	5.1	34.1
Perennial lespedeza (*Lespedeza* spp.)	4.2	56.8
Milk pea (*Galactia* spp.)	4.2	52.3
Sumac (*Rhus* spp.)	2.9	18.2
Nightshade (*Solanum* spp.)	2.4	6.8
Crab grass (*Digitaria* spp.)	1.7	9.1
Dogwood (*Cornus florida*)	1.5	4.6
Plume grass (*Erianthus* spp.)	1.2	27.3
Butterfly Pea (*Centrosema virginianum*)	1.1	18.2
Jewel-weed (*Impatiens* spp.)	0.8	4.6
Loblolly pine (*Pinus taeda*)	0.7	9.1
Green leaves	0.6	36.4
Beauty-berry (*Callicarpa americana*)	0.6	6.8
Virginia creeper (*Parthenocissus quinquefolia*)	0.5	4.6
Honeysuckle (*Lonicera japonica*)	0.4	15.9
Sunflower (*Helianthus* spp.)	0.4	4.6
Prickly poppy (*Argemone* spp.)	0.3	6.8
Black gum (*Nyssa sylvatica*)	0.2	2.3
Panic grass (*Panicum* spp.)	0.1	29.6
Sweet-gum (*Liquidambar styraciflua*)	0.1	2.3
Cranesbill (*Gernium carolinianum*)	tr.	11.4
Prickly mallow (*Sida spinosa*)	tr.	6.8
Ash (*Fraxinus* spp.)	tr.	4.6
Three-seeded mercury (*Acalypha* spp.)	tr.	4.6
Wild bean (*Strophostyles* spp.)	tr.	4.6
St. Andrew's cross (*Hypericum hypericoides*)	tr.	4.6
Broomsedge (*Andropogon* spp.)	tr.	2.3
Elm (*Ulmus* spp.)	tr.	2.3
Sericea lespedeza (*Lespedeza cuneata*)	tr.	2.3
Hog-peanut (*Amphicarpa bracteata*)	tr.	2.3
Paspalum (*Paspalum* spp.)	tr.	2.3
Poor joe (*Diodia teres*)	tr.	2.3
Beak-rush (*Rhynchospora* spp.)	tr.	2.3
Unidentified grass	tr.	2.3
Total	100.0	

birds and 17.9 per cent occurred in two birds. Pokeweed was not abundant on any of the study areas and did not occur on any of the transect lines. It generally occurred in windrows or brush piles. When the above foods are disregarded, seeds of the species sampled with the line transects comprised 87.3 per cent of the total foods in the crops. The data indicate that the plants we selected account for the bulk of the quail food produced on the study areas.

Since all birds collected for analysis of crop contents were from plantations one to three years old, crop contents are compared with transect data from plantations of the same ages (Table 3).

The five most abundant quail food plants on plantations of ages one through three years were in descending order: ragweed, perennial lespedezas, common lespedeza, partridge peas (both species combined), and beggarweeds (Table 3). These species also represented five of the top six in crop volume.

Table 3. Per cent occupancy and frequency of quail food plants on transect lines from plantations of ages one through three years

Species	% Occ.	% Freq.
Ragweed (*Ambrosia artemisiifolia*)	8.7	21.3
Perennial lespedezas (*Lespedeza* spp.)	5.9	17.4
Common lespedeza (*Lespedeza striata*)	3.7	9.1
Partridge peas (*Cassia* spp.)	3.1	11.1
Beggarweeds (*Desmodium* spp.)	2.0	7.8
Crab grass (*Digitaria* spp.)	0.6	1.4
Milk pea (*Galactia* spp.)	0.2	1.0
Wild bean (*Strophostyles* spp.)	0.1	0.6
Butterfly pea (*Centrosema virginianum*)	tr.	0.1
Goat's rue (*Tephrosia virginiana*)	tr.	0.1
Rhynchosia spp.	0.0	0.0
Total	24.3	

Annual plants seemed to be the more important producers of quail foods on the study areas. Excluding pokeweed and foods not produced on the study areas, annuals comprised 70.9 per cent of the volume of foods occurring in the quail crops as compared with 28.2 per cent for perennials.

Milk pea exhibits the most striking inconsistency between line occupancy and crop volume. Perennial lespedezas had thirty times the line occupancy of milk pea (Table 3), yet they had the same per cent volume in the crops (Table 2). The sampling method was no doubt biased against the delicate vine of milk pea, but it is difficult to believe that it could account for a difference of this magnitude. It seems much more likely that the birds showed a preference for milk pea, and consumed all available seed when they found it.

Wild bean, with just a slightly smaller line occupancy than milk pea (Table 3), had no measurable volume in the crop contents (Table 2). Wild bean was very visible on the plantations and seemed to be well distributed, but pods examined were producing few seed.

Common lespedeza, though only third in per cent occurrence on the transect lines (Table 3), accounted for more than twice the volume of the next most abundant species in the quail crops (Table 2). Common lespedeza is commonly considered one of the most important quail food plants in the Southeast.

The food habits data indicate that quail feed to a significant extent in older woods adjacent to the plantations. Of the crops examined, 22.7 per cent contained significant amounts of foods produced off of the study area, and 11.3 per cent of the total volume of food was produced by plants not occurring in a fruiting condition on the study areas. The use of foods from older forests appeared to decrease as the season progressed. Foods from off the areas occurred in 28.1 per cent of the crops collected in the fall and they made up 15.7 per cent of the volume. These foods occurred in 8.3 per cent of the crops collected in winter and comprised only 0.3 per cent of the total volume of winter food.

Quail Populations

In addition to yielding data on food habits, hunting provided indexes to relative abundance of quail (time expended per covey found), incomplete censuses based on number of different coveys found (usually on the same day), and distribution of coveys relative to woods edges, brush piles and windrows. Only areas one to three years old were readily huntable, and most hunting was done on these age classes. Several four-year-old areas were hunted less intensively, but only one covey was found. Older areas were so densely vegetated that we considered it impractical to attempt to hunt on them.

Quail population data are presented in Tables 4 and 5. More birds were found per unit of area and the least hunting effort was expended per covey found on two-year-old areas. The data indicate that one-year-old areas were second in numbers of quail supported, followed by three-year-old areas. This ranking of age classes is in accord with the ranking of total quail foods by frequency and of annual quail food plants by occupancy and by frequency (Fig. 2), but line occupancy by annuals and perennials combined was greater on three-year-old areas (Fig. 1).

Table 4. A comparison of the success of systematic hunting on plantations of ages one through four years

	Age of Plantations (years)			
	1	2	3	4*
Number of times hunted	18	19	18	8
Time hunted (hours)	47.33	52.25	52.50	21.50
Number of coveys flushed	19	23	18	1
Hours per covey find	2.49	2.27	2.91	21.50

*Because four-year-old- areas were hunted fewer times, data from them are not exactly comparable to data from the other three age groups.

Table 5. Estimated quail densities for plantations of ages one through three years

	Age of Plantations (years)		
	1	2	3
Total area of plantations (acres)	692	673	741
Number of birds counted	175	221	177
Acres per bird*	3.95	3.05	4.19

*Densities were calculated from the number of birds actually counted on the areas. These estimates represent minimum densities as we may have failed to find some birds, and in calculating the estimates we used only those coveys that we were reasonably sure we had not previously counted. On most of the plantations all coveys used in the estimate were located during the same day at least once during the census period.

There may be some error in the census data tending to favor the one- and two-year-old areas because they were less densely vegetated and thus were easier to hunt. However, we do not think that this error is significant; we think the census data reflect real decreases in quail populations on the censused areas in the third year after site preparation, and we attribute this decrease to the greater density of ground cover. On many three- and four-year-old areas, vegetation in windrows formed thickets that dogs and hunters could hardly penetrate. Blackberries often formed thick patches that were not always worked out well by the dogs, and hardwood sprouts further inhibited movement on these areas.

A disproportionate number of coveys were located near woods edges, windrows, brush piles, or densely-vegetated drains, especially on the sparsely-vegetated one-year-old areas. But some coveys were found as far as 500 yards from heavy cover. Most areas probably contain enough cover that they support quail over the whole area regardless of its size, but tracts with much woods edge tend to support more dense populations.

Despite the fact that not all coveys were located, the numbers of different coveys actually found on each age group indicate populations ranging from at least one bird per three acres on two-year-old areas to at least one bird per four acres on one- and three-year-old areas. These are relatively good populations for unmanaged areas. If these areas were hunted in the way in which sport hunters usually hunt, restricting their efforts to portions of the areas that comprise the best habitat, covey finds per unit of time probably would be considerably higher than ours.

One- and two-year-old pine plantations offer the best prospects for quail hunting. Three-year-old areas are generally past optimum for quail hunting, although occasionally on dry sites, they may be nearly as open and huntable as the two-year-old plantations. Plantations four years old and older can be expected to provide little quail hunting in the Georgia Piedmont.

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CONCENTRATIONS OF SELECTED CHLORINATED HYDROCARBON INSECTICIDES IN BOBWHITE QUAIL IN SOUTH CAROLINA[1]

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Chlorinated hydrocarbon insecticides have been the subject of considerable controversy. DDT, the most controversial insecticide, and other chlorinated hydrocarbons have been used extensively until recently when their uses were altered by state and federal legislative and judicial actions. The use of these materials has declined but the problem of environmental pollution still exists because of the persistence and ubiquity of these "hard" pesticides.

Insecticides have been implicated as being the causative factor in the decline of some predatory bird populations. The concern herein is not with a species at the top of a food chain but with the bobwhite quail (*Colinus virginianus*. L.), a favorite game bird which consumes primarily plant material. As a farm game species, the bobwhite is compatible with agriculture and in many instances exists in high populations on farmed areas. Consequently, during all stages of its life history this bird and its food are subjected to direct applications of pesticides of many kinds.

The bobwhite quail may serve as an indicator of the presence of certain persistent insecticides in the areas tested. A decision was made to determine residues of DDT in six tissues and crop contents of bobwhite quail collected from eight areas which had been exposed to various degrees of insecticide application.

METHODS

One hundred seven bobwhite quail from eight areas within South Carolina were collected by shooting (Figure 1). Four areas were primarily agricultural lands (Goat Island, a Hampton County farm, a Holly Hill farm, and Tupelo farm). Major crops produced on these lands were cotton (*Gossypium hirsutum* L.) and soybean (*Glycine max* (L.) Merr.). Four additional areas were included because of the limitations on the use of pesticides. Pesticides had never been used on Hobcaw Plantation. Francis Marion National Forest was treated with mirex in 1969 for control of the imported fire ant (*Solenopsis saevissima richteri* Forel) and BHC had been used for control of the Southern pine beetle (*Dendroctonus frontalis* Zimmerman). Pesticides had not been used on Groton Plantation (Goosepond and Jointstock collection sites) for 10 years prior to quail collection during the 1969-70 South Carolina hunting season.

Individual specimans were frozen intact in plastic bags as soon after collection as possible. Specimens were transported to the laboratory on ice and placed in a freezer at 0°C until they were removed for thawing and excising of various tissues. Prior to insecticide analysis, crop contents were analyzed to determine volume and frequency of each food item represented therein.

Six tissues-fat, liver, kidney, brain, breast, and gonads—and crop contents were removed from each bird, weighed, freeze dried, weighed again, and ground with mortar and pestle prior to extraction of insecticide. Samples were extracted directly with hexane with the exception of fat samples which were extracted with

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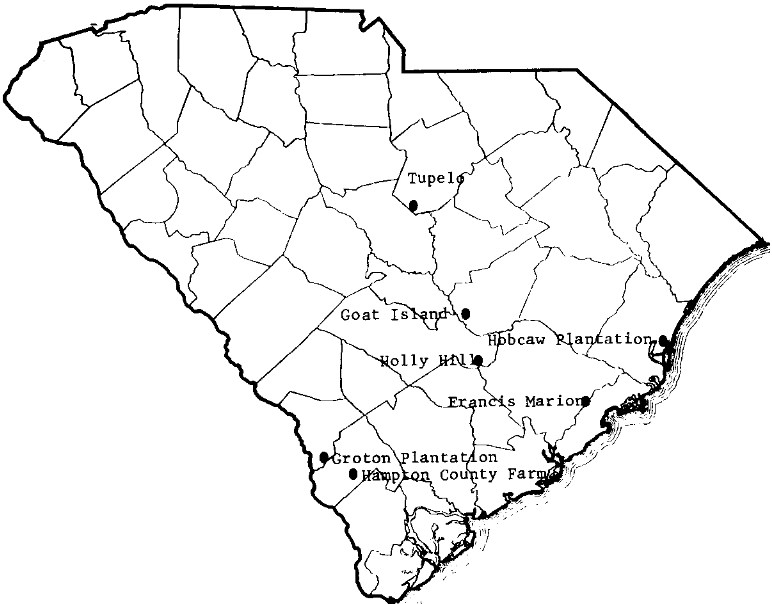

Figure 1. Locations of collecting sites

petroleum ether. Extracts were passed through Florosil (R) columns to remove impurities. The eluants were evaporated to dryness under vacuum and adjusted to 5 ml with nanograde hexane and 5 ul aliquots were injected into the gas chromatograph for analysis.

A ^{63}Ni electron capture detector was utilized to determine insecticide residues. Separations and confirmations were made on 6 ft. X ¼ inch U-shaped glass columns packed with the following materials: 10% DC-200 on Gas Chrom Q (80/100), 10%U.C. W-98 on Chromosorb W (60/80), 2% OV-101 and 3% QF-1 on Gas Chrom Q (80/100), and 5% OV-210 on Gas Chrom Q (80/100).

(Goosepond and Jointstock collection sites) for 10 years prior to quail collection

Operating parameters of the gas chromatograph were:

Injection port temperature:	220°C
Column temperature:	180°C
Detector Temperature:	275°C
Carrier gas:	High purity nitrogen
Carrier flow:	100 cc/min.
Detector operating conditions:	DC mode
Electrometer:	Pulsed mode 60/6
	Input attenuator 10^2
	Output attenuator 8, 16, 32

A profile was performed periodically to allow adjustment of the detector to operate at its most efficient voltage output.

Standards utilized in this study were prepared from analytical reagents. Levels of p,p'-DDT, p,p'-DDD, and p,p'-DDE less than 0.01 ppm were recorded as a trace. Recovery tests were performed for each tissue but values given herein were not corrected for the recovery rate. Recovery rates by tissue for p,p'-DDE are as follows: fat, 79%; brain, 80%; breast, 84%; gonad, 80%; and kidney, 86%. All concentrations were recorded on a dry weight basis. The conversion factors for determining wet weight concentrations are as follows: fat, 0.77; brain, 0.24; liver, 0.30; breast, 0.29; gonad, 0.31; and kidney, 0.27. No conversion factor was calculated for crop contents since there was so much variation in food items between individual samples.

RESULTS AND DISCUSSION

Importance of food items based on volume appeared to be a function of availability. In primarily agricultural areas (Table 1) agricultural crops inevitably occurred in the diet of quail. Quail collected from Tupelo, Holly Hill, and Hampton County areas showed a strong dependence upon agricultural crops, mainly soybean and corn)*Zea mays* L.). These areas were also prime examples of "clean farming" wherein all but low areas or forested areas were tilled. Sweetgum (*Liquidambar styraciflua* L.) and pine (*Pinus* spp.). mast were also used as food on these areas. The Goat Island area had more cotton than other areas and birds collected near cotton fields did not have as many agricultural crops upon which to feed. Additionally, an attempt was made on the Goat Island area to leave edges for quail and to burn woodlands for increased quail production. Although the Goat Island area was strictly an agricultural area the quail were not as dependent upon planted fields for food as they were on the other study areas.

The relationship between high percentages of food items by volume and apparent availability was also seen in the food habit data of birds collected form the non-agricultural areas studied (Table 2). Birds from Goose Pond and Jointstock divisions of Groton Plantation showed a preference for native legumes and cultivated crops. As the plantation was managed intensively for bobwhite quail, these food items would be expected to be utilized by the quail. Birds collected on Francis Marion National Forest and Hobcaw Plantation consumed more mast crops since cultivated crops were not available.

Table 1. Crop contents of bobwhite quail collected from four agricultural areas in South Carolina.

Food Types	percentage of total volume GI	T	HH	HC
Mast	66	13	2	38
Native Legumes	18	3	1	2
Cultivated Crops	8	80	96	59
Others	8	4	1	1

GI - Goat Island; T - Tupelo Farm; HH - Holly Hill Farm; HC - Hampton County Farm.

Table 2. Crop contents of bobwhite quail collected from four non-agricultural areas in South Carolina.

Food types	percentage of total volume GP	J	FM	H
Mast	9	3	47	17
Native Legumes	42	58	47	77
Cultivated Crops	46	30	0	0
Others	3	9	6	6

GP - Goose Pond; J - Jointstock; FM - Francis Marion; H - Hobcaw

Legumes consistently occurred in high volumes and frequencies. Beggar lice *(Desmodium* spp.), partridge pea (*Cassia fasciculata* Michx), milk pea (*Galactia* spp.), and bicolor lespedeza (*Lespedeza bicolor* Turez) appeared to be the important foods common to all eight study areas. Mast apparently was utilized to a great extent when available or when other foods were not available. Comparison of utilization of mast crops between agricultural areas (Goat Island, Hampton County, Hooly Hill, and Tupelo), forested areas (Francis Marion and Hobcaw), and Groton Plantation was of interest. Mast crops were least utilized on the Groton areas where a wide range of foods, both cultivated and native, was available to the birds. From these data, legumes and mast from sweetgum, oak *(Quercus* spp.), and pine may be assumed to be the staple winter foods on the eight study areas. Where available, cultivated crops were heavily utilized.

From the data collected very little can be said of the relationship between availability and consumption of animal material. The greatest occurrence of animals in the diet was observed in quail collected from Groton and Hobcaw Plantations, the areas of greates and least habitat diversity respectively.

Gas chromatographic detection of p,p'-DDT, p,p'-DDD, and p,p'-DDE was accomplished. Mirex was detected in fat, liver, brain and breast of quail from Francis Marion National Forest which was the only area studied that was included in the 1969 fire ant eradication program utilizing mirex as a toxicant. Several compounds which were suspected to be present in tissues of quail but were not verified were BHC, heptachlor, heptachlor epoxide, aldrin, and dieldrin. Discussion of resultst therefore will be concerned only with residues of p,p'-DDT, p,p'-DDD, p,p'-DDE, and mirex.

DDT was found in all tissues and crop contents from all areas studied with the exception of brains of birds collected from Hobcaw Plantation (Table 3). Quail from agricultural areas had higher concentrations of total DDT (the sum of residues of p,p'-DDT, p,p'-DDD, and p,p'-DDE) than those from areas upon which insecticides had not been used. The most commonly occurring and abundant DDT metabolite was p,p'-DDE.

The mean concentration of total DDT in all tissues from the Hampton County area was significantly greater ($P=0.05$) than from all other study areas (Table 4-A). The mean concentration in quail tissues from Tupelo and Goat Island was significantly greater ($P=0.05$) than from all others except the Hampton County farm. Residues in tissues from Goose Pond, Joinstock, Holly Hill, Francis Marion and Hobcaw were not significantly different.

No significant difference in mean concentrations of p,p'-DDT (Table 4-B) or p,p'-DDD (Table 4-C) were found to exist among quail from the study areas. However, there were significant differences among concentrations of p,p'-DDE in quail from the study areas (Table 4-D). Birds from the Hampton County area had significantly greater concentrations of p,p'-DDE than those from the other areas and birds from Tupelo and Goat Island had significantly greater concentrations than those from Goose Pond, Holly Hill, Jointstock, Hobcaw, and Francis Marion National Forest.

The fact that there were significantly higher insecticide concentrations in birds from agricultural areas where pesticides had been used was of interest. Birds collected from the Hampton County farm contained consistently higher concentrations of total DDT and were more dependent upon agricultural crops than those from any other areas. Because of a limited food supply bobwhite quail possibly may have consumed more insecticides by being forced to feed on waste grain and seed that were lying on contaminated soils. Quail on the Goat Island area, for example, were exposed to aerial applications of pesticides used on cotton and soybeans but because other foods and cover were available, they were not as dependent upon the treated fields as were birds from the Hampton County farm.

Hobcaw Plantation and Francis Marion National Forest were relatively free of total DDT contamination as compared to the other areas. Both areas were quite remote and, having had no history of DDT usage, demonstrated the ubiquitous nature of that environmental contaminant. Although chlorinated hydrocarbons have not been used on Groton Plantation since 1960, DDT contamination was found in tissues of quail from Goose Pond and Jointstock divisions. The county in which Groton Plantation is located was heavily farmed and this fact may account for some of the contamination.

A significant difference ($P=0.05$) in mean concentrations of mirex residues in quail collected from the Francis Marion National Forest was determined by the Duncan's Multiple Range Test (Table 4-E). A mean residue concentration of 0.79 ppm was significantly different from the trace concentration in birds from the Hampton County area. No mirex was detected in tissues of quail from any of the other areas. The Francis Marion National Forest was included in the 1969 imported fire ant eradication program in which mirex was utilized as a toxicant. The Hampton County farm was not included in the eradication program but was close enough so that contaminated birds could have moved into the area.

Table 3. Mean concentrations of total DDT in six tissues and crop contents of bobwhite quail collected from eight locations in South Carolina.

	Mean concentration (ppm)						
Location	Fat	Liver	Gonads	Kidneys	Brains	Breast	Crop Contents
Agricultural Areas	13.72	4.76	2.82	2.01	1.61	1.22	2.65
Goat Island	14.29	3.15	1.80	0.98	0.45	0.09	2.82
Hampton County	10.71	11.98	8.97	7.82	8.57	7.20	8.74
Holly Hill	2.52	2.91	0.11	0.59	0.14	0.02	0.06
Tupelo	19.73	3.96	1.68	0.95	0.14	0.11	0.36
Non-agricultural Areas	1.15	1.16	0.12	0.25	0.06	0.03	0.30
Francis Marion	0.22	0.25	0.02	0.03	0.01	0.02	0.58
Goose Pond	3.41	2.68	0.47	0.52	0.21	0.06	0.14
Hobcaw	0.25	0.48	TR	0.07	0.00	TR	0.11
Jointstock	1.69	1.79	0.11	0.45	0.06	0.03	0.20
MEAN	6.41	2.64	1.21	0.97	0.75	0.52	1.28

Table 4. Significant differences (P=0.05) of insecticide residues in bobwhite quail collected from eight locations in South Carolina.

Location	Mean Residues (ppm)			
A. Total DDT.				
Hampton County Farm**	9.14	a*		
Tupelo**	3.93		b	
Goat Island**	3.37		b	
Goose Pond	1.08			c
Holly Hill**	0.95			c
Jointstock	0.62			c
Francis Marion	0.16			c
Hobcaw	0.13			c
B. p,p'-DDT.				
Goat Island**	0.27	a		
Francis Marion	0.05	a		
Holly Hill**	0.03	a		
Tupelo**	0.03	a		
Hampton County Farm**	0.02	a		
Jointstock	0.02	a		
Goose Pond	0.01	a		
Hobcaw	0.01	a		
C. p,p'-DDD.				
Tupelo**	0.40	a		
Goat Island**	0.08	a		
Francis Marion	0.02	a		
Hampton County Farm**	TR	a		
Jointstock	TR	a		
Hobcaw	TR	a		
Goose Pond	TR	a		
Holly Hill**	TR	a		
D. p,p'-DDE.				
Hampton County Farm**	9.11	a		
Tupelo**	3.50		b	
Goat Island**	3.02		b	
Goose Pond	1.07			c
Holly Hill**	0.91			c
Jointstock	0.60			c
Hobcaw	0.12			c
Francis Marion	0.09			c
E. Mirex.				
Francis Marion	0.79	a		
Hampton County Farm**	TR		b	
Tupelo**	0.00		b	
Goat Island**	0.00		b	
Goose Pond	0.00		b	

Location	Mean Residues (ppm)	
Hobcaw	0.00	b
Holly Hill**	0.00	b
Jointstock	0.00	b

*Means followed by different lower case letters are significantly different (P=0.05).
**Denotes agricultural areas.

Significantly higher concentrations (6.41 ppm) of total DDT were found in the fat tissues with residues in liver (2.64 ppm) also being significantly greater than concentrations in crop contents, gonads, kidney, grain, and breast tissues (Table 5-A). Significantly greater concentrations of p,p'-DDT were found in crop contents than in the tissues although only a comparatively small amount (0.47 ppm) was located in the crop contents. Fat contained 0.01 ppm p,p'-DDT but this concentration was found not to be statistically different from trace concentrations in gonads, breast, and brain, or from no detectable residues of p,p'-DDT in liver and kidney (Table 5-B).

Concentrations of p,p'-DDD (Table 5-C) were detected only in fat (0.33ppm), crop contents (0.15 ppm), and gonads (trace concentrations).

Fat and livers of bobwhite quail analyzed contained greater concentrations of p,p'-DDE than any of the other tissues (Table 5-D). However, all tissues contained at least some p,p'-DDE with the lowest mean concentration of 0.52 ppm in breast tissue and highest mean concentration of 6.07 ppm in fat.

Crop contents contained significantly greater concentrations of p,p'-DDT than the tissues and also contained p,p'-DDD. Although a certain amount of post-mortem breakdown of DDT has been demonstrated (Jefferies and Walker, 1966), the evidence herein indicated the metabolism of DDT to its more stable metabolite p,p'-DDE. The liver, the suspected site of DDT metabolism (O'Brien, 1967), contained no detectable concentrations o p,p'-DDD or p,p'-DDT but contained significantly greater concentrations of p,p'-DDE than any of the other tissues analyzed with the exception of fat. All other tissues, except the kidney, contained at least trace concentrations of p,p'-DDT, but only the crop contents and the highly lipoidal tissues, gonads and fat, contained detectable concentrations of p,p'-DDD (Table 5).

Table 5. Significant differences (P=0.05) of insecticide residues in six tissues and crop contents of bobwhite quail collected in South Carolina.

Tissue	Tissue Mean (ppm)			
A. Total DDT.				
Fat	6.41	a*		
Liver	2.64		b	
Crop contents	1.28			c
Gonad	1.21			c
Kidney	0.97			c
Brain	0.75			c
Breast	0.52			c

Tissue	Tissue Mean (ppm)			
B. p,p'-DDT.				
Crop Contents	0.47	a		
Fat	0.01		b	
Gonad	0.01		b	
Breast	TR		b	
Brain	TR		b	
Liver	0.00		b	
Kidney	0.00		b	
C. p,p'-DDD.				
Fat	0.33	a		
Crop Contents	0.15	a		
Gonads	TR	a		
Liver	0.00	a		
Kidney	0.00	a		
Breast	0.00	a		
Brain	0.00	a		
D. p,p'-DDE.				
Fat	6.07	a		
Liver	2.64		b	
Gonad	1.20			c
Kidney	0.97			c
Brain	0.75			c
Crop contents	0.66			c
Breast	0.52			c
E. Mirex				
Fat	0.87	a		
Liver	0.20		b	
Breast	0.07		b	
Brain	TR		b	
Kidney	0.00		b	
Crop contents	0.00		b	
Gonad	0.00		b	

*Means followed by the different lower case letters are significantly different (P=0.05).

Fat contained significantly higher mean concentrations of mirex than other tissues (Table 5-E). Concentrations in liver, breast, and brain tissues were detected but were not significant.

This study was conducted in only one season of the year. There is a probability of seasonal variation in dosage of agricultural insecticides in nature. Barrier (1970) found seasonal differences in DDT residue levels in tissues as well as in rumen contents of white-tailed deer (*Odocoileus virginianus* L.) collected in Calhoun County, South Carolina. There was no reason to suspect that the same may not be true of the bobwhite quail found in agricultural areas but this could be substantiated only by seasonal collections and residue analyses. The levels of total DDT and mirex residues in the fat of some of the quail studied approached or surpassed the acceptable limits (7.0 and 1.0 ppm., respectively) for poultry set by the USDA (1969). Thus, it is fortuante that DDT usage has since been curtailed. Since these levels are not excessive, any inherent danger in human consumption of these birds is considered doubtful. In most instances, the meat of these birds is considered a delicacy and would not approach the intake of poultry products, a staple source of protein in diets of many humans. The breast muscle is the most commonly eaten portion of quail and had consistently lower concentrations of the insecticides than any of the other tissues studied. Consumption of the other organs and tissues that have higher concentrations of residues is usually avoided. Additionally, the concentrations listed by the FDA are wet weight concentrations and residues in this study were recorded as dry weight concentrations.

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ABSTRACT

A study was conducted involving the analysis for insecticides of selected tissues of 107 bobwhite quail (*Colinus virginianus* L.) collected from eight locations in the Coastal Plain of South Carolina. Six tissues—brain, fat, breast muscle, liver, kidney, and gonad—and crop contents were analyzed by gas chromatographic techniques for p,p'-DDT, p,p'-DDD, p,p'-DDE, and mirex. Total DDT residues were found to differ significantly among areas and tissues studied with highest concentrations being in fat and liver of quail from agricultural areas. Mirex was detected in birds collected from only two of the eight areas studied. Most mirex was found in birds from an area in which mirex had been applied in the 1969 imported fire ant (*Solenopsis saevissima richteri* Forel) eradication program. Mirex was detected in fat, liver, breast, and brain tissues with significantly higher concentrations in the fat samples.

A food habit study was also performed to determine if principal winter foods of quail were those normally affected by application of chlorinated hydrocarbons. Legumes, cultivated crops, and mast of oaks (*Quercus* spp.) and sweetgum (*Liquidambar styraciflua* L.) were among the most important food items. In agricultural areas, crops such as corn (*Zea mays* L.) and soybean (*Glycine max* (L.) Merr.) were utilized heavily as food. Food availability was an important factor. In areas where a large degree of diversification of food and cover was maintained, a large number of plant species occurred in the quail diet.

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