PROCEEDINGS

of the

First National Bobwhite Quail Symposium

APRIL 23 - 26, 1972

Oklahoma State University
Stillwater, Oklahoma

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FIRST NATIONAL BOBWHITE QUAIL SYMPOSIUM

23-26 April 1972

Oklahoma State University
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Published by
Oklahoma State University, Research Foundation
Stillwater, Oklahoma

FOREWORD

This symposium was conceived in 1970 when several interested persons in Oklahoma independently thought of getting landowners, sportsmen, academicians, businessmen, legislators, and wildlife managers together to discuss improvement of living conditions for bobwhite quail in the state. Although Oklahoma has one of the greatest bobwhite populations in the country, the bird's numbers here are diminishing along with decreasing habitat quality wrought by the universal problem of intensifying land-use practices. Broad public understanding is needed to cope with this trend; unification of quail enthusiasts behind a feasible educational program is an important first step.

During several informal discussions about the proposed conference, we evolved the more ambitious plan of holding a national meeting to fully air current problems and management philosophies from all parts of bobwhite range. Our goal would be maximum exchange of ideas and opinions, and for bobwhite enthusiasts from as wide a variety of backgrounds as possible to congregate and become better acquainted and learn ways to help each other. We realized that the entire range of topics concerning bobwhite could not be covered within the limitations of one meeting, so we asked for supplemental papers to be published in the proceedings and proposed that subsequent meetings be held regularly in the future to provide further exchange of information.

In retrospect, the symposium achieved much of what we hoped for. A notable exception was that we did not attract as many laymen as desired, thus the attendants included a large proportion of professional wildlife workers. We hope that future organizers of conferences will give special emphasis to attracting landowners and other citizens who have great influence on the welfare of bobwhite quail.

Several personnel of the Oklahoma Department of Wildlife Conservation, the U. S. Soil Conservation Service, and the Oklahoma State University provided skillful, dedicated assistance in planning and conducting the meeting. The secretarial staffs of the Oklahoma State University Research Foundation and the Oklahoma Cooperative Wildlife Research Unit were extremely helpful in preparing the final manuscript and in having the proceedings printed.

Several nationally prominent individuals provided worthwhile suggestions that helped us considerably in forming the program. They deserve much of the credit for whatever good we achieved. Any shortcomings are strictly my responsibility.

John A. Morrison, Chairman
Program and Publications Committee

SIDELIGHTS OF THE N.B.Q.S.

The National Bobwhite Quial Symposium was attended by 320 scientists, wildlife managers, wildlife commission members, newspapermen, bird dog trainers, game farm operators, fieldtrialers, and laymen interested in the ecology and management of quail. Conferees came from as far as Maine and California but the heaviest attendance was from the southeastern United States. There was much more information presented than could possibly be absorbed during the three and one-half days of the Symposium. Therefore, these proceedings should provide a most valuable reference work for the state of the art as it existed in 1972.

The success of the Symposium was due to the efforts of a number of individuals and organizations. First, of course, was the excellence of the technical presentations. Dr. John Morrison and his program committee deserve the thanks of all for organizing the program and obtaining the most knowledgeable and competent speakers of the nation. The papers were well prepared and to the point and the discussions were lively and stimulating but the Symposium also provided an opportunity for many individuals who knew each other 'only on paper' to make face-to-face contacts and to exchange ideas on current theories and research findings.

Apart from the technical proceedings, there were numerous other activities most worthy of mention. Mr. George Wint, Oklahoma Department of Wildlife Conservation, arranged an outstanding exhibit of wildlife paintings and wood carvings, which included paintings valued up to $20,000 and superb wildlife wood carvings. Though Mr. Wint is most widely known as an outstanding wildlife biologist, his creative talents also place him in the front rank of wildlife artists.

The field dog event, narrated by William F. Brown, editor of The American Field, included champion bird dogs of five popular breeds. English Setters--Johnny Crockett, and Susan Crockett; Irish Setters--Clancy O'Ryan and Saturday Night Zeke; English Pointers--Oklahoma Palidon Polly, and Crossmatch; German Short Hair Pointers--Albrecht's Tena Hi and Albrecht's Cassy Elheinie, and the Brittany Spaniels--Brandy's Bullet and Sno Fun Mac were shown on game before an enthusiastic assemblage. An excellent Retriever Demonstration featured Black Labradors shown by Dr. Roy Stonecypher and Mr. Dick Cook.

We are indebted to the Harper Ranch for providing the quail used in the field dog demonstration and to Mr. Delmar Smith and his two fine sons, Tom and Rickey for handling the bird field chores. Mr. E. B. (Bud) Epperson, Judge Lee West and Dr. Dorwin Hawthorn shared with the group their vast knowledge of bird dog performance.

Following a Hawk and Falcon Demonstration, Mr. Addison Warner, president of Imco Dog Food Company was host for a social reorientation hour and barbeque. In addition to providing the food and refreshments, he constantly enlivened the proceedings with his wit and wisdom.

Mr. Jim Lewis, Oklahoma Cooperative Wildlife Research Unit, and Mr. Tommy Hines, Oklahoma Department of Wildlife Conservation, took a group of about thirty interested early-risers to a nearby prairie chicken booming ground for the spectacular spring rites of the greater prairie chicken. The event was so enjoyable that an additional group went out each morning of the Symposium. This was the first opportunity that many had had to observe wild prairie chicken at first hand.

Mr. Irvin Bollenbach, prominent Oklahoma cattleman, hosted the conference field trip at his ranch, near Kingfisher, where we also were treated to a barbecue served by the Grand National Quail Hunt Club of Enid, Oklahoma. The field trip was concluded with a tour of the Canton Wildlife Management Area under the guidance of Clark Derdyne and Frank Carl, Wildlife Biologist of the Oklahoma Department of Wildlife Conservation.

The ladies program, arranged by Mrs. Phyllis Luebke and Mrs. E. B. Epperson, included visits to the Gilcrease and Philbrook Museums in Tulsa, the Cowboy Hall of Fame in Oklahoma City, and to the home of OSU President and Mrs. Robert B. Kamm in Stillwater.

And then, there were the myriad services performed by graduate and undergraduate wildlife students of the Department of Zoology, who turned on the switches, drove the cars, collected the money, and generally sweated and strained as a labor of love. May they all achieve their lifetime ambition which is generally not a whole lot more than seeing that this old planet survives and that its wildlife gets a fair shake.

Howard R. Jarrell
Secretary
National Bobwhite Quail Symposium

FIRST NATIONAL BOBWHITE QUAIL SYMPOSIUM

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Moderator -- William F. Brown, Editor
The American Field

BOBWHITE QUAIL ON SHOOTING PRESERVES

Edward L. Kozicky, Winchester-Western Div., Olin, East Alton, Illinois

Let there be no doubt that the bobwhite quail is king among game birds south of the Mason-Dixon line, whether found in the wild or on shooting preserves. No one can accurately estimate the number of bobwhite quail being shot annually on the shooting preserves; however, a conservative indication would put the annual increase in harvest at about 10%.

Quality quail hunting on shooting preserves is not easily achieved. It requires attention to a multitude of details, as contrasted to the flighting of pheasants, chukars, and mallards. Yet quality birds on a shooting preserve can so closely simulate wild hunting of bobwhites that you have to blink your eyes to tell the difference.

As with all animals, the behavior of bobwhite quail depends on heredity and environment, and it is difficult to tell which of these factors is more important. Quail are delicate and can lose an ounce of weight within 1 or 2 days. And we know that good, wild, pen-reared stock can, in a matter of a few weeks, perform in an unsatisfactory manner in the field. Birds that yesterday or last week were a challenge to any hunter now are poor flyers, run in the open ahead of the dog, and hesitate to flush.

I wish it were possible to define exactly what we mean by "wild stock," but it isn't. I do know that there is a difference between strains of bobwhite quail produced by various game bird breeders--some have a wild spark and some don't. And I have yet to see a thoroughly domesticated strain of bobwhite quail perform well in the field. Efforts to provide optimum quail environment simply will not compensate for a lack of "wildness" in a bobwhite quail; it is essential to start with good wild stock.

Our experience at Nilo Farms indicates that isolation of the birds from human disturbance is important. We permit no visitors at our quail-holding pens; and as much as possible, only 1 man takes care of feeding and watering these birds.

Overhead cover apparently affects the birds' behavior in the field. Our present holding pens were constructed in a timbered area, and the quail behaved beautifully in front of the bird dogs and hunters until frost removed the leaf cover from the trees. To correct the situation, we attached some sheet metal roofing over about 0.75 of the pen. It did the trick--at least, our released birds no longer sought an open spot when released in the field.

There are few things on a shooting preserve more embarrassing than a covey of birds milling around in an opening in the vegetation when a dog is on point. Providing overhead cover, either natural or artificial, has virtually eliminated this for us.

Weather conditioning is also important. Our birds are maintained in the open in standard holding pens--not in an enclosed brooder house--since this helps to develop proper feathering which, in turn, results in good flyers and quail which can survive the elements following release.

Bobwhites are quite fastidious, and it's essential that dust pans be available, and that the dirt in the pans be changed every few days. And they cannot be crowded. We provide a minimum of 2 sq ft per bird to prevent cannibalism.

Feed conditioning is another critical factor. We maintain the birds on the same rations used by the game breeder from whom they were purchased, but supplement their diet with baled millet. This accustoms the bird to the grain they will find on the shooting areas and keeps them occupied and contented while in the holding pen. Naturally, fresh water must be available at all times, including periods of subfreezing weather.

The greatest scourge of pen-reared bobwhite quail is ulcerative enteritis, a disease which has been the bane of existence to many a game breeder and shooting preserve operator over the years. Our holding pens have a wire floor, and this may be the reason we have had only 2 minor outbreaks of the disease during the past 15 years.

We were lucky. Both outbreaks were diagnosed quickly and the following medication promptly administered: 5 cc of streptomycin added to each gallon of water for 5 days, then 1 cc to each gallon for at least 5 more days. I have a hunch that the speed with which treatment for ulcerative enteritis is started is a deciding factor in its control. I say "hunch" since we dare not risk allowing the disease to gain momentum before administering the streptomycin.

Ten years ago we constructed a flight pen for conditioning bobwhite quail. It was the "thing to do." However, we soon learned that good-quality bobwhites, isolated from human disturbance and not overly crowded, get abundant exercise in a pen 8 ft wide by 28 ft long and 3 ft high. Our former quail pen has now been converted to a chukar-holding pen.

There are probably almost as many ways to release bobwhite quail on shooting preserves as there are preserves. We still adhere to the technique outlined in our book, "Shooting Preserve Management--The Nilo System." The birds are handled by man only once between the holding pen and the field--when they are taken out of the catch box and put into the release crate. Again, experience has shown that a knowledgeable birdhandler quickly learns to distinguish between a potentially good or poor flyer by the reaction of the quail when he has it in his hand.

We try to provide our guests with a covey rise of 5 to 6 birds, and then follow up any singles which we're able to mark down. For a good covey rise, the birds should be released in appropriate cover. We look for thick ground cover such as a brome grass or a harvested wheat field with an understory of Korean lespedeza and little overhead cover. Birds planted in heavy overhead cover that's open at gound level will run ahead of the dog and go out as singles. May I suggest that you pay particular attention to the cover when you view "The Show-Me Hunter" following the banquet Tuesday evening.

Precipitation presents special problems in handling shooting preserve quail north of the Mason-Dixon line. Bobwhite quail don't perform at their best during snowfall, or even when an inch or 2 of snow is on the ground. Nor do they fly in a satisfactory manner on rainy days. Rather than be embarrassed by subquality behavior of birds before guests, we do not flight bobwhite quail under such conditions; we substitute either pheasants or chukars.

Contrary to popular opinion, pen-reared quail are not always warmly welcomed into coveys of wild birds. We have 12 to 15 coveys of wild quail on our 700 acres at Nilo Farms, but those birds seldom accept pen-reared quail that are not harvested by our hunters. More often than not, they are unwelcome--and we have had very few observations of pen-reared birds within the wild coveys.

So much for the birds; let's discuss the shooting preserve industry.

Shooting preserve operators need the patience and understanding of the public. Though many people think so, operating a shooting preserve is no Golconda. To a great extent, it's a labor of love though it does provide a fair return on the operator's investment, providing he and his family have a compassion for the general public and are willing to work long hours.

It is essential that state game departments work closely with preserve operators; the state people can be of immense help for they are in an excellent position to provide publicity for the concept and to enforce minimum quality standards for shooting preserves.

Everyone loses when even one individual operates a substandard shooting preserve. Granted, it's only a question of time before he goes out of business. But until he does, he creates a terrible public image for the good shooting preserve operator and leaves a trail of disillusioned hunters. Eventually the state game departments will insist on minimum standards; and when they do, they will have the cooperation and backing of the majority of shooting preserve operators.

There's been a lot said about quality hunting on shooting preserves. But quality isn't entirely a matter of management. Frankly, I've reached the conclusion that the quality of hunting also depends on the type of customer. During the years I've been at Nilo Farms we have had both quail and pheasants so difficult to bag that some hunting parties were embarrassed by their poor shooting. Had these hunters been paying for only birds bagged, we would have gone broke. Unfortunately, our supply of supercharged quail disappeared; however, the birds now available allow our guests to come back from the field happy and full of pride in their shooting prowess.

For the last 3 years we have worked with a cross of the usual pen-reared pheasant and the Korean strain--a small, wild and touchy bird. It soon became apparent that these Korean crosses were too wild for some of our guests, and now we have wild pheasants and not-so-wild pheasants to accommodate the good shooters and not-so-good shooters.

What I'm driving at is the fact that the shooting preserve operator has to cater to his customers. Actually, he can provide hunting just about as difficult as anyone wants.

It's also been my observation that most hunters are more interested in action than communing with nature.

It is indeed unfortunate that shooting preserve operators have had to guarantee bags to attract patrons since, in reality, they are in the business of outdoor recreation--selling a sporting chance to harvest a given number of birds, not carcasses. So the next time you feel like criticizing a shooting preserve operator--remember that he is trying to earn a living, and that "the customer is always right." If he doesn't supply an acceptable product at a reasonable price, his competition will.

THE TRADITIONAL SOUTHERN BOBWHITE QUAIL PLANTATIONS

Leon Neel, Tall Timbers Research Station, Thomasville, Ga.

The private shooting plantations of the southeast occupy a most interesting place in the history and development of wildlife management in our country. Dedicated principally to the classic sport of bobwhite quail shooting, these properties stretched from Virginia to Texas and ranged in size from a few hundred to thousands of acres of southern land.

In the Thomasville, Georgia - Tallahassee, Florida area, private ownership of land for recreational purposes, specifically quail shooting, began in the late nineteenth century. Prior to this the sport was exercised in varying degrees by local people as the need for food or recreation demanded, or by visitors, who with local guides and dogs trooped the surrounding countryside in search of their explosive quarry. The acquisition of land for private quail shooting plantations continued throughout the South for many years as affluent individuals or groups learned that only by actual ownership could their socio-recreational desires be assured. South Carolina became a choice location for ownership because of direct rail connections with New York. Preserves were developed in Tennessee, Mississippi and North Carolina, and they had interesting influences on their parent locations and people. Alabama natives, with a natural affinity to quail hunting, dogs and horses, welcomed the development of the great preserves in their state, and today a large number of the top dog trainers and managers of southern plantations are Alabamans.

Management developed as problems arose. Vegetation manipulation became and is a foremost problem for plantation managers. The old cotton fields and farmsteads, abandoned after the defeat of the South in the war between the states, had gone through the early stages of plant succession and by 1920 offered new challenges to those responsible for the quail crop. This was the beginning of the single most important sequence in the history of bobwhite quail management in the South, and indeed helped to mold concepts in management that have withstood the test of time. This sequence began with a decline in the quail population through the deterioration of habitat caused by excluding fire. The classic study by Herbert L. Stoddard, Sr. (6), in the 1920's was a direct result of the deterioration of the shooting quality on existing plantations and it was financed by unhappy plantation owners. One of the most important underlying principles to emerge from Stoddard's research has to be the concept of an ecological approach to management, including fire as a necessary and useful tool. Stoddard, joined by Edwin V. Komarek in 1934, continued management research on plantations throughout the South (7). Komarek, recognizing the importance of fire as a natural agent (1,2,3,4), has fought long and hard over the years to secure the proper role of fire in our environment. Through such private research, the southern plantations have had considerable impact on wildlife management as a profession, and bobwhite quail management in the South in particular.

Perhaps the optimum period in the life of southern quail plantations as an entity began to decline after World War II. Changing social and economic conditions made it difficult to put together new plantations in more desirable locations. The old, established properties have begun to disappear as shooting preserves as death or inflated land values and ever-increasing taxation whittle away at them.

An interesting management phenomenon has occurred over the years that in part has led to the loss of certain properties as shooting plantations. The pioneer owner generally had a well-developed esthetic sense. As timber stumpage prices were very low until World War II, most owners preferred to retain and encourage all timber. The timber volumes increased until these properties became woodland plantations, some with very high timber values (5). Consequently many fine plantations have passed into the hands of commercial timber-utilization companies and are thus lost from the ranks of private shooting lands.

While there is usually an attempt by the timber concerns to maintain quail shooting, at least in part, it is never very satisfactory in the traditional sense as quail management values become secondary to commercial timber values. Some of the finest southern plantations are now nothing more than land owned by commercial timber companies, with the once magnificent stands of old-growth timber gone, generally along with the quail.

Population increases and growth and development have taken their toll also. Florida has lost several fine properties to "progress," and some of the remaining Tallahassee plantations are even now experiencing the threat of absorption by the pressures of a frenzied development boom. Other properties in the South are becoming smaller by division, as heirs seek to each retain part of the old life. Oftentimes the owners of these smaller acreages have less personal wealth and less interest in management for quail, thus concepts of a continuation diminish.

Several attempts have been made to perpetuate certain individual properties by donating them to educational institutions for the purpose of conducting research in a directly related field for the public good. The Ames Plantation in Tennessee and Tall Timbers Plantation near Tallahassee, Florida are examples of once great private shooting preserves that are now serving the public through research on many subjects related to the bobwhite quail and its management. Of course their function as traditional quail plantations has ceased, but hopefully these properties will continue to be managed as an ecosystem that will include a bountiful population of bobwhite quail.

Other excellent plantations, such as Nilo Plantation at Albany, Georgia have, through the generous efforts of their owners, become laboratories for certain research projects conducted by competent biologists on various aspects of bobwhite quail ecology and management.

In summary, the traditional southern bobwhite quail plantations had their beginning as an entity some 100 years ago. Bobwhite quail management largely developed on these properties, scattered throughout the South, and this in turn contributed much to the development of wildlife management as a science in the United States. The success of this management effort can be attributed primarily to the fact that these properties have been privately owned, and their management is free from the pressures of bureaucratic or public control. Increased taxation and the "progress" of growth and development are the major threats to the continuation of these great private shooting preserves, and even today many have passed into history. Regardless of their place in the future, the southern bobwhite quail plantations have made their contribution to all who share the many pleasures derived from the bobwhite quail.

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BOBWHITE QUAIL MANAGEMENT ON STATE CONTROLLED WILDLIFE AREAS

Ralph J. Ellis, Oklahoma Department of Wildlife Conservation, Oklahoma City

Introduction

The public's use of bobwhite quail depends upon the presence of the birds and upon access to lands where they are found. Access to state fish and game lands is rarely a problem. However, providing desired quail populations is usually a challenge. The purpose of this report is to discuss what the state fish and game agencies are doing to produce bobwhites on lands they manage.

Techniques

All states known to have bobwhite populations were queried concerning: (1) numbers of acres under their control, (2) numbers of acres under their control inhabited by bobwhite quail, (3) percent of managed land receiving treatment beneficial to bobwhites, (4) kinds of quail management practices in use, (5) numbers of acres in each practice, (6) estimated effect on quail populations of each practice, and (7) plans for future quail management.

Findings and Conclusions

Twenty-five states answered the inquiry (Fig. 1). This included 9 states having so few bobwhite quail that management for this species did not exist or was of a token nature.

The responding states indicated that they controlled 16.9 million total acres of state fish and game lands (Fig. 2). One-third (5.6

million acres) of this was reported to be inhabited by bobwhite quail. Management practices designed to benefit quail were being employed on 2 million acres - 36% of the inhabited lands.

Seven management practices beneficial to quail were in common use (Fig. 3). Several states commented that management practices in use were designed to benefit several species including quail. In general, states in the heart of the quail range employed management directed principally to quail while peripheral states were mostly concerned with other species.

Fig. 1. Illustrative comparison of states responding and not responding to questionnaire

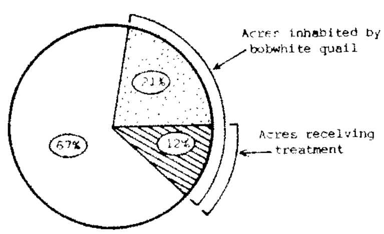

Fig. 2. Bobwhite quail management on state-controlled fish and game lands.

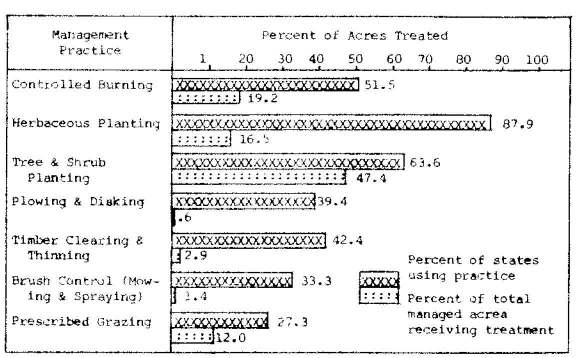

Fig. 3. Extent of use of seven most popular quail management practices.

Herbaceous planting was the most common practice reported and is being used by 88% of the states. In most cases, herbaceous plantings involved agreements with cooperating farmers who planted prescribed crops and were permitted to harvest a portion of the grain or forage. Small food patches apparently were planted where sharecropping was not practical. One state noted that although food crops should be small irregular patches, their sharecroppers prefer large square fields. Herbaceous plantings ranked third in acreages treated, and were in common use throughout the bobwhite quail range.

Tree and shrub planting was the second most-used practice (Fig. 3). It was used most extensively by states on the north and west borders of the bobwhite quail range. Usually it was used to break up large fields. More than twice as many acres were treated with tree and shrub plantings than were treated with any other practice.

Controlled burning was employed by about 0.5 of the states reporting (Fig. 3). About 0.2 of all game and fish lands were so treated. Most of the states using fire to any appreciable extent were in the Southeast. None of the New England states reported using fire.

Timber clearing and thinning was used by 42% of the states on small portions of their lands (Fig. 3). The same can be said for mowing and spraying brush. In both cases, the practice was usually employed to break up dense extensive stands of woody cover and create more edge.

Prescribed grazing was used by 27% of the reporting states, usually for control of brush and grass. One state fenced covey headquarters areas to protect them from cattle trampling.

Plowing and discing were used by nearly 40% of the states, but on a very limited scale. They were employed to control grass and to generate natural quail foods.

Several other worthy practices were reported by a few states. Four states reported the use of brush piles - including "living" brush piles produced by cutting individual trees partly in 2 and then pushing them over.

The planting of a grass-legume mixture as nesting cover next to cropland was reported by one state. The clipping of vegetation to produce "bugging" areas for broods was mentioned. Also 1 state made bare dirt trails for travel lanes and dusting areas.

Herbicide use on timber and root plowing of brush were each under test in 1 state. "Quail food blocks" are also under study in 1 state.

The states were asked to classify the practices they were using as to good, questionable, or poor with respect to their value for increasing quail numbers. All practices except herbaceous plantings, tree and shrub plantings and prescribed grazing were considered good by all states employing them (Fig. 4).

According to this measure, controlled burning was the most useful tool employed (Fig. 4). Timber thinning or clearing was second. Brush control and plowing and discing were also favored practices.

Herbaceous plantings, although popular with most, were considered questionable by 26% of the respondents. Sixty-one % of the states using tree and shrub plantings considered this practice to be good, 31% considered it questionable and 8% felt it was poor. Prescribed grazing was considered poor by 60% of the states; 40% believed it was good.

Whether or not any of the practices are good or poor depends much on how they are used. A good example is grazing in Oklahoma. On state-owned lands where the Department can control when and how much grazing occurs, it is a useful low-cost tool. However, on Department-managed Corps of Engineer lands, it has been a poor practice because the Department has been unable to prevent frequent overgrazing.

The states were also asked to indicate their plans for future management. With one exception, no major changes in management seem likely (Fig. 5). The exception is that about 65% of the responding states intend to increase their use of controlled burning. There were indications of small increases in the use of grazing.

Several states indicated that they did not feel qualified to evaluate the practices they were using. They suggested a need for more research to do this. Six or more states are now engaged in such research. A look at the list of papers being presented at this symposium will indicate the nature and location of some of this research. Yet there are large regions where so little is known about the effects of practices in use that management is a hit-or-miss proposition. In these areas, research to develop productive management practices has first priority.

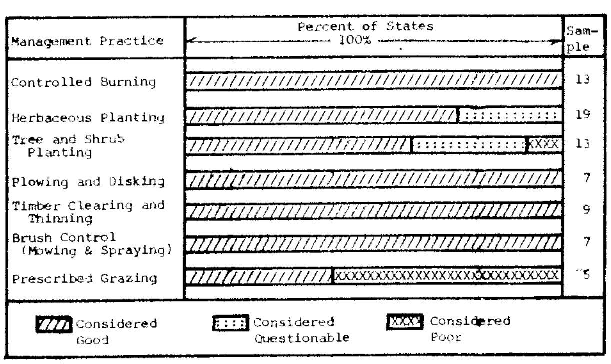

Fig. 4. Percent of states that considered individual management practices being used as "good", "questionable" or "poor".

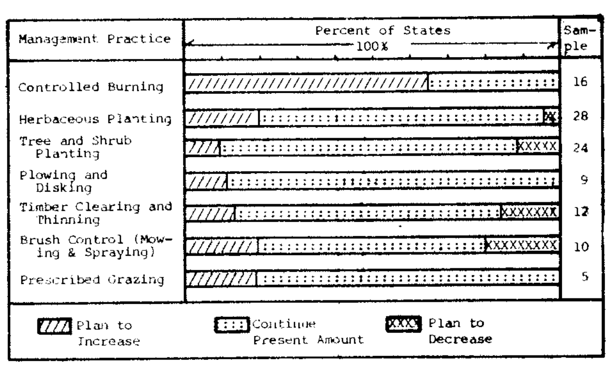

Fig. 5. Plans of states for future use of quail management practices now in use.

TRENDS IN MANAGEMENT OF THE BOBWHITE QUAIL ON COMMERCIALLY OWNED FOREST LAND AND NATIONAL FORESTS OF THE SOUTHERN REGION

Dale H. Arner, Mississippi State University, State College, Miss.

Introduction

It has been amply documented that good populations of bobwhite quail can be maintained on forest land where at least 0.25 of the area is maintained in scattered small openings (1,2).

Even-aged timber management has become a common silvicultural practice in southern woodland management. This type of management entails clearcutting, and invariably includes some type of site preparation such as burning, mist blowing of herbicides, or the use of mechanical equipment such as choppers and KG blades. The size of the clearcuts, the span of time involved in the cutting cycles, and the type of site preparation will all have an effect on quail populations. According to personal communication with Mr. Carroll Perkins (1972), International Paper Company economists have determined that clearcuts of 400 acres approach the maximum in economic efficiency, cuts larger or smaller than this increase the cost of land clearing. Many of the clearcut areas produce excellent quail hunting for the first 2 or 3 years after clearcutting. This is especially true on cleared forest land which has at one time been in cultivation.

This survey was initiated to ascertain the trends in forest management and bobwhite quail management on commercially owned forest land and on National Forests of the Southern Region.

Procedure

Addresses of owners of extensive areas of commercial forest land in the Southeastern United States were obtained from the Wood and Woodlands Directory of the January, 1972, issue of Pulpwood. A questionnaire was developed with the help of Mr. Ross Shelton, Extension Specialist, Mississippi State University, and with Mr. Carroll Perkins of the Department of Wildlife and Fisheries, along with personnel of the Forestry Department at Mississippi State University.

This questionnaire was sent to timberland managers of all timber companies listed in the aforementioned directory for the Southeastern Region of the United States. This area included the states of Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Mississippi, Louisiana, Tennessee, Alabama, and Kentucky. A total of 70 questionnaires were sent to timber companies and 47 (67%) responded.

A similar questionnaire for determining quail management trends in the national forest area of the Southern Region was prepared with the help of Herman L. Holbrook of the Wildlife Management Division of Region 8 of the United States Forest Service. Mr. Holbrook sent the forms to forestry personnel in charge of management of national forest lands in Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Arkansas, Mississippi, Alabama, Kentucky, Louisiana, Tennessee, Texas, and Oklahoma.

Results

Forest Management on Commercial Forest Land

Ninety-one % of the timber companies responding showed that even-aged management was being practiced on their land. Forty-three companies reported a total of 17,213,525 acres of forest land under even-aged management out of a total of 25,392,551 acres, which is approximately 67% of the total forest land area owned by the companies reporting. The total acreage that was reported as being clearcut annually was 605,500 acres with an average of 14,719 acres reported per company. Of more significance for quail management was the average acreage size of clearcut reported by the timber companies. This amounted to an average of 227 acres per company with a range of 50 to 1500 acres. Although 23% of the timber land managers said that there was no maximum size limit on the clearcuts, only 16% of the companies reported clearcut acreage of 400 acres and over.

The average span of time between clearcutting of adjacent blocks ranged from 1 year to 30 years. Fifty-one % of the companies reported short cutting spans of 10 years and under.

The majority of the timberland owners are utilizing some form of site preparation with 75% of the companies reporting that 80% or over of the clearcut areas were site prepared, with a total acreage of 535,470 acres reported as site prepared in 1971. A large majority of the timber companies reported burning and soil scarification with heavy equipment as being the main technique used in site preparation. Fourteen companies reported a total of 33,100 acres of land site prepared by burning alone, while 39 companies (91%) reported a total of 370,124 acres site prepared by a combination of heavy equipment and burning. Severe criticism of this method used in site preparation was limited. Nine companies (21%) reported criticism of the clearcutting operations with most of the criticism coming from local sportsmen's groups.

Quail Management on Commercial Forest Land

Only 11% of the companies reported any specific consideration given to the site preparation program for quail habitat management. Forty-five % of the companies reported using food strips in a quail management program. A total of 4,539 food strips with a combined acreage of 1,746 acres was reported. The proportion of land planted to food plots to total acreage was 1 to 14,543 acres.

Only 6 companies reported using quail feeders, the range being 28 to 750 feeders per company. Only 1 company reported the release of pen-reared quail.

Fourteen companies (33%) reported a total of 71,400 acres of land managed specifically for quail. Of the total acres owned by timber companies, 1 acre of land was managed for quail out of each 355 acres of timberland owned. Only 21% of the companies reported leasing lands specifically for quail hunting.

Thirty-seven % of those responding indicated that interest for leasing land for quail hunting had increased, none of the companies reported any decrease in interest, whereas 54% reported interest was remaining about the same as in previous years.

Forest Management on National Forest Lands

Questionnaires returned by the U. S. Forest Service personnel in Region 8 showed that out of a total 12,205,894 acres of forest land, even-aged management was practiced on 10,831,000 acres. The total acreage on 30 national forest areas reported to be clearcut annually was 112,150 acres, with the annual clearcut ranging in size from 1,250 acres to 20,000 acres per national forest. The average size per clear-cut was 43 acres in the Mountain area, 65 acres in the Piedmont, and 90 acres in the Coastal Plains. Maximum size of clearcuts averaged 63 acres in the Mountains, 125 acres in the Piedmont, and 117 acres in the Coastal Plains.

The span of time between clearcuttings on a given site ranged from a minimum of 10 to 20 years to a maximum of 10 to 100 years with the majority of the national forests reporting a range of 10 to 30 years.

All but 3 national forests reported that 100% of their clearcut land was site prepared. In the other 3 national forests the reports showed 90% of the land was site prepared. In the Southern Region a total of 133,125 acres was site prepared in 1970-71.

The most commonly used technique involved in site preparation was the tree injecting method (55,661 acres) followed closely by preparation with heavy equipment (52,995 acres). Burned sites accounted for only 17,287 acres (Table 1).

Sixty-six % of the respondents reported they were criticized for the site preparation techniques used, with the majority of the criticism coming from local sportsmen and ecology groups.

Quail Management on National Forest Lands

Nearly 0.5 (47%) of the national forest rangers reported that some specific consideration was given to site preparation for quail habitat management.

Only the national forests in the deep southern states of Alabama, Arkansas, Florida, Georgia, and Mississippi established food strips for quail. National forest areas in these states reported a total of 1,135 acres of quail food plots, which amounted to 1 acre of food plantings per 10,754 acres of timberland.

Reports indicated that in only 5 southern national forest areas was there a substantial acreage specifically managed for quail. The total acreage reported in these 5 areas was 206,000 acres.

The interest in quail hunting increased in Arkansas and in the 5 deep southern states and remained constant elsewhere.

Table 1. Acreage Involved in Three Types of Forest Site Preparation on National Forest Lands of Region 8 for 1970-71.

	Burning	Heavy equipment	Comb. of both	Tree injecting	Total acres
Alabama	6,104	1,520	7,624	3,417	18,665
Arkansas (Okla.)		6,000		18,000	24,000
Florida		17,300	17,300		34,600
Georgia	130	3,850		4,750	8,730
Kentucky		1,242		4,619	5,861
Louisiana	1,300	2,700	1,400		5,400
Mississippi	648	7,983		10,169	18,800
North Carolina	1,627			1,567	3,194
South Carolina	2,400	4,800	350	1,750	9,300
Tennessee				1,440	1,440
Texas	5,080	6,300	5,080	1,060	17,520
Virginia		1,300		8,889	10,189
TOTALS	17,289	52,995	31,754	55,661	157,699

Discussion

The total acreage of clearcut and the size of clearcut areas were substantially greater on commercial forest land than on national forest land. The majority of the companies reported having clearcut acreage approximately twice as great as the acreage of clearcut on national forest land. This increase in size of harvested area would be expected on commercial forest land where significant monetary savings accruing from harvesting larger areas are usually considered to be more mandatory than on nationally owned forest lands.

Burning as a technique in site preparation was much more commonly used on commercial lands, whereas tree injecting was much more commonly used on national forest lands. Injection was not mentioned by any of the reporting timber companies. Plant successions developing from tree-injecting techniques do not normally have as many good quail food plants as do the plant communities developing from burning or discing techniques.

The total acreage developed for quail food plots in both commercial forest land and national forest land was insignificant considering the acreage involved. The reported increase in interest in quail hunting reported by Rangers in 6 southeastern states should point out the need for greatly increased habitat management programs in Region 8.

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PANEL SESSION II

HERETICAL IDEAS ABOUT BOBWHITE ECOLOGY AND MANAGEMENT

Moderator -- Ralph W. Dimmick,
Associate Professor of Forestry
The University of Tennessee

THE ONE QUAIL PER ACRE MYTH

Forest E. Kellogg and Gary L. Doster, Southeastern Cooperative Wildlife Disease Study, University of Georgia, Athens

Edwin V. Komarek, Sr., and Ray Komarek, Tall Timbers Research Station, Tallahassee, Florida

Abstract:

Data are presented which conflict with the 1-bird-per-acre saturation point concept for bobwhites (Colinus virginianus). Conclusions are that if a saturation point exists it is at a level greater than 2 bobwhites per acre.

A well-accepted dictum in bobwhite management has been that 1 quail per acre is the maximum attainable population level. Present-day concepts were summarized by Rosene (6:221) who indicated that the maximum stable population was only slightly over 1 bird per acre. He suggested that regardless of habitat quality, bobwhites would not tolerate greater densities since mature birds refused to be crowded beyond that point.

Data gathered by the authors during the first 4 years of a bobwhite management study appear to refute the validity of a 1-bobwhite-per-acre maximum.

Funds for this study were provided by Tall Timbers Research Station, Tallahassee, Florida; the Federal Aid in Wildlife Restoration Act (50 Stat. 917); and through Contract No. 14-16-0008-676, Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior.

Methods

This study was conducted at Tall Timbers Research Station, a 2800-acre area located in a limestone region of broken terrain in the northern part of Leon County, Florida. Prior to 1800, vegetation on most upland sites in the area was largely pine (*Pinus* spp.) and wiregrass (*Aristida stricta*). At some time during the 1800's most upland sites were in cropland. By 1900 many of the fields had reverted to woodland, and annual burning in late winter or early spring was the local practice. As a result of such treatment a rich herbaceous flora developed as an understory in an open pine woodland. The area under consideration was managed primarily for quail hunting from 1895 until 1964 when it was transferred to Tall Timbers Research Station (1). Tall Timbers Research Station is bordered on the south by a large lake, on the west by a dense hardwood hammock, and on the north and east by quail-hunting lands of other plantations. The bobwhite population on Tall Timbers was high in 1964 and remained high throughout the present studies.

In 1968, a portion of the Research Station, including corn fields, fallow fields, botanical plots (9), mature pine woodlands, and some thickets in wet areas, was selected for study. Ninety % of the area in thickets and woodland was burned annually, whereas the fields and scattered 0.5-acre botanical plots were not. An extensive network of fire lanes was plowed each year to protect the plots. Mature pine (*Pinus taeda* and *P. echinata*) and live oak (*Quercus virginiana*) predominated in the open woodland areas, whereas water oak (*Q. nigra*), sweetgum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), and mockernut hickory (*Carya tomentosa*) were the primary species along water courses. Partridge pea (*Cassia* spp.), native lespedezas (*Lespedeza* spp.), beggarweeds (*Desmodium* spp.), and other herbaceous plants were common each spring after the February and March burns. Over 200 species of plants, 29 of which were legumes, were recorded in an experimental plot of 20 acres (unpublished data, Tall Timbers Research Station). No food patches were planted for quail.

Estimates of the bobwhite population density on 1118 acres were made in November 1968 and February 1969 (4). Using data obtained during these population estimates as a guide, 2 study sites of approximately equal population density were selected (Fig. 1). Sizes of the study sites--1 of 505 acres and 1 of 524 acres--were dictated by the amount of manpower available for census work. At the nearest point the 2 sites were separated by approximately 200 yards.

In the springs of 1969, 1970, and 1971 most of the fields on Study Site 1 were planted in corn, whereas cultivation was terminated in the spring of 1969 on Study Site 2. Annual burning of the woodlands was continued on both areas. Herbicides and pesticides were not used in the corn fields. Corn was harvested with mechanical pickers in October and November of each year, and in 1969 and 1970 the fields were plowed in December. Little grain was available after the fields were plowed. In accordance with plans for a future study, the fields were not plowed in December 1971.

In February of 1970, 1971, and 1972, quail populations were estimated using the Lincoln Index method. Quail traps (7) were placed at selected high-use sites, baited with cracked corn, and checked twice daily. Approximately 1 trap was used per 6 acres. Quail were banded and released at the trapping site. Efforts were made to band approximately 0.5 of the population. Additional traps were set 200 to 400 yards from the boundaries of the study sites in 1970 and in 1971 to determine if banded birds were moving off the study sites due to increased human activity. Birds captured off the study sites were not banded. In no year did trapping take more than 2 weeks. Collection by shooting commenced 2 days after banding operations ceased and is assumed to have provided a random sample of the population. The collection parties, using dogs, swept back and forth across each study area covering the total area as many times as necessary to collect an estimated 20% of the population. Collections usually took 6 to 9 days. Population estimates and 95% confidence levels were calculated using the method of Davis (2:107).

Results

In 1970 and 1971, population density on the study site with corn fields exceeded 2 bobwhites per acre, and in 1972 increased to more than 3 bobwhites per acre (Table 1). The study site with fallow fields held more than 1 but less than 2 quail per acre during each year of the study.

Trapping records indicated that quail moved only short distances during our trapping sessions. Seldom were quail trapped more than 200 yards from the original point of capture. In one trap, 58 different birds were caught in a period of 9 days. Three different coveys were often captured at a single trapsite within a week, and it was not uncommon to catch 20 or more birds in a trap at 1 time. Trapping conducted off the study sites in 1970 and 1971 did not yield birds banded on the study sites.

Discussion and Conclusions

Stoddard's (7) early work on bobwhites indicated that a November population of 1 bird per acre over areas exceeding 1,000 acres was exceptionally high and was approached "only on the finest and most diversified quail ground." He also noted that intensive quail preserve development was just beginning and that there was no basis upon which to predict the maximum density of quail that could be produced in the future. In reports to the Cooperative Quail Study Association in the mid thirties, Stoddard (8) indicated a belief in a saturation point for bobwhites.

The saturation point concept for bobwhites, with a 1-bird-per-acre maximum, was developed by Leopold (5). Saturation point was an upper density limit determined by competition among individuals of the same species. It was considered an inherent property of certain species. and was said to exist when the same maximum population densities existed on a large number of widely separated optimum ranges. Leopold based this 1-bird-per-acre maximum density concept for bobwhites upon wide experience in game surveys, historical records, and Stoddard's (7) quail investigations. He believed that bobwhite populations occasionally surpassed 1 bird per acre, but only for a short time.

Leopold's 1-bird-per-acre concept was well accepted by wildlife managers, and little information has been presented to challenge such a viewpoint. However, Stoddard in his later years (1964, personal communication) surmised that fall population densities on managed lands in the Thomasville, Georgia/Tallahassee, Florida region were approaching 2 bobwhites per acre over large areas. Ellis et al. (3) contended that with proper management, bobwhite densities in the fall could exceed 1 bird per acre. Kellogg, Doster, and Williamson (4) reported a late winter density of 1.2 bobwhites per acre. Although Leopold (5:71) undoubtedly was responsible for the widespread belief in the 1-bird-per-acre limit, he did not close the door to new ideas. His chapter on density limits was summarized in the following manner:

> This account of what little is known, or guessed at, about fluctuation and density limits in game, contains a high percentage of surmise or speculation, because the accumulated labor of naturalists contains a low percentage of attention to this fundamental subject. Scientists have been studying it in the handmade glass-bottle environments of the laboratory. This is proper--they will some day extend their experiments to the hills and fields.

Our experiments were extended to the field, and at this interim point in our study we have documented bobwhite densities greater than 1 bird per acre for a period of 4 years. There is no indication that the high population densities on our study areas were the result of recruitment from outside. On adjoining plantations supplemental feeds were abundantly available as were natural feeds. We suspect that the weedy corn fields on Study Site 1 produced good brood-rearing range and thereby contributed to the high population density indicated by the February estimates. It should be emphasized that these population estimates are not the usual fall estimates upon which the concept of saturation point has been based. These are late winter estimates. Fall estimates would have indicated even higher population levels. These findings do not necessarily invalidate the concept of a saturation point for bobwhites, but they do suggest that if such a population density limit exists, it is at a level greater than 2 bobwhites per acre. Population densities of 2 to 3 quail per acre are not rare in the Thomasville, Georgia/Tallahassee, Florida region today.

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Table 1. Banding data and population estimates.

Area	Date	Bobwhites banded	Bobwhites collected	Banded bobwhites collected	Total population estimates ($P<0.05$)	No. bobwhites per acre	Total # coveys* on study site	Average # acres/covey
Study Site 1 (505 acres with corn fields)	1970	663	219	127	1143 ± 132	2.3	95	5.3
	1971	684	237	117	1386 ± 182	2.7	115	4.4
	1972	806	312	163	1543 ± 177	3.1	128	3.9
Study Site 2 (524 acres with fallow fields)	1970	284	127	50	721 ± 159	1.4	60	8.7
	1971	438	140	74	829 ± 132	1.6	69	7.6
	1972	335	135	77	584 ± 87	1.1	48	10.9

*Average covey size = 12 birds

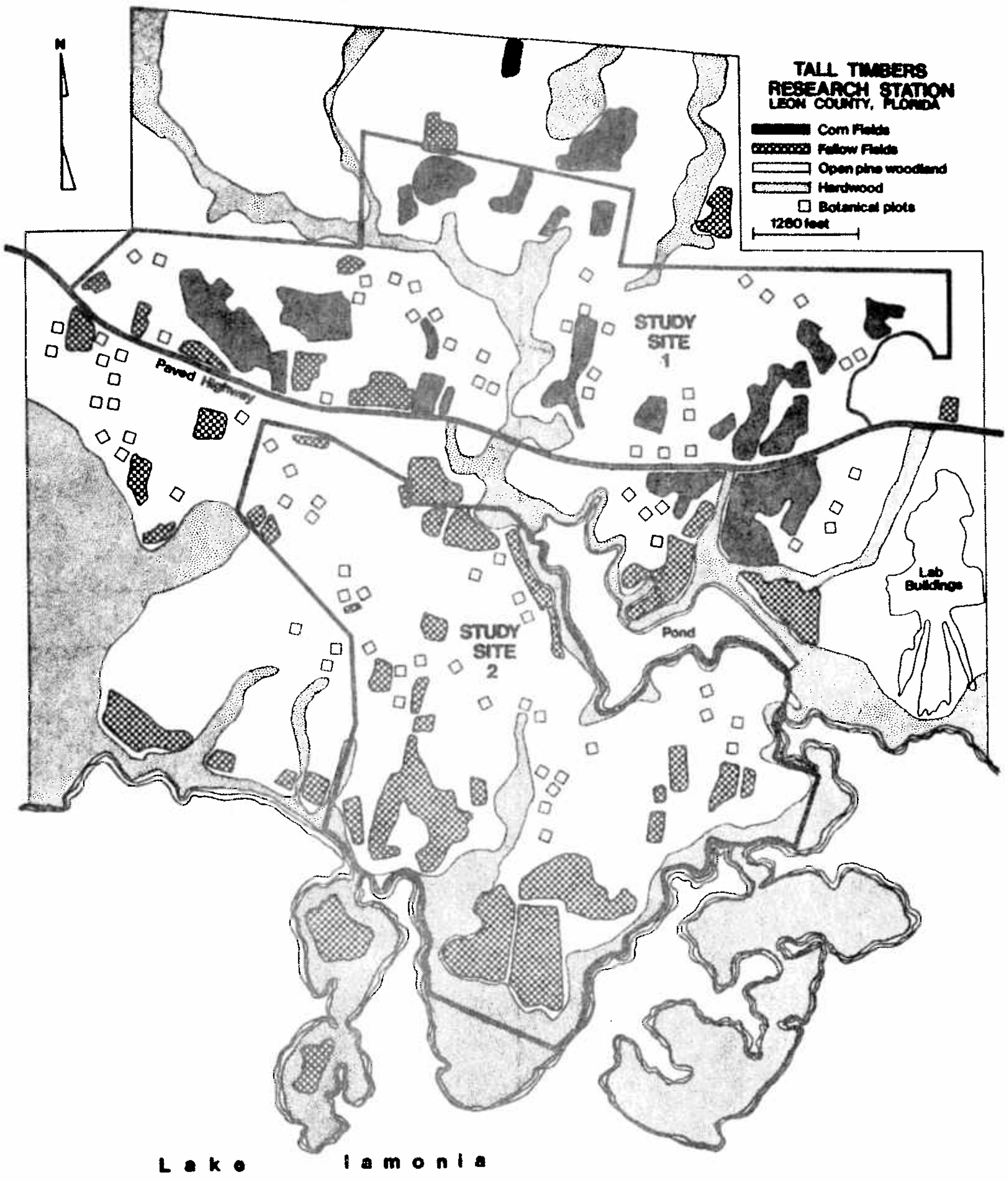

Figure 1. Study Site 1---80.2 acres in 17 corn fields averaging 4.7 acres each and 19.1 acres in 7 fallow fields averaging 2.7 acres each. Study Site 2---102.1 acres in 23 fallow fields averaging 4.4 acres each.

SECOND BROODS IN BOBWHITE QUAIL

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Abstract:

Data on second broods in bobwhite quail is limited due to a lack of information on molting patterns, quiescence of female gonads, nesting chronology, and parental behavior in males and females.

An analysis of these factors is presented along with a discussion of 19 occurrences of second-clutches in Missouri. The impact of second broods on quail populations is discussed.

Of many topics pertaining to the life history and biology of bobwhite quail, that relating to second broods is most shrouded in speculation and mystery. The lack of information is due to 2 factors: (A) time involved in studying an entire nesting season to secure second-brood data, and (B) difficulty of observing the double-brood sequence in wild populations. Chance observation is an important factor.

But awareness that second broods exist is the greatest key to understanding the subject. By learning the patterns of quail behavior and production associated with second broods, we increase our chance of evaluating the phenomenon.

The occurrence of second broods in bobwhites seems to have been fairly common knowledge to earlier ornithologists and to rural folks having opportunity to observe pairs producing first and second broods. However, the occurrence of second broods has been questioned or denied by many students of bobwhite behavior, despite strong indications that they may be common in normal reproduction, and perhaps a most important factor in the rapid recovery of quail populations following severe population "lows."

I do not question the occurrence of second broods for bobwhites; second broods are a documented reality. The question is, how many occur, and under what specific conditions are they most likely to occur?

Dr. Frank H. Knowlton of the U. S. National Museum stated (5) of the bobwhite quail, "The male assists in caring for the young, taking full charge of the first brood while the female is hatching the second." Bent (1) also referred to second broods in bobwhite, but expressed doubt as to the existence of proof of such occurrences.

Since these writings, some people have accepted as fact that bobwhite quail have second broods; others have not. Many biologists have been skeptical that second broods are a logically expected occurrence in the life cycle of such a short-lived, high-turnover species as the bobwhite quail. Some commentators have misquoted facts or expressed undocumented beliefs in concluding that bobwhite lack second broods. It is time to set the records straight on this most interesting subject.

Workers who have devoted considerable time to the study of bobwhite population dynamics and reproductive behavior have often knowingly or unknowingly made observations that indicate a possibility of second broods. Hickey (4) stated "Because the number of young per adult is roughly twice that of any other galliform species thus far reported, speculation always seems to arise that this species may raise 2 broods. This possibility ought to be settled by close observation of marked birds under semi-captive conditions." Lehman (6), in observing and studying population fluctuations of Texas bobwhite quail, considered ". . . the possibility of not only 1 brood of young from most pairs, but 2 broods in a single season from some."

Frank Schley (8) discussed first and second broods in quail so logically that one can easily relate to the rural observation and discussions that form the basis of the article. Present day stories about observations of second broods by rural people ("first brood under the spirea bush and then the renesting hen under the climbing rose with the hen joining the cock and young in the road for feeding") parallel Schley's conclusions.

Unfortunately, we have too often discarded such observations by rural individuals who have often lived closer to the birds than do many people who write about them. Stoddard (11), while not recording occurrences of second broods in his most excellent work, would have, I believe, ultimately observed them had his carefully concentrated nesting-production studies continued. The accumulated evidence of most long-term work gradually points to the occurrence of second broods. Stoddard states, ". . . many broods are encountered afield in charge of one parent." But his subject reference pertains to topics other than second broods. I believe that time alone would have expanded his findings to include second broods, if they are characteristic of quail in the southeastern portion of the range. This latter comment is made because of the possibility that an inclination for second broods may be more characteristic of birds in the more rigorous portions (snow-cold and droughty fringe areas) of the quail's range. Francis (2) speculated that second broods were a possibility in California quail (Lophortyx californicus). Gullion (3) also found evidence of second broods in Gambel's quail (Lophortyx gambelii). Thus, there accumulates interesting speculation and evidence that point to the possibilities of more than 1 brood per season in bobwhites and related Galliformes.

Today there arise repeatedly, under topics of facts, fancies and myths in game biology, so-called logical reasons why bobwhite quail cannot or do not have second broods. To clear the record on these traditional misbeliefs, I offer the following comments based on investigations of bobwhite quail production in Missouri.

1. A most authorative reason given for no second broods in bobwhite quail is that "Stoddard says so." I have heard this reason given by professional scholars and biologists who should have known better.
   ANSWER: This is a gross misstatement of Mr. Stoddard's reference to second broods. In his book The Bobwhite Quail (11) he states. ". . . no evidence of attempts to produce

second broods, when a first was successful, came to light during the course of the investigation." In discussing this topic with Mr. Stoddard, however, I received strong encouragement from him to pursue further studies "that might reveal the occurrence and place of second broods in bobwhite biology."

2. "Bobwhite quail can't raise second broods because the hen must brood the young." This statement ties in closely with the quote that "second broods are an impossibility because 'everybody knows' that it takes about 170 days or around 5.5 months to produce and rear a brood of quail; there just isn't time to have 2 broods."
ANSWER: Bobwhite chicks are definitely brooded early in life by both male and female parents. The male bird readily assumes brooding duties when a hen is lost or renests for a second brood. My data show that a hen will renest within 8 days after hatching brood number 1, and that the cock readily takes over brooding and rearing duties. The hen appears to lose all interest in the first brood at such times. Thus, by sharing care of the brood, quail pairs can, and do, have the physical and behavioral capabilities to rear 2 broods in 1 production year.

Figure 2 shows that the total time involved in producing double broods from first nesting to completion of molt by hen and young may vary from 247 days (7 June hatch) to 194 days (19 July hatch).

3. Hens are no longer in adequate physical condition to produce and rear a second brood after incubating a clutch and hatching it.
ANSWER: This has been partially answered in the preceding question. Many hens successfully hatching first clutches during June possess quiescent gonads through early August, which may be activated to laying condition shortly after the chicks are hatched or even after 10-day-old young are lost.

4. After successfully completing and hatching a clutch, quail hens molt; such molting is recognized as the cessation of active productive effort.
ANSWER: The latter portion of this statement is partially correct because molting usually, but not always, signifies the end of production effort. Actually, after an early onset of molt and the replacement of 1 or 2 primaries, a hen may be triggered to cease molting, resume nesting, and produce a second clutch or brood. The statement that hen quail molt immediately after hatching their young (as is typical of some chickens) is false. Data from Missouri for "normal" production years show that about 18% of the hens hatching chicks in June undergo onset of molt within 2 weeks following the hatch; the remainder molt later in the summer. Many hens with broods may not molt until late in August or even early September (Stanford 1972). Thus, many hens not molting in June, July, or August remain in condition to have clutches of eggs through mid-August and occasionally into early September. A few hens nest as late as September.

Fig. 1 presents production phenology of Missouri quail and hen molting patterns for "normal" weather years.

5. When quail pairs are observed in late July through September with young of 2 age groups, 1 "age-size" represents "strays" that have been adopted. They are not from second broods. ANSWER: Although the above may actually happen, there is ample evidence that family groups constituted of young of 2 age classes may be the product of successful first and second broods. Careful observations bear this out as do collections of hen and young, which often reveal that the youngest chicks are the product of a hen with full brood patch, and that all young are of proper age to be from a first and second brood sequence.

   Also, limited studies of adoption tendencies in wild quail, strongly indicate that wild hens are not as prone to adopt small, strange birds as is popularly supposed. Much remains to be learned concerning wild hen response to, and acceptance of, chicks other than their own.

One could go on discussing such misconceptions that are offered to debunk the second-brood concept. The facts easily override such contentions. Actually quail can, and do, have second broods and probably to an extent far greater than we realize.

Quail production and molt studies in Missouri have been in progress for 25 years. Original study objectives did not provide for observations on second broods; however, the accumulated evidence through years of study and observation have removed all doubt as to the physiological ability and behavioral potential of quail pairs to produce and rear 2 broods per season.

Since 1950, our quail projects have involved an annual average of 30 January-February wild-trapped pairs held in isolated field-ground pens. Observation and study of monthly production and primary feather molt patterns of young birds and adult hens (some cocks) have been the major objectives. But through the years, wild pairs having second broods occurred to such a degree that studying them became a separate "spin off" project.

Stanford (9), after 6 years of bobwhite field studies, reported field observations of second broods in a feral pair and 2 wild pairs held in isolated ground pens, all in the same year. Such observations were not designed to be a study of second broods, but the work turned out that way.

During the last 2 decades, we have accumulated considerable data on molt onset and progression of primary molt in young and adult wild birds, along with much information on nesting behavior of bobwhite quail (Stanford, unpublished). The data have been supplemented with annual field collections of wild birds in various stages of producing and rearing broods. These studies, and information from other quail investigations in Missouri, show that:

1. Bobwhite quail in Missouri abandon winter covey units around mid-to-late April. Mass nesting efforts during May produce a first hatching peak at about 15 June which yields 64% of the annual crop of young. July-August nesting effort of (A) late nesting birds, (B) birds that have lost early clutches or broods, and (C) possibly successful first-brood hens attempting second broods result in a second hatching peak at around 15 August. This later effort contributes about 36% of the annual production. The period of egg-laying through hatching embraces about 122 days (May through August).

2. Hens associated with the 15 June hatching peak may or may not begin molt. Approximately 18% do molt at this time, but the remainder do not, remaining in a potentially productive condition until a much later onset of molt. A study of wild birds in the field and wild pairs in pens plus the annual analysis of the molt pattern of 10,000 hen wings collected from hunters show that most hens begin molting during late July, August, and early September (Fig. 1).

3. During the early and middle portions of the annual production season, many hens remain in a physiological condition to mate, lay eggs, and produce young. Some male birds are receptive to mating and are capable of fertilizing these hens.

4. Along with the many field observations of wild, mixed-age, July-August young, some of which may be second broods, we have recorded and followed through on 19 documented cases of second brood attempts in wild bobwhite (feral and penned wild birds). Of these 19 fertile, second clutches following first broods, 14 hens successfully hatched young while the male cared for the first brood. The 5 unsuccessful second clutches failed because the hens were lost to blackhead or to predation, or they deserted their nests.

5. Onset dates of molt of some second-clutch and/or second-brood hens reveal the delay of onset of molt in bobwhite quail during a nesting season: 12, 15, 24, 28 July; 3, 5, 5, 9, 15, 19, 20, 27 August; 4, 5, 5, 12 September.

6. Of the birds involved in second brood attempts, 11 (58%) were adult hens and 8 (42%) were yearling birds. On the basis of age groups in the nesting studies, adult hens appear to be 5.5 times more likely to attempt second broods than do yearling hens. Most renesting attempts occur from late June through early August.

Should the high percentage of adult hens showing propensity for second broods be applicable to the wild, we might assume that second broods would never reach significant proportions. Under normal conditions, adult hens represent only a rather small percentage of a nesting population.

Following severe winter snow-cold conditions and during and following prolonged high-temperature drought, normal age structures may be so altered as to cause significant changes from the normal pattern of reproduction. High population densities concentrated in limited habitat, accelerated production efforts resulting from markedly improved habitat in previously drought-seared areas, and a greater-than-normal proportion of adult hens following a severe drought period with poor production may interact to set the stage for much production of second broods. Rapid population changes from extreme lows to sudden, dramatic highs (irruptions) may well result from the quail hen's ability to fill an expanding habitat by second-brooding.

Our data clearly document the occurrence of second broods and shed much light on the chronology of such events as nesting, onset of molt, and completion time of primary molt in both hens and young. Fig. 2 presents comparative data for 1 single-brood occurrence and 2 second-brood attempts that were documented for hen and young over the entire production-growing period.

Of particular interest is the timing of primary molt onset in hens at different nesting periods, and the time required for completion of primary feather growth. For both adult hens and their young, the time required for feather growth shortens when the production-molting events occur late in the nesting period. The marked variation in primary feather growth of young wild quail is striking when compared with similar growth information based upon pen-reared birds (7).

I conclude that while second broods are most difficult to study and carefully document, their occurrence in a quail population probably adds far more young to an annual bird crop than we are aware of or may ever be able to ascertain. Studies on the droughty, fringe areas of the quail's range may have the greatest potentiality for providing large amounts of information on second broods.

Additional studies, based on an awareness of the bobwhite's potentiality for producing second broods should be forthcoming through careful observations. Collecting adult and young birds and paying special attention to the study of molt, brood patch and primary feather growth progression also may provide new insights on this subject.

The case for documented information on second broods in bobwhite quail does not rest, but goes on in Missouri quail studies. Although we know that quail can and do have second broods far more than we previously suspected, the all-important questions remain as to how much, and under what environmental-population conditions.

Such questions provide a challenge in continuing studies of the bobwhite quail--and in time, they will undoubtedly be answered.

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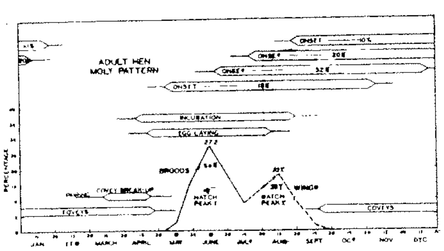

Figure 1. Annual reproduction-behavior-molt phenology of Missouri bobwhite quail.

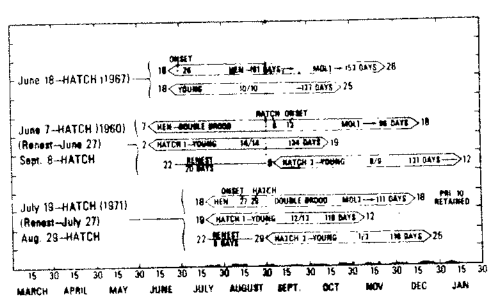

Figure 2. Hatching and primary feather growth in adult hens and young in single and double broods of bobwhite quail in Missouri; birds trapped in February and held in field ground pens.

CHANGES OF COVEY AFFILIATION BY BOBWHITE QUAIL IN TENNESSEE

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Abstract:

This study was conducted on a 214-acre area of the Ames Plantation, Fayette County, Tennessee. Information on behavior of bobwhite quail (Colinus virginianus) during winter was obtained through flushing, trapping, color-marking, and telemetering quail during January-March, 1970. Interchange of quail between coveys was common; at least 20 incidences of change in covey affiliation were recorded. An average covey lost and gained a member every 3 days. Rapid replacement of birds lost from covey ranges was attributed to communication between coveys.

The degree to which bobwhite (Colinus virginianus) coveys retain the integrity of their membership has been discussed by several authors. Stoddard (6:169) noted changes in covey composition in southeastern United States, but believed that quail attempted to remain with a given covey. Harvey (3) concluded that exchange of individuals between coveys in Virginia may be common throughout winter. In a population of quail in Iowa with density sufficiently low that covey ranges did not overlap, individuals did not change coveys (1,2). The fact that covey ranges overlap, however, does not necessarily indicate that interchange will occur. Murphy and Baskett (4) investigated coveys in Missouri with overlapping ranges and concluded that individuals did not change their covey affiliation during the study period.

This paper estimates the extent of interchange of quail between coveys in a moderately high density population in southwestern Tennessee. A discussion of the biological significance of changes in covey affiliation by quail is offered.

The Study Area

The study area was located on the Ames Plantation, an 18,600-acre tract in Fayette and Hardeman counties, Tennessee. Quail behavior was studied on a 214-acre plot within a quail management unit. A census conducted immediately prior to this study (December, 1969) revealed a density of 1 quail per 2 acres on the study area. At the termination of the study the population had declined to 1 quail per 2.4 acres.

Methods and Materials

Quail were live-trapped on the study area, and marked with radios or colored back streamers, and released at the point of capture (7). Coveys containing a telemetered bird were located at 2-hour intervals

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diurnally. The bird was approached to within 30 to 70 yards as indicated by signal intensity and then circled to discern its exact location. Each captured covey was assigned 1 of 6 easily discernible colors of back streamers. Systematic searches were conducted to flush coveys on the study area; data recorded at each flush included the number of birds seen, color of streamers seen, if any, and flush location and landing site of coveys.

Results and Discussion

Density of quail on the area was sufficiently high that several coveys often utilized a unit of habitat in a fashion resulting in great overlap of their ranges. Our efforts to define individual covey ranges and to evaluate preferences for specific cover types were repeatedly complicated by shifts of individuals from one covey to another. Observations of color-marked birds, data obtained from telemetered birds, and counts of covey size at time of flushing all supplied evidence of interchange of quail between coveys.

Despite the transitional quality of its membership, each covey unit displayed rigid fidelity to its home range. Only once did a covey wander across a range perimeter previously established by a week or more of telemetry data. Flushed birds were never observed to fly across established range boundaries. However, the number of birds counted at flush for each covey fluctuated irregularly as winter progressed (Fig. 1). Stoddard (6:170) and Rosene (5:96) noted similar changes in size of coveys.

Changes in Covey Affiliation by Banded, Color-marked Quail

In the southeast portion of the study area we banded and color-marked 16 quail in Covey 1, 15 quail in Covey 3, 8 quail in Covey 4, and 13 quail in Covey 5. Of the 52 birds banded in these 4 coveys, 24 were recaptured at least once. Ten of these were recaptured after changing covey affiliation; 1 quail was captured in 3 different coveys. Quail captured in 2 or more coveys included 3 adult males, 3 juvenile males, 1 adult female, and 3 juvenile females. These 10 quail were recaptured over an average span of 40 days. The 14 quail recaptured each time in their original covey were followed over an average of 25 days.

Observation of color-markers during covey flushes in the southeast portion of the study area provided additional information on interchange of quail between coveys. Covey 1 was flushed 11 times, Covey 2 11 times, Covey 3 17 times, Covey 4 8 times, Covey 5 6 times, and Covey 6 16 times.

In 5 instances the number of color-marked quail observed to have shifted covey affiliation was greater than the shift indicated by trapping records. Nine color-marked quail changed covey affiliation but were not recaptured during their association with the second covey. We recorded a total of 20 incidents of banded and color-marked quail changing affiliation (Fig. 2).

Changes in Covey Affiliation by Telemetered Quail

Four of 13 birds carrying functional transmitters changed coveys during the period of observation. Although it is possible that transmitters on quail affected their behavior, our data indicated that telemetered quail were not noticeably deviant in behavior after rejoining a covey. Telemetered birds were always with a covey after having rejoined one. Also, telemetered quail were not readily recognizable from other quail during any of 35 covey flushes involving a telemetered bird. Since behavioral patterns of harnessed quail did not seem to deviate greatly from the norm, a crude estimate of the rate of interchange of quail between coveys could be obtained. We derived this estimate by dividing the 148 days birds carried transmitters (13 birds-average 11 days/bird) by the 4 times that harnessed quail changed coveys. These quail then, changed coveys once every 37 days. By this estimate an average covey of 13 birds would lose and gain a bird roughly every 3 days.

Mechanism of Covey Interchange

Rapid replacement of missing birds on covey ranges was believed common. On several occasions coveys from which a number of birds were trapped and held captive were near original size the following day prior to the release of trapped members. A marked decrease in the number of color-marked quail often occurred from 1 day to the next without a corresponding drop in covey size. However, a corresponding increase in the number of these color-marked birds in other coveys was not observed. Quail probably did not often lose color-markers in such a short time, but the fate of these birds was not determined.

This consistent, rapid replacement of birds between covey ranges suggests that replacement may be facilitated through communication between quail. Often members of several coveys give covey calls simultaneously. Perhaps members of coveys which have been reduced in size issue characteristic calls which signify their desire to join or be joined by other individuals. Quail separated from coveys may be attracted to these coveys by recognizable characteristics of the covey call.

Conclusions

Fluidity in covey membership apparently occurs most in populations of quail that are dense enough to provide considerable overlap in covey ranges. The adaptive advantage of this fluidity may be important. The observed receptivity of coveys to "newcomers" serves to prevent excessive and uneconomical strife and aggression that might otherwise occur in dense populations. Efficient exploitation of food resources and spatially close units of favorable cover is thus enhanced. As winter progresses and covey sizes are reduced through mortality, this phenomenon of interchange may maintain adequate covey size in those coveys occupying superior habitat units within the range.

Because bobwhites do not normally move long distances in their daily or annual travels, adjustments in home range will likely be small and internal to the population. Large scale emigrations or immigrations will not occur, though translocation of individuals or groups of quail across borders between good habitat and poor habitat may be significant.

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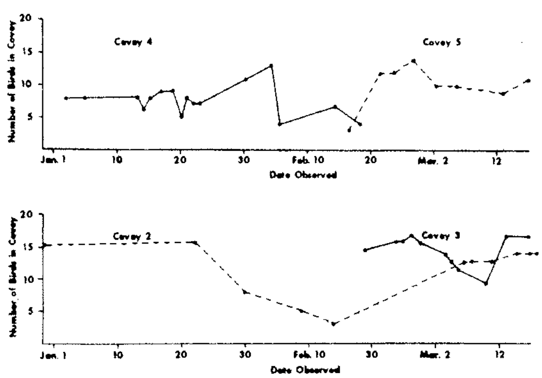

Fig. 1. Variation in size of four coveys observed during winter, 1970 on Ames Plantation.

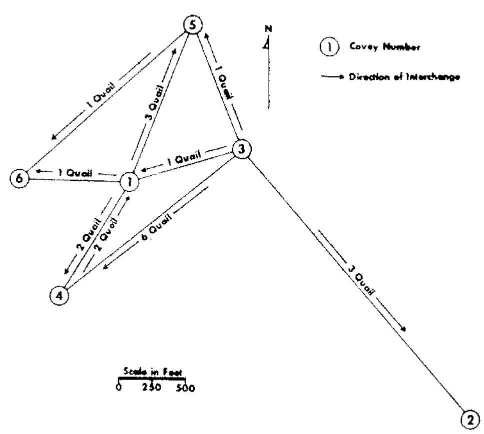

Fig. 2. Interchange of quail between coveys during winter, 1970 on Ames Plantation. Circled numbers represent activity centers for covey units.

IMPACT ON BASE POPULATION DENSITY AND HUNTER PERFORMANCE OF STOCKING WITH PEN-RAISED BOBWHITE

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Abstract:

In 1962, the Kansas Fish and Game Commission initiated an investigation to determine the effect of semiannual releases of pen-raised bobwhite quail (Colinus virginianus) on population densities of native wild quail populations, on availability of birds to hunters, and on hunter success.

Stocking during spring resulted in 7% fewer birds in the fall population on the stocked area than on the control area. Stocking during fall resulted in 14% more birds, at the time hunting season began, on the stocked area than on the control area. Neither of these differences were statistically significant, and it is concluded that there was no significant difference attributable to stocking between population densities of stocked and control areas. On the stocked area, however, there was a significant net increase of 25% in population density between the fall census period and the preseason census period. It is concluded that the density-depressing influence of spring stocking combined with the density-elevating influence of fall stocking, on the stocked area, produced a significant increase, attributable to stocking, between the population density preceding fall release and the population density preceding the hunting season. It is further concluded that in the comparison of preseason population densities for the treatment and control areas, the depressing effect of spring stocking and the elevating effect of fall stocking resulted in a treatment-area population that was significantly larger than that found on the unstocked control area.

Some pen-raised birds established themselves as a part of the population on the stocked area, but there was not a proportional increase in population density. There were fewer native quail on the area when treated with semiannual stocking than when under control condition. The difference in density of native birds between stocked and control areas was not statistically significant.

Stocking significantly increased hunter success by 30% and 35% on areas in Cherokee and Linn Counties, respectively, but the number of coveys flushed per hour was not significantly increased by stocking pen-raised quail.

Bobwhite quail (Colinus virginianus) stocking has been an active program in Kansas since 1922 when the Kansas Fish and Game Department purchased 486 quail from Mexico and experimentally released them in 42 counties. Trapping and transplanting wild native birds or purchasing pen-raised birds for release continued through 1934.

In 1933 and 1935, the Department opened the Pittsburgh and Calista game farms, respectively, to raise quail for release in Kansas. Production from the 2 farms totaled 5,268 birds in 1935. The peak of quail stocking in Kansas came in 1955 when 40,789 birds were released. In 1969, the Calista farm was closed, production at the Pittsburgh farm was reduced, and releases of quail were restricted to the eastern 0.25 of the state.

This paper is based on information obtained under Pittman-Robertson Project W-23-R, Job A-3 entitled Survival and Harvest of Pen-raised Bobwhite Quail. The study had as its primary objective to measure, in terms of hunter success, availability of birds to the hunter, changes in population densities, economics, and the effect of supplementing native wild populations of bobwhite quail with releases of pen-raised quail.

Study Areas and Methods

Data presented in this paper were collected from 3 pairs of study areas. These areas represented some of the variations in cover conditions typical of primary quail range in Kansas.

Two pairs of areas were designated as "extensive" areas from which only weekend hunter bag-check data were collected. On these areas the effect of stocking on hunter performance was the sole objective evaluated. One pair of areas was designated as "intensive" study areas where hunter bag checks were conducted throughout the season and population census data were collected for evaluating the effects of stocking on both hunter performance and population density.

The extensive study areas were located in Cherokee and Greenwood Counties, and the intensive areas were located in Linn County. Data were collected on the extensive areas during 1962-1967. A change in location of the Linn County areas delayed the study of these areas to the 1964-1969 period.

The Cherokee County areas were located primarily on state-owned strip-mined lands, although some private acreage was involved. Cherokee County is situated in extreme southeast Kansas and is within the ecotone between tall-grass prairie and deciduous forest. Vegetation on the areas is dense and topography is considered rugged for Kansas. The Greenwood County areas were situated on the state-controlled Fall River Game Management Area, located within tall-grass prairie at the southern end of the Flint Hills. The Linn County areas, typical of east-central Kansas farmland, were privately owned. Brushy pastures and small cultivated fields, bordered by hedgerows, characterize the Linn Co. areas.

Each study area was approximately 1-mile square and located at least 1 mile from any other study area to minimize movement of birds from 1 area to another. One area of each pair was stocked for 3 consecutive years (Code Sc) while the other area (Code Cs) served as an unstocked control. After 3 years, the roles of the areas were reversed for the second 3-year period. Thus variability due to differences in site would be controlled statistically.

Quail were released during April and October on all treatment areas. One hundred and forty-four quail were released on each of the extensive treatment areas during each release period. During the first year of study, 120 and 144 birds were released in the spring and fall, respectively, on the Linn County stocked area; however, due to excessive egress the stocking rate was reduced to 60 birds per release period, with a 6-year average stocking rate of 70 and 74 birds for the spring and fall releases, respectively. The average spring stocking rate in Linn County was 108% of the average spring base population (65 birds) and the average fall stocking rate was 48% of the average fall base population (154 birds).

Eight-to-10-month-old birds were released in the spring and 16-to-17-week-old birds were used for the fall release, each release containing an equal number of males and females. Fall releases were made approximately 1 month prior to the opening of quail hunting season.

Dense cover types were chosen as release sites, and no additional food or water was provided at a release site. When 144 birds were stocked, 6 releases of 24 birds each were made at various locations on the area; 3 releases of 20 birds each were made when 60 birds were stocked.

Hunter bag checks were conducted by Department personnel on opening weekend on the extensive areas and throughout the season on the intensive areas. In addition, persons wishing to hunt on the intensive areas were required to obtain the landowners' permissions. If permission was granted, the hunting party received a data sheet and instruction sheet from the landowner. Boxes for deposit of these sheets were located on the perimeter of the areas.

A major proportion of the total investigative effort was devoted to censusing quail populations on the Linn County areas. Censusing was practically continuous from the end of a hunting season (various dates in January) until the next hunting season began (third Saturday in November). The overall censusing effort was divided into 5 periods: (1) end of hunting season to 15 March, (2) 16 March to spring stocking date in mid-April, (3) spring stocking date to 31 August, (4) 1 September to fall stocking date in mid-October, and (5) fall stocking to opening of the hunting season. These 5 periods were designated as: (1) winter census, (2) spring census, (3) summer census, (4) fall census, and (5) preseason census, respectively. Census data revealed that numbers of quail in the population declined during winter and spring, increased during summer, and varied up or down during the fall and preseason census periods. Therefore, final census figures presented in these pages represent the numbers of quail in the populations at the end of each period.

Censusing methods employed varied with the time of year. The primary method used during all periods was to walk through all areas containing vegetative cover (bare ground, such as a recently plowed field, was not searched) recording the location and numbers of all quail observed. Large areas of cover were censused by walking along transects, the transect line spacing depending on the density of the cover present.

Small areas were searched along a zig-zag course. In either case the objective was to get a complete census of the entire study area rather than a sample from which to estimate the numbers of quail on the study area. A bird dog was used to locate quail when conditions were favorable. Approximately 1 week was spent on each study area during each census period to obtain final flush counts for the period.

Other sources of information concerning population status were track counts when snow was present, recapture of marked quail, and reports from resident farmers. During the summer, perimeter and interior roads were patrolled by vehicle through the early morning and late evening to locate broods and pairs. Attention to calls produced by the birds was helpful during the general censusing. The study leader performed all censusing.

Data were analyzed by 2-way analysis of variance in which variation among years and variation between treatment and control were tested for significance. Differences among test data were considered significant at $P<0.20$.

Results

Population Density

Population data from Linn County, presented in Table 1, were used to test the effects of spring stocking on subsequent fall populations and on the effect of fall stocking on subsequent preseason and breeding population levels.

The average numbers of birds in the fall populations (before fall stocking) were 154 on the stocked area and 166 on the control area. There were 7% fewer birds on the stocked area than on the control area, but the difference was not significant. We concluded that spring stocking produced no significant difference between fall population densities of the stocked and control areas.

The average numbers of birds in the preseason populations (after fall stocking) were 193 on the stocked area and 170 on the control area. There were 14% more birds on the stocked area than on the control area but the difference was not significant. We concluded that fall stocking produced no significant difference between the preseason population densities of the stocked and control areas. More exactly, semiannual stocking produced no significant difference in population density of the stocked area when compared with population density of the control area during the fall census period (before fall stocking) or the preseason census period (about 30 days after fall stocking).

On the stocked area, spring stocking produced a depressing effect on the fall population density and fall stocking produced an elevating effect on the preseason population density. There was a gross population increase of 39 birds on the stocked area and of 4 birds on the control area, between the fall census (before fall stocking) and preseason census periods. The net increase in population (35 birds) on the stocked area amounted to 23% of the fall population (before fall stocking) present on the stocked area; this difference in population density between the fall census and preseason census periods was statistically significant ($P<0.05$) and attributable to stocking. If this study had been limited to pre- and poststocking censusing of a single-treatment area (no control) the conclusions drawn would have been quite different (see preceding paragraph).

The average numbers of birds in the spring populations (before spring stocking) were 65 on the stocked area and 63 on the control area. The 2 figures did not differ significantly. Because this was a test of the effects of releases in previous years on the subsequent breeding population, 1964 spring census data was omitted as this was the first year of the study. Mean data cited were for years 1965-1969. It is concluded that semiannual stocking produced no significant difference between the subsequent spring population densities (before spring stocking) of the stocked and control areas; in other words, there was no increase in spring population densities attributable to semiannual stocking during a previous year.

Twenty-three % of all birds bagged on the Linn County stocked area were birds released during fall; 3% of the harvest on stocked areas were birds released in the preceding spring. If the composition of the harvest is used as a measure of composition of the total quail population on the stocked area, there were 6 birds from the spring stocking, 44 from the fall stocking, and 143 birds that were native birds or progeny of spring-stocked birds in the preseason population of 193 birds. Thus, 91% of the spring-stocked birds and 41% of the fall-stocked birds were no longer on the stocked area when the hunting season began. Furthermore, the stocked area contained 143 native birds (possibly less if progeny of spring-stocked birds could be identified) and 50 pen-raised birds, while the control area contained 170 native birds. The inferences drawn are: (1) spring stocking had a depressing influence on fall population density, resulting in 7% fewer total birds in the population and 16% fewer native birds (not a statistically significant difference) in the population; (2) fall stocking had an elevating influence on the depressed fall population, resulting in 23% more birds than the depressed level before fall stocking and 14% more birds than the control or normal population level; and (3) semiannual stocking produced a mixture of 74% native birds and 26% pen-raised birds in the fall population, but did not produce a significantly higher population density than occurred on the control area.

Immediately after spring stocking there were 135 birds on the stocked area and 58 birds on the control area. The preseason populations were 193 birds on the stocked area and 170 birds on the control area. The ratios of spring (poststocking) populations to preseason populations were 1:1.43 and 1:2.93 for the stocked area and control area, respectively. Even though the stocked area received a fall stocking (74 birds, average) the rate of recruitment was much higher on the control area. From this we hypothesize: spring stocking causes a reduction in summer recruitment (chick production) which results in a fall population density no higher (probably lower) than occurs without spring stocking;

fall stocking causes an excessively high population density accompanied by an increase in rate of loss of birds (pen-raised and native) from the area; and, the proportion of pen-raised birds in the preseason population is a function of reduced summer recruitment (chick production) and lingering effect of fall stocking.

Hunting Data

Hunter success (gun hours/bird bagged) and availability of birds to hunters (party hours/covey flushed) were used to measure the effects of stocking in terms of tangible benefits to the hunter. If stocking is of significant benefit we would expect better hunting success and increased availability of birds to the hunter on areas where pen-raised birds have been released.

In Linn County, hunters required 1.00 gun hour to bag a quail on the stocked area and 1.53 gun hours on the control; this difference was significant ($P<0.20$). The stocked area yielded 35% better hunter success than the control area in Linn County.

On the Greenwood County areas, the mean gun hours/bird bagged was 1.80 for the stocked area and 1.77 for the control; the difference was not statistically significant.

On the Cherokee County areas, the mean number of gun hours/bird bagged was 1.13 on the stocked area and 1.62 on the control. The difference between the 2 means was significant ($P<0.10$) and amounted to 30% better hunter success on the stocked area.

Hunting parties in Linn County required 1.07 hours per covey flushed on the stocked area and 0.97 hours on the control. These means were not statistically different.

On the Greenwood County study area, parties hunted 1.56 hours/covey flushed on the stocked area and 1.27 hours/covey flushed on the control. The difference between the 2 means was significant ($P<0.10$), indicating 19% greater availability of birds to the hunter on the control area than on the stocked area.

On the Cherokee County areas, the means of party hours/covey flushed, 1.13 for the stocked area and 1.31 for the control, did not differ significantly.

Conclusions

Pen-raised quail are released in spring to add breeding stock to the population of native birds, in the hope of increasing fall population due to progeny of the released birds. We did not attain this objective, as there was no significant difference between the average fall population on the stocked and unstocked areas. In fact, the average population size prior to stocking in the fall was lower on the stocked area than on the control area, demonstrating that birds stocked in spring did not add significantly to the fall population. We believe that spring stocking caused a reduction in summer recruitment (chick production), resulting in a lower average fall population on the stocked area.

Fall releases are made to increase the total fall population and thereby increase hunter success. A secondary purpose for increasing fall populations by fall stocking is to increase fall population carryover into the spring breeding population. Fall stocking did not result in a significantly higher prehunting season population on the stocked area than on the control area. However, as a probable immediate result of increased population pressures produced by fall-released birds, native quail are more likely to be lost from the stocked area at a higher rate than would occur without fall stocking, being replaced by pen-raised birds that survive on the area. As a result, there was actually a lower native population (though not significantly lower) on the stocked area than on the control area. It seems likely that native quail lost through poor production and increased rate of loss from the population are replaced by released pen-raised birds that trigger the losses, but the mechanics of cause-and-effect remain obscure and the concept is hypothetical.

Birds released in the fall did not contribute significantly to the subsequent breeding populations.

Hunter success was increased by stocking pen-raised quail. A population containing 26% pen-raised birds and 74% native birds resulted in increased vulnerability of birds to the gun and an increase in hunter success.

Stocking of quail did not significantly increase the availability of birds to the hunter. Behavior of released birds may contribute to an actual increase in the amount of time spent between covey flushes, as was the case on the Linn and Greenwood county areas.

Table 1. Number of bobwhite quail on the Linn County study areas during each census period 1964-65 - 1969-70.

Treatment	Study year	Spring	Fall	Preseason	Winter[a]
Stocked areas					
Sc[b]	1964	68	104	179	63
	1965	62	190	243	78
	1966	63	239	278	114
Cs[c]	1967	60	94	114	67
	1968	63	149	179	86
	1969	75	146	164	80
Mean		65	154	193	81
Control areas					
Cs[c]	1964	32	99	99	39
	1965	38	182	182	57
	1966	46	155	155	60
Sc[b]	1967	109	208	208	94
	1968	74	232	220	64
	1969	50	120	154	72
Mean		58	166	170	64

[a] Census made in years 1965-1970.

[b] Sc = areas stocked 1964-1966; control 1967-1969.

[c] Cs = areas control 1964-1966; stocked 1967-1969.

Table 2. Gun hours/bird bagged on the Linn, Greenwood, and Cherokee county areas, 1962-1969.

Area	Treatment	Year and gun hours/bird bagged								Mean
		1962	1963	1964	1965	1966	1967	1968	1969	Gun hours/bird bagged
Linn	Stocked	----	----	1.00	0.77	0.89	1.06	0.90	1.40	1.00
	Control	----	----	1.61	2.71	0.76	1.31	1.60	1.21	1.53
Greenwood	Stocked	2.89	1.15	1.25	2.07	1.62	1.84	----	----	1.80
	Control	2.09	1.58	1.38	2.27	1.86	1.46	----	----	1.77
Cherokee	Stocked	1.02	1.16	1.27	1.27	1.36	0.70	----	----	1.13
	Control	0.86	2.40	1.36	2.44	1.71	0.98	----	----	1.62

Table 3. Party hours/covey flushed on the Linn, Greenwood, and Cherokee county areas, 1962-1969.

Area	Treatment	Year and party hours/covey flushed								Mean
		1962	1963	1964	1965	1966	1967	1968	1969	party hours/covey flushed
Linn	Stocked	----	----	1.18	0.99	0.91	1.62	0.69	1.05	1.07
	Control	----	----	1.09	0.89	0.89	0.91	1.13	0.91	0.97
Greenwood	Stocked	1.29	1.11	1.39	2.13	1.84	1.60	----	----	1.56
	Control	0.92	1.06	1.00	1.41	1.76	1.45	----	----	1.27
Cherokee	Stocked	1.28	1.15	0.96	0.96	1.46	1.00	----	----	1.13
	Control	1.00	1.00	1.45	1.73	1.96	0.75	----	----	1.31

PANEL SESSION III

LANDHOLDER - SPORTSMEN RELATIONS: SOLUTIONS FOR A PROBLEM

Moderator -- John A. Morrison, Leader
Oklahoma Cooperative Wildlife Research Unit

THE LANDHOLDER'S VIEWS OF THE PROBLEM: THE OPEN ACRES PROGRAM AS A SOLUTION

The Honorable Henry Bellmon, U. S. Senator for Oklahoma

As the chairman says, I am to talk about the landowners' view of the problem and to discuss the Open Acres Program as a solution. I'm not going to spend much time on the landowners' view because others can present it better. It is true that I'm in a unique position, being a landowner, a quail hunter, and also a politician. I feel strongly about all 3 viewpoints, and have to admit that there is certainly room for a great deal of improvement in all interests.

One of the problems is that city people and country people just don't seem to understand each other very well. A lot of city people think you can go out and befriend a farmer in a few minutes, but they are wrong. You get to know a farmer the way you get to know the people next door, and that is over a period of time and over a series of mutually satisfactory encounters, not by coming in on him 3 or 4 days before hunting season believing you will gain immediate acceptance. It just isn't done. Now I know that many farmers like to go hunting once in a while, but lack a good bird dog. They might enjoy an invitation to accompany you and your dogs, so if you want to become friends with a farmer, do him a favor and invite him to go along. You'll find most of them make pretty good hunting companions. Farmers generally want to be good "Joes," but they have had some bitter experiences that make them guarded about letting strangers in.

Any one who gets permission from the landowner to go on his property has to recognize that it is for 1 day. When he wants to hunt again he must ask again and let the farmer know that he recognizes the farmer's rights to his own privacy.

Now, to get on to the politician's view of the problem. We get tremendous pressure on the government from people who want public hunting areas. There's great pressure to buy land. The Federal Government is spending around 4 or 5 hundred million dollars a year to buy private land and turn it into public access areas. Now even though we do spend these huge sums we are still far short of providing the total amount of land our increasingly urbanized population desires for hunting, hiking, camping and other outdoor activities.

Of course there is, believe it or not, a limit to how much money the Federal Government has. We have the printing presses, and we are doing a fair job this year of running up a 38-billion-dollar debt. We are spending it just about as fast as we can print it. But there is a limit to how far we can go in this business, and so we are writing a new farm bill. We put into it this thing called the "Open Acres Program."

I am not going to go into all of its details now, but just sum up quickly the theory behind it. We now find that most private lands in this country are rapidly being posted. The problem is that if you are a private landowner and do not post your land but your neighbors all post, then pretty soon your unposted land is virtually overrun. So you are forced to post in self-defense. We hope this bill will encourage private landowners not to post but rather to create recreational opportunities and organize ways to make these opportunities available to the urban people who do not have access to public hunting areas.

I might pay tribute to the fellow who really started this whole idea and that is Wendell Bever. You all remember him as former State Wildlife Director here in Oklahoma and later as one of the regional directors, or coordinators, for the National Wildlife Federation. During the time I served as Governor, Wendell came up with the idea that state-owned lands in Oklahoma ought to be opened for public hunting. He was thinking of the areas that are used for parks in the summertime but generally are almost abandoned in the wintertime, yet are not open to the public for hunting. Wendell stirred up a real hornet's nest when he tried to open up state school land leases; he could not get anywhere. He took the position that it was never going to be possible for the state, federal, or local government to own as much land as the public needed for outdoor recreational uses. The only answer lay in the multiple-use concept which in brief says that land can produce both agricultural products, crops or livestock, and recreational opportunities. The key to it is to work out a system that will encourage the landowners first to produce the game, or the fish, or the recreational opportunities, and secondly to permit nonrural people to come in and enjoy these benefits.

So we wrote a farm bill and put into it the Open Acres Program. Now you folks who are in the farm business know that it is very tough to pass a farm bill. Most of the members of the Congress represent consumers or urban areas. They have a very difficult time going back to their constituencies and explaining why the Federal Government spends each year some 3 to 4 billion dollars on a farm program that a lot of people believe has the negative effect of keeping food prices high. These city dwellers generally would much rather see that money go for hospitals, schools, mass transit, or pollution control. It is very difficult for congressmen from New York or Los Angeles or Dallas or Chicago or other big cities to explain why they cannot provide some of the services their cities need, and yet support a 4 billion dollar appropriation for price support and the farm program. Consequently, Congress has put into the farm bill some things that city people like. For instance, the school lunch program is in the farm bill. Now farmers complain about this because it seems that the cost of that program is actually on the farmers, but they get nothing from it. So the Open Acres Program was added to the farm bill in the belief that it is something both rural and urban people will like. I must say that the bill as written was drawn up here in Oklahoma by a group made up of representatives from the State Wildlife Conservation Department, U. S. Soil Conservation Service, and Agricultural Stabilization and Conservation Office.

Briefly, here is how the program is supposed to work. We asked the USDA to allocate a certain amount of dollars for the Open Acres Program. The USDA chose 5 counties in each of 10 states. Each of these counties was allocated a portion of the money to be made available to farmers who would put their land into the Open Acres Program. Farmers were given a period of time to sign up, and from indications here in Oklahoma an adequate number of farmers are participating to give the program a pretty good test in the 5 counties.

After the farmers have signed up, the State Wildlife Department is supposed to inspect their land and certify its eligibility. They have to check to be sure the land has outdoor recreational potentiality. Then there is supposed to be Wildlife Department supervision to see that the lands are managed as well as possible to produce maximum wildlife and outdoor recreational opportunities. The land is supposed to be permanently posted with signs saying it is in the Open Acres Program and accessible to the public. The farmers are to be paid for opening their land to the public. I'm not sure just what the price is going to be. In some areas a flat rate will be paid, and in other areas participation will be offered at the highest bid to see just what must be paid to get farmers to open their land.

After the program is put into effect, it will be closely monitored by the USDA to see how much use is made of the land, how much good the people get from the land, and what kind of relationships the farmers have with those who come to utilize the outdoor recreational opportunities being provided. Based upon what happens this year, the program will either be expanded or dropped from the new farm bill that we are going to write in 1973.

I am very hopeful that the results this year will be good and that farmers who open their land will be treated with the respect that they are due. I am hopeful that the people utilizing those open spaces will find that the game or the recreational opportunities they are looking for are present and that this program can be expanded both for the purpose of paying farmers for this valuable public service and of making available to city dwellers outdoor recreational opportunities close to where they live. I see this country rapidly moving toward posting of most of our private land. Then only urban people with sufficient wealth to lease land and people living close to public-owned areas will have access to the great outdoors. This will be a great tragedy for our country. The Open Acres Program is an opportunity for the farmers to increase their income while generating much good will among their city cousins and for city people to better understand agriculture and farmers as well as to have access to outdoor recreation under a new, vital, and very satisfactory arrangement.

I would like to urge all of you in the room to watch the program and to lend a helping hand to insure that it works.

Discussion

Question: Senator what method of controlling hunters will be used on these areas?

Senator Bellmon: The administration will be handled by the State Wildlife Department. I cannot speak for them, but it is my feeling that they will at least keep a record of the harvest and amount of game remaining. When the populations go below a safe level then I assume the gates will be closed.

Question: Will they have to restrict the number of people using these areas on certain days or will they be open, uncontrolled, to the general public?

Senator Bellmon: The areas, I assume, will be open to the general public as long as the game populations will stand the hunting pressure. There is nothing in the law that covers this point.

Question: Do you have some idea as to what fees will be paid to the land owner on this?

Senator Bellmon: As near as I can tell you, and there is nothing official about it, it will be somewhere between $1.00 and $3.00 per acre. A wheat field could not be used in the program; the land would have to afford some recreational opportunities.

Question: Will access to these farms in the program be limited only to resident hunters living in the vicinity of the selected farms? Will the public be notified about the locations of the farms?

Senator Bellmon: Access is not meant to be limited to the local vicinity where the farms are located; it is intended to be available to people no matter where they live. I don't know how much advertising has been done; I doubt that any has been made because the program only began in January and I doubt that the lands will be open until some weeks after. We're trying very hard to get USDA to add a person to their staff to administer this program. We want someone who knows the wildlife business and who will insure that the public is aware of this new opportunity.

Question: Senator Bellmon, I am Chester McConnell, Tennessee Game and Fish Commission. I would like to commend you, your colleagues and the A.S.C.S. officials for the efforts being made to create environmental improvement programs. The pilot Public Access Program presently being tested by the A.S.C.S. will certainly be beneficial but leaves much to be desired. The Public Access Program pays landowners to allow hunters and other persons to have access on private land but does nothing to improve wildlife habitat. In many cases landowners having poor wildlife habitat conditions on their land are receiving government funds. If no suitable wildlife habitat exist on the land in question, there is no need for sportsmen to have access. A good program is needed which will pay landowners a just sum for developing wildlife habitat on their land. Then, these 2 programs combined, the habitat development and public access programs, would be what our country needs.

I am presently chairman of the Farm Game Committee of the southeastern section of the Wildlife Society which represents 16 states. Our committee is attempting to persuade the U. S. Department of Agriculture to adopt a more realistic wildlife habitat development program. The A.S.C.S. is obligated by law to consider wildlife needs in their Rural Environmental Assistance Program (REAP).

The REAP does have several wildlife practices that cost-shares wildlife habitat projects with landowners. But, there are several serious weaknesses in the program and landowners do not participate in the wildlife practices very much. The Farm Game Committee has identified the weaknesses and brought them to the attention of the U.S.D.A.

We feel that:

1. The wildlife habitat practices are having to compete with regular farm practices for funds. Landowners normally select the other available practices which will help improve their income. Wildlife practices are the only practices which do not necessarily improve landowners income. Most often someone other than the landowner will benefit from the wildlife practices.

2. The REAP program should provide 100% payment for wildlife practices and special funds should be established which could be used for no other purpose.

3. Wildlife practices should automatically be placed on all county REAP programs.

We do not feel that our requests are unreasonable.

During 1970 approximately $181 million was paid to landowners in cost-share assistance through the REAP. Less than 2% of this sum was spent on wildlife practices. The U.S.D.A. also spent approximately $4 billion on agricultural crop subsidy programs. Much of this money being spent by U.S.D.A. actually encourages destruction of wildlife habitat. The least that should be done is for our government to have a realistic program to pay those landowners who are willing to devote a part of their land to wildlife. We feel this would be a popular program with the general public which is presently not receiving much benefit from agricultural subsidy programs. In our nation which spends billions of dollars for all kinds of programs we certainly should be willing to spend a just sum for 1 of our greatest natural resources, our wildlife.

Will you do what you can to help us get needed improvements in existing wildlife programs in the U.S.D.A.?

Senator Bellmon: I would be very happy to look at it. Let me urge you to contact your own Senator or Representative and tell him what you have just expressed. A lot of people don't grasp the idea of multiple land usage and they think that a farming area and a hunting area are something completely different. I think you could be very helpful in generating support for a Federal multiple-land-use approach. Also, I might say that I have been appalled to find there is not 1 single wildlife expert in the USDA. They turned this whole thing over to the Soil Conservation Service. I am not complaining about this because I think the SCS is a fine service, but they don't have any idea of the immensity of this problem. We can't get the USDA to add 1 man to their staff to supervise this thing. You folks in this room could help by getting the USDA to find these people, and I'd sure appreciate it.

Question: Do you believe a 1-year test of the program is adequate to determine whether to keep it or drop it?

Senator Bellmon: Not adequate. But you see the program is on the books for 3 years, and it took about 18 months after we wrote the bill to get them to move at all. So we lost last year. We got started in January of this year. The farm program we have runs through 1973. We have to write another bill before the present 1 runs out so we'll be writing a new bill in 1973. I agree with you that this is bad but I hope we will keep going another time around. I believe we will, but a lot of the Congress' attutude is going to depend on whether or not people like yourselves respond. Letters to your congressmen or senator will help keep the thing going.

Question: Why should the Open Acres Program be necessary when farmers are already being paid to set aside 34 million acres from production in the Soil Bank Program? Why can't we expect the subsidized soil bank acres to be opened to public hunting by the taxpayers paying the subsidy?

Senator Bellmon: May I make just 2 points? First, you mentioned 34 million acres of farmland withdrawn from production; it's actually 60 million. The Federal Government is keeping 60 million acres of farmland out of production this year because we don't need the crops, and it is costing about 4 billion dollars to do this. Second, under the Soil Bank Program these long-term contracts, as you may or may not know, almost put a large part of the country out of business because there are areas where agriculture is so marginal that farmers went into the set-aside program en masse, and the feed dealers and the fertilizer dealers and nearly everybody lost customers. That program would be very hard to get approved by Congress again. So I don't think there are going to be any wide-scale, long-term, set-aside land programs in the future.

In the Open Acres Program there is a provision whereby we're going to get involved in something similar to set-aside lands although we probably shouldn't. For instance, on my farm I am required to have 243 acres set aside. Under the terms of the Open Acres Program I would be paid to put 24 acres, that is 10% of my present set aside, into permanent wildlife cover. At the present time the farmer cannot put land in the set aside if it qualifies as crop land. If it is grown up in brush or scrub the ASCS people will come out and say that is not farm land, so plow it under and clear it up. They are working against wildlife management. This bill gives the farmer and landowner the right to put 10% of the present set aside into wildlife habitat and still get federal support. I don't think from the farmer's viewpoint that you'll ever get them to agree to leaving land out of cultivation for 3 years, because it is not good farm business to summer fallow land that long. In my case for instance, we'll put 100 acres of land in set aside this year; next year that will be our best wheat. It will probably make 10 bushels more an acre than it did before summer fallow. So I think from the agricultural standpoint we won't get away from the present program of using different land for set aside year after year unless we allow brushland to qualify as set aside. That and encourage farmers to plant cover for wildlife.

Mr. Chairman, if I could just say one thing more. It seems to me every state's situation is different: Iowa's situation is different; Tennessee's is different; Oklahoma's is different. There is no way Congress can write a program to fit the whole country. It seems to me the thing we ought to do is to stand on the authority that is in the law and on the finances that are available. We've got to sell the USDA on the idea that this land has a use beyond agricultural use, that the greatest outdoor recreational opportunities in this country are on private agricultural land. The USDA needs to concern itself with the way this resource is developed and utilized, and until we get them to see this we are not going to get anywhere. Congress can pass laws until we are voted out of office. Unless the Department of Agriculture's administrators add people in your state, my state, and Washington, D. C. who understand what we're trying to do, we are not going to get very far. You folks in this room can help us very much if you will just sell the USDA on the idea that here is a tremendous resource and it is up to them to see that it is better developed and utilized. Let's get a wildlife person on each state ASCS committee and in the USDA office.

PENNSYLVANIA'S PROGRAM TO IMPROVE LANDHOLDER - SPORTSMEN RELATIONS

Harvey A. Roberts, Pennsylvania Game Commission, Harrisburg

Probably the best place to start would be with a very brief thumbnail sketch of Pennsylvania for those of you who have never been there or have gone through it very hurriedly. The state is roughly rectangular in shape and consists of 45,000 square miles. That makes it about 33rd in size among the 50 states, and we have a human population of 11.5 million people. That makes us 3rd in the nation. So you can see we have people and land problems. One-half of Pennsylvania is forested, and the state is bisected in a northeast-southwest direction by the Appalachian and Alleghany Mountains. Probably we have 1 of the most heavily hunted pieces of real estate in any part of the country. An example of some of the hunting pressure we get is on our primary pheasant range where we have had ongoing studies for a number of years. On a 3,000-acre area, we averaged 220 man hours of hunting each day during the 25-day season. We sell in excess of a million resident hunting licenses and we sell approximately 100,000 nonresident licenses. In both categories we lead the nation.

Historically, Pennsylvania hunters and landowners have never been too prone to erect or abide by no-trespass signs. Even by today's standards the Pennsylvania hunter does not hold a no-trespass sign in quite the same respect or esteem or fear that it is held in other states.

Despite this fact, back in the early 1930's it became rather evident to the people in the Pennsylvania Game Commission that more and more land was being posted and a conflict between the hunter and the landowner was developing. I think a lot of this conflict took the form of frustration on the part of the landowner due to disrespect for privately erected no-trespass signs. The Game Commission realized that the sport of hunting small game on agricultural lands depends on safeguarding the rights of the farmer to a peaceful existence and certainly to protection of his property, crops, and livestock. The Commission devised a plan that experience has shown to be of benefit to both the landowner and the sportsman. Inaugurated in 1936 and known as the Cooperative Farm Game Program, this method of keeping privately owned land open to public hunting currently involves 2 million acres of farm land and 16,528 individual landowners. The program consists of 172 projects ranging in size from a minimum of a 1,000 acres to a maximum of about 30,000 acres. These projects are found in 57 of Pennsylvania's 67 counties. Under the provisions of our game laws, and rules and regulations as developed by our Commission, we can govern the administration and the management of these project areas.

A project area consists of a group of farms and accompanying woodlots that are suitable for the propagation of game and for public hunting. These farms have to be contiguous so that we get a large unit with very few noncooperators scattered through it. To become a cooperator, the owner institutes an initial agreement with the Pennsylvania Game Commission for a period of 5 years. After the 5-year period the agreement automatically renews itself on an annual basis. However, either party can terminate the agreement with 60-days written notice. The Commission has cancelled agreements when farms became unsuitable for hunting due to urban sprawl or other reasons, or the cooperator has sold his land. Some farmer-cooperators became disenchanted with sportsmen or with the Game Commission and terminated after the 60-day written notice.

I think the thing that finally made Christians out of a lot of our sportsmen is the fact that they do respect Game Commission signs. So, part of our service to the landowner cooperating with us in this program is to erect safety-zone signs and various other signs that protect his property. In Pennsylvania it is illegal to hunt within 150 yards of an occupied dwelling or adjacent farm buildings without specific written permission from the owner. So each fall, prior to the hunting season, our personnel erect our safety zone signs around each cooperator's home. They take them down after the hunting season ends. I won't take time know to show you all of our signs, but here is another. put up by our people for the farmers wanting hunters to stay out of unharvested cornfields. These signs, backed up by a good law enforcement program, have the attention of the sportsmen and we have pretty good compliance.

In our projects, we try to prevent setting aside more than 0.33 of a project area as a safety zone or refuge. In other words, 0.66 of each project area is open to the hunting public. The landowner retains the right to hunt without a hunting license on his own property and on the two farm properties adjoining his. A landowner may also reserve the trapping rights on his farm. Pennsylvania has quite a number of farmboy trappers and by erecting this sign it warns people not to trap on this particular farm.

We still do some game stocking in Pennsylvania. I won't pursue that right now, but with approval of the landowner our Pennsylvania Game Commission does give preferential treatment to our Farm Game Project. This has a public relations value; I know a lot of our farmers like to see Commission trucks go by with a few crates of pheasants to put out. So there are a number of benefits to our cooperators in our Farm Game Program. I'll just run through them briefly here: protection of life and property through patrolling and enforcement by our Game Protectors and Deputy Game Protector force; posting of signs; free subscription to our Conservation magazine; advice from our area land managers on management practices beneficial to wildlife; free tree and shrub seedlings that produce wildlife breeding cover; and, as our budget permits, we also cut woodland borders and hedgerows to remove shade from cropland and to create immediate and long-lasting cover for wildlife in these farm areas. Our administrative costs in this particular program run about 25¢ an acre.

I think the key to our whole program is that our semiskilled laborers, the people we call our food and cover force, are born and raised in these project areas. They are farmers themselves. They are grassroots contacts with our cooperators, and I think that if togetherness is beneficial, this is just what makes this program work.

We have several themes and variations of this program that I will touch on. One we call our Safety Zone Program. You will recall I mentioned in our Cooperative Farm Game Project that we wanted contiguous farms. We have had a lot of people who wanted to get into the cooperative program and for one reason or another they couldn't get in; either we didn't have the money to expand the program or they had neighbors who didn't want to cooperate. So we set up the Safety Zone Program which in many ways is a scaled-down version of the cooperative program I just described. To date we have Safety Zone farms in 66 of our 67 counties, involving almost 14,000 different tracts of land. This has opened 3 million acres of additional land to public hunting. About the only thing we provide to people in our Safety Zone Program are Safety Zone signs which they erect themselves. We do give areas in our Safety Zone Program more law enforcement patrol than we do areas that are posted against hunting. We figure the administrative costs on our second program are about 10¢ an acre.

The newest program was started in 1971 and is called the Forest Wildlife Cooperative Program. Again, this is a version of the Cooperative Farm Game Program. It is designed to keep forest land open to public hunting. The program originated because many forest owners complained about the total disregard for their property by the hunting public. Running automobiles on their access roads when freezing and thawing conditions exist created maintenance problems for these large concerns. Consequently, we set up the program for forest owners. Initially, we had 5 big forest industries signed up in our program. Prior to this time some of the large forest industries decided it might be wise to lease hunting rights to small groups of hunters and close their lands to public hunting. They really defeated their main purpose because the deer herd was underharvested. This had an impact on the forest reproduction that was bread and butter to the big companies. Excessive deer browsed too heavily on forest regeneration. The forest industries soon became disenchanted with that approach and signed up in our program.

We provided some special signs and special patrols for these cooperators and in the process opened up 0.5 million acres of forest land that was not previously open to the public.

Now I'm certainly not in the position to prescribe any of Pennsylvania's programs as a panacea for all states represented here. I think the fact remains that we in Pennsylvania have been quite successful with it, and I believe it is certainly worth a try anywhere. One of the many pleasures that came out of my trip here was to find that Oklahoma has started a program similar to ours, and at this time has about 300,000 acres in its program.

Discussion:

Question: What about access; is it on a first come, first served basis?

Mr. Roberts: We do not control hunting pressure on these areas and I think as time goes by this will be a problem. In a sense, it is somewhat self-regulating because after X number of hunters are afield in a given area it no longer becomes attractive for additional hunters. When latecomers see a concentration of hunters they move on somewhere else. So at least to a degree it does regulate itself. The present level of self-regulation is tolerable in Pennsylvania, but in other parts of the country it may be intolerable, I can't say.

Question: Does this program prevent the land owner from leasing out hunting at all; can he charge for hunting on his property?

Mr. Roberts: No, absolutely not. As soon as he puts up his first no-trespassing sign, he is out of the program.

Question: Do you have any type of program in Pennsylvania for people who want to lease their hunting?

Mr. Roberts: The only people we are working with directly are regulated shooting ground operators. As far as going out and encouraging people to get into a hunting and lease program, this is kind of self-defeating, I think, and we ignore these people.

Question: You don't feel there are any possibilities between those 2 extremes?

Mr. Roberts: Apparently there is. Senator Bellmon just spoke of a program that is similar to a pilot study we have going in Pennsylvania that scares us to death, to tell the truth. When it comes right down to it we're getting something here for nothing. Now the Federal Government is coming in and they are going to pay people for the same thing that we used to get for nothing. I don't know where we're going to go.

Question: If the landowner feels that game is over harvested, what can he do about it?

Mr. Roberts: We have no control over this. Despite heavy hunting pressure in small areas, we have no situations over large areas where we don't have enough brood stock escape to give us a crop the next year. For example, we're killing over a million pheasants in Pennsylvania each year. We do raise and release pheasants in Pennsylvania, but we purposely put these birds in areas of 3rd- and 4th-class range, where they don't survive anyhow, and we hope they are all harvested.

Question: How many law enforcement people patrol the cooperative areas?

Mr. Roberts: In addition to our game protector force of 150 full-time employees, we have a force about 1,500 deputy game protectors. Many of these are farm game managers or day laborers on our food and cover forests, so they serve a dual function. They are not only in close contact with our cooperators, but they are also authorized to make arrests.

Question: You said the contract period was for 5 years; after that what is the dropout rate?

Mr. Roberts: I don't recall the figures now. We have a very high retention rate, and this is a self-defense mechanism on the part of a lot of landowners. They are going to go to the outfit that can give them the most muscle to cope with the sportsmen.

Question: Is there a predetermined fine on each violation, and who gets the fine money?

Mr. Roberts: Oh, yes, our people are allowed to settle these cases on what we call a Field Acknowledgement of Guilt; it's just like getting a parking ticket. This serves 2 purposes: it doesn't delay the hunter; he is free to hunt after he has paid the fine, and it doesn't take a lot of his day's hunt looking for the nearest magistrate. It expedites matters all the way around. The next question is how much of this money goes into the Game Protectors' pockets? It doesn't work that way. The person being arrested gets a numbered receipt, the Game Protector has a stub from it, and that goes into Harrisburg. Everything is closely accounted for.

Question: Do you have any companion programs, or any plans for 1, to work with your cooperators in improving habitat and if so how successful is it?

Mr. Roberts: Yes, with limited success because we lack the funds and manpower to implement this sort of thing. But we produce in our nursery about 5 million tree and brush seedlings annually to create wildlife food and cover, and these are given to cooperators requesting them.

THE SPORTSMEN'S HOPES FOR THE FUTURE OF HUNTING ON PRIVATE LAND

Robert E. Apple, National Wildlife Federation, Dardanelle, Arkansas

First of all I think we have to realize that the farming situation has changed in the last few years. This is a quail symposium, and that poses some special problems about hunting on private land. I think there are some kinds of hunting for which we can provide a fair-to-middling type of hunting on private lands, but quail hunting poses another problem altogether because it requires quite a few acres to provide ample territory to hunt in. For that reason I think the Open Acres Program described by Senator Bellmon, also called REAP, is not going to be as helpful as we hope it will.

Most of the farming operations today, and I happen to be a farmer, have changed considerably in size. We no longer have the little family-type farms. Small farms supported the quail populations we had 30 years ago. People farming today are using 4- to 6-row equipment. There are very few fence rows left, and that little brush patch that used to exist for quail is no longer there. There are still some places on farms suitable for quail nesting and occasional dusting, but they are not as plentiful as they used to be.

Paying a farmer $3 an acre to put his land into various types of practices, such as planting certain types of crops to enhance the game population, is a drop in the bucket. In the first place farmers are fairly affluent people and I think they are going to consider carefully before they open their land. If the program is going to work they may carry it on; but if they do, they are going to hunt over the place themselves. They can lease hunting rights to people from the city and probably get a lot more out of it than $3 an acre. So I don't think this is going to solve the problem of public access to private land. I don't know that anything else can solve the problem, but I sure don't think that REAP will.

We read about some of the problems that bring about the no-hunting signs and the no-trespassing signs, but I don't think I should pass the opportunity to say that 1 of the biggest things hurting us today is the bad hunter. I constantly read in the magazines like <u>Field and Stream</u> and <u>Outdoor Life</u>, and various other publications of this type, that the type of hunter I am going to describe is in the minority, perhaps representing less than 5% of all the hunters who go on the land. I think that figure is much too small. I'm talking about the so-called slob hunter. He does everything in the book that he shouldn't do and antagonizes the landowner. Then some poor unsuspecting soul comes along and asks the farmer to hunt. He is in trouble to begin with because of what the slob caused. I think that the number of slobs has increased; it must have, because the population has increased.

Back to quail hunting, I don't know if there is any answer to this thing, but I think first of all there are some current programs that offer more solutions than the REAP program. In Arkansas we have several opportunities. For instance, in the western-most part of the state there is a large military installation that has about 75,000 acres of land, and it is used periodically by the National Guard to train during the summer. For the most part, during the hunting season there are no people on this land other than a small force to maintain the buildings. The reservation could provide some recreational opportunities for a large number of people.

There are several problems with this situation. First of all there is a long-time cattle lease. The cattle are competing with the wildlife for available feed, especially with the deer. Cattle are grazing everything down to the ground. Some of the range is pretty well eroded and deteriorated. But we do have an agreement with this installation signed, I believe, by the Governor of Arkansas and the Department of Defense. It is hard to have a program for wildlife there because of the cattle. The problem is to get the agreement worded to guarantee enforcement of grazing restrictions and provide enough habitat. Then I think public hunting would be much better. We have spent 3-4 years trying to do this, and we still haven't been successful. I think you have some opportunities like that here and in other states.

This is, of course, public land. I would also like to point out something else. I am sure that some of you are familiar with the Alabama trespass law. If you are going to hunt on someone else's land in Alabama, you have to have a signed piece of paper in your pocket saying you have permission to hunt. If you don't have, the owner can turn you in and you are in deep trouble. As a result, a great deal of the land in Alabama, I guess the majority of it, is leased to people that want 5 or 6 thousand acres. That excludes the public from the land. I think the acreage under lease agreement is increasing.

At 1 time in Arkansas, a bill was introduced in the Legislature to impose Alabama's type of trespass law in Arkansas and make the Game and Fish Department enforce it. Game officers would have to spend more than 0.5 of their time enforcing no-trespass laws. This really disturbed folks in Arkansas. This could happen, and it could happen as a result of sportsmen simply not using good sense. I think that sportsmen could do much to help eliminate some of these feelings, and I'll give you an example. As a farmer, I know that on opening day of bird season I've got some territory that is real good, and when you people talked about 2 birds per acre, my mouth watered. There is a limited amount of this habitat where I live that will support that. The reason it will is that the Arkansas River got on a rampage back in 1943 and broke over a levy and dumped sand over some of this land that used to grow 2 or 3 bales of cotton per acre. It won't grow 3 bales of cotton an acre anymore, but it does produce much of what we call beggar lice or tick clover. The area has a lot of weeds, partridge peas, and cottonwoods, and the birds can find cover. You can hardly kill them out.

To get back to my story, on the first day of bird season I could almost get elected Governor, I think, just by inviting in people that like to hunt on this kind of area. Initially it was that way, but it's not any more. I don't post the area, and on the first day of bird season I usually get up and drive down there before daylight and park with my dog and gun. You have to be there before the sun comes up or you are going to be hunting behind some other folks if you don't. They don't come ask you if they can hunt, they are there waiting. So this year I went through the same routine. I got there before daylight and was sitting there waiting and heard folks start shooting. I have no idea how they could see a bird, because it was dark! Now this isn't going to help any and we all know it. So I think if hunters want to hunt on private land they should go see the farmer before the opening day.

One of my duties as a private citizen is serving on the local school board. As a board member one of the responsibilities you have to assume is looking at the tax records from time to time to see that every 1 is paying his share of the ad valorem taxes that support the public schools. While I was checking these records with another school board member, we found 175 acres of untaxed land that had been set aside for hunting by a farmer. We went back and got the old plats of that area and found that it had been listed as a navigable lake. In Arkansas, areas such as this become public land if no taxes have been paid on them. So we checked a little further and went to the State Land Commissioner and found out that part of it belonged to the state and part of it to the Federal Government. The Land Commissioner happened to be quite a hunter himself and was sympathetic with us. We contacted the Attorney General and asked him to give us an opinion as to whom the land really belonged, and what the possibilities were of turning this land over to a suitable state agency to administer.

We've gotten a sort of off-the-cuff favorable decision. It hasn't been written up yet, but it will be. In looking at this particular case we can look around and find thousands of similar areas in the State of Arkansas that are in the same type of situation. They are public lands and there should be public access to them. I think that by researching the records we can find a lot of land that can be opened up to public access. I assure you that we are going to do a much better job of researching records in Arkansas.

I don't know what the answers are. In our state the attitudes differ greatly from the northern part to the southern part. Some people in the southeast and northeast know that hunters can provide extra income. This philosophy has not yet reached the northernmost counties. I think their attitudes will change in the near future, and they will realize that there is money to be made from hunters. So for our own good, I think it behooves us to do a little bit better job of public relations with the landowner, and help him feel hospitable to hunters.

Comments from Members of the Audience

1. All my life I have preached that wildlife is a crop and a farmer should sell wildlife just as well as he sells his hay crop, cattle crop, or any other crop. Because conditions in the U.S. today are such that land values, taxes, and everything are increasing, the farmer has to take advantage of everything that he has at his disposal to be able to stay in business. Wildlife is a crop for us, and when you compare the money we get, we also raise purebred cattle,

we can make a heck of a lot more money in our wildlife program than we ever can from cattle. It is much more enjoyable because I like to do it.

2. Here's another idea on this idea that a farmer has a social obligation to open his land to everybody else. Let's forget it, because the farmer is subsidizing you. I've been in the cow business for 30 years and got out of it because I was selling cows for the same price 3 years ago that I was selling for 25 years ago. I can prove that since 1847 the price of corn per bushel has not varied more than 10-12%. The American city person today is paying less of his earning capacity for food than does a person in any other country. This is a matter of record, but somehow the idea has developed that farmers get rich. Another viewpoint is that farmers should furnish wildlife to hunters simply for the asking. Our problem here goes back to the original premise that in a pioneer country a man could put his gun on his shoulder and go anywhere because the game belongs to the people. Migratory game does, but when the landowner determines by his habitat management whether there is game or not, then the situation changes.

3. I'm from Oklahoma and there are a few of us who are trying to open our property to leased hunting. I've opened my property to quail hunting about 3 years now. I have a group of construction workers from Oklahoma City that pay for a hunting lease so that they don't have to hunt after someone else. I also lease to professional people. To me this proves that there is a place in this whole scheme for all of these programs you are talking about. To me I see no reason why there can't be a place for people to pay an in-between price if they can't afford to pay the big price. One thing I can't understand is the reluctance on the part of the Wildlife Department to encourage all phases of these. I don't see that 1 necessarily has to work against the other. For various reasons, there is going to be the man who has such small property or poorly arranged property he can't develop it for good-paying agriculture. At little expense to the Wildlife Department they could lease these for public hunting, open up an additional acreage that we evidently need for quail and other game, and thereby relieve pressure on public hunting areas. I can't see where 1 program necessarily works against the other.

NOTE: Most of the questions and answers after Mr. Apple's presentation were too indistinctly recorded by the tape recorder to be transcribed accurately.

TECHNICAL SESSION I

PROBLEMS AND METHODS IN BOBWHITE MANAGEMENT

Chairman
Walter Rosene, Jr.
Private Consultant
Gadsden, Alabama

Discussion Leader
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MANAGING BOBWHITES IN THE CUTOVER PINELANDS OF SOUTH FLORIDA

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Abstract:

Because the principles governing production of quail are similar throughout its range, only problems and techniques unique to the flatwoods of southwest Florida are discussed. A description of these pinelands includes geology and soils, climate and key plant communities. The Florida bobwhite and its foods and other needs are discussed briefly. A major portion of the text is concerned with the effects of primary land uses on quail habitat, and management modifications to improve quail production.

The bobwhite quail (Colinus virginianus L.) is unquestionably the most popular game species in the pinelands of the southeastern United States. As a result of research begun some 50 years ago, management techniques are probably more highly developed for this bird than for any other species--we know how to manage for sustained, huntable populations. Although problems and techniques of management discussed in this paper relate specifically to the flatwoods region of southwest Florida, the principles for increasing quail are similar throughout this bird's range.

The Flatwoods

Topographically, flatwoods are relatively flat, low pinelands of imperfectly to poorly drained acid soils. They are young soils of marine origin atop relatively impervious deposits of marl, limestone, and calcareous sandstones (1).

The climate is subtropical--more maritime than continental. The weather is characterized by mild year-round temperatures and marked by seasonal differences in rainfall. For example, nearly 0.75 of the annual precipitation of 53 inches in the Fort Myers area falls between May 15 and October 15. When the rainy season ends, moisture is lost rapidly, primarily through evapotranspiration. A dry winter culminates with a distinct and often severe drought in April and early May.

Ecologically, the flatwoods are characterized by open stands of longleaf pine (Pinus palustris Mill.) and south Florida slash pine (Pinus elliottii var. densa Little & Dorman) growing in association with saw-palmetto (Serenoa repens (Bartr.) Small) and pineland threeawn (Aristida stricta Michx.). A high summer rainfall coupled with very slight differences in local elevation and poor drainage, has caused the development of numerous small wet prairies and freshwater marshes as well as several other minor plant communities (1).

The pine-palmetto community covers about 75% of the land area. Saw-palmetto covers 20% or more of the area. A number of other shrubs occur--most are evergreen. Pineland threeawn the common "wiregrass," is the dominant herb but numerous other grasses, grasslikes, and forbs are found. Legumes are scarce.

Wet prairies are short-grass meadows in a seasonally flooded ecotone between the pinelands and freshwater marshes, and are locally called "sloughs." They frequently form drainageways connecting freshwater marshes and typically occupy 10-15% of the area. Common species are pineland threeawn, panicums (Panicum spp.), beakrushes (Rhynchospora spp.), and razorsedges (Scleria spp.).

Freshwater marshes, or "ponds" as they are locally called, occupy an additional 10-15% of the area. These treeless hydric communities are dispersed along natural drainageways (sloughs). Most are somewhat circular depressions often with centers of pickerelweed (Pontederia lanceolata Nutt.), arrowhead (Sagittaria lancifolia L.), fire flag (Thalia geniculata L.), or sawgrass (Mariscus jamaicensis (Crantz) Britton). Water usually stands in the deeper centers year-round, but many shallow "sand" ponds dry up during the spring. Freshwater marshes are of little value to quail except during the dry spring when green vegetation is available.

The Florida Bobwhite

The Florida bobwhite quail (Colinus virginianus floridanus Coues) is slightly smaller and darker than the typical eastern bobwhite (C. v. virginianus L.). The Florida subspecies averages about 5 oz (12) as compared with 6 oz for the eastern subspecies.

The Florida bobwhite occurs throughout southern Florida and northward about 0.75 up the peninsula. To the north there is considerable overlap with the eastern subspecies (12).

Frye (2) noted that breeding activity starts early in south Florida with some pairing off as soon as February; breeding may extend into October. Nesting usually peaks in May and June but will vary depending upon weather.

Frye (2) found reproductive success to be inversely related to summer rainfall. As noted previously, summer is the rainy season in south Florida and a dry summer rarely occurs. Rainfall will average about 8.5 inches per month during this period. Sudden downpours are common.

Fall populations in Charlotte County ranged from 1 bird per 63 acres to 1 bird to nearly 6 acres over a 7-year period, an average of 1 bird per 23 acres (2).

Because the vegetation of the flatwoods is quite different from that occurring elsewhere in the bobwhite range, foods available and taken by quail can also be expected to be different. Laessle and Frye (8) found that annual razorsedge (Scleria muhlenbergii Steud.), commonly called "sloughgrass," constituted about 27% of the diet. Achenes of sloughgrass and the fruits of dwarf waxmyrtle (Myrica pusilla Raf.) together were more than 40% of the total diet on the Webb Wildlife Management Area.

Puffball fungus and green plant material are also important items during the winter. Insects and seeds of many weeds and grasses make up the summer diet. Various masts and fruits are utilized during late summer and fall as available.

For all practical purposes, food and cover are the habitat essentials subject to management. On most quail ranges in the South, winter foods and nesting cover give managers the most trouble (2, 13, 15). These seem to be the primary problems in south Florida as well.

Management

Since Ponce de Leon brought the first cattle to this country in 1521, the pinelands of south Florida have been extensively grazed and for years a low level of range management was practiced. The woods were burned as frequently as possible to control shrubs, remove the herbaceous "rough," and "freshen" forage (14). During the 1940's the pinelands were heavily cut over, and shallow canals connecting ponds and sloughs were dug to enhance surface drainage.

Although most grazing still depends on native range, improved pastures are rapidly increasing in importance, but intensive forestry is not yet a widespread practice. Other agricultural enterprises such as citrus and vegetable production have invaded the region and are on the increase. Extensive urbanization has accompanied phenomenal human population increases during recent years and is expected to continue.

Extensive forestry and ranching operations over much of the present quail range stand to be overwhelmed by intensive agriculture, land speculation, and urbanization. These latter uses drastically alter the land's natural features, and quail habitat is degraded or destroyed. Managers in the future will face the increasing difficulties of integrating habitat essentials within landscapes managed primarily for other uses.

Cattle Ranges

Grazing

Range specialists recommend rotational grazing to increase efficiency of forage use and to improve vigor of important range plants (6); however, continuous year-long grazing is still commonly practiced. Cattlemen normally burn the range in alternate years and subsequently practice rotational grazing whether planned or not. Cattle utilize freshly burned range while 1-year-old roughs receive comparatively light use. According to Frye (2), this rotational burning-grazing system improves quail habitat.

Wiregrass, the principal herbaceous cover, quickly becomes impenetrable roughs for quail if not constantly kept open. Frye (2) noticed that moderately heavy grazing reduces this mechanical barrier by breaking up and thinning out ground vegetation. Grazing and trampling tend to be spotty or uneven and create a more diverse ground cover that is preferred by quail.

In many sections of the Southeast, grazing even at moderate levels is considered detrimental because cattle consume important quail food (11, 15, 16). With the exception of sloughgrass and several panic grasses, however, quail food plants are generally not a part of the cattle diet in these pinelands. The occasional heavy use of these species by cattle does not appear to be detrimental. In fact, Frye (2) found thick stands of sloughgrass benefited when moderately grazed. Removal of some plants allowed for greater crown development which resulted in a greater seed crop.

Where grazing is permitted, Stoddard (15) noted that quail tend to select nesting spots protected by briers, pine saplings, or other shrubby growth. Of 2 dozen or so nests observed locally over the last few years, all were located under the protective canopy of shrubby growth, usually saw-palmetto or dwarf waxmyrtle. In view of this, nesting-cover management on cattle ranges should include small clumps of low shrubs.

Quail habitat benefits when rotational grazing programs properly combine improved pasture with native range. When fall-burned native range is grazed throughout the winter and spring, perennial vegetation is thinned out. Then, while cattle graze improved pasture during the summer and fall, food-producing annuals will develop and nesting activity can proceed unmolested.

A major concern, however, is the tendency of landowners to establish large, rectangular improved pastures completely cleared of saw-palmetto and other brushy cover. They are typically planted to improved grasses such as bahiagrass (*Paspalum notatum* Flugge) or pangolagrass (Digitaria *decumbens* Stent.) and then closely grazed. These pastures are of little benefit to quail.

When quail management is a consideration, pastures should be small and narrow, containing a few mast-producing trees as well as scattered brushy cover (15). Frye (2) recommends strips of pasture 50 to 100 yards wide alternating with similar widths of natural vegetation. Clumps of saw-palmetto or islands of other undisturbed shrubby vegetation scattered throughout these strips provide additional refuge and protective nesting cover. Stoddard (15) suggested that such a pasture configuration might greatly benefit quail when placed in extensive roughs difficult to maintain by burning or grazing and in young pine plantations where fire is temporarily excluded.

Burning

The flatwoods consist of fire-dependent communities of highly flammable species. Burning, therefore, has only a temporary effect. Fire consumes dead plant material and thins out the perennial fire subclimax vegetation by reducing plant size. Annual plants are stimulated the first year. The resulting vegetation is open and in good condition for quail to feed. One fire-free year is normally required for a burn to fully recover.

Frye (2) found sloughgrass production greatly improved on winter-burned areas as compared with similar adjacent unburned sites. My trials underway near Fort Myers are providing substantiating information. Although burning 2-year roughs and applications of rock phosphate did not increase plant numbers, increases in plant size resulted in improved production of sloughgrass achenes as compared with 2-year-old roughs. Burning alone produced twice as many achenes (2.5 lb/acre) and the addition of rock phosphate (1 ton/acre) 7 times as many (7.3 lb/acre).

Frye (2) found time of burning important. Burning in the fall and early winter while the soil was still moist and the vegetation green provided spotty, incomplete burns creating diversity and "edge." Early burning also favored sloughgrass production, but spring burning consumed many seeds of value to quail. Burning after February becomes hazardous and difficult to control. Hot sweeping fires result when both soil and vegetation are dry. Large areas may be completely cleaned and rendered temporarily unusable. Moist areas subject to flooding may be the only places to escape burning, and quail are attracted there to nest (15).

Frye (2) concluded that early burning appeared beneficial to cattle by producing several months of slow-growing, tender forage while spring burns produced rapid growth that tended to "get ahead" of the cows and become tough and unpalatable quickly. However, as reported by Hilmon and Hughes (5) some ranges are burned progressively from October through the winter to as late as May to extend the period when nutritious forage is available for cattle. Ranges burned in March or May produce 2 to 4 times as much herbage in the 60 days after fire as ranges burned in October or November (9). In a well-managed cow and calf operation, therefore, the breeding season is planned to provide calves that are large enough to consume the considerable quantities of herbage when forage quality is highest in the spring and summer (7).

In summary, fall and winter burning appears to be compatible with optimum production of quail on ranges grazed yearlong by cattle. About 0.33 to 0.5 of the range should be burned each year, but burning should not be done after nesting begins in March.

Discing

Discing is widely used by game managers to control unwanted perennials and to stimulate seed-producing annuals. In south Florida, discing more or less destroys the dominant wiregrass cover. Sloughgrass and other annuals respond vigorously the first year (2) but are rapidly replaced by bluestems (*Andropogon* spp.), panicums, goobergrass (*Amphicarpum muhlenbergianum* (Schult.) Hitchc.), and other species, most of which are palatable to cattle.

In my study near Fort Myers, discing failed to benefit sloughgrass plant numbers but did increase plant size and seed crop of sloughgrass. Discing 2-year-old roughs produced 6 times as many seeds (6.2 lb/acre) while the addition of fertilizer to disced strips increased the yield 40 times over that on 2-year-old roughs (41.4 lb/acre). On these sites, however, cattle concentrate, overgraze, and destroy most of the vegetation beneficial to quail. Moreover, when rock phosphate is added, the vegetation is so closely grazed it provides low-maintenance firebreaks. Consequently, strip discing is not considered practical on cattle ranges unless protected from grazing.

Seeded strips or food patches have not been successful. Many cultivated legumes and grains have been tried (2) but none survived the poorly drained soils and extreme weather conditions.

Chopping

Chopping refers to a method of controlling unwanted vegetation to improve cattle grazing or to prepare planting sites for pine. Treated areas are "cross-chopped" at right angles with heavy drum choppers. The sod is cut into 1-ft squares resulting in considerable surface soil disturbance, but the sod is not turned as with discing. Saw-palmetto and wiregrass cover is reduced considerably, often as much as 90% (10). However, annuals do not respond as vigorously as when disced, and sites revert more quickly to a perennial vegetation valuable as cattle forage. Treated areas are frequently too large and shrubby cover too sparse for ideal quail habitat.

When chopping is employed as a grazing improvement practice, areas treated should be small to benefit quail. If done in alternating strips as recommended by Frye (2) and Stoddard (15) for improved pastures, it would undoubtedly be most beneficial to quail because this treatment produces a variety of plants, including native panicums and paspalums. Grazing is generally moderate if adequate acreage is provided.

Pine Plantations

Intensive forestry is secondary to grazing in the cutover pinelands. Many ranchers disregard pine production with their burning and grazing programs, consequently much of the area continues to be unstocked with pine. Some landowners, however, are beginning to plant both the typical and the south Florida varieties of slash pine to increase revenues. The typical variety is gaining favor because of better form and superior early growth, but the south Florida variety is more fire resistant and might be best adapted to an integrated program of cattle-quail-timber management.

Traditionally, pines are planted to provide a uniform distribution of trees. The current recommendation of 8 x 10 ft produces maximum shade impact on understory vegetation; consequently such plantations are often referred to as "biological deserts." During much of the rotation they are of little value to quail or cattle.

If timber is to be integrated with cattle and quail production, silvicultural practices must be modified to permit more direct sunlight to reach the plantation floor. Rosene (13) recommends reducing the basal area of fully stocked merchantable stands by at least 30%. A similar reduction in planting density should also be effective.

An alternative might be to alter the planting configuration without drastically affecting stocking. Increasing the planting space between rows to, say, 24 ft and decreasing the within-row space to 4 ft would allow much more sunlight to reach the understory during the sapling stage while maintaining stockings at recommended levels. Another possibility would be 42 ft between double rows 6 ft apart planted 4 ft apart in rows. These configurations are being tested on cattle range. Another possible alternative is planting pine closely in narrow strips with greater distances between strips.

Feeders

The effectiveness of automatic feeders is a controversial subject. Haugen (4) found feeders to be of little or no value on a study area in Alabama. Frye (3), however, observed an increase from 1 bird per 10 acres to 1 bird in less than 6 acres, and concluded that feeders were useful on areas where food is in short supply, such as on heavily grazed range or near improved pastures. The practice is expensive and probably impractical on public areas. Feeders should be considered a last resort for providing food.

Urbanization

In many respects, urbanization is the most destructive and most intolerable land use so far as game is concerned. There is little hope for integrating huntable populations of quail within urbanized areas. However, recent new ideas in urban planning, such as cluster development, make possible the integration of open spaces containing natural vegetation. The inclusion of wildlife as an aesthetic resource appears promising. In many suburban landscapes, quail already have important aesthetic appeal--where a little open space provides habitat essentials, quail are often attracted to the dooryard with artificial feeders. Rarely do we observe in the wild an entire family group so close at hand.

Summary and Recommendations

Many problems and techniques of quail management in Florida's "semi-aquatic" pinelands are unique. The Florida bobwhite is very sensitive to weather extremes. Both winter food production and nesting activity are affected by severe spring droughts and excessive summer rains. Inadequacy of winter foods and nesting sites appears to be the main problem. Florida's human population is expanding rapidly and the ability to provide habitat essentials is becoming acute as land use intensifies.

The rotational burning-grazing system practiced by cattlemen improves quail habitat. Frequent burning prevents a buildup of old grass. Moderately heavy grazing complements fire by breaking up and thinning out herbaceous vegetation. Recommendations for optimum results follow:

- Burn native ranges on 2- or 3-year cycles.
- Burn during the fall and winter before nesting activity starts in March.
- Graze native range during the winter and spring.

- Rotate cattle to improved pasture during the summer and fall. This relieves native range of grazing pressure while quail food plants develop and birds nest.

- Establish improved pastures and other range improvements in narrow strips, 50 to 100 yards wide, with alternating strips of natural vegetation.

- Leave scattered clumps of saw-palmetto or other natural vegetation for nesting cover.

Discing is effective in south Florida. The native wiregrasses are eliminated and desirable annuals respond vigorously. Discing, however, invites overgrazing and is not practical unless protected from cattle.

- Disc strips during the fall and early winter while the soil is moist.

- Application of rock phosphate will greatly increase response.

Pine plantations stand to degrade quail habitat unless silvicultural practices are modified to permit more direct sunlight to reach the forest floor throughout the rotation. A reduction in stocking is effective, but there are other alternatives.

- Plant more trees in rows to provide greater distances between rows.

- Alternate strips of closely planted pines with strips of natural vegetation.

- Burn and graze pine plantations as early as possible after planting.

Grazing can usually commence after a 1-year deferment. Burning under the south Florida variety of slash pine can usually start at age 4 or 5 years.

Automatic feeders for quail are expensive but useful on cattle range when food is in short supply.

- Feeders should be considered a last resort method of providing food.

Although huntable populations are probably not practical in urban areas, quail can be an important aesthetic resource in suburbs where some open spaces are provided.

- Urban planners should consider cluster development or other designs that provide for an intermingling of natural vegetation with building sites.

With the proper manipulation of burning and grazing, and with modifications in improved pasture and pine plantation design, high populations of quail can be maintained in south Florida. Sustained yields of 1 bird per 5 to 8 acres of rangeland should be practical.

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INSECTS AND BOBWHITE QUAIL BROOD HABITAT MANAGEMENT

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Recipient of the "Wendell Bever" award presented by the Oklahoma Wildlife Federation to the best paper of the Symposium. The award was in memorium to the late Wendell Bever, former Director of the Oklahoma Department of Wildlife Conservation and Regional Representative of the National Wildlife Federation.

Abstract:

Small insects were the most important foods eaten by quail chicks 2 to 20 days of age. The foods eaten, in order of importance, were beetles, leafhoppers, true bugs, spiders, grasshoppers, ants, larvae, snails, and flies. Important seeds ingested were *Panicum* spp., *Carex* spp., *Scleria* spp., *Paspalum* spp., and *Setaria* sp.

The effect of fire, a major tool in southern quail management, on insect populations was studied by sampling burned and unburned plots with a sweep net and a D-vac machine. On an old-field type of habitat, population densities and biomass of herbivorous insect populations were significantly greater on February-burned plots than on 5-year-old unburned plots. Two peaks in numbers of insects were found. The first peak of ca. 64,000/acre (sweep net) occurred in mid-June. The second peak occurred in mid-August (D-vac) with a density of ca. 90,000/acre. Total insect biomass, excluding individuals over 0.035 g dry weight, averaged 147 g/acre (sweep net) and 128 g/acre (D-vac).

In the second phase of the study, in a longleaf pine forest habitat, grasshoppers were the only species of insect having significantly greater density and biomass on unburned, 3-year-old "roughs" than on annually burned plots. Lack of litter on annually burned plots probably caused this disparity. At peak density, in the period of mid-July to early August, sweep-net density was 19,500/acre and D-vac density was 58,500/acre. Total insect biomass averaged 79 g/acre (sweep net) and 52 g/acre (D-vac).

The major considerations for brood habitat are abundance and availability of insects. In old-field habitat, fire increases insect abundance and removes accumulated litter, opening the area for ease of chick movement. If the soil is fertile, then annual burns are feasible. The interval of burning advocated is 1 or 2 years, but local problems may

modify this. Burning annually in the poor-soil region of the longleaf forest type is not necessary.

The reproductive season is the most important phase of bobwhite quail life history, but little is known about needs of quail chicks. Indeed, the phrase "brood habitat management" is probably new to most game managers. We lack knowledge about the survival of young stages of many wildlife species, so the problems of youth in nature must be studied (12).

A study conducted in Georgia (4) found an average mortality of 50% in quail between hatching and 15 weeks of age. The highest mortality occurred during the first 2 weeks of life. Causes of chick mortality vary, but I believe the abundance and availability of foods should be considered foremost (3,5). Quail chicks have an extremely high demand for protein during the first 2-3 weeks of life; about 28% of their diet must be protein (11). Few data are available concerning the food habits of quail chicks. The most detailed study (5) reported that chicks mainly ate insects in the first 2 weeks posthatching then gradually changed to a diet containing more vegetable matter. One objective of my research was to obtain data on quail chick food habits, emphasizing the ingestion of insects.

In the Coastal Plain region of the South, 2 quail management practices are used widely: controlled burning and food plots. The effects of controlled burning on insect populations have not been studied extensively (8). The second objective of my research was to study the effects of fire on insect populations.

I want to thank Mr. Alton Dunaway for his assistance in the longleaf pine study which was financed by the Bass Pecan Company, of Lumberton, Miss. I wish to particularly thank Mr. Robert Clanton and Mr. Vernon High of that Company.

Many thanks are due various people and organizations who helped with the right-of-way study. Special gratitude is extended Dr. Walter Drapala and Mr. Dave Horton, Department of Experimental Statistics, Mississippi State University. I also want to acknowledge the help of Dr. Dale Arner and others of the Department of Wildlife and Fisheries, MSU. Finally, I thank my wife "Ting" for her many hours of help in the field and sorting insects.

Study Areas

Two study areas are referred to in this paper. The first area is a 150-ft-wide power line right-of-way (ROW) located 10 miles W of Starkville, Mississippi. The land form present is the Interior Flatwoods of the Upper Coastal Plain, in Oktibbeha County. The ROW was originally cleared in 1965 and has not received any maintenance. Second growth mixed hardwoods and pine forest, about 30 years old, border the ROW. The plant community on the ROW is a dense growth dominated by broomsedge (*Andropogon* spp.) and to a lesser extent by panic grasses (*Panicum* spp.). Forbs, such as *Eupatorium* spp. *Helianthus angustifolius*, and Erigeron spp., are numerous, as are many other less abundant herbaceous types, especially various lespedezas (Lespedeza spp.). Soil on the ROW is Prentiss silt loam, with a hard pan at a depth of 8-12 inches and a slope of 0-8%.

The second area is located in a longleaf pine (Pinus palustris) forest 10 miles NW of Lumberton, Mississippi. Its land form is Pine Hills (PH) of the Lower Coastal Plain, in Lamar County. The PH area has a long history of grazing by free-ranging cattle and sheep and of burning by annual, wide-sweeping, uncontrolled fires. The 45-year-old longleaf stand had not been cut until the fall of 1968, when Hurricane Camille "thinned" the stand, which had a basal area of 75 sq ft/acre but lacked hardwoods in the overstory. Ground vegetation is dominated by broomsedge and wiregrass (Aristida spp.). The third most important species is hoary pea (Tephrosia spp.), and panic grasses are fourth. PH-area soils are McLaurin fine sandy loam on the hill tops and McLaurin-Lucy association on the slopes; these soils are very low in natural fertility. Slope varies from 0-25%.

The PH study area was divided into 2 parts. The first part was located in an area burned annually for an unknown number of years. The fires usually were set in late winter or early spring, but some summer or fall burns also have occurred. The first part is devoid of hardwoods and is essentially a grassland-pine woods pasture. The second part, a 3-year-old "rough" (3-YOR), located about 1 mile from the first part, has not been burned since the fall of 1968. This second part contains many young hardwoods about 2-3 ft high.

Methods

The ROW study was based on 10 plots, each 0.4 acre in size, located along 1 mile of the right-of-way. Plots were adjacent or continuous in some cases, but were separated by dirt roads or small, temporary creeks in 4 cases. Insects on the plots were sampled, 5 sweep net (SN) and 4 D-Vac Vacuum insect net (DV), in the summer of 1968. An analysis of variance of the total insect dry weights on the plots showed the plots to be comparable. The 10 plots were then subdivided into 20 0.2-acre subplots. In February 1969 one subplot, selected randomly, of each plot was burned. In the summer of 1969, from early June to late August, the subplots were sampled again, including 4 SN and 3 DV.

The PH study contained 2 study areas located about 1 mile apart but in the same longleaf pine forest. In 1 study area there were 3 1-acre plots which had been burned annually (AB) for years, the last burn having taken place in February, 1971. In the other study area there were also 3 1-acre plots. These latter plots were 3-year-old "roughs" (3-YOR) and had not burned since the fall of 1968. In both study areas the plots were from 100 to 200 yards apart and were subdivided into 0.25-acre subplots to allow subsampling. Insects on the subplots were sampled, 4 SN and 3 DV, from mid-June to mid-September, 1971.

A completely randomized design was used in the ROW study. An analysis of variance (AOV) compared numbers and dry weights of major species of insects on the 10 burned plots versus those on the 10 unburned plots. An AOV was also used to compare total dry weight of insects on the treated (burned) plots versus total weight on unburned plots. The total numbers of insects collected on burned and on unburned plots were compared statistically by a 2 x 3 and a 2 x 4 factorial AOV.

When all samples had been completed, a multiple AOV was used to determine significance for the lumped samples, 3 DV and then 4 SN, each type of sample being analyzed separately. Duncan's New Multiple Range Test (DNMRT) was used to distinguish significant means.

A randomized complete block design with subsampling was used in the PH study. An AOV was used to compare quantities and dry weights of the major species of insects on the AB plots versus those on the 3-YOR. Total dry weight of insects in the samples was included in the AOV. Factorial analysis for total insect numbers was not performed due to unequal sample size.

Admittedly, sampling of insect populations is not a precise science. In an attempt to gain valid results, I used 2 different sampling techniques. Sampling was done by 1 technique every 2 weeks. The SN consisted of a 19-inch handle, 30-inch deep heavy-duty net, and a hoop diameter of 15 inches. A SN sample consisted of 144 strokes per 0.2 acre (ROW) and 72 strokes per 0.25 acre (PH). Sample size was reduced in the PH study because the vegetation was not as dense and was more uniform than in ROW. A stroke was made so as to strike as near the ground as possible and to remain parallel to the ground for 50 inches. I moved at a fast walk (28-32 sec to take 36 strokes). The strokes were taken on straight lines from 1 end of a subplot to the other, 36 strokes per line (ROW) and 24 strokes per line (PH). A different starting point was chosen randomly for each sample. A single SN stroke was calculated to have a volume of 8,831 cu. inches, a 15 inch circle traveling 50 inches. Therefore, 144 strokes (ROW) would be 6.83% of the total possible volume within 15 inches over 0.2 acre. The PH sample (SN) was calculated to be 3.75% of the total possible volume within 15 inches over 0.25 acre.

The DV machine having an intake nozzle diameter of 6.5 inches, was held about 6 inches from the ground or litter. A DV sample consisted of carrying the machine in a straight line, 4 lines per 0.2 acre (ROW) for a total of 525 ft and 4 lines per 0.25 acre (PH) for 420 ft. I moved at a fast walk (25-30 sec to travel 100 ft). The lines went from one end of a subplot to the other end, with a starting point being randomly chosen for each sample. The DV sample was trapezoid in shape, the top being 6.5 inches wide, the bottom 12 inches wide., and 6 inches high. A DV sample was calculated to be 4.67% of the total possible volume within 6 inches over 0.2 acre, and 3.40% within 6 inches over 0.25 acre.

Insects in a sample were killed by spraying them with carbon tetrachloride after which they were sorted manually from the debris, identified, counted, dried at 83 C for 7 hr, and weighed on a top-loading balance. All weights listed are oven-dry. Individual insects weighing more than 0.035 g were discarded as they were considered too large to be ingested by quail chicks.

The 2 sampling methods give quite different results for total number and total insect weight. The SN is more efficient at collecting large, fast-escaping types, especially grasshoppers. Therefore, this method collects greater total dry weight of insects. The DV captures considerably more of the extremely small insects, thus it collects a much higher quantity of insects. The DV represents best what is available for quail chicks because it samples in the feeding zone of chicks, up to 6 inches above ground, collects tiny insects of the size usually eaten by chicks, and collects the types (slow moving) usually eaten by chicks.

The main objective of the research was to determine if the insect total weight or total number, by insect type, differed between burned and unburned subplots. Thus the 2 types of sampling methods would have to agree in capture characteristics in order for the results to be acceptably comparable. Regarding the question of insect density and biomass, the differences in the sampling methods must be remembered. The results of the sampling can be converted because sampling of the same plots on the same day showed the following ratios, DV:SN, to exist as far as number caught: spiders 3:1, flies 5:1, ants 4:1, and homopterans 1.6:1. The SN and DV collected beetles and hemipterans at about the same ratio. The SN collected twice as many orthopterans as did the DV. The total dry weight of insects in the SN was about twice as much as in the DV.

Newly hatched quail chicks, 126 in the ROW and 38 in the PH study, were placed with a broody bantam hen. When adoption was complete, a brood containing 7-20 chicks was released on a burned plot in the ROW study and on both 3-YOR and AB plots in the PH study. Fewer chicks were used in the PH study than in the ROW study due to a lack of time and personnel. Also, chicks not eating anything were not included in the results, and there were a greater number of noneating chicks in the PH study. The chicks, age 1-20 days, were able to move about the entire plot in search for food items. Each brood remained on the plot for 5-10 hr, then was picked up and killed immediately at dusk. Crop and gizzard contents were combined for the ROW study, but in the PH study only crop contents were counted to reduce a possible bias.

Three criteria were used to arrive at a relative-importance value for the insects eaten: average number of a given species of insect per chick, frequency of occurrence, and my ocular estimate of the weights of the insects eaten. Having weighed the same insects many times from the insect samples, I could estimate quite accurately relative weights of the insects eaten by chicks. Weight estimates were ranked from 1 to 8, with 1 being the heaviest. The relative importance of seeds found in chick crops, or in crops and gizzards combined, was based on the average number of certain species per chick.

Results

Quail Chick Food Habits-Insects

Adopted Quail Chicks

A total of 126 quail chicks, age 2-15 days, was used on the ROW plots. Table 1 presents the 3 relative-importance criteria for insects eaten by these chicks from early June to late August.

Table 1. Average numbers of insects in crops and gizzards of 126 quail chicks, age 2-15 days, released on the ROW burned plots.

Criterion	Type of insect						
	Spider	Ant	Fly	Leaf-hopper	True bug	Grass hopper	Beetle
Avg. No./ chick	1.2	3.6	0.7	1.7	2.2	1.2	3.6
% Frequency occurrence	27	74	9	21	61	12	83
Rank of wt. importance	4	6	7	3	2	5	1

Combining the 3 criteria, and emphasizing weight, insect types rank from most important to least important as follows: beetles, true bugs, leafhoppers, spiders, ants, grasshoppers, and flies. Chicks ate some larval forms (lepidopterans), tiny hymenopterans, snails, and moths, but did not eat any type of insect that was not collected by the SN or DV sampling techniques.

Beetles eaten were mostly small weevils (Curculionidae) and leaf beetles (Chrysomelidae). The important true bugs included a herbivorous lygaeid (Oedancala spp.), the negro bug (Corimelaena spp.), and stink bug nymphs (Pentatomidae). Ants consumed were mostly fire ants (Solenopsis spp.), whereas spiders eaten were ground spiders (Lycosidae). Grasshoppers taken as food were first or second instar stages of Conocephalus strictus and Melanoplus spp.

Chicks less than 1 week old ate more insects than did older chicks. Younger chicks averaged 9 beetles each, whereas older chicks averaged only 2.8 each. The other comparisons, presenting first in each case the average numbers in younger chicks, were: ants 7-3.1, spiders 4-0.8, true bugs 5-1.8, leafhoppers 4-1.4, grasshoppers 2.4-1.1, and flies 2-0.5. Frequency of occurrence percentages were also higher for the younger chicks.

Insects eaten by 38 chicks, age 1-20 days, but mostly 6 days, in the PH study, are summarized in Table 2. According to the 3 criteria, rank of importance, from most important to least important would be: beetles, leafhoppers, ants, spiders, larval forms, true bugs, grasshoppers, and flies.

Table 2. Insects in crops and gizzards of 38 quail chicks released on the AB and 3-YOR PH plots.

Criterion	Insect category							
	Spider	Ant	Fly	Leaf-hopper	True bug	Grass-hopper	Bee-tle	Larval* forms
Avg. No./ chick	5.2	6.4	1.9	4.2	1.9	2.5	3.2	2.0
% Frequency occurrence	50	95	32	32	24	10	45	37
Rank of wt. importance	5	3	8	2	6	7	1	4

*Mostly Lepidopterans

Wild Quail Chicks

A summary of food items found in the crops of 6 wild quail chicks is presented in Table 3. Chicks labeled A-C were captured in habitat very similar to the ROW, and chicks D-F were caught in the longleaf pine forest habitat (PH).

Table 3. Insects found in the crops of 6 (A-F) wild quail chicks, age 7-14 days.

Arthropod type	Actual number found in the crop					
	A	B	C	D	E	F
Spider	10	9	2	5	3	44*
Fly	0	1	0	0	0	0
Ant	1	2	0	2	0	0
Grasshopper	2	2	1	0	1	2
True bug	8	7	3	3	0	5
Leafhopper	36	12	9	5	1	12
Beetle	3	3	4	12	3	3
Hymenopteran	0	0	0	0	0	2
Larval form**	3	0	0	3	0	24
Snail	1	0	0	24	0	0

*Including one female with 42 newly hatched young
**Lepidopteran and Coleopteran

Leafhoppers ranked first in number eaten per chick, followed by spiders, beetles, and true bugs. In frequency of occurrence, beetles, spiders, and leafhoppers all rated 100%, followed by true bugs and grasshoppers. According to the 2 criteria above and my weight estimates, the rank of importance, most important to least, is: beetles, leafhoppers, true bugs, spiders, larval forms, grasshoppers, and the other types.

The chicks, whether adopted or wild, ate extremely small insects in most cases. Most food items were <8 mm long and weighed <0.005 g. The largest item eaten was a grasshopper that was 20 mm long and weighed 0.051 g. This individual was partly in the crop and extended all the way into the chick's gizzard. This grasshopper was the only exception to the weight of 0.035 g chosen as being too big for ingestion by quail chicks. Other large examples were a June beetle (0.027 g), a ground beetle (0.022 g), an adult stink bug (0.030 g), and a lepidopteran larval form 20 mm long and weighing 0.021 g.

It is not known how much food, insects and/or seeds, quail chicks eat or need per day. Some preliminary data are presented as indicators. A wild quail chick, about 9 days old, had a total of 0.212 g of insect food in its crop and 0.017 g of seeds in its crop and gizzard combined. The greatest amount eaten by an adopted chick, 14 days old, was 0.203 g of insect food in the crop and 0.014 g of seeds in the crop and gizzard combined. These were the largest amounts found in crops of chicks; most chicks had eaten much less.

Quail Chick Food Habits-Seeds

Estimates of seed abundance and availability on the study areas were not made. Consequently the results of this phase of the chicks' food habits will be restricted to a brief summary of the more important species of seeds found in the chicks' crops. The ROW chicks, age 2-20 days, ate mostly *Panicum lindheimeri* and *Carex cherokeensis* seeds. Other important species were *Scleria* spp. and *Paspalum* spp. *Panicum anceps* became important in August, when the seeds matured. Many seeds of P. *lindhimeri* and Scleria spp. were eaten directly from the plants. Wild quail chicks caught in habitats similar to the ROW had eaten mostly *Panicum* spp. seeds, as well as *Scleria* spp., *Digitaria* spp., and *Setaria* spp. Adopted chicks in the PH study ate *Panicum* spp. seeds mostly, but also consumed *Scleria* spp., *Cardamine* spp., and *Paspalum* spp. Wild quail chicks captured in the PH area had eaten mostly *Panicum* spp. seeds, along with some *Scleria* spp. and *Cardamine* spp. seeds.

Insect Samples-ROW Study

Results of the 7 samples, 4 SN and 3 DV, taken in the summer of 1969 on the ROW plots are presented in Tables 5 and 6. The AOV results for insect mean numbers and mean dry weights are also given.

Spiders were most numerous and had the greatest dry weight on the burned plots, but differed from unburned plots significantly in only 2 samples by number and 3 samples by weight. Ants were significantly greatest in number in all 7 samples and significantly heavier in total

Table 4. Tabulation of arthropods reported from the bobwhite.

Arthropod	Type of report and geographical location if given*	Refer. No.
MITES		
Androlaelaps sp. (= Atricholaelops sp.)	checklist-N.C.	119
Boydaia colini	sp. rev., case rept.-Ill.	11
Haemogamasus sp.	checklist-N.C.	119
Megninia cubitalis	case rept.-Ill.	11
Megninia sp.	case rept.-Fla. checklist-Ohio	133 119
Neoschoengastia americana (= Neoshongastia americana)	checklist-Va. gen. rev.	119 9
Ornithonyssus sylviarum (= Liponyssus placificus)	case rept.-Fla.	133
Ornithonyssus sp. (= Liponyssus sp.)	gen. rev.	129
Pterolichus sp.	case rept.-Ill.	11
Speleognathidae	case rept.-Md.	25
Trombicula (Eutrombicula) alfreddugesi (= Trombicula irritans)	case rept.-Fla.	133
TICKS		
Argas miniatus	checklist	13
Amblyomma americanum	checklist-Va. checklist case rept.-Texas	119 13 110

Table 4. (continued)

Arthropod	Type of report and geographical location if given*	Refer. No.
TICKS (continued)		
Amblyomma americanum (continued)	case rept.-Texas	111
	case rept.-Va.	131
Amblyomma cajennense	case rept.-Texas	76
Amblyomma maculatum	checklist-Ga.	119
	esp. inf.	13
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-La.	107
Amblyomma sp.	case rept.-Ga.	133
Dermacentor variabilis	case rept.-Ill.	11
Haemaphysalis chordeilis	checklist	13
Haemaphysalis leporispaulstris	case rept.-Fla., Ga.	133
	checklist-Fla., Ga., N.C., S.C., Va., Tenn.	119
	case rept.-Ohio	82
	checklist	13
	case rept.-Texas	110
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-Texas	111
	case rept.-Ill.	11
	gen. rev.	9
	case rept.-Va.	131
Ixodes brunnes	case rept.-Va.	131
Ixodes diversifossus	checklist-Md.	119

Table 4. (continued)

Arthropod	Type of report and geographical location if given*	Refer. No.
TICKS (continued)		
<u>Ixodes</u> sp.	case rept.-Fla.	133
<u>Rhipicephalus</u> sp.	case rept.-Fla.	133
LICE		
<u>Brueelia illustris</u> (= <u>Bruellia illustris</u>)	case rept.-Texas	111
<u>Colinicola numidiana</u> (= <u>Lagopoecus numidianus</u>) (= <u>Lipeurus aberrans</u>)	case rept.-Fla.	133
	case rept.-Ohio	155
	checklist-Md., Ohio, S.C.	119
	checklist-Fla., Ga., Ohio, Okla.	63
	case rept.-Texas	110
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-Texas	111
	checklist	96
	case rept.-Ill.	11
	case rept.-West Texas	157
<u>Cuclotogaster maculipes</u>	checklist	96
<u>Goniodes gigas</u> (= <u>Goniocotes gigas</u>)	case rept.-Ga.	133
<u>Goniodes mamillatus</u> (= <u>Goniodes mammillatus</u>)	case rept.-Fla., Ga.	133
	gen. rev.	129
<u>Goniodes ortygis</u>	case rept.-Ohio	155
	checklist-Md., N.C., Ohio, S.C., Va.	119

Table 4. (continued)

Arthropod	Type of report and geographical location if given*	Refer. No.
LICE (continued)		
Goniodes ortygis (continued)	checklist-Ala., Fla., Ga., Mont., Ohio, Ore., Texas, Wash.	63
	case rept.-Texas	110
	case rept.-Texas	111
	case rept.-Texas	76
	case rept.-Texas	90
	checklist	96
	case rept.-Ill.	11
	case rept.-West Texas	157
	case rept.-La.	107
Lipeurus caponis (= *Lipeurus dovei*) (= *Esthiopterum dovei*)	checklist-Ohio	119
	checklist	96
Menacanthus pricei	case rept.-Miss., N.C., Okla., Texas	157
Menacanthus spp.	case rept.-Fla.	133
	case rept.-Ohio	155
	checklist-Md., Ohio, Va.	119
	checklist-Okla.	63
	case rept.-Texas	110
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-Texas	111
	case rept.-Ill.	11
Otidoecus dissimilis (= *Lipeurus dissimilis*)	case rept.-Fla., Ga.	133
	checklist-Va.	119
	gen. rev.	129

Table 4. (continued)

Arthropod	Type of report and geographical location if given*	Refer. No.
LICE (continued)		
<u>Oxylipeurus clavatus</u>	case rept.-Fla., Ga.	133
(= <u>Esthiopterum clavatus</u>)	case rept.-Ohio	155
(= <u>Lipeurus clavatus</u>)	checklist-Md., Pa., Va.	119
(= <u>Oxylipeurus cubanus</u>)	gen. rev.	129
	checklist-Md., Okla.	63
	case rept.-Texas	110
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-Texas	111
	checklist	96
	case rept.-Ill.	11
	case rept.-West Texas	157
LOUSE FLIES		
<u>Icosta americana</u> (= <u>Lynchia americana</u>)	gen. rev.-North America	10
<u>Microlynchia pusilla</u>	case rept.-Texas	110
	gen. rev.-North America	10
	case rept.-Texas	76
	case rept.-Texas	90
	case rept.-Texas	111
<u>Ornithomyia anchineuria</u>	checklist-Pa.	119
(= <u>Ornithomyia fringillina</u>)	gen. rev.-North America	10
FLEAS		
<u>Echidnophaga gallinacea</u>	case rept.-Ga.	133
	gen. rev.-Eastern U.S.	66

Table 4. (continued)

Arthropod	Type of report and geographical location if given*	Refer. No.
FLEAS (continued)		
Echidnophaga gallinacea (continued)	case rept.-Texas	110
	case rept.-Texas	76
	case rept.-Texas	90
	gen. rev.	9
Orchopeas howardi	case rept.-Texas	110
	case rept.-Texas	111

*Abbreviations used: gen. rev. = mentioned in a general review of diseases; sp. rev. = review of that specific disease or a specific parasite description; exp. inf. = experimental infection; case rept. = case report or survey.

Funds supporting this presentation were provided by Tall Timbers Research Station, Tallahassee, Florida; the Joseph H. Thompson Fund, Riverbend Plantation, Quitman, Georgia; the Federal Aid in Wildlife Restoration Act (50 Stat. 917); and through Contract No. 14-16-0008-676 Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior.

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SOME ASPECTS OF THE DYNAMICS OF A HUNTED BOBWHITE POPULATION

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Abstract:

Dynamics of a hunted bobwhite population have been investigated on a 1,450-acre study area near Carbondale, Illinois since 1952. Habitat conditions have not changed greatly during the study, and November densities have oscillated regularly about a rather stable long-term mean. Most of the variance of annual rates of population change is due to variation in net productivity from spring to fall rather than to variation in net losses from fall to spring. Population declines from November to April averaged 66% (range 36 to 81%); about 0.66 of this resulted from hunting. Post-hunting mortality, which was slightly density-related, partially compensated for hunting losses. Spring densities were correlated with ($r = +0.75$) and almost as variable as preceding fall populations. Net increases from spring to fall varied from 17 to 383 and averaged 235% of the breeding population. Multiple regression analysis showed that annual rates of productivity were significantly influenced by the combined effect of breeding density, length of snow cover during the previous 2 winters, and amounts of prenesting rainfall. Annual rates of population change were inversely related to the preceding fall density, but strong correlations between successive seasonal population levels caused periods of change as well as highs and lows to persist for several years. Major highs and lows each occurred at 8- to 10-year intervals. It was not clear whether 2 severe winters caused the apparent cyclic regularity or merely accentuated the lows.

Introduction and Methods

In 1952, the Cooperative Wildlife Research Laboratory (CWRL) of Southern Illinois University and the Illinois Natural History Survey initiated a long-term investigation of the dynamics of a hunted bobwhite population on 1,450 acres of privately owned, unmanaged farmland (Carbondale Research Area) in southern Illinois. From 1953 to the present, seasonal population levels have been censused by crews of 6-12 men using trained bird dogs. Counts are made in early November (prehunting), early January (posthunting), mid February and late March prior to covey breakup. During the hunting season, each hunter is interviewed and his quail checked to determine size and composition of the harvest and total hunting pressure. Land-use and cover conditions have been recorded continuously since the project began. From 1953 through 1963 field crews attempted to locate and study all nests on the area.

Maximum census error is estimated at ±10% and average deviations ≤5%. Hunting pressure and harvest estimates (which include known cripples) are minimal but thought to be at least 95% accurate. Annual trends in quail abundance in southern Illinois, as determined from wing collections and hunter questionnaires (unpublished data, CWRL), have been similar to those on the Carbondale Research Area (CRA) with 1 exception. The 1960 decline was apparently much less severe on our study area than throughout the entire region of southern Illinois.

The research area is located about 5 miles northeast of Carbondale at 37° 46' N latitude. Topography is gently rolling, and unimproved soils are of low to very low permeability and productivity. The climate is characterized by relatively hot, humid summers and mild to occasionally cold winters. Annual precipitation averages 44.8 inches with 54% occurring from April through September (3). Maximum daily temperatures average 89.8 F during the period June through August. January is the coldest month with daily lows averaging 25.4 F. Temperatures of 0 F or less occur, on the average, only 1 day a year. During the study, the number of days with ground snow cover ≥ 1 inch averaged 12.6 and ranged from 3 to 36.

Land use has averaged about 30% intertilled crops, 30% forage, 8% small grains, 21% idle and fallow, 10% woods, and 1% miscellaneous. Seventeen lots averaging 8.6 acres in size (range 2 to 32 acres) constitute most of the wooded acreage. These lots have remained essentially stable, but fencerow and roadside cover had declined. Idle, fallow, and forage acreages have increased slightly, primarily at the expense of small grains and to a lesser extent of intertilled crops. From 1953 through 1958, corn was the principal crop, with only 27% of the intertilled acreage planted to soybeans. During the next 9 yr, soybean acreage increased to 57% and since 1968 has constituted over 70% of the intertilled acreage. Subjectively, it appears that secondary plant succession has caused some deterioration of nesting habitat in several fields formerly utilized heavily for nesting. Conversely, some prime habitat has been developed by land use and secondary succession in other parts of the area.

Of the many past and present graduate and undergraduate workers of the Laboratory and the long hours they spent in the field collecting data, we are deeply appreciative. We also thank Tony J. Peterle, Ohio State University, William R. Edwards, Illinois Natural History Survey, and Samuel R. Jewell, Southern Illinois University, for their helpful criticisms of the manuscript.

Population Levels and Fluctuations

Although there has been considerable annual variation in November and March population levels on the CRA (Fig. 1), a degree of long-term stability is evident. Net population changes between November censuses (i.e. annual population changes) have exceeded 15% in 12 of the 18 years of study. Six of these changes have been increases averaging almost 41% and 6 have been declines averaging just over 30%. The net population change for the 18-yr period is +4.3%. The maximum November density was 1 bird per 2.2 acres and the minimum 1 bird per 8.2 acres.

Most populations are likely to fluctuate annually even under conditions of relatively stable habitat (24), but the level about which these fluctuations occur is a function of habitat quality among other things. Wagner et al. (36) stressed the importance of maintaining the distinction between population balance and density determination when attempting to explain population behavior. We believe that overall habitat conditions on the Carbondale Research Area during these investigations have been sufficiently stable to permit a discussion of factors other than habitat that may be influencing annual fluctuations. We realize, however, that subtle, short-term changes in habitat quality may have caused some of the variance in seasonal population levels and thus in estimated rates of productivity and mortality.

Fig. 2 represents a simplified compartmental model of some of the more important components and interactions contributing to annual population change on the study area. Except for sampling error, these annual changes and their variance are accounted for by the 2 major components of the model, i.e. net losses from fall to spring and net gains from spring to fall. The relative importance or input of recognizable components of any system should be understood before attempting to interpret the subcomponents (22). Thus, we attempted to determine how much of the variation in annual population change was attributable to variation in net rates of gain from spring to fall as opposed to rates of loss from fall to spring. Initially, we cast rates of gain and loss as independent variables in a multiple regression model which predicted annual population change, then examined the several indicators of relative "importance" (4). However, Tukey (33) and Darlington (4) have warned that any attempt to quantify exactly the relative importance or contribution of each individual predictor variable in a set is probably not advisable when there is intercorrelation among these predictors. Consequently, we will merely state that differences in rates of productivity from spring to fall have contributed substantially more to the variance of annual population change than have rates of loss from fall to spring.

Net Losses from Fall to Spring

Population decline from November to April is the cumulative result of hunter harvest, natural mortality, and the effect of differential ingress-egress. No attempt will be made here to distinguish between losses due to mortality and egress. We have observed that while some covey movement across study area boundaries does occur during this time, the net result is not great. Thus, most nonhunting losses actually reflect mortality, most of which are believed due to predation.

November to April losses have averaged 66.2%. During the seasons of 1970-71 and 1971-72, low fall populations declined only 36 and 37%, respectively. Prior to these years, winter losses varied only from 60 to 81% (Table 1). Of the total number of birds lost each year from November to April, hunting takes an average of 67% while natural mortality during the hunting season and from January through March accounts for 11 and 22%, respectively.

The percentage of birds removed from the fall population by hunters has averaged 43.9% (range 22.3 to 67.1). Annual rates of harvest have not been strongly correlated with fall densities ($r = +0.33$). However, the harvest rate is correlated with the amount of hunting pressure ($r = +0.84$), which has varied from 162 to 457 and averaged 321 gun hours per season. No strong correlation exists between fall densities and hunting pressure even though late-season declines in effort were often noticeable during years of low populations. Kill per unit effort averaged 0.61 bird per gun hour (range 0.25 to 1.16) and, as would be expected, was strongly correlated with fall population size ($r = +0.90$).

Percent population decline from November to April is definitely related to hunter harvest rates ($r = +0.60$) but the correlation does not seem particularly strong because harvested birds usually constitute 0.66 of all losses during this period. Apparently, rates of harvest and total winter loss are not more closely correlated because posthunt mortality from January through March is somewhat dependent ($r = +0.32$) on January densities which in turn depend partially on harvest rates. The slight density-related nature of these posthunt losses may reflect Errington's contention (5,6,7) that predation varies directly with population density in relation to habitat quality. The fact that populations are lowered by hunting on our study area may reduce the effect of density on late-winter mortality.

While some compensation to hunting is effected by the slight density-related nature of posthunt losses, hunting does increase total winter loss to some degree. On a nearby nonhunted study area, we found winter losses to average about 54% which may not be an unrealistic approximation of what they would be on the CRA if it were not hunted. There is prima facie evidence that the CRA population is maintaining equilibrium in spite of annual harvests which average 44%. However, stabilization of an exploited population does not necessarily mean that it exists at natural equilibrium density (35). We will pursue this question in a later paper.

As shown in Fig. 3, annual breeding densities are quite dependent on ($r = +0.75$), and almost as variable as, preceding fall densities (coefficients of variation = 31.4 and 34.3%, respectively). The strong correlation between these 2 seasonal levels implies that fall to spring mortality rates are mostly independent of fall densities. Actually, a moderate correlation ($r = +0.54$) exists between November densities and percent declines from November to April. However, this correlation is due almost entirely to the seasons of 1970-71 and 1971-72, when both variates were quite low. Prior to 1970, the small variations in rates of winter loss appeared to be independent of fall densities, possibly because (A) harvest rates, which contribute substantially to total losses, are apparently not density-related and (B) the relatively heavy annual harvests may tend to keep posthunt populations below the area's late-winter carrying capacity. This latter possibility is further suggested by the apparent lack of a relationship between winter weather and rates of nonhunting losses.

Latham and Studholme (19) said that of all the environmental factors affecting the bobwhite, snow caused the greatest hardship. Studies of lightly or nonhunted populations in Wisconsin (12), Iowa (16), and Virginia (21) all demonstrated a positive correlation between length of snow cover and winter losses. The detrimental effect of snow on bobwhite survival has been noted also in Missouri (32). Using multiple linear regression (MLR), we tested the effects of length of snow cover and low temperatures on posthunting survival, but no relationship was evident at any level of population density. The fact that weather has not had a measurable influence on survival over the entire range of our data does not mean that losses, either directly or indirectly attributable to weather, have not occurred. Mortality amounting to 18% of the mid-February population accompanied a 23-day period of severe weather in late winter, 1960 (26). Field observations suggested that these losses, which mainly resulted from increased vulnerability to predation, would have been considerably higher if most coveys had not had access to standing corn and soybeans left unharvested the previous fall.

Net Productivity From Spring to Fall

Net population increases from March to November expressed as percentages of March populations are referred to in subsequent discussion as percent summer gains. These gains, which have ranged from 17 to 383 and averaged 235%, are strongly correlated with corresponding rates of annual population change (r = +0.74; Fig. 4). Variations in percent summer gains could be influenced by differences in reproductive rates or survival of chicks or both. Mortality of adult hens could also be involved although most of such losses are thought to occur after hatching (12,27) and thus would not influence reproduction. Lack (17,18) believed that density-related variation in rates of summer gain reflected differences in survival of young rather than reproductive rates; Hickey (9) agreed with this assumption. Conversely, we feel that variation in annual summer gains on the CRA is influenced more by differences in the number of chicks that hatch than by variation in rates of survival.

We have no direct data on chick mortality, estimated at 2 to 4% per week in other areas (12,14,28). However, from 1954 to 1963, there was a correlation of +0.85 between the ratio of the known number of chicks hatching to the estimated breeding population and the percent summer gain. This implies that 72% of the variation in gains was attributable to variation in the number of chicks hatching versus the estimated breeding population, thus leaving only 28% of the variance to be associated with other factors such as survival rates of chicks.

Our nesting studies indicated that total and relative productivity were not influenced by annual differences in mean clutch size or hatchability rates of eggs, but did correlate directly with the number of successful nests found in relation to the estimated breeding population. Further, differences in annual rates of successful nests per breeding bird were due not so much to differences in the proportion of total nests that hatched as in the total number of nests built.

In an attempt to interpret the influence of weather on productivity, we calculated average maximum, minimum, and mean daily temperatures and total rainfall for 10-day intervals throughout the year. These data were tested, by simple correlations against the corresponding percent of gains during summer to select biologically meaningful parameters of temperature and moisture conditions during the periods of winter, prenesting, egg laying, and hatching. The following predictor variables were thus selected and tested by step-wise multiple linear regression in an IBM 360 computer for their combined and individual contribution to the variance of yearly rates of summer gain from 1954 through 1971 (criterion variance):

(1) breeding density

(2) number of days of snow cover ≥1 inch during the previous winter

(3) number of days of snow cover ≥1 inch during 2 winters previous

(4) average minimum daily temperature during the previous 1 February to 21 March

(5) average mean daily temperature from 22 March to 30 April

(6) total rainfall from 22 March to 30 April

(7) average maximum daily temperature from 1 May to 19 July

(8) total rainfall from 1 May to 19 July

(9) average maximum daily temperature from 1 July to 28 August

(10) total rainfall from 1 July to 28 August

When considered in the presence of (with knowledge of) the other predictors, breeding density, snow cover during the previous 2 winters, and rainfall from 22 March to 30 April, were each found to account individually for a significant ($P<0.001$) portion of the criterion variance. Collectively, these predictors accounted for almost 75% of the variance in annual rates of summer gain ($R^2 = 0.747$; $P<0.01$). None of the remaining variables contributed significantly ($P>0.05$) to the predictability of rates of summer gain. Although the mechanism by which the variables influence productivity is not revealed by the MLR analysis, the extent and form of this influence is indicated. First high breeding density and snow cover during the previous 2 winters tended to depress gains while prenesting rainfall increased productivity. Secondly, breeding density and snow cover during the previous winter had a greater effect on rates of gain than did prenesting rainfall or snow cover 2 winters previously. Thirdly, the negative regression of productivity on snow cover in the previous winter was significantly ($P<0.001$) curvilinear with the detrimental effect becoming relatively greater as length of snow cover increased.

Several previous studies of bobwhites (5,6,12,16) have shown a tendency for percents of summer gain to be correlated negatively with breeding density. This relationship is the well-known "inversity principle" (6). Annual rates of summer gain on the CRA are plotted against corresponding breeding densities in Fig. 5. The negative correlation is not particularly strong (r = -0.44) which is not unexpected because productivity is also significantly affected by other factors (weather) besides density. Notwithstanding the negative influence of density on rates of gain, total production has varied directly with breeding densities resulting in an essentially linear relationship between spring and subsequent fall populations (Fig. 6).

The possibility that duration of snow cover may adversely influence productivity in the following summer is made tenable by numerous studies of penned ring-necked pheasants (Phasianus colchicus) demonstrating that malnutrition or other stress prior to the breeding season can impair reproductive performance. A common response to artificially induced stress is delayed egg laying (1,2,8). Stanford (32) reported a marked delay in nesting of wild bobwhites in Missouri following the severe winter of 1960. We did not observe this delay on the CRA although, as mentioned earlier, unusually favorable food supplies may have lessened the impact of the weather. But in southern Illinois as a whole, the 1960 hatch was quite late as judged by analysis of a large sample of wings. In fact, these data have shown a positive correlation between duration of snow cover and subsequent lateness of hatch from 1951 through 1970. Also, late hatches have usually been associated with poor reproductive years based on fall age ratios and hunter questionnaires (unpublished data, CWRL). Similar findings have been reported in Missouri (30).

A possible explanation for the decline in productivity with increased duration of snow cover may be that bobwhite hens stressed by snow or high density or both have reduced vigor which delays nesting and decreases the probability of renesting. This would also explain why a low number of nests per breeding bird and late hatches are commonly associated with poor reproductive seasons.

During years of high densities, some coveys winter in marginal ranges that are normally unoccupied during years of lower populations (31). This phenomenon, coupled with the possibility that good habitat quality may buffer the influence of winter stress on the birds, suggests that the adverse effect of winter weather on productivity may not be constant over all levels of population density. We investigated this hypothesis, which is contrary to the concept that the effects of weather are essentially density-independent (9,23), by adding interaction terms to the MLR model allowing the expression of different regressions of productivity on snow cover at different levels of population density. When tested by the F statistic, this interaction was not significant at the 0.05 level. However, the probability of the amount of additional criterion variance thus accounted for being due to chance was only about 10%. Further, a model plot of this interaction simulated from computer-determined regression coefficients fit the hypothesized concept. That is, the adverse effect of snow on productivity was greater at higher than at lower densities. Or stated another way, the negative influence of breeding density on productivity was less after mild winters than after severe ones.

Latham and Studholme (19) wrote that in Pennsylvania: ". . . reproduction of bobwhite quail is adversely affected for at least 2 seasons following severe winters." We presently consider this hypothesis tenable but not proven on the CRA, based on the MLR analysis which showed a slight but significant ($P<0.001$) portion of the variance in rates of summer gain to be accounted for by knowledge of length of snow cover 2 winters previous (when breeding density, snow cover the previous winter, and prenesting rainfall are also known). If the influence of snow does extend for 2 seasons, it suggests that the adverse effect of stress is somehow transmitted from parents to their offspring. Lower survival rates have been reported for Hungarian partridge (*Perdix perdix*) chicks whose parents had been stressed previously by crowding (11).

As noted earlier, total rainfall during the 6 weeks prior to egg-laying exerted a statistically significant, though not particularly strong, positive effect on productivity. The mechanism of this influence is unknown but may operate through nutritional or cover characteristics of the vegetation. Jackson (10) believed that the effect of rainfall deviations on vegetation contributed to oscillations of bobwhite densities in marginal ranges of Texas. Lehmann (20) linked rainfall and corresponding vegetative growth to initiation of nesting in the same state. Interrelationships between rainfall, vegetation, and nesting would conceivably be more pronounced in arid regions of the bobwhite's range than in southern Illinois where extremes of early season rainfall and corresponding vegetative response are not so great.

Many workers contend that cool, moist summers are more conducive to good reproduction than hot, dry summers (25,28,29,32). However, several long-term studies (12,16), including ours, have failed to demonstrate a significant relationship between summer weather and productivity. The absence of a correlation between these variables on our study area does not negate the *potential* importance of summer weather to reproduction. It simply means that during the years 1954 through 1971, variations in rates of productivity did not seem attributable to variations in temperature and moisture conditions as we measured them. This is not surprising considering that each year of the study, except 1954, had a mean maximum daily temperature for the period June-August that was cooler than the 1910-53 long-term mean (3,34). Furthermore, nesting studies from 1954 through 1963 indicated that individual nests and eggs were affected only rarely by heat, drought, or heavy rains although maximum July-August temperatures may have influenced termination dates of egg-laying (15). Extremely hot weather during peak egg laying in June of 1952 and 1953 may have abbreviated the nesting season and increased nest abandonment, but the effect on total productivity was not clear.

The Pattern of Population Change Between Years

Three characteristics of long-term population behavior on the CRA are evident from Fig.1. First, there is a tendency for between-year changes to be negatively related to previous densities. Secondly, periods of increase, decline, highs, and lows each generally persist for several years. Finally, there is an apparent regularity of oscillation with 8-10 year intervals between major highs and lows, respectively.

The negative relationship between population change and density is clearly seen in Fig. 7 which plots annual rates of change as a function of previous fall densities (r = -0.49). This population characteristic, which is implicit in the concept of balance, is apparently a manifestation of the previously described density-related nature of both mortality and productivity and possibly of the interaction between density and weather. However, response to deviations from mean density is usually not immediate. Instead, increases or declines tend to overshoot the mean by a considerable margin then persist for several years at more stable densities well above or well below the mean. This population momentum, which apparently results from the strong correlations between successive seasonal levels (Figs. 3 and 6), seems able to persist for several years before other pressures, presumably density related, finally stabilize the population or impel it in another direction.

Serial correlations between seasonal densities may not be the only cause of momentum. It has been observed that some populations tend to remain at low levels for a time following declines even when apparent causes of the decline (e.g. weather, high density) are no longer operating directly on the individuals. When this occurs in short-lived species, it suggests that the offspring of parents which originally suffered the decline are somehow "disadvantaged" in terms of their own survival or reproduction or both. Errington (6) termed this period a "depression phase" while others (12,36) have mentioned the possibility of stress-induced weakness being transmitted nongenetically from parents to young. Obviously, further research is needed regarding the effects of various kinds of stress on bobwhite population behavior and the possibility that these effects may be delayed as well as direct.

Whether "cyclic" population tendencies are due entirely to intrinsic mechanisms or are the result of periodically occurring extrinsic factors has long been a subject of great interest among population ecologists (9,13). At least some of the regularity observed in our data seems attributable to the combined effects of momentum and density-related changes operating in tandem. Complicating the picture, however, is the effect of weather, especially snow cover, which our study and others have shown to be considerable. It would seem that randomly occurring years of severe weather would tend to mask or dampen any intrinsic tendencies toward regularity of oscillations. However, both winters of heavy snows occurring on the CRA in 1960 and 1970 came immediately after periods of high densities, just as the population appeared to be beginning a decline. In addition, it is likely that the adverse effects of these winters were at least somewhat intensified by the high densities. Thus, it is not entirely clear whether the winters of 1960 and 1970 actually caused or merely accentuated the population lows which followed. We anticipate that information from our study will ultimately provide valuab new insight into the phenomenon of population cycling. However, in order to clarify the role of weather, it will be necessary to quantify

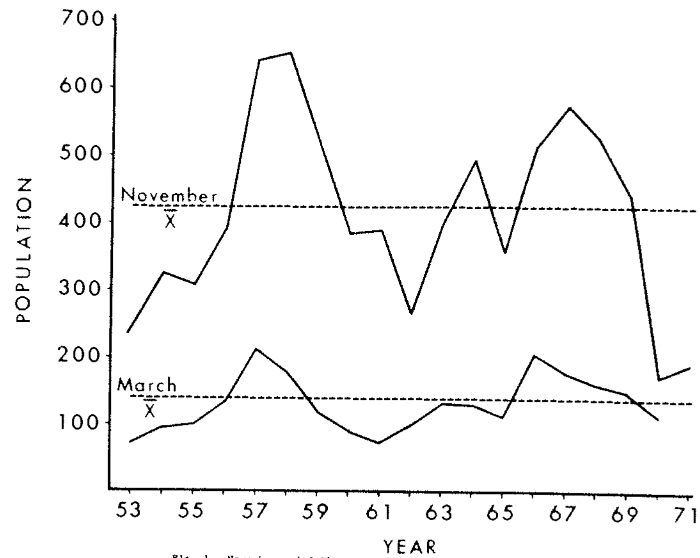

Fig. 1. November and following March population levels, Carbondale Research Area, 1953-1971.

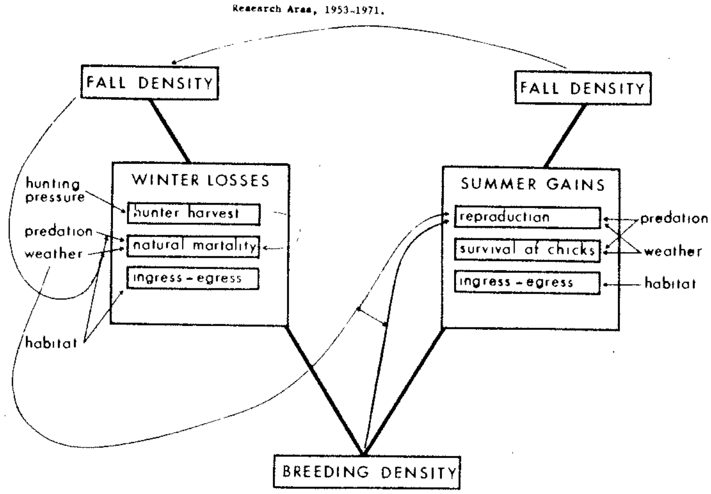

Fig. 2. A simplified model of November to November population change on the Carbondale Research Area.

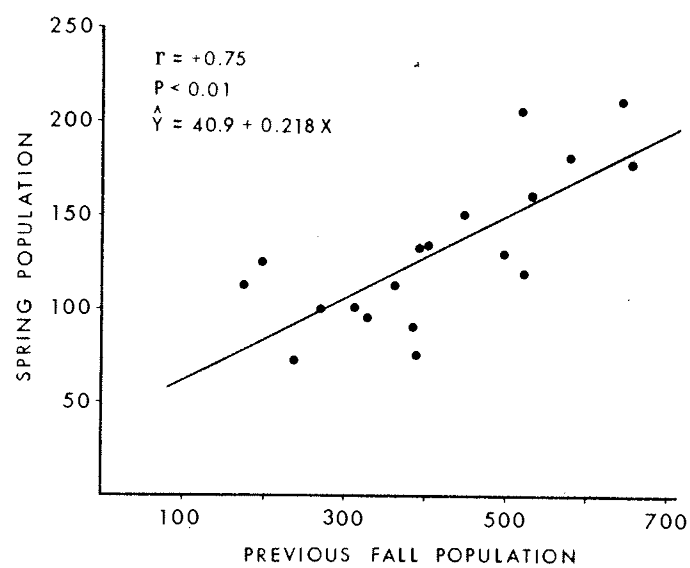

Fig. 3. Relationship of fall to following spring population levels, Carbondale Research Area, 1953-1972. Line fitted by method

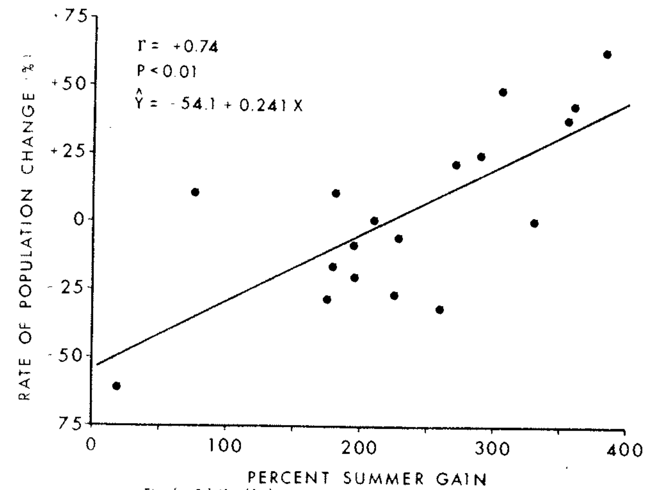

Fig. 4. Relationship between percent summer gain and rate of population change, Carbondale Research Area, 1954-1971. Line fitted by method of least squares.

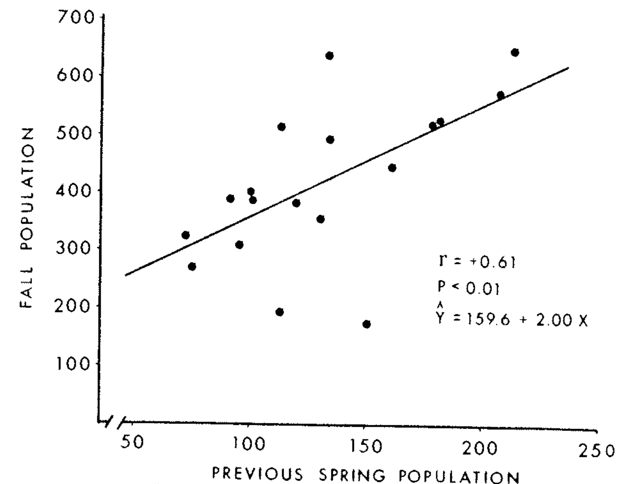

Fig. 6. Relationship of spring to following fall population levels, Carbondale Research Area, 1954-1971. Line fitted by method of least squares.

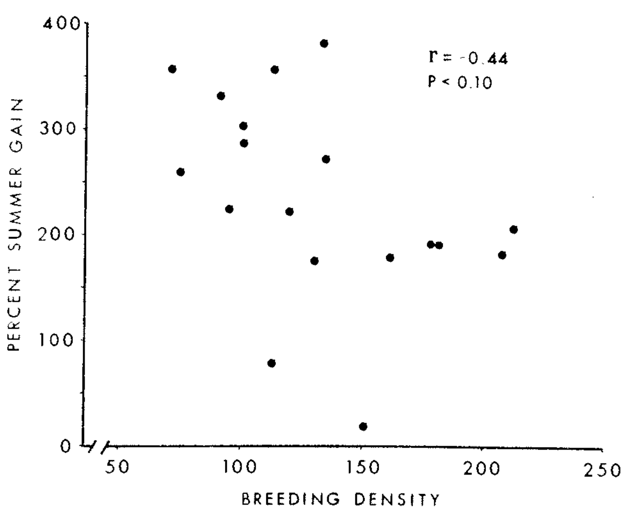

Fig. 5. Relationship between breeding density and percent summer gain, Carbondale Research Area, 1954-1971.

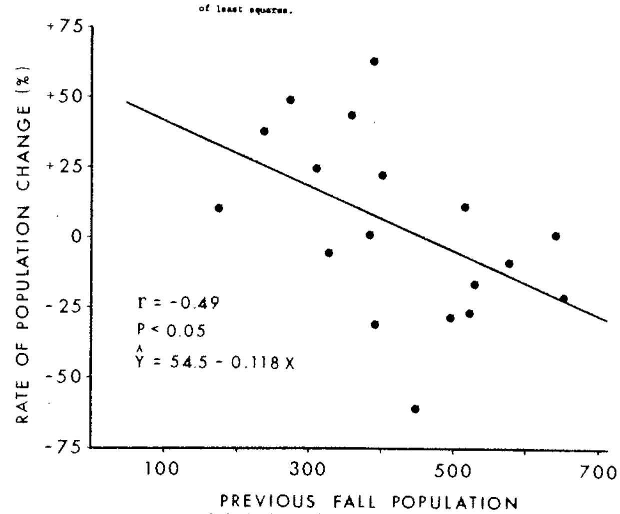

Fig. 7. Relationship between fall densities and rate of population change the following year, Carbondale Research Area, 1954-1971. Line fitted by method of least squares.

Table 1. Some bobwhite population data, Carbondale Research Area, 1953-1972.

Year	Estimated population as of: Nov. 10	Jan. 1	Mar. 20	% Gain previous summer	Hunter harvest #	%	% Loss Jan. to Apr. (of Jan. level)	% Loss Nov. to Apr. (of Nov. level)
1953-54	237	139	72	-	-	-	48.2	69.6
1954-55	328	199	95	356	119	36.3	52.3	71.0
1955-56	311	151	101	227	130	41.8	33.1	67.5
1956-57	392	228	133	288	210	53.6	41.7	66.1
1957-58	643	240	212	383	357	55.5	11.7	67.0
1958-59	655	285	178	209	273	41.7	37.5	72.8
1959-60	523	197	119	194	198	37.9	39.6	77.2
1960-61	386	110	91	224	259	67.1	17.3	76.4
1961-62	392	132	75	331	222	56.6	43.2	80.9
1962-63	270	189	100	260	82	30.4	47.1	63.0
1963-64	404	143	134	304	258	63.9	6.3	66.8
1964-65	497	136	130	271	224	45.1	4.4	73.8
1965-66	359	171	113	176	163	45.4	33.9	68.5
1966-67	518	272	207	358	198	38.2	23.9	60.0
1967-68	579	303	181	180	217	37.5	40.3	68.7
1968-69	531	192	161	193	233	43.9	16.1	69.7
1969-70	449	256	151	179	190	42.2	41.0	66.4
1970-71	176	129	113	17	54	30.7	12.4	35.8
1971-72	197	144	125	74	44	22.3	13.2	36.5

its effects during other phases of the "cycle".

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BOBWHITE WHISTLING ACTIVITY AND POPULATION DENSITY ON TWO PUBLIC HUNTING AREAS IN ILLINOIS

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Abstract:

Eight years of data from 2 public hunting areas in southern Illinois demonstrate high multiple correlations (r = 0.97 and 0.84) for prebreeding densities and call indices with the prehunt densities of bobwhites (*Colinus virginianus*). Models derived from multiple correlation analyses produced satisfactory predictions of prehunt densities. The average number of calls per stop was the key element in the predicting model. The number of whistling cocks heard per stop is of limited value as an index because of difficulty in determining numbers when more

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than 7 whistling cocks are within hearing. The models for the 2 areas appear different, but this possible difference cannot be satisfactorily confirmed on the basis of data for only 8 years.

This paper discusses the correlation between audio-census indices and fall population densities of bobwhites on 2 public hunting areas in southern Illinois during 1964-71. In Illinois, counts of whistling bobwhites have long been used as indices of summer abundance (6). Norton et al. (5) evaluated published data relating to the use of whistle counts as indices of fall quail populations from Missouri, Indiana, South Carolina, Alabama, Iowa, and southern Illinois and concluded (p 403): "In the several sets of data we examined, there was little indication that year-to-year changes in numbers of whistling cocks in summer was predictive of autumn populations, and hence only a relatively small portion of the variance could be explained."

The data evaluated by Norton et al. (5) used the number of individual males whistling as the basis for their predictions. In our analysis, we have evaluated the number of bobwhite calls per listening stop and the prebreeding census data, as well as the numbers of whistling cocks, as bases for predicting fall populations.

The editorial assistance of G. C. Sanderson, W. R. Edwards, and Helen C. Schultz is gratefully acknowledged. This paper is a contribution from Illinois Federal Aid Project W-66-R, the Illinois Department of Conservation, the U. S. Bureau of Sport Fisheries and Wildlife, and Illinois Natural History Survey, cooperating.

Methods

Data on quail population density and whistling were collected on Stephen A. Forbes State Park (2,930 acres), Marion County, Illinois, and on Sam Dale Lake State Park (1,300 acres), Wayne County, Illinois. Detailed descriptions of these areas and the management programs employed for upland game have been published (2). Upland game management on these areas has remained unchanged except for the incorporation of a 260-acre portion of the Dale area in 1970 and a 250-acre segment of the Forbes area in 1968 into a sharecropping program including corn (*Zea mays*), soybeans (*Glycine max*), and wheat (*Triticum aestivum*). The Dale area is located in a more extensive area of high-quality quail range than is Forbes. The Forbes area is surrounded on 3 sides by relatively flat, gray-prairie cropland that is devoid of the brush and woodlands essential for quail habitat of high quailty.

Audio-Censuses

Audio counts of quail were made at approximately weekly intervals along a standardized route on each area from mid-May to mid-July during 1964-71 (Table 1). The censuses began at sunrise on mornings when the wind velocity was less than 7 mph and the cloud cover was less than 75%. Counts of 2-minutes duration were made at each stop. The number of bobwhite calls, and as many of the individual whistling cocks as could be distinguished, were recorded. It was difficult to identify the number of calling cocks when more than 7 individuals were whistling, as was frequently the case. When there were more than 7 cocks whistling, we recorded the count as 7-plus cocks, along with the total number of calls. We concentrated on counting accurately the total number of calls. Actively calling cocks whistle every 12-20 sec or 6-10 times per 2 min, with each call lasting about 2 sec. When more than 7 whistling cocks are within hearing distance, calling is virtually continuous.

The census route of 6.25 miles, including 6 equidistant stops, on the Dale area was established along the public road bordering the area. The census route measured 6.14 miles on the Forbes area, with 2 stops located on the public road that bordered the park and 6 equidistant stops along the main park road. Thus, on a portion of the census route on Forbes and along the entire route at Dale, whistling quail both on and adjacent to the study areas were recorded during the audio-censuses. No distinction was made as to the location of whistling cocks relative to boundaries of the areas.

Population Estimates

The areas were censused during early November (prehunt), early January (posthunt), and early March (prebreeding), with bird dogs to locate coveys of quail. Harvest data were recorded at compulsory hunter check stations located on each area. Two methods were used to derive estimates of the prehunt populations: (1) prehunt censuses, using bird dogs, and (2) adding the numbers of birds harvested to the posthunt census figures obtained after the hunting season. The latter method was considered more reliable during periods of high population densities. However, both methods tend to underestimate the population, the first because of missed coveys and the second because of known crippling losses and natural mortality. Under low densities, census data can be adjusted for coveys that are routinely observed but missed during the census; this adjustment is not possible at high densities.

Analysis of Data

Census data were evaluated using multiple correlation analysis performed by computer facilities of the University of Illinois, Urbana. In the analysis, the estimates for the prebreeding census, average whistle counts, and average numbers of whistling males were treated as independent variables and the prehunt population estimates as the dependent variables.

Findings

Although data for only 8 years (Table 1) were available for analysis, it is obvious from the single-factor correlation coefficients that call counts have been closely correlated with prehunt quail density, particularly on the Dale area (Table 2). Multiple correlation coefficients indicated that about 94% of the annual fluctuation in the prehunt population estimates for quail on the Dale area and 71% for the

Forbes area were associated with changes in the prebreeding census and audio indices.

The unstandardized regression coefficients for the 3 independent variables (Table 2) appear different for the 2 areas. Tests of differences between areas for the 3 independent variables failed to reject the hypothesis of no significant difference. However, because the analysis was based on data for only 8 years, it is not fitting that we proceed on the assumption that no significant difference existed, or that if a difference existed, it was of no real consequence.

Models for predicting prehunt quail density from prebreeding census and audio counts were derived from the analysis. For the Dale area the prehunt quail density is predicted as:

$$\hat{Y}_{Dale} = 15.934 - 0.42848X_1 + 2.9593X_2 - 10.269X_3$$

and for the Forbes area:

$$\hat{Y}_{Forbes} = 4.9003 + 0.82404X_1 + 0.64895X_2 + 0.33379X_3$$

where X_1 is the number of bobwhites per 100 acres in the prebreeding population, X_2 is the average number of quail calls per 2 min on the audio-census of quail, and X_3 is the average number of whistling males per 2 min.

There was good agreement between quail densities predicted using the above models and the densities estimated from censuses of the 2 areas (Table 3).

Discussion

In a discussion of the reproductive calls of the bobwhite, Stokes (10) noted that the bobwhite call is purely sexual in function, unmated males and those separated from their mates for several hours use the bobwhite call, and the female "hoy-poo" call elicits bobwhite calls from males. The duration of the intervals between successive whistles by an individual male probably varies as a function of the motivational influences.

Some investigators (1,9) reported that summer whistling cocks represent surplus (nonmated) males. Our observations, as well as those of Rosene (7) and Kabat and Thompson (4), suggest that both mated and unmated cocks whistle during the period of calling. Observations of cock-hen pairs along the census routes near the listening stops indicated that these males did not whistle. We believe that the majority of cocks whistling during the period from late May to mid-July were those whose mates were tending nests--probably incubating. This contention is supported by data obtained from juveniles (ages were determined by wing molt) taken by hunters. The majority of juveniles harvested during the first 7 days of each hunting season were from nests that were incubated from the first week of June to the third week of July (Ellis, unpublished data).

The close correlation between whistle counts and the abundance of quail in the fall suggests that fall populations depend primarily on the number of birds available during the breeding season. No tendency towards inversity, as demonstrated for Wisconsin quail (3), was noted in this study. We believe, as does Rosene (8), that the audio-censuses reflect the quality of nest cover on an area and that variations in nest success and juvenile mortality are minor factors in determining year-to-year fluctuations in quail numbers in the fall. Thus, winter survival of quail and winter carrying capacity appear critical in quail management on the Dale and Forbes areas.

At this time, we can only hypothesize why other workers have not found strong correlations between audio counts and quail abundance in fall. One possibility is that reproductive success of quail on private land is more variable than on managed public hunting areas. Another possibility is that the quail harvest size often used as an index to quail abundance in fall is influenced by factors such as crop harvest and weather during key segments of the hunting season and thus is a biased index of quail density.

The lack of a stronger correlation between the prebreeding and prehunt censuses is also a puzzle. One possibility is a reorientation of quail in April and early May to better nesting situations and in response to social interactions involved with the breakup of coveys. This idea supports the concept that calling activity reflects the quality of summer range (that is, the quality of available nesting cover), whereas the prebreeding census reflects the quality of winter range.

Use of the prebreeding estimates and the average numbers of whistling cocks did little to increase the accuracy of our predicting models. If the objective for conducting spring and early summer censuses of bobwhites is primarily to predict fall populations and harvest, there appears to be little reason to census prebreeding populations or, under situations of high density, to attempt to determine numbers of whistling cocks during routine call counts. However, if data on prebreeding populations and whistling cocks are readily available, it is only logical to include them in a predicting model.

The matter of whether the unstandardized regression coefficients differ significantly among areas is of considerable importance. If they do not, it will ultimately be possible to develop a single predicting model that will allow prehunt quail densities to be estimated for an area by using only standardized audio counts made on that area. A single predicting model would have great utility in both management and research.

If the relationship between audio counts and prehunt populations differs among areas, or changes over a period of years on a particular area, it will be necessary to develop predicting models for individual areas and perhaps refine them on an annual basis. Several more years or data and information from other areas are needed before final decisions can be made on techniques for predicting prehunt quail density from audio counts. However, for now, we conclude that on public hunting areas in Southern Illinois, carefully standardized call counts will provide reliable indices to the relative abundance of bobwhites in the fall on the area censused.

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Table 1. Summary of quail census estimates and audio indices for the Dale and Forbes areas, 1964-71.

Year	(1) Prebreeding census	(2) Avg. calls per stop	(3) Avg. whistling cocks per stop	(4) Prehunt census
Dale area				
1964	4.3	20.0	4.9	26.9
1965	3.8	15.4	3.9	18.5
1966	3.5	21.6	4.6	29.7
1967	7.8	28.3	5.5	36.4
1968	9.4	29.9	5.2	49.7
1969	12.7	29.0	5.3	41.7
1970	10.0	27.1	5.4	37.1
1971	10.5	25.5	5.7	27.4
Forbes area				
1964	5.3	12.1	3.9	18.2
1965	3.4	5.7	1.5	9.4
1966	1.9	8.0	2.3	14.2
1967	4.9	17.4	4.0	27.1
1968	4.8	27.6	5.2	33.3
1969	7.3	26.9	5.0	26.1
1970	4.6	18.5	4.2	23.3
1971	3.1	21.4	4.8	16.3

Table 2. Summary of results of multiple correlation analysis using (1) the prebreeding census, (2) average calls per stop, (3) average number of calling males with (4) prehunt census as the dependent variable. Data are from the Dale and Forbes areas, 1964-71.

Area	Forbes	Dale
Single factor correlation	(1) 0.61907	0.65551
	(2) 0.83206	0.90146
	(3) 0.79447	0.57654
Multiple correlation	0.84346	0.96968
F Ratio for multiple "*r*" (df = 3,4)	3.28707	20.99257
Standard error of estimate	5.5731	3.1657
Unstandardized regression coefficient	(1) 0.82404	-0.42848
	(2) 0.64895	2.9593
	(3) 0.33379	-10.269
Standard error of unstandardized regression coefficient	(1) 1.6439	0.63383
	(2) 0.78415	0.51192
	(3) 4.8023	3.9673
Standardized regression coefficient	(1) 0.17132	-0.15286
	(2) 0.67408	1.54519
	(3) 0.05600	-0.61132
Standard error of standardized regression coefficient	(1) 0.34178	0.22611
	(2) 0.81451	0.26730
	(3) 0.80570	0.23618
Dependent variable intercept	4.9003	15.934
t = Regression coefficient/standard error	(1) 0.50126	-0.67602
	(2) 0.82758	5.78075
	(3) 0.06951	-2.58841

Table 3. Summary of estimated prehunt quail density on the Dale and Forbes areas, 1964-71, with the density of quail predicted on the basis of multiple correlation analysis of the prebreeding and audio censuses. Density is expressed as quail per 100 acres.

Year	Forbes		Dale	
	Estimated	Predicted	Estimated	Predicted
1964	18.2	18.4	26.9	23.0
1965	9.4	11.9	18.5	19.8
1966	14.2	12.4	29.7	31.1
1967	27.1	21.6	36.4	39.9
1968	33.3	28.5	49.7	47.0
1969	26.1	30.0	41.7	41.9
1970	23.3	22.1	37.1	36.4
1971	16.3	12.0	27.4	28.4

AN EVALUATION OF SOME MARKING TECHNIQUES USED ON BOBWHITE QUAIL

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Abstract:

Summarized are data obtained from field testing various marking techniques used to distinguish individual, unrestrained bobwhite quail. Four methods and combinations of each included various types of back tags, colored leg bands, dyes, and radio transmitters. Discussed are methods, advantages, and limitations as based upon field observations of 195 back-tagged quail, 86 quail with colored leg bands, 55 dyed quail, and 91 radio-marked quail.

The ability to mark individual animals so that they can be recognized at a later date under field conditions is essential to many studies. Back tags have been employed successfully in numerous investigations including those by Blank and Ash (3) in studying partridges and by Labisky and Mann (10) in studying pheasants. Colored leg bands have been used extensively in researching ruffed grouse (7), turkeys (11), and prairie chickens (8). Dyes have been used to mark game birds with varying success (2,5,6,9,12). Radio-transmitters have been employed for numerous studies of game-birds, but with limited success on the bobwhite quail (1) because of their small size. This paper summarizes data obtained from field testing of the above techniques on individual, unrestrained bobwhite quail (*Colinus virginianus*).

The authors wish to acknowledge D. L. Rose and the late R. M Bartholomew for their aid in collecting portions of the data presented. This publication is a contribution of Project No. 1 of the Cooperative Wildlife Research Laboratory of Southern Illinois University.

Methods and Findings

Back Tagging

Tags were constructed of Fibre-thin and Amor-tite (vinyl material bonded to nylon mesh). Tag size varied from 2.75" x 1" to 5.25" x 0.75". Ten different colors were used (white, yellow, light blue, dark blue, orange, red, black, bright green, armor green, and pink). To maximize the number of individually marked birds, various numbers and letters were painted (vinyl weathercoat paint) on the tags.

A total of 195 quail were back-tagged. Tags were attached by means of a calf-skin harness or Fibre-thin strips which were passed from the front of the tag under the wings and stapled to the front of the tag. It is essential that the harness is not too tight and that the strap is passed under the scapular feathers instead of over them.

Both materials employed were considered adequate for use, but Fibre-thin tags curled upward after a short time in the field. The curling was caused by the paint used to put symbols on the tag and was alleviated by painting the symbol on both sides of the tag. All sizes of tags used worked well; but the narrower tags seemed to interfere less with flight than the wider ones.

Certain difficulties in recognition were noticed between tags of similar colors, particularly in poor lighting, or when the observation must be brief because of intervening vegetation or rapid movement. Inability to distinguish between the colors red and orange occurred most commonly, both on the ground and in flight. We do not recommend use of both colors in the same covey. The 2 shades of blue were also difficult to differentiate. There was no difficulty in distinguishing between the 2 greens. However, we do not recommend using armor green because the drab color is difficult to see on a flying bird. Dark colors (black, dark blue, and red) were not visible or were indistinguishable beyond 50 yards. The most visible colors were white, yellow, and pink, respectively.

The use of 2-color tags increased the number of quail individually identified, both in flight and on the ground. Division of the 2 colors on the tag should be arranged longitudinally and should include both sides of the tag. Motion of the tag in flight makes it quite difficult to determine colors if the tag is painted on 1 side only; horizontal division of the color results in the impression of a single color tag. Contrasting primary colors should be used.

Any numeral, letter, or other symbol chosen as a marker should be placed in the center of the lower half of the tag. The scapulars often cover the upper half of the marker, which obscures the identification symbol. We identified all symbols tested on tags up to 50 yards using 7 x 50 binoculars. Occasionally, identification of 2 number tags at this distance was difficult. When quail are feeding, the tag rests in a horizontal plane and the smaller number necessary on such tags is more difficult to read. When observations were made at distances of 80-85 yards, 2-number tags were seldom identified while the larger single number was discernible. Increasing the observational distance to 100 yards resulted in loss of definite recognition of all symbols; under poor lighting conditions even the color of the tag cannot be recorded.

Colored Leg Bands

Colored plastic leg bands (National Band and Tag Co., Newport, Ky.) were placed on 86 quail. Two bands were placed on 1 leg to increase the visibility of the marking.

This method for identifying individual quail was used with little success. However, on several occasions where dyed birds were seen at such an angle that the back tag was not visible, the identification of the bird was obtained by use of the leg bands and dye colors. In our opinion, 1 or 2 such observations justify the use of colored bands, considering the small amount of expense and the time involved in placing the bands on the quail's leg.

Color Dyeing

Fifty-five quail were color dyed in an attempt to increase the number of individually recognizable birds. Rhodamine BXP, Rhodamine 60, Auramine, Brilliant Green, Victoria Blue B, Brilliant Scarlet 3R, Crocien Orange Y, and picric acid were used. There was some evidence that mixing of dyes might produce desirable colors; this was not investigated fully.

Auramine, Rhodamine BXP, and Brilliant Green were recognizable dyes in the field. Picric acid yielded an acceptable color at application, but it faded to a greenish yellow. All other dyes faded rapidly under field conditions.

The birds were dyed by either dipping them in the solution, swabbing them with cotton, or spraying them with a perfume atomizer or a "Windex" spray bottle. Swabbing with cotton proved to be the only method acceptable. An excellent job of dyeing was obtained by dipping the quail into solution; however, the feathers tend to become saturated and the resulting temperature loss as the alcohol and water evaporated caused stress to quail. The use of a perfume atomizer and a "Windex" spray bottle did not give a sufficient dyeing of the feathers.

No noticeable change of behavior due to dyeing was noted; dyed quail were accepted by covey mates and mated dyed quail were observed many times.

Dyeing quail for identification was successful as they were recognized easily on the ground and in flight. It is limited, however, by the small number of acceptable dyes available. This problem can be solved in part by using secondary markers. It must be recognized that any dye will be recognizable only until the time of molt. During this study dyed quail were not observed after mid-July; loss of dyed feathers during molt probably was responsible for this.

Radio Transmitters

Ninety-one quail were radio marked during the past 7 years. This entailed the use of 3 different types of transmitters: Type A with a loop antenna (26.550 to 26.640 megacycles); Type B with a whip antenna (148.000 to 148.330 megacycles) and a battery packaged as described by Brander (4); and Type C which was the same as Type B, except that the battery was packaged with the transmitter. A single mercury cell (Mallory RM-625) was used as the power source for all transmitters. Estimates of theoretical transmitter life varied from 30 to 50 days depending on the power drain of the particular transmitter. All transmitters weighed between 9 and 11 g.

Method of attachment varied with the type of transmitter employed. Type A used the same type of harness as used with the backtags; the harness simply passed from the front of the transmitter, around the wings, and was attached to the front of the transmitter. Type B used the same harness as described by Brander (4). This entailed running the harness with battery leads to the battery on the breast, and then passing the harness straps under the wings and attaching them to the back of the transmitter. On Type C, the harness straps led from the front of the transmitter thence around the neck to the front of the breast. Here they were crossed over and passed under the wings and attached to the back of the transmitter.

Transmitters were believed to have had a minimal effect on quail if the harness was adjusted properly. All birds with properly adjusted harnesses flew readily when released and flushed normally at later dates. Instrumented birds appeared to pair normally and nesting instrumented birds were noted in several instances. However, birds had to adjust to all 3 types of transmitters. During adjustment mortality was high (13%); 54% of all mortality occurred within the first 5 days after instrumentation.

A comparison of the 3 types of transmitters is presented in Table 1. Type C transmitter produced the best results. This transmitter yielded best life expectancy and least premature termination of signal. It was carried readily by quail, including several cases by quail of only 60 days of age; 1 quail carried an operable transmitter for 121 days. The Type A transmitter appeared cumbersome, and on 2 occasions quail were found dead after the loop antenna became entangled in vegetation. The leads to the battery of the Type B transmitter broke after a short time in the field. Also, this type of transmitter was never recovered from birds believed killed by predators; apparently the predators broke the leads.

Summary

Each of the 4 methods of marking has limitations as well as advantages. The use of any 1 of these methods depends solely on the type of study and the types of data the researcher wishes to obtain. Important to consider is how readily the marker is distinguishable in the field. While back tagging and color dyeing give acceptable results, the radio transmitter is unquestionably the easiest way to locate and distinguish individual animals. Also of concern is the duration of the marker. Back tags and color leg bands may last the life of a quail, while color dyeing will last only until the time of molt. Data for radio-marked quail rarely are obtained for a period more than 2 months. A third point to consider is the type of data the researcher wishes to gather. The radio transmitter yields continuous data, while the other methods yield only interrupted data. A fourth constraint is the number of birds the investigator desires to mark. Obviously, radio-marking is somewhat limited due to the expense involved.

Table 1. Comparison of radio-transmitters field tested on bobwhite quail.

Type	No. used	Suboptimum transmitters			Transmitters recovered while still operating			Transmitters operating expected life			Overall average life
		No.	%	Average life in days	No.	%	Average life in days	No.	%	Average life in days	
A	14	6	42.9	5.0 (1-11)	7	50.0	8.4 (1-17)	1	7.1	39.0	9.1 Days
B	10	7	70.0	6.8 (1-23)	1	10.0	19.0	2	20.0	39.0 (36-42)	14.5 Days
C	85	23	27.0	10.3 (1-27)	29	34.1	8.3 (1-29)	33	38.8	36.8 (30-56)	20.0 Days

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INTERRELATIONSHIPS BETWEEN VARIOUS QUAIL POPULATION MEASUREMENTS

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Introduction

Early investigators of the bobwhite used covey counts to measure population numbers. We do not know when quail were first censused by this method, but we do know that Leopold and Errington put much emphasis on these counts. Covey numbers and their sizes are of great importance because to a large degree they reflect the quality of quail environment. In recent years data have been gathered on other facets of quail populations so that now it is possible to study relationships between many population measurements.

A technique for a census of "bobwhite" calls was started in 1938 by Rudolf Bennitt. Bennitt (1) and Reeves (3) reported on the relationships between whistling cocks, soils, and hunting success. Rosene (4) studied the relationship between whistling cocks in summer and coveys in the subsequent winter. Norton et al. (2) examined all previous published data and reported on whistling cocks and coveys from tracts on the Crab Orchard National Wildlife Refuge and on 2 areas in Davis County, Iowa.

The proportion of juveniles to adults in quail populations can be determined from samples of wings from birds killed by hunters. Given the total population (number of coveys X average size of coveys), the number of individuals in an age class, juvenile or adult, can be found by multiplying the total population by the percentage of that age class found in the wing samples.

Study Areas and Procedures

We collected data from 2 different tracts 115 miles apart in South Carolina: Groton near Estill and Oakland Club near Pineville (Table 1). These enabled us to make some preliminary correlations to determine mutual relationships between various population measurements.

When studying these data the question arose as to the most appropriate statistic. For example, if numbers of whistling cocks in summer depended on the spring population of males, and we wished to predict the number of whistling cocks to follow a spring population of males, then a regression analysis would be in order. For this study we assumed that the paired variates we wanted to test were associated in some way but that neither variate operated as a consequence of the other. It is entirely possible that many of the 2 variates tested could be more appropriately studied as a regression, but our aim was to determine correlations for the entire 2 lots of data.

A correlation (r) was figured from 9 sets of paired data from Groton. Thus it was possible to investigate the relationship between 36 items. Oakland Club had 8 sets of paired data, so 28 different correlations were computed.

Groton Plantation

Groton is privately owned and managed for quail. Records on quail have been kept from 1957 through 1970. Insecticides were used on Groton during the period of this study. In the summers of 1958, and 1959, DDT was dusted on growing soybean plants, and during the spring planting of corn in 1964, 1965 and 1966, some kernels remained on the surface of the soil at ends of rows where they were available to quail at a critical time of food shortage. It seemed advisable to eliminate the data for these 5 years because of abnormal fluctuations in the quail population caused by the adverse effects of DDT (5).

Twelve thousand acres of this plantation are used for quail hunting. One wing was removed from each bird shot, and feather molt was studied to learn the individual's age. As a territory was hunted, covey locations were depicted by map-tacks on an aerial photograph. As hunting proceeded during the season, newly discovered coveys were recorded on an area after each day's hunt only after all previously located coveys had been found on that particular day; thus, covey numbers were conservative. Average covey size was calculated annually by repeatedly flushing and counting individuals in an adequate number of coveys. Coveys were recorded on the entire plantation making it possible at the end of the hunting season to count the number of coveys found on the transects where whistling cocks were recorded in summer.

To count whistling cocks in summer, 1 transect containing 14 stops at 0.5 mile apart was established through the center of the plantation. At each stop, quail calling "bobwhite" were plotted on an aerial photograph. Plotting was always done on the mornings of 20 and 21 June. Start was at sunrise; 8 min were spent at each listening stop and 2 min driving between stops. After 2 mornings of work, the estimated number of whistlers present was determined.

Oakland Club

Oakland Club lands are managed differently than Groton. This Club owns 7,000 acres and leases another 35,000. Hunting takes place on 29,000 acres. Records were kept from 1959 through 1970. Ages of quail were determined in 9 of the 12 years. All other records are continuous for the 12-year period.

To check whistling cocks on Oakland, 2 transects of 12 stops each were established using the same interval between stops as on Groton. "Bobwhite" calls were counted once on each of these transects and always on the mornings of 18 and 19 June, using the same routine as on Groton.

Unlike Groton, coveys were not plotted on a map, but when hunters and guides returned from a day in the field they reported the number of coveys flushed, thus providing cumulative records of covey flushes.

Results and Discussion

On Groton we heard a total of 1,156 whistling cocks on 1 transect in 10 years. In 9 years hunters found 5,070 individual coveys on the entire plantation of which 1,098 were on the whistling-cock transect. Sportsmen shot 13,547 quail in 8 years. We determined sex-age ratios (from the entire kill) and average covey size. It was possible to calculate 9 items from the original data (Table 2).

In 12 years on Oakland the 2 transects had 1,701 whistling cocks, hunters spent 4,882 days afield flushing 26,036 coveys and killing 25,258 quail. We determined sex-age ratios for 9 of the 12 years. In all, 8 items were used in the analysis (Table 2).

Groton Plantation

Significant correlations were found for 21 of the 36 items investigated (Table 3). Of the 21, 14 were positive.

Previous investigators (1,2,3) have reported a positive relationship between number of cocks whistling "bobwhite" in summer and number of coveys present in the subsequent winter. Our data show a similar positive relationship between whistling cocks and coveys in the first following winter; coveys tested were those found on the same transects used for the whistling cock census. The relationship was not significant when whistling cocks were tested with coveys on the entire plantation in the second winter that followed. Cocks whistling in summer also showed a significant positive relationship with populations of males, females and subadults in the first subsequent spring.

On Groton there was a positive relationship between spring populations of males, females, and subadults when tested with coveys in transects during the first subsequent winter. These same 3 categories had a similar positive relationship with coveys on the entire plantation in the second subsequent winter. This indicates that the number of quail remaining in a given spring is related to the number of quail that will be present in the first and second winter coming after that given spring.

Total kill in 1 winter was positively related to coveys on the entire plantation 1 year later. In other words, the higher the kill in 1 year, the greater the number of coveys in the following winter; and the lower the kill, the fewer the coveys in the following winter. This appears to be contrary to the statement about the importance of spring populations. A high kill in winter should logically result in a low population of males, females and subadults in the spring. At this point in research the best explanation is that hunting pressure was so light that it had little effect on spring populations; however, hunting pressure was sufficient to have a positive effect on reproduction. It seems that up to a certain point the removal of quail by hunting is beneficial.

Significant negative correlations were shown in 2 comparisons: (A) young per adult female in the hunting season X kill in the same hunting season, and (B) percent subadults X coveys in transects. Biologists have thought that the greater the number of young per adult female in fall the higher the production in the previous summer and therefore the greater the population size in the winter and thus the better the hunting. On Groton, as young per adult female increased, the kill decreased. A negative correlation was also found between young per adult female and kill on Oakland Club, but it was not significant. This paradox needs additional study.

Table 1. Comparisons between Groton Plantation and Oakland Club.

Characteristics	Groton	Oakland
Acreage	12,000	29,000
Mean population per year		
Number of quail	10,134	6,014 est.
Acres per bird	1.2	4.8
Whistling cocks	115	71
Percentage of subadults	71.9	79.5
Mean hunting pressure per year		
Covey finds per hour	3.7	2.0
Kill	1,694	2,105
Percent of population removed by hunting	16.5	35.0 est.

Table 2. Various quail population measurements tested.

Groton	Oakland Club
1. Summer whistling cocks	1. Summer whistling cocks
2. Coveys in transects in winter	2. Total kill
3. Total kill	3. Young per adult female
4. Young per adult female	4. Percent subadults
5. Percent subadults	5. Coveys found
6. Spring population of males	6. Coveys per party day
7. Spring population of females	7. Total gun days
8. Spring population of subadults	8. Kill per gun day
9. Coveys on entire plantation 1 year later	

Table 3. Calendar diagram showing sequential relationships of data.

Location and starting season	First year		Second year		
	Summer	Winter	Spring	Summer	Winter
Groton	1. Whistling cock census	2. Coveys in transects	6. Population of males		9. Coveys on entire plantation
		3. Total kill	7. Population of females		
		4. Young per adult female	8. Population of subadults		
		5. Percent subadults			
Oakland Club	1. Whistling cock census	2. Total kill			
		3. Young per adult female			
		4. Percent subadults			
		5. Coveys found			
		6. Coveys per party day			
		7. Total gun days			
		8. Kill per gun day			

Table 4. Significant correlations at Groton.

At the .05 level

- \- .76 Percent subadults X coveys in transects.
- \+ .73 Spring population males X coveys on entire plantation.
- \- .67 Young per adult female X spring population of females.
- \+ .71 Spring population subadults X coveys on entire plantation.
- \- .70 Young per adult female X coveys on entire plantation.
- \+ .74 Summer whistling cocks X coveys on transects.
- \+ .74 Summer whistling cocks X spring population of females.
- \+ .78 Summer whistling cocks X spring population of subadults.
- \+ .77 Spring population of females X coveys on entire plantation.
- \- .74 Young per adult female X total kill.
- \+ .78 Total kill X coveys on entire plantation 1 year later.

At the .01 level

- \+ .80 Summer whistling cocks X spring population of males.
- \+ .88 Spring population of males X coveys in transects.
- \+ .86 Spring population of females X coveys in transects.
- \+ .87 Spring population of subadults X coveys in transects.

Table 5. Significant correlations at Oakland Club.

At the .05 level

- \+ .63 Summer whistling cocks X kill.
- \+ .71 Young per adult female X percent subadults.
- \+ .67 Kill X total gun days.
- \+ .69 Summer whistling cocks X coveys found.

At the .01 level

- \+ .77 Summer whistling cocks X coveys found per party day.
- \+ .78 Total gun days X coveys found.
- \+ .78 Kill per gun day X coveys found.

At the .001 level

- \+ .90 Kill X kill per gun day.
- \+ .96 Kill X coveys found.
- \+ .91 Kill X coveys found per party day.
- \+ .89 Kill per gun day X coveys found per party day.
- \+ .90 Coveys found X coveys found per party day.

Oakland Club

The data for Oakland presented the opportunity to make correlation tests for 4 of the same items as were measured on Groton (Table 2) and, in addition, to find relationship between these 4 items and hunting success. Oakland had a lower population, lower hunting success, and a higher kill (Table 1) so the same correlations as tested on Groton can be expected to vary on Oakland in their amount of significance.

On Oakland Club all significant correlations were positive (Table 4). Summer whistling cocks were closely related to coveys found, similarly to Groton, but on Oakland whistling cocks were significantly related to kill. This was not so on Groton. Numbers of birds shot (kill), amount of time spent afield, and coveys found were significantly interrelated.

Young per adult female was significantly related to percent subadults on Oakland, which was not the case on Groton.

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SUPPLEMENTAL PAPERS

MAXIMIZING EDGE AND COVERTS FOR QUAIL AND SMALL GAME

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Abstract:

A computer-generated table is presented, enabling the land manger to maximize on a given acreage the length of edge and the number of coverts (or corners where 3 or more cover types come together).

Between-field connections are provided for sportsmen and farm machinery. The equations are presented along with diagrams of field layout and graphs of the relative changes in edge and coverts resulting from certain decisions related to management efficiency.

The effectiveness of quail and other wildlife habitat management should be measured against a concept of potential production rather than percent change from past populations. The concept of highest potential production of quail on an area is useful not only for evaluating management effectiveness, but also for preventing over-investments made to achieve increases in natural populations past the potential.

One aspect of intensive quail habitat management is believed to be the production of linear distance of edge (cover) and coverts or corners where more than 2 types of cover come together. Food supplies are essential, but these are only of secondary interest in this paper.

With proper management, fall quail densities can exceed 1 bird per acre by several times. Under ideal habitat conditions, the only logical limit to a quail population is that of spatial tolerance associated with social behavior. When such limits are approached, coveys tend to become spaced at uniform distances apart (1). Implementation of the concept presented herein may help to achieve the highest possible densities of quail populations.

The question posed of the manager is: How does he produce simultaneously the greatest amount of edge per unit area and the greatest number of coverts, yet retain some practical field reality such as cultivation and the possibility for hunting or observing wildlife?

The solution is quite empirical. Long strips of cover close together produce much edge per acre. Very small patches of cover, say 1 m^2, produce abundant coverts, but few managers would evaluate the results as functional edge for wildlife. Among the regular nesting geometric structures that can be fitted throughout a management area (Fig. 1), equilateral triangles provide the most edge per area enclosed with the maximum corners.

Fig. 1 shows a management area, all of which is potentially developable for quail. The task of the manager is to fit as many triangles into the area as possible, or that "make sense", given the local conditions. The lines shown can be any type of hedgerow or cover strip. The interiors of the triangles should be regularly (or randomly) cultivated food plots for quail or other small game. They could be in corn, bird-food mix, clover, fallow, or any similar rotation. Openings (12 ft) are provided for hunters, dogs, and farm equipment.

Computer-generated Table 1 will enable the land manager to maximize the amount of edge and coverts he can create on a given acreage. The table is based on the function of establishing equilateral triangles of the same size within 1 large equilateral triangle. The basis for the tables is:

Table 1. The linear feet of edge (E), the number of coverts (C), and the area of the triangle not encomposed or residual (R), are presented as a function of the length of the leg of the interior triangles and the acres within the management area.

Area in acres	Length of leg of interior triangles in feet: 24			36			48			60			72			84			96			108		
	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R
0.5	2268	90	0.0	1836	42	0.0	1248	20	0.1	972	12	0.2	1188	12	0.0	708	6	0.2	816	6	0.1	924	6	0.0
1.0	4524	182	0.0	3120	72	0.2	2592	42	0.2	2400	30	0.1	1968	20	0.2	1404	12	0.4	1620	12	0.2	924	6	0.5
1.5	6720	272	0.0	4740	110	0.2	4416	72	0.0	3348	42	0.2	2940	30	0.2	2328	20	0.4	2688	20	0.0	1836	12	0.5
2.0	8424	342	0.1	6696	156	0.1	5508	90	0.1	4452	56	0.2	4104	42	0.1	3480	30	0.2	2688	20	0.5	3048	20	0.1
2.5	10320	420	0.2	7800	182	0.3	6720	110	0.2	5712	72	0.2	4104	42	0.6	3480	30	0.7	4020	30	0.2	3048	20	0.6
3.0	12408	506	0.2	10260	240	0.1	8052	132	0.2	7128	90	0.1	5460	56	0.5	4860	42	0.5	4020	30	0.7	4560	30	0.1
3.5	14688	600	0.2	11616	272	0.2	9504	156	0.2	7128	90	0.6	7008	72	0.2	6468	56	0.1	5616	42	0.2	4560	30	0.6
4.0	17160	702	0.1	13056	306	0.3	11076	182	0.1	8700	110	0.4	7008	72	0.7	6468	56	0.6	5616	42	0.7	4560	30	1.1
4.5	19824	812	0.0	14580	342	0.3	12768	210	0.0	10428	132	0.2	8748	90	0.3	8304	72	0.0	7476	56	0.0	6372	42	0.3
5.0	21228	870	0.2	16188	380	0.3	12768	210	0.5	10428	132	0.7	8748	90	0.8	8304	72	0.5	7476	56	0.5	6372	42	0.8
5.5	22680	930	0.3	17880	420	0.3	14580	240	0.3	12312	156	0.3	10680	110	0.3	8304	72	1.0	7476	56	1.0	6372	42	1.3
6.0	25728	1056	0.1	19656	462	0.3	16512	272	0.1	12312	156	0.8	10680	110	0.8	10368	90	0.3	9600	72	0.1	8484	56	0.3
6.5	27324	1122	0.3	21516	506	0.3	16512	272	0.6	14352	182	0.5	12804	132	0.3	10368	90	0.8	9600	72	0.6	8484	56	0.8
7.0	28968	1190	0.4	23460	552	0.2	18564	306	0.4	14352	182	1.0	12804	132	0.8	10368	90	1.3	9600	72	1.1	8484	56	1.3
7.5	32400	1332	0.1	25488	600	0.1	20736	342	0.1	16548	210	0.5	15120	156	0.1	12660	110	0.5	11988	90	0.1	10896	72	0.1
8.0	34188	1406	0.2	25488	600	0.6	20736	342	0.6	16548	210	1.0	15120	156	0.6	12660	110	1.0	11988	90	0.6	10896	72	0.6

Table 1 (Continued)

Area in acres	Length of leg of interior triangles in feet: 120			132			144			156			168			180			192			204		
	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R	E	C	R
0.5	348	6	0.4	384	6	0.3	420	6	0.3	456	6	0.3	492	6	0.2	528	6	0.2	564	6	0.1	600	6	0.1
1.0	1032	6	0.4	1140	6	0.3	1248	6	0.2	1356	6	0.0	492	6	0.7	528	6	0.7	564	6	0.6	600	6	0.6
1.5	2052	12	0.2	1140	6	0.8	1248	6	0.7	1356	6	0.5	1464	6	0.4	1572	6	0.2	1680	6	0.0	600	6	1.1
2.0	2052	12	0.7	2268	12	0.4	2484	12	0.1	1356	6	1.0	1464	6	0.9	1572	6	0.7	1680	6	0.5	1788	6	0.3
2.5	3408	20	0.2	2268	12	0.9	2484	12	0.6	2700	12	0.3	1464	6	1.4	1572	6	1.2	1680	6	1.0	1788	6	0.8
3.0	3408	20	0.7	3768	20	0.2	2484	12	1.1	2700	12	0.8	2916	12	0.5	3132	12	0.1	1680	6	1.5	1788	6	1.3
3.5	3408	20	1.2	3768	20	0.7	4128	20	0.2	2700	12	1.3	2916	12	1.0	3132	12	0.6	3348	12	0.2	1788	6	1.8
4.0	5100	30	0.4	3768	20	1.2	4128	20	0.7	4488	20	0.1	2916	12	1.5	3132	12	1.1	3348	12	0.7	3564	12	0.3
4.5	5100	30	0.9	5640	30	0.2	4128	20	1.2	4488	20	0.6	4848	20	0.0	3132	12	1.6	3348	12	1.2	3564	12	0.8
5.0	5100	30	1.4	5640	30	0.7	4128	20	1.7	4488	20	1.1	4848	20	0.5	3132	12	2.1	3348	12	1.7	3564	12	1.3
5.5	7128	42	0.3	5640	30	1.2	6180	30	0.3	4488	20	1.6	4848	20	1.0	5208	20	0.3	3348	12	2.2	3564	12	1.8
6.0	7128	42	0.8	5640	30	1.7	6180	30	0.8	4488	20	2.1	4848	20	1.5	5208	20	0.8	5568	20	0.1	3564	12	2.3
6.5	7128	42	1.3	7884	42	0.3	6180	30	1.3	6720	30	0.5	4848	20	2.0	5208	20	1.3	5568	20	0.6	3564	12	2.8
7.0	7128	42	1.8	7884	42	0.8	6180	30	1.8	6720	30	1.0	4848	20	2.5	5208	20	1.8	5568	20	1.1	5928	20	0.4
7.5	9492	56	0.5	7884	42	1.3	8640	42	0.1	6720	30	1.5	7260	30	0.5	5208	20	2.3	5568	20	1.6	5928	20	0.9
8.0	9492	56	1.0	7884	42	1.8	8640	42	0.6	6720	30	2.0	7260	30	1.0	5208	20	2.8	5568	20	2.1	5928	20	1.4

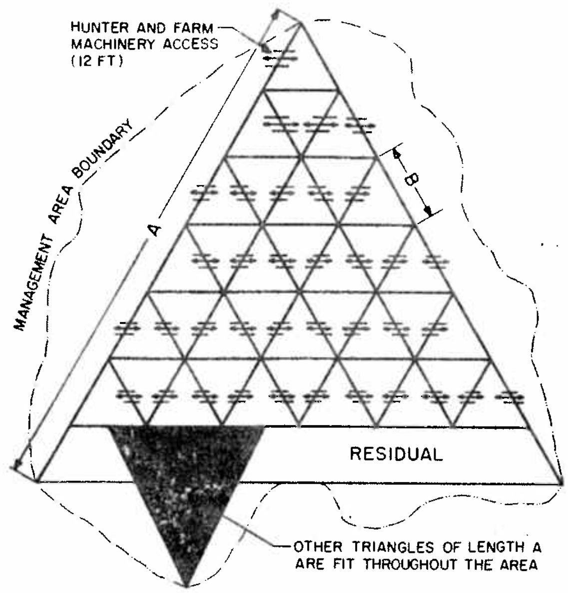

Fig. 1. A management area for maximum management of quail. Equilateral triangles fit throughout the area can maximize edge and coverts (see Table 1.)

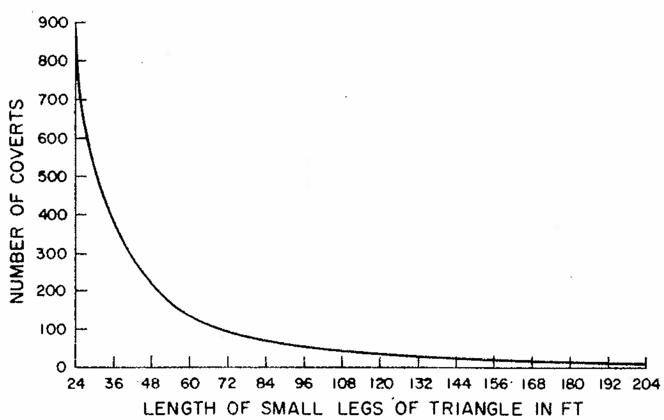

Fig. 2. Relationship of number of coverts to length of the legs of small equilateral triangles on an area of 5 acres.

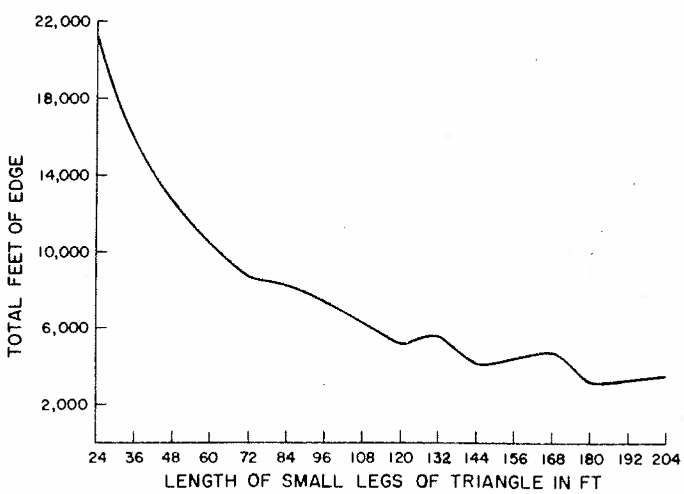

Fig. 3. Relationship of edge to length of the legs of small triangles on an area of 5 acres.

$$E = [(\Sigma_{k=0}^{[A/B]}[A/B] - k) \times 3B] - [[A/B]^2 * G]$$

Where E is the total length of all edges

A is the length of the legs of the large equilateral triangle

B is the length of the leg of the interior smaller triangles

k is the count of the number of triangles without common edges

and G is the width of the opening or gate between each area, assumed throughout to be 12 ft. .

[] symbolizes the absolute value.

The number of coverts, C, is calculated from

$$C = \sum_{i=2}^{[A/B]} N_{(i-1)} + i + 1$$

where $N_{(1)} = 3$.

The land manager should determine on a map or photograph the size, in acres, of the largest equilateral triangle that he can fit into his management area. Within this large triangle, smaller equilateral triangles will be made. The manager, after deciding on the length of the legs of these smaller triangles, will be able to determine the amount of edge and number of coverts he can create. He can also see how much of the area is not being used either as edge or as coverts (considered residual due to the length of the legs of the small triangle). Subsequent triangles can then be fitted into the area until all spaces are developed.

Fig. 2 shows how the number of coverts decreases as the interior triangles approach the size of the larger triangle for a 5-acre tract.

On the same area, though, the length of edge decreases as the interior triangles increase (Fig. 3). The decrease is not as rapid. A balancing of the 2 factors is possible and by plotting any desired ratio of coverts to linear ft and observing the breaking point, it is possible to identify an optimum length of the leg of the interior triangle.

With the tables, the trade offs between maximum habitat and maximum harvests or maximum quality hunts can be more rationally discussed and decided.

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THE OKLAHOMA QUAIL HUNTER

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Abstract:

A questionnaire study of 2,690 Oklahoma quail hunters revealed that the most common type of hunter is a married man, 21 to 40 years old, who hunts 5 to 6 hr per day and 10 days per season. He hunts mostly on private lands about 35 miles from home and often has difficulty obtaining access for hunting. He is successful on 0.75 of his hunting trips and harvests an average of 3.8 quail per trip. He spends about $9.60 per day while hunting. Saturday is his favored hunting day.

Semiskilled workers earning about $7,000 per year are the most common type of hunter. The hunters are in agreement with the existing season, but many want 1 more day per week for shooting.

Management implications of the findings are discussed.

Oklahomans hunt bobwhite quail more than they hunt any other species of wildlife. Continued high levels of sporting use of quail cannot be taken for granted. Quail habitat is being reduced annually as brush is cleared from pastures and fence rows are cleared. Brushy draws are being bulldozed clean, channeled, and planted to bermuda grass. The result is more income for the farmer and fewer quail. It is folly to think that wildlife habitat can be preserved by asking farmers to stop clearing brush. A more practical solution is either to develop alternate habitat components that are acceptable to quail and will produce income for farmers or to facilitate marketing of quail-based recreation by farmers.

Before either of the above suggestions can be seriously attempted, it becomes necessary to determine the size, distribution, and other characteristics of the public need for quail. The present study concerns one aspect of this need: the quail hunter. When all pertinent information about quail hunters has been examined we will know better where to put effort into habitat preservation and how far to go.

Support of this study by the Oklahoma Wildlife Conservation Commission is gratefully acknowledged. Rangers Ballew, Clepper, Hembree, Hughston, Kidd, Randall, Reedy, Sanders, Smeltzer, and Sparger are due thanks for conducting interviews. Mary Usry, Becky Roberts, and Gene O'Brian are thanked for helping to analyze the data and prepare the report.

Methods

This study is based on information derived from questionnaires returned by Oklahoma hunters (Fig. 1). Ten thousand questionnaires were mailed to persons who purchased 1967 resident hunting licenses. Three weeks after the initial mailing a second mailing was made to non-respondents. The mailings were distributed geographically in the same proportions as the resident licensed hunters (2).

Of the 5,280 questionnaires returned, 5,122 contained useful information. Question 26 (Fig. 1) was answered by 4,410 hunters, 2,646 of whom hunted quail. This study, being concerned only with quail hunters, is based on returns from quail hunters only except where specified otherwise.

Resident hunters 16 and 65 yr of age were not sampled because they are not required to purchase licenses, consequently a random list of addresses for them was not available. However, there were 52 hunters of more than 65 yr who purchased licenses and returned questionnaires. These were included in the study.

People who did not return questionnaires may have different attributes than those who did. To help detect such bias, the names of 300 persons who did not return questionnaires were selected at random. Rangers were asked to visit these people and ask them for the information called for on the questionnaires. Information was obtained from 44 (15%) of these hunters. One hundred and thirty-two (44%) were out of state, deceased, in military service, moved, or at unknown locations. The remaining 124 either would not cooperate or could not be reached with reasonable effort.

Employment classifications were modeled after those used by the Oklahoma Employment Security Commission. Examples of the classifications are: Professional = teachers, bankers, doctors; White Collar = bookkeepers, store clerks, bank clerks; Skilled Workers = electricians, machinists, construction foremen; Semiskilled Workers = truck drivers, oil field pumpers, barbers; Unskilled Workers = janitors, yardmen, guards; Agricultural Workers = those working on farms, ranches, or feedlots; Nonworkers = students, retired persons, housewives, disabled, and unemployed persons.

All population data was derived from Oklahoma Data Book (4). State planning regions (Fig. 2) were used where geographic comparisons were made.

Results

Vital Statistics of Hunters

Three-fourths of all respondents, including nonquail hunters, hunted quail in at least 1 of the past 3 seasons (Fig. 3). More than 60% of this group hunted quail in 1967 (Fig. 4). No other species was hunted by as many people that year (Fig. 4). More than 68% of the interviewed hunters hunted quail in 1967 (Fig. 4), suggesting that the 60% figure is conservative.

Persons of all ages sampled (16-65 yr) hunted quail (Fig. 5).

However, a larger percentage of persons 21 to 40 yr of age hunted than did age groups younger or older. Persons 16 to 20 and 41 to 64 yr old made up about 2% less of the responding hunters than they did of the statewide population (Fig. 5). Conversely, those 21 to 40 yr old made up about 7% more of the responding hunters than they did of the statewide population.

Eighty-two % of the hunters were married. Eighty-four % indicated that they were the head of the household and 13% said they were a child of the head of the household. Women constituted 2.4% of the hunters. Most quail hunters (88%) came from households that contained only 1 or 2 quail hunters including the respondent (Fig. 6). The households averaged 4.9 persons.

The number of quail hunters in Oklahoma during the study period was approximately 167,000 (Table 1).

People of all income levels hunted quail (Fig. 7). Interviewed hunters earned considerably less than those returning questionnaires, suggesting that low income hunters were not as responsive as those earning more.

About 33% of the hunters were semiskilled workers (Fig. 8). Otherwise, the most abundant groups were agricultural workers (16.9%) and nonworkers (16.2%). The interview sample differed from the mail sample by having a smaller percentage of semiskilled workers and larger percentages of unskilled and agricultural workers (Fig. 8).

Possession of Dogs; Hunting of Game Other Than Quail; Party Size

Eighty-seven % of the quail hunters hunted in parties of 2 or 3 people (Table 2). Average party size was 2.5 and the median was 2.0.

More than 98% of the quail hunters indicated that they owned 1 or more bird dogs (Fig. 9). It seems unlikely that such a high percentage of hunters own a bird dog. What is more likely is that hunters not owning a bird dog omitted the question rather than put zeros in the blanks. Nevertheless, the data do indicate that of those who own dogs, most own 1 dog and very few own more than 2.

Most quail hunters also hunted other species (Fig. 10). Only 11.3% of those answering the questionnaires hunted quail only. Species other than quail hunted most by the quail hunters were doves, squirrels and rabbits in that order. Usually these species are not hunted at the same time as quail. Reasons for this condition are that either the seasons do not overlap (doves), or the animals inhabit different areas (squirrels), or such hunting is considered bad for bird dogs (rabbits).

More than 23% of interviewed hunters who hunted quail hunted nothing else (Fig. 10). Other species hunted were about the same as hunted by mail respondents.

Amount of Time Hunted

Questionnaire respondents averaged hunting 5.7 hr per day (Fig. 11) and 10 days per season (Table 3). Interviewed hunters averaged 5.5 hr per day and only 6.2 days per season. The most persistent hunters seemed to have a greater tendency to return questionnaires.

Nearly 0.5 (46%) of the hunters hunted quail during the 1967 season and in the 2 preceding seasons (Fig. 3). The 8% who hunted during the 1967 season but not in the 2 preceding ones possibly represent annual recruitment. Interviewed hunters hunted somewhat less than the mail respondents (Fig. 3).

Hunters' ages seemed to affect how much they hunted. Hunters 16 to 20 yr old hunted about 0.5 hr less per day than older hunters (Fig. 12). However, they hunted more days per season (Fig. 13). In terms of total hunting effort (hr per season), the 21 to 40 yr old group hunted 56.8 hr or nearly 2 hr more than the 16 to 20 yr olds. (Fig. 14). Hunters more than 40 yr old reported hunting less than 50 hr per season.

More than 0.5 of total hunting effort (hunters x aver hr hunted) was expended by hunters in the 21 to 40 yr old group (Fig. 15).

Control of land hunted on affected how much hunters hunted. Those hunting on leases and on lands of friends and relatives hunted more hours per season than those hunting on other kinds of land (Fig. 16). Persons hunting on their own land and on public land seemed to hunt less than those hunting on other land.

Quail hunters who hunted mostly on public land hunted the least number of days and the most hours per day of any group (Fig. 16). These hunters, it seems, do not go hunting often but when they go, they make the most of it.

The number of times a hunter hunts quail appears to be related to his occupation (Fig. 17). Unemployed persons hunted quail more days per hunter than the other respondents. Semiskilled workers and agricultural workers hunted the least number of days per hunter. Even though semiskilled workers hunted the least number of times per hunter they exerted more hunting effort, as a group, than any other employment group (Fig. 18). This condition was due to the large proportion of semiskilled workers in the hunter population (Fig. 18).

Quail hunters owning 5 or more bird dogs hunted more times than the others (Fig. 19). Hunters owning no bird dogs hunted the least number of days.

Hunters hunting quail close to home (0.20 miles) hunted fewer hr per day than those hunting farther (61-80 miles) (Fig. 20). This relation did not hold well for distances beyond 80 miles. No apparent relation was noted between the distance traveled and the number of days hunted by hunters (Fig. 21).

Preference for 3 to 4 days per week open for quail hunting was indicated (Fig. 22). This preference was for nearly 0.5 day per week or 3.6 days per season more than then allowed by law. Quail hunting was permitted only on Tuesdays, Thursdays, Saturdays, Christmas Day and New Year's Day--a total of 26 days.

Locations and Ownerships of Hunting Lands

Where hunters go appears to be governed mostly by their desire to hunt near home and to have a productive hunt. Nearly 53% of the respondents drove less than 21 miles one way to where they hunted quail (Fig. 23) and 73% drove less than 41 miles. The average distance for all hunters was 34 miles.

Hunters should be expected to go to areas offering the best hunting. This was true except when the good areas were 100 or more miles from where the hunters lived. For example, Planning Regions 10 and 11 (Fig. 2) were good hunting areas (Fig. 24,25) but received only moderate hunting pressure (Fig. 26), apparently because they were more than 100 miles from Oklahoma City in Region 8, the nearest major concentration of hunters (Table 4). However, the greater distance driven by those who did hunt Regions 10 and 11 (Fig. 27) suggest that some hunters from midstate are willing to drive 150 miles or more for good hunting.

Planning Region 5, which was not a particularly good quail hunting area, received one of the highest concentrations of hunters (Fig. 26). Apparently this occurred because the region is located midway between the 2 largest concentrations of hunters in the state (2): Oklahoma City and Tulsa. Regions 6 and 8--where Tulsa and Oklahoma City are located--contained more hunter residences but received less hunting pressure than any other 2 regions (Fig. 26). The best explanation for this condition is that opportunities for hunting are very limited in these regions and access to the supply is difficult to obtain (Fig. 28).

Regions 1, 2, 3, 4, 6 and 8 probably are hunted mostly by hunters staying in their region of residence (Fig. 26). The average distance driven by people hunting these regions is approximately the distance from the center of population to the center of the hunting opportunities (Fig. 27). For example, the major quail area in Region 8 is in Lincoln County, about 32 miles (Fig. 27) from Oklahoma City.

Hunters indicated that they would drive, on the average, 24.3 miles 1-way for 5 quail per day and 51.4 miles for 10 quail per day (Fig. 29). On the other hand, they reported driving an average of 34 miles to the hunt area (Fig. 23) and an average harvest of 3.8 quail per trip (Fig. 30). This suggests that most quail hunters would not drive further for the kind of hunting they experienced in 1967.

One's income appears to affect where he hunts. The more affluent hunters drove farther than the less affluent (Fig. 31).

Sixty-nine % of the hunters indicated that they hunted on private lands not leased or owned by them (Fig. 32). This finding held true for hunters of all income levels (Fig. 33). Hunters earning < $7,000 per year hunted on their own lands and on hunting leases much more than expected. No reason for this finding was noted. Persons earning $7,000 to $15,000 annually hunted on public lands more than did persons earning more or less. Those earning less appear to be less able to travel to the public lands (Fig. 31) and less likely to be informed about these lands. Persons earning > $15,000 annually seem more likely to seek private hunting lands. Thus persons earning $15,000 to $25,000 hunted on leases more than any other group (Fig. 33). Also, hunters earning > $25,000 (sample=9) hunted their own lands much more than did other groups.

A large percentage of hunters in all income groups hunted on lands that they owned. It is suspected that some of this land was not owned by the hunter but by near relatives such as parents.

Leasing of lands for hunting appeared uncommon. Less than 3% of the hunters reported hunting on leases (Fig. 32). Some of those who hunted leases were guests and not lease holders.

Where quail hunters hunted was related to their employment. For example, hunters from all employment groups except agriculture hunted private lands, not owned or leased, more than any other type (Fig. 34). Agricultural workers hunted mostly on their own lands.

Agricultural workers hunted public lands more than any other group. Frequent use of these lands by nearby farmers may account for this condition. Persons from all employment groups were represented by people hunting on hunting leases (Fig. 34). Probably some of the unskilled and nonworking persons hunting on leases were visitors and not lease holders.

Where quail hunting occurred seemed to be related to ease of obtaining access. People hunting in Planning Regions 1, 6, 8, and 9 had the most difficulty (Fig. 28) gaining access. Two of these regions (6 and 8) are small and had large numbers of hunters (Fig. 26). Under such conditions landowners are subjected to more harassment from hunters than in areas with fewer hunters, and the landowners react by increasing posting. Why hunter access in Regions 1 and 9 was restricted is not clear.

Hunter access in Region 7 was the best of any region (Fig. 28). Also, quail hunting there was good for many hunters (Fig. 24,25, and 26). This situation is confusing because Region 7 does not have abundant quail range and has very limited public hunting lands.

The presence of large public hunting areas affording good quail hunting should ease the access problem. Such areas exist in Regions 1, 2, 3, 4, 6, 10 and 11. Public hunting areas in other regions are either small or not especially good for quail. The effect of these areas on access appeared to be small, probably because they accomodate such a small part of the hunters. About 42% of the hunters from all regions experienced difficulty obtaining access. This figure does not represent "would-be hunters" who did not go hunting due to a lack of suitable access.

Persons hunting quail out of state at least once during the 1967 season made up 7.5% of those sampled. More than 70% of those hunting quail out of state hunted in a state contiguous with Oklahoma (Fig. 35). Kansas and Texas were the most popular by far.

Hunters were not asked why they hunted out of state. However, the frequency of such hunting was not high, and apparently much out-of-state hunting was done by people who live close to the states where they hunted. For example, hunters hunting out of state averaged spending only 11¢ per day more for gasoline than hunters who did not hunt out of state (Table 5). If the hunters hunting out of state had done so frequently and traveled far, the difference in gasoline expenditures would have been greater.

Where quail hunting occurred probably was not related to crowding of hunters - at least not on private lands. Fifty-three % of the responding hunters indicated that they encountered other hunters on private land 1 or more times during the 1967 season (Fig. 36). Those who had such encounters did so an average of 3.4 times. This may indicate that the more productive or accessible private lands attract a majority of the quail hunters.

The highest rate of encounters occurred in Region 3 where 65% of the quail hunters had encounters. The most likely explanation for this is that large numbers of deer hunters were afield in this region during quail season. The rate of encounters in Region 5 was high also, probably for the same reason.

Time of Hunting

The quail season for 1967 permitted shooting on 26 days. Eight (31%) of the days for hunting were Saturdays (Fig. 37). All other hunting days were on Tuesdays and Thursdays except Christmas and New Year's Day which were on Mondays. Only on December 25 and 26 was it possible to hunt on consecutive days.

Thirty-seven % of the quail hunting occurred on Saturdays, making this the leading day of the week (Fig. 37). Saturday hunting was pronounced in the case of those hunting on public lands and somewhat favored by hunters on private lands not owned or leased (Fig. 37). Persons hunting on leases showed a slight preference for week-day hunting.

The hunters averaged hunting quail about 1 day per year while on vacation (Table 6). Those earning the most vacation time hunted more days, but a lesser proportion of their vacation time than did persons with shorter vacations.

White-collar workers, agricultural workers and nonworkers hunted on week days more than other groups did (Fig. 17). On the other hand, semiskilled workers hunted on weekends (i.e. Saturdays) more than did any other group. This situation is related to the nature of employment of the groups. The semiskilled workers are tied to a Monday-through-Friday work schedule more than the other groups. Thus they are less able to hunt on week days. White-collared workers are also tied to a Monday-through-Friday work schedule, but by nature of being more at the executive level, are more free to be off the job on days they choose.

Skilled workers, nonworkers and professional people hunted more on vacation than did the other groups (Fig. 17). Agricultural workers did little vacation hunting. Most farmers are not accustomed to thinking of a day off for hunting as a day of vacation in the sense a factory worker would. Furthermore, farmers often work during mid day and hunt in the early morning or late evening. Vacation hunting by nonworkers probably relates to students hunting on Thanksgiving or Christmas holidays.

Older hunters hunted more on week days and less on weekends and vacations than young hunters did (Fig. 38). This finding suggests a desire to hunt week days and avoid the Saturday crowd. Older persons, by nature of tenure on the job, are more able than young people to get off from work on week days.

Persons hunting near home hunted more on week days than did persons hunting far from home (Fig. 39). Hunters possibly did not like to drive far for a 1-day hunt knowing that they would get home late and have to get up early for work the following day. Saturday hunters did not face this problem. The number of days of hunting quail on Saturdays and vacations apparently was not related to the distances driven to the hunting area.

Hunters apparently liked the season to which they were accustomed. Tuesday-Thursday-Saturday quail hunting had been the law in Oklahoma for many years and hunters have become accustomed to it. In response to the question on hunting days preferred, 7 of 10 hunters wanted quail hunting on Tuesdays and Thursdays whereas 9 of 10 wanted Saturday hunting (Fig. 40). Three of 10 wanted to hunt quail on the other week days and 4 of 10 wanted to hunt on Sundays.

Hunters were asked which starting and ending dates they preferred. The most popular starting date was 20 November which is the date set by statute many years ago (Fig. 41). There was considerable interest in opening the season during the first week of November.

The period of January 11 to 15 was the most popular ending date (Fig. 41). Considerable interest was also shown for ending the season in the first week of January. The closing date set by statute is January 15.

Hunting Success

Success of hunters in bagging quail varied greatly according to the region hunted. Persons hunting in Region 8 (Fig. 2) averaged 2.4 birds per day while Region 11 hunters averaged 4.6 birds (Fig. 24). The average for the entire state was 3.6 birds per day or 17.4 per season.

With the exception of Region 8, quail hunters throughout the state were successful on 72% or more of their hunting trips (Fig. 25). The low success experienced in Region 8 was expected because quail range there is limited and numbers of hunters were high (Fig. 28). Western Oklahoma, particularly Regions 7, 9, 10 and 11, afforded the best hunting in 1967 (Fig. 24). Region 6 in the northeast was also good.

Quail hunting in western Oklahoma is poor during drouth years and good during years of normal rainfall. Excellent hunting occurs during most years following drouth years, provided that moisture is adequate. By this measure, the 1967 season should have been good to excellent. Rainfall for west-central Oklahoma during 1966 was 17.4 inches or 6 inches below normal (5). During 1967 rainfall was 0.5 inch below normal.

Persons hunting on leases reported a higher degree of success than did those hunting on other kinds of lands (Fig. 42). Those hunting on public lands had the lowest success. This difference in success probably relates to differences in hunter proficiency, hunter densities, and harassment of game.

Hunter success generally increased with hours per day hunted (Fig. 43). Two exceptions to this relationship involved those hunting only 1 hr per day and those hunting more than 7 hr per day. The latter exception may represent either ineffective persistent hunters or hunters who counted travel time, meal time, etc. as hunting time. The 13 hunters who averaged hunting 1 hr per day and were successful in 67% of their trips may be people such as farmers, oil field pumpers, and mail carriers whose daily routes through the country enable them to learn of covey locations.

Dogs added to quail hunting success. Hunters who reported owning dogs were successful on 75.4% of their trips (Fig. 44). This is compared to 68.5% for those not owning dogs. No doubt many hunters not owning dogs hunted with someone who did. If so, the effect of dogs on hunter success probably is more pronounced than suggested by Fig. 44.

The degree of success expected is somewhat indicated by the season and bag limit desired. Most respondents (73%) indicated a preference for a daily bag of 10 quail (Fig. 45). The legal limit in effect during 1967 and before was 10 quail per day.

Expenditures for Quail Hunting

The average expenditure per day reported by quail hunters was $9.62 (Table 5). Gasoline was by far the largest item. Since the question asked for expenses only "while hunting", such items as clothing, guns, licenses and the costs of keeping a dog throughout the year are not included. The average of $96 spent during quail season may represent less than 0.5 of the annual cost of hunting quail.

Management Implications

Information in the foregoing pages can be helpful to administrators and managers when they plan wildlife programs and make regulations. Some applications are discussed below.

This study supports the common belief that the most pressing problem for quail hunters is a place to hunt. Quail numbers and hunter access are both decreasing. Public hunting areas are more important than ever but they can furnish only 15% to 18% of the need.

The only possibility for greatly increasing quail hunting opportunities exists on private lands. The lands are not crowded and a large portion of the quail produced there are seldom if ever hunted.

It is not likely that farmers will open their lands to the city hunter unless there is a profit motive. When farmers learn that they can market hunting opportunities and when other conditions, particularly longer hunting seasons, are conducive to their doing so, almost anyone with $5 to $10 can have a good day's quail hunt near his home. The average hunter spends this much driving to western Oklahoma seeking free hunting. The need to assist farmers in marketing hunting opportunities was pointed out 42 years ago by Aldo Leopold and others (3). He noted that while paid hunting repulses some, "no game" is even more repulsive. In Oklahoma we are headed toward "no game".

Quail seasons such as existed in 1967 do not induce farmers to manage quail and market the opportunity to hunt. Forty to 60 consecutive hunting days are needed.

In view of the great demand for quail hunting opportunities, every feasible effort should be made to accommodate more hunters on public lands. Efforts to obtain hunter access to public lands now closed should be continued. Publicity to direct hunters to unused hunting opportunities on public lands should also be continued.

This report provides information about hunters that is useful for preparing plans for public hunting areas. For example, hunters wanted to hunt near home, and where this was possible they hunted more days per season. This finding demonstrates the need for developing hunting opportunities near the people. Planning Regions 3, 1, 6 and 9 in that order (Fig. 23) need more hunter access. Region 8 and 5 need more intensive management to increase hunter success.

Literature Cited

1. Craighead, M. R. 1970 Oklahoma Outdoor Recreation Demand Study Forestry Dept., Okla. State Univ. and Okla. Indust. Dev. and Parks Dept. 60 p. Mimeo.

2. Ellis, R. J. 1969. Distribution of Licensed Resident Fishermen and Hunters in Oklahoma, 1968. Admin. Plan. Rep. 9, Okla. Dept. of Wildl. Conserv. 11 p.

Table 1. Estimated numbers of hunters in Oklahoma, 1961-1971.

Year	Resident Hunters	Quail Hunters
1961	252,387	151,143
1962	296,777	178,066
1963	274,674	164,804
1964	269,062	161,437
1965	281,606	168,964
1966	306,472	183,883
1967	278,619	167,171
1968	253,895	152,337
1969	285,056	171,034
1970	302,221	181,333
1971	352,347	211,408

* Includes licensed and non-licensed hunters; numbers of licensed hunters determined from license sales figures and numbers of non-licensed hunters estimated using figures from Craighead, (1).

Table 2. Percent of quail hunters in different sized hunting parties.

Hunters Per Party	Parties	% of Parties
1	93	4.2
2	1,151	51.9
3	778	35.1
4	167	7.5
5 or more	30	1.3
	2,219	100.0

Table 3. Days per season hunted by male and female quail hunters.

Sex	Sample	Av. Days Hunted
Male	2,041	10.1
Female	51	6.6
Both	2,092	10.0

Table 4. Distribution of Resident Licensed Hunters in Oklahoma, 1968 (2).

Planning Region	% of Oklahoma Population	% of Resident Licensed Hunters
1	6.2	6.9
2	7.5	13.5
3	5.8	7.0
4	6.9	9.0
5	9.0	8.8
6	15.6	12.2
7	7.9	10.6
8	22.8	14.3
9	10.8	8.5
10	5.1	4.9
11	2.4	4.3

Table 5. Average daily expenditures of quail hunters who did and did not hunt out of state.

Item	Average Daily Expenditure	
	Hunters Not Hunting Out of State	Hunters Hunting Both In and Out of State
Gasoline	$3.69	$3.80
Food	1.85	2.22
Ammunition	1.98	1.71
Lodging	1.06	.88
Other	1.04	1.90
Total	9.62	10.51
Sample	2023	164

Table 6. Vacation days earned and vacation days used for quail hunting.

Vacation Length (Days)	Percent of Vacation Days Hunted	Average Number Vacation Days Hunted	Sample
1 - 5	12.8	.36	80
6 - 10	10.0	.72	361
11 - 15	10.0	1.06	326
16 - 20	10.1	1.51	129
21 - 25	6.3	1.14	46
More than 26	6.0	1.29	106
Total	9.0	.97	1048

OKLAHOMA QUAIL HUNTER QUESTIONNAIRE (1967-68 Season) Planning Form # 8, Okla. Dept, of Wildlife Conservation

NOTE: If you did not hunt quail in Oklahoma last year, please complete only questions 1, 2, 17, 18, 19, 22, 23, 24, 25, and 26. These answers are needed to show how quail hunters differ from other hunters.

1. Please check the seasons when you hunted quail in Okla:( )1967-68 ( )1966-67 ( )1965-66 ( ) none
2. Please indicate your age ( ), and sex ( )
3. How many days did you hunt quail during the past season?
   a. On weekdays (excluding vacation)?_________
   b. On weekends (excluding vacation)? _________
   c. On vacation? _________
4. Did you hunt quail out of state last year?_____ If so, where? _________________
5. On which lands did you hunt quail last season?
   a. Own land _____ b. Public lands _____
   c. Lands of friends or relatives ____ d. Hunting lease _____ e. Other private lands __
6. Did you experience difficulty in finding places to hunt? Yes ( ) No ( )
7. What was the usual number of hunters in your hunting party? _______
8. Please indicate the type of quail season you would like to have seen during the past fall: Season dates from _______to ________. Hunting to be legal on: (circle choices) Mon. Tues. Wed. Thurs. Fri. Sat. Sun. Bag limit of ________quail per day.
9. How many bird dogs do you own (include all ages): Pointers ____ Setters ____ Brittanys ____ others ___
10. How many miles would you drive for a one day hunt yielding 10 quail per day? ________; 5 quail per day _________
11. How many times last season did you encounter other hunters while hunting on private land? __________
12. About how much money per day did you spend last season for the following items while quail hunting? Gasoline ______ food _______ ammunition _____ lodging _______ other (specify) _______
13. On a normal quail hunting trip, how many hours per day do you hunt? ___________
14. In what counties did you hunt 2 or more times last season? ______________________
15. On what % of the days when you hunted quail last season did you bag: no quail ___% 1-5 quail ___% 5-10 quail ___%
16. How many miles did you travel on an average quail hunting trip last season from your home to where you hunted? _____________
17. Are you married? _________
18. Indicate your position in your household: head of household ____, spouse of head of household _____, child of head of household____, other________.
19. How many persons (including yourself) are members of your household: Persons over 16 years; males ____, females ______: Persons under 16 years; males _____, females ______.
20. How many members of your family hunt quail (include yourself)? _________
21. How many years have you lived in Oklahoma?_____
22. What is your primary occupation (if unemployed, indicate "none")? _______________
23. Circle the days that you normally have off each week. Sun. Mon. Tues. Wed. Thurs. Fri. Sat. None
24. How many days (working days) annual vacation do you have? _________
25. Please check the box that fits your annual income before taxes (we need this information to tailor programs you can afford) ( )less than $3,000, ( )$3,001 to $7,000, ( )$7,001 to $15,000, ( )$15,001 to $25,000, ( )over $25.000.
26. Circle animals you hunted last season: waterfowl, dove, pheasant, turkey, crow, rabbit, pr. chicken, squirrel, deer, raccoon, coyote, bobcat.

Fig. 1. Oklahoma quail hunter questionnaire.

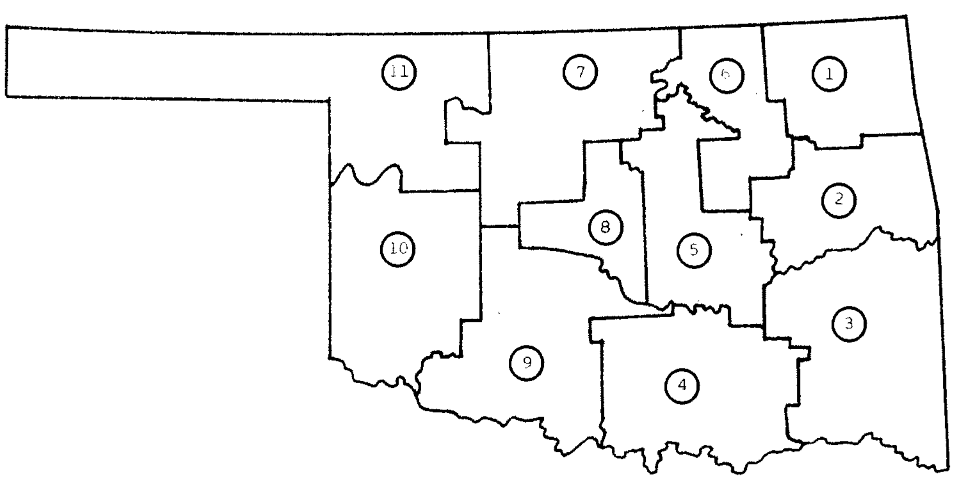

Fig. 2. Planning regions of Oklahoma.

weight in 5 of the 7 samples on burned plots. Flies were generally more numerous, but not significantly so, on unburned rather than burned plots. Leafhoppers numbered and weighed significantly more on burned plots in all samples. True bugs were more numerous and weighed more on burned plots, but the differences were significant only at peak true-bug density. Beetles were most numerous and totalled greatest weight on the burned plots in 4 of the 7 samples. All families of the Order Orthoptera (grasshoppers, etc.) were significantly more numerous and weighed significantly more on burned than on unburned plots.

Total dry weight of insects was significantly greater on burned plots in all 7 samples. Mean dry weight of insects in the 4 SN samples was 2.657 g on burned and 1.356 g on unburned. The 3 DV samples averaged 1.222 g on burned plots and 0.660 on unburned plots.

The multiple sample AOV, one for each sample type, confirmed the results of the individual sample AOV. In fact, Duncan's New Multiple Range Test disclosed significant differences both in number and in dry weight of some species of insects, on a given date, that the AOV had shown to be nonsignifcant. Significant interactions between treatment (burn) and date of sample were found and were attributed to increase or decrease in insect populations.

The factorial analyses for SN and for DV disclosed significantly more insects on burned plots than on unburned. The mean sample number for SN was 586 on burned and 311 on unburned. The mean sample number for DV was 718 on burned and 432 on unburned.

Insect Samples-PH Study

The results of the PH samples, 4 SN and 3 DV, taken during the summer of 1971, are shown in Table 7. The mean number, mean dry weight, and the AOV results are presented for the major insects by sample date. Most insects were more abundant and heavier in total dry weight on the unburned 3-YOR than on the AB plots. These differences were usually not significant. Only one type of insect, grasshoppers, had significantly more numbers and dry weight, occurring in the 3-YOR, in all 7 samples.

The 3-YOR plots contained greater total dry weight of insects in all samples, the differences being significant in 5 of the 7 samples. Grasshoppers made up 64% of the total insect weight, so they greatly influenced the total insect dry weight, in favor of the 3-YOR. The average of the 4 SN samples, total insect dry weight, was 0.630 g on the 3-YOR and 0.414 g on the AB plots. Total insect dry weight, in the 3 DV samples, averaged 0.375 g on the 3-YOR and 0.174 g on the AB plots.

Insect Density and Biomass

Total insect density and biomass for the 2 studies are presented in Tables 8 and 9. The reader should recall that sampling was conducted from the quail chick's "point-of-view", near the ground, and that large specimens of insects were disregarded. The less numerous types of insects, moths, damselflies, etc. were not included. The expanded figures, insects/acre or biomass/acre, were made on the basis of the calculated volume of a single SN or DV sample. The data for the 2 sampling methods was kept separate, and the reader must remember the great differences between the 2 types of samples.

Table 5. Comparison of mean number and mean dry weight (g) and the statistical significance for arthropods on burned and unburned plots for the 7 ROW samples, 1969.

Sample date & type	Treat-ment	Araneida No.	Araneida Wt.	Formicidae No.	Formicidae Wt.	Diptera No.	Diptera Wt.	Homoptera No.	Homoptera Wt.	Hemiptera No.	Hemiptera Wt.	Coleoptera No.	Coleoptera Wt.
6/3 DV[1]	B[2]	72	.193	67*[3]	.034	68	.035	102**	.106**	83	.152**	38	.073*
	U	71	.184	30	.016	53	.035	70	.058	63	.105	28	.050
6/17 SN	B	74	.292*	51*	.026	27	.058	210**	.370**	219**	.395*	174**	.316**
	U	64	.200	31	.017	35	.043	84	.131	105	.240	47	.154
7/1 DV	B	90	.206	105**	.041**	42	.026	198**	.243**	104**	.222**	103**	.138
	U	87	.177	42	.017	55	.044	90	.134	60	.115	62	.094
7/14 SN	B	61*	.256**	29**	.011*	12	.011	78**	.141**	74	.280	111**	.190
	U	41	.126	9	.003	26	.038	52	.092	61	.261	65	.171
7/29 SN	B	61*	.237*	28**	.010*	21	.018	115**	.177**	58	.188	84	.136
	U	43	.117	10	.004	22	.023	57	.090	42	.197	55	.101
8/11 DV	B	158	.153	165**	.052**	128**	.027	186**	.150**	58	.102	121	.107*
	U	142	.132	51	.017	78	.028	102	.097	46	.078	64	.053
8/29 SN	B	53	.198	61**	.024*	21	.013	119**	.130*	50	.189	127*	.150**
	U	40	.142	16	.006	22	.021	52	.091	50	.156	89	.102

1. DV=d-vac and SN=sweep net 2. B=burned and U=unburned 3. *=5% and **=1% level of significance

Table 6. Comparison of mean number and mean dry weight (g) and the statistical significance for families of Orthoptera and the total arthropod sample dry weight on burned and unburned plots for the 7 ROW samples, 1969.

Sample date & type	Treat-ment	Orthoptera--Family								Total dry weight of sample
		Tettigoniidae		Gryllidae		Acrididae		Tetrigidae		
		No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	
6/3 [1]	B [2]	70** [3]	.144**	6*	.022*	37**	.086**	19.0**	.076*	0.942**
DV	U	24	.040	4	.010	4	.013	0.5	.002	0.545
6/17	B	65**	.331**	9**	.053	41**	.234**	3.4**	.034*	2.196**
SN	U	38	.156	6	.030	18	.063	0.3	.003	1.089
7/1	B	43**	.157**	10**	.054*	30	.177**	4.7**	.078*	1.418**
DV	U	24	.048	5	.022	20	.068	0.3	.004	0.764
7/14	B	40**	.316**	4**	.028*	70**	.769**	3.6*	.055*	2.477**
SN	U	17	.111	1	.012	31	.240	0.2	.004	1.189
7/29	B	35**	.369**	3**	.016	63**	.984**	3.1**	.067*	2.665**
SN	U	15	.147	1	.005	27	.364	0.0	.000	1.223
8/11	B	13**	.178**	9**	.009	15**	.230**	0.1	.001	1.305**
DV	U	6	.060	2	.008	8	.126	0.0	.000	0.673
8/29	B	16	.317**	9**	.014	16**	.268**	0.6	.015	1.414**
SN	U	12	.198	3	.012	8	.162	0.1	.001	0.954

1. DV=d-vac and SN=sweep net 2. B=burned and U=unburned 3. *=5% and **=1% level of significance.

Table 7. Comparison of mean number and mean dry weight (g) and the statistical significance for arthropods on annually burned and 3-year-old "roughs" (unburned) for the 7 PH samples, 1971.

Sample date & type	Treatment	Spider No.	Spider Wt.	Ant No.	Ant Wt.	Fly No.	Fly Wt.	Orthop. No.	Orthop. Wt.	Homop. No.	Homop. Wt.	Hemip. No.	Hemip. Wt.	Coleop. No.	Coleop. Wt.	Total dry wt.
6/12 SN[1]	UB[2]	21	.103	15	.004	11	.009	40**[3]	.563	17	.021	2	.016	15	.024	.767
	B	14	.035	12	.002	6	.005	15	.287	16	.022	1	.006	18	.030	.459
7/1 DV	UB	56**	.127*	63	.013	69**	.030**	35*	.221**	32	.035	1	.004	21	.028	.478**
	B	23	.027	82	.017	27	.014	15	.076	42	.032	1	.004	16	.018	.209
7/15 SN	UB	39	.134**	20	.007	22	.021*	37**	.570**	22	.042	2	.010	30**	.078*	.862*
	B	27	.058	25	.006	14	.005	20	.209	28	.026	2	.007	16	.036	.568
8/4 DV	UB	89**	.081*	68	.010	205**	.030**	22**	.142**	35	.029	12*	.012	51	.055*	.398**
	B	36	.032	30	.005	89	.011	10	.062	33	.018	2	.011	26	.018	.180
8/18 SN	UB	35	.078	25	.005	39	.019	24**	.372**	13	.022	3	.009	22	.037	.588
	B	27	.053	24	.008	40	.023	12	.179	26	.046**	4	.011	26	.043	.480
9/2 DV	UB	37	.042	55	.010	0 a/	0	10**	.105**	31	0.31	14	.014	17*	.022*	.249**
	B	28	.026	63	.011	0	0	3	.031	50	.039	5	.005	13	.009	.133
9/23 SN	UB	26**	.038**	36	.007	45*	.022*	7**	.117*	20	.029	9	.016	18	.038	.306**
	B	13	.017	32	.005	28	.012	2	.045	22	.027	5	.010	15	.027	.152

1. SN=sweep net; DV=D-vac machine 2. UB=3-year-old "rough"; B=annual burn 3. *=5% level of significance; **=1% level of significance; a/=not counted.

Insect Density

The SN sample of 17 June, with an expanded insect density of about 64,000/acre on burned plots, was significantly greater than the other 3 SN samples and could be considered the peak of insect density. The remaining 3 SN samples showed insect density to be about 35,000/acre. This density was not significantly greater than the 31,000/acre on unburned plots at the peak density, but was significantly greater than the other densities (dates) on unburned plots.

The 3 DV samples on burned plots showed an increase in density, from 59,000/acre to 77,000/acre to about 90,000/acre, in mid-August. DNMRT determined that the last sample, in mid-August, was significantly different from the previous 2 and could be considered as a peak in insect density. Apparently, 2 peaks in insect density occurred on the ROW plots.

In the PH study (Table 9), a comparison of total insect numbers on the 3-YOR and the AB plots was not tested for significance. There seems to be little difference, however, except on 4 August. On the 3-YOR plots, the DV total density varied from about 33,000/acre in early July to a peak of 58,500/acre in early August. It appears that the August total density would be significantly different from the much lower 33,000 in July or the 21,500 in September. There does not appear to be much difference in the SN densities, from 13,300 in 12 June to a high of 19,500 in mid-July. The highest density was recorded just previous to the peak DV density, suggesting that a single peak in insect density occurred in late July and early August.

Insect Biomass

The burned plots (ROW) always held significantly more dry weight of insects than the unburned, so the expanded figures would also be significantly different. The total insect biomass figures were not tested for differences by dates, but with the SN method the differences, 104 g/acre to 195 g/acre, do not appear to be too great. The lower figure in late August was due to most grasshoppers being larger than 0.035 g, and therefore discarded from the sample. The DV method showed an increase from 99 g/acre in early June to 149 g/acre in early July. The mid-August sample is about the same as the early July total.

Total dry weights of PH samples were significantly different, favoring the 3-YOR in 5 of the 7 samples. The expanded figures on total insect biomass were also significantly different. The SN totals on the 3-YOR plots were much alike for the first 3 samples: 82, 92, 63 g/acre, but decreased in late September to only 33 g/acre. The DV method indicated the same trend, about the same biomass in July and August, 56 and 47 g/acre respectively, and then a drop to 29 g/acre in early September. If there was a peak in insect biomass, it occurred in the period of early to mid-July.

Differences in total insect density or biomass on ROW plots versus PH plots were not tested for significance, but the differences appear to be great. The ROW plots produced many more insects. The PH area was particularly devoid of true bugs and had far fewer beetles. These notations were reflected in the number eaten by quail chicks on the respective study areas.

Table 8. Insect density and biomass on ROW burned and unburned plots, 1969.

Sample		Density (No./acre)		Biomass (g/acre)[2]	
Date	Type[1]	Unburned	Burned	Unburned	Burned
Jun 3	DV	36,555	59,034	57	99[3]
Jun 17	SN	31,405	63,982	80	161
Jul 1	DV	46,850	76,681	80	149
Jul 14	SN	22,255	35,360	87	181
Jul 29	SN	19,912	34,553	90	195
Aug 11	DV	52,416	89,706	70	137
Aug 25	SN	21,450	34,627	70	104

1 DV=D-vac machine SN=Sweep net
2 Excluding all individuals over 0.035 g and less numerous types of insects
3 All significantly different at 1% level

Table 9. Insect density and biomass on AB and on 3-YOR plots in the longleaf pine forest (PH).

Sample		Density (No./acre)		Biomass (g/acre)[2]	
Date	Type[1]	3-YOR	AB	3-YOR	AB
Jun 12	SN	13,332	9,387	82	49
Jul 1	DV	33,412	24,706	56**	24
Jul 15	SN	19,520	15,468	92*	60
Aug 4	DV	58,472	28,472	47**	21
Aug 18	SN	18,452	17,920	63	51
Sep 2	DV	21,412	19,884	29**	16
Sep 23	SN	17,812	12,692	33**	16

1 DV=D-vac machine SN=Sweep net
2 Excluding all individuals over 0.035 g dry weight, and less numerous insects
**Significantly different 1% level, * 5% level

Discussion

The results of the study illustrate the great importance of insects in the diet of young quail chicks. The highest rate of chick mortality has been reported to be in the first 2 weeks of life (4), the same period when insects are the most important food items. The survival of chicks might be decreased by a decrease in the quantity of insects in June or July, at which time they are vital (3,6). A greatly lowered insect biomass, due to the use of herbicides in agricultural crops, was thought to be the most important cause of grey partridge (Perdix perdix) chick mortality in England (15).

Quail chicks need an abundance of tiny insects and the insects must be available. The study on the ROW showed significantly more insects and significantly more insect biomass on the burned plots than on the unburned areas. The herbivorous types of insects: beetles, true bugs, leafhoppers, and grasshoppers, were particularly more abundant on the burned plots. These same types of insects were the most important chick foods. The increase in insect density on the burned plots was attributed to the lush, succulent vegetative growth that followed the burn. The abundance of foliage insects is dependent upon the amount of green foliage (7) and the nutritional level and palatability of the plant material (10). The increased palatability and nutritional value of plants on recently burned areas has been documented previously (9).

Not only were there more insects on the burned areas, but the insects were more available (21). The question of availability of insects as chick food items is complex, involving insect density, size, type, and vegetative conditions. Quail chicks must be able to move about freely in search of insects. A dense "jungle-like" plant community or a deep layer of accumulated litter renders an area unfit as brood habitat. The chances of a chick becoming entangled, exhausted, lost, preyed-upon, or wet-chilled, are increased by having a dense layer of dead or living plants at the chick's level (2,17). Fire will remove most of the accumulated litter and thus open an area so that quail chicks can use it as brood habitat. In an area with good soil fertility, such as the ROW, annual burning is a must to increase the availability of insects.

At first glance, the results of the PH study appear to contradict the beneficial aspects of fire as a brood habitat management tool. The 3-YOR plots had more insects than did AB plots, but the only significant difference was in the number of grasshoppers. Grasshoppers were not an important chick food, although other studies have found them to be important (5). Grasshoppers were not eaten in proportion to their abundance, or particularly in proportion to their great amount of biomass, which was 64% of the total insect biomass. Grasshopper density was probably lower on the AB plots because litter was lacking. On the Minnesota Prairie, grasshopper density is highest where there is a light-to-medium amount of litter (23). If the litter increases or decreases from optimum, due to fire or grazing or to no fire, grasshopper density decreases. The exact relationship between grasshopper density and litter is not known, but cover, shade, soil temperatures, and oviposition sites must be considered.

Three years of accumulation of litter is too much in the longleaf pine habitat; a 1-to-2-year interval between burning has been recommended (20). This recommendation seems well founded for improving brood habitat. A 1-year-old-"rough" will provide adequate litter so that grasshopper density will increase.

The ROW plots produced much more insect density and biomass than the PH plots. Undoubtedly the difference is due to the rather infertile soils of the longleaf pine habitat and to past history. The "piney woods" were grazed by sheep and cattle for many years, and these herbivores account for a plant community dominated by broomsedge and wiregrass (19) and the lack of a rich flora. Native legumes and palatable grasses have been practically eliminated. Ill-timed fires also contributed to the lack of a more varied flora. Insect density and biomass seems adequate on the ROW plots, but PH habitat has a low carrying capacity as brood habitat.

Another feature of brood habitat carrying capacity is the amount and availability of seeds. The youngest chicks used in my studies ate seeds. A 4-day-old chick ate 165 panic grass seeds. A 6-day-old consumed 240 panic grass, 70 Carex spp., and 17 miscellaneous species of seeds in 1 afternoon. The importance of seeds, especially early maturing panic grass species, was reported earlier (5). Fire is routinely used to increase commercial seed production, so this would further add to the advantages of using fire in brood habitat management.

Insect abundance and availability are the prime factors to consider in trying to determine the carrying capacity of an area as brood habitat. Currently, not enough is known about wild quail chick needs, their daily insect consumption, or about availability of insects (16). Insect abundance is influenced by many factors (14), the type of plant community being prominent. Legumes were thought to attract or produce more insects than nonlegumes (17). The attractiveness of certain crops, soybeans, peas, and other developing fields of legumes, for young quail has been noted (13,17). A study in Georgia (1), found that mixed-forb fields, early seral stages of plant succession in the southeast, produced many more insects than did later stages, such as broomsedge fields. From the aspect of insect abundance, brood habitat should favor legumes and mixed forbs. Fire, used properly, will produce a variety of luxuriant vegetation and favors legumes (9,17). When using fire the manager should finish all burning before insect emergence and hatching of the overwintering eggs takes place. Woody-brushy areas, which serve as brood-holding areas, should be saved from burning. Burning in strips or patches is recommended, to leave preferred nest habitat adjacent to brood habitat. The interval of burning will depend on local conditions, but the factors of insect abundance and availability should be considered equally. To have many insects under poor feeding conditions, dense vegetation, or accumulated litter, is worse than having fewer insects under ideal "catching" conditions.

Another way of increasing insect abundance and availability is by planting an agricultural crop or wildlife food plant species; properly fertilized, it will generally produce a lush, green vegetative growth.

So-called "clean" farming is not desired; weedy fields are the goal. A low-growing species is preferred so that insects are concentrated in the chicks feeding zone; 0-8 inches above the ground. Although not completely tested, kobe lespedeza appears to be an excellent species for high insect production, but its density must be controlled by light discing.

During the patch-farm era in the South, quail densities were high. The many small, scattered, cultivated fields and the continued use of fire in the woods combined to produce ideal quail habitat (18). Brood habitat was certainly abundant. High quail densities, 1 or 2 birds to the acre, are found on areas in the South today and these areas use fire and food (brood) plots. While speaking of the needs of wild turkey poults, the Dean of Quail Management, Herbert L. Stoddard, said that "preferred insect catching grounds" should be created (22). These insect or "bugging" habitats can be created by fire or cultivation, or a combination of the two.

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THE RESPONSE OF BOBWHITE COVEYS TO DISTURBANCE DURING FIELD TRIALS

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The characteristically sedentary nature of bobwhites is well documented by intensive research and is generally well known to hunters and others acquainted with the life habits of this species of game bird. Early studies (1,7) indicated that quail often spend their lives traveling less than 0.5 mile between the widest points of their range. Other workers have shown that while the majority of individual bobwhites in a population have similarly restricted ranges, the mean size of home range expressed as cruising radius may be up to 0.5 mile or more (3,5,6). In some cases, where environmental stress is great or where seasonal changes markedly alter the condition of habitat, bobwhites may move distances of several miles (2). In Missouri, the greatest amount of movement occurs in spring, when the population undergoes changes relative to its breeding status, and a lesser amount in the autumn (4). The situation is the opposite in Florida, where greatest mobility is observed in summer and fall, and least mobility in spring (5).

The studies cited above, while illustrating regional differences in specific movement patterns, emphasize the commonly accepted contention that covey ranges of quail are small and that over short periods of time quail may be expected to move within a cruising radius of 0.25 to 0.5 mile. In addition, these studies illustrate that a potentiality for marked shifts in range occurs in some populations of quail.

This study reports on the impact of a major field trial on some aspects of density, distribution, and behavior of a bobwhite population on a field trial area. Relationships between quail density, daily disturbance, and bird dog performance are discussed. We are grateful to William Brown, Editor, The American Field Magazine, for providing detailed accounts of the field trial competition and to John Rennie, The University of Tennessee, for aid in statistical analysis of the data. This study was supported by funds from McIntire-Stennis Project MS-3.

Study Area

The study was conducted on Ames Plantation, an 18,600-acre tract in Hardeman and Fayette counties, Tennessee. The plantation is located in the Eastern Gulf Coastal Plain physiographic region, and is generally representative of the western 0.3 of Tennessee. Major crops grown on the plantation include soybeans (Glycine max), corn (Zea mays), and cotton (Gossypium hirsutum). Beef cattle and forestry are other major enterprises.

A 2,100-acre area was used for intensive study of the quail population (Fig. 1). Land use on the area is divided between forest land (31%), idle land (28%), cultivated land (23%), and pasture (15%). A subunit of about 214 acres within this area was selected for studying the behavior of quail during winter with the aid of radiotelemetry. This unit contained proportionately more cultivated land and less of other types of land use than the remainder of the area.

Of particular significance to this study is the annual running of the National Championship Field Trial for pointing bird dogs. This event is conducted over 2 separate courses, each approximately 12 miles long, during the last 2 weeks in February. During the running of the trial, a brace of dogs is started on the Morning Field Trial Course at about 0830 and another brace is run on the Afternoon Course at 1330 each day of the event except Sunday, weather permitting. The courses are marked prior to the first day's running, and each dog is required to follow the same course. Thus, the courses are run the same time each day over the same route. In addition to the dogs, handlers, and judges, a gallery ranging from about 60 to 600 mounted spectators follows a route coinciding with or closely paralleling the field trial courses.

A significant feature of the Morning Field Trial Course is its frequent looping and doubling, permitting a thorough searching of large blocks of habitat by the dogs. This feature facilitated management of this area, as management efforts could be concentrated in areas that would be traversed 2 or more times during each heat.

Methods

Density and distribution of quail on the study area were determined by direct censuses conducted twice annually during the periods of December 1966 and March 1972. These censuses employed 5 to 7 men walking 20 to 30 yards apart to flush coveys. The counts were believed to be a consistent but low estimate of the density and spatial distribution of the population. Statistical limits of confidence could not be established, however, because of the impracticality of obtaining replicate counts for any season. Each census required 4 to 6 days, and neither time nor manpower was available for replication.

Home ranges of coveys and other aspects of quail behavior were studied with the aid of radio telemetry (8). Transmitters weighing about 14 g were placed on the backs of quail, and signals were monitored with the aid of a portable receiver. Signal strength varied greatly, occasionally being detectable at distances of 0.5 mile or more, but usually at ranges of 50 to 100 yards.

The performance of bird dogs in locating coveys during the field trials was determined from examining the accounts of the running of these trials published in The American Field Magazine. These accounts recorded the number of coveys pointed per heat, and the total time on the course logged by each dog. Data from heats for which neither dog finished the course were excluded from the analyses.

Results

Quail Populations

The quail population was studied with respect to its density on the study area and its distribution along the field trial course.

Density

The mean number of coveys on the 2,100-acre study area was 94 in December and 80 in March during the period 1966-1972 (Table 1). The autumn-to-spring decline in covey count during this period ranged from about 10 to 20%, averaging 15.4% for the 6 years. This seasonal decline in numbers of coveys on the study area was accompanied by comparable changes in numbers of individual quail (Table 1), and generally indicates that a relatively stable population of quail occurred on the study area. The decline in numbers corresponded roughly to the estimated hunting mortality on the area, most of which occurred after the December census. We observed extremely little egress of quail from the study area that could be attributed to the activities associated with the field trial.

Distribution

The distribution of coveys with respect to that portion of the study area traversed by the field trial (42.5%) appeared to be similarly unaltered. In 1971-72, for example, 49 of 111 coveys located during December were on that portion of the study area encompassing the field trial grounds (Fig. 2). During March, 1972, less than 2 weeks following the trial, about 48 of 95 coveys were on that same portion. This pattern of distribution occurred during all other years of the study period (Table 2). That part of the study area used by the field trial is intensively managed for quail, and is more attractive to quail during late winter. Consequently, it appears that the general distribution of coveys on the study area is determined by the availability of good habitat, and is relatively unaffected by the potentially disruptive activities of the field trial.

Covey Ranges

The home ranges of 5 coveys of quail during the winter period of 1970 were defined through the use of radio-telemetry equipment. These coveys were monitored for periods ranging from 26 to 79 days during January through March, 1970. Home range sizes varied from 10.0 acres to 28.9 acres, averaging 16.7 acres for the 5 coveys studied.

The effect that the field trial could exert on a covey's use of its established range was observed during the 1970 field trial. The range of 1 covey lay in the path of the field trial, and the effect of this disturbance on the covey's range utilization is illustrated in Fig. 3. At approximately 1700 on the first day of the trial, large numbers of horsemen entered the covey's range, many of them riding at full gallop. The covey, situated in a small cover strip, became extremely active, ran erratically through its range, and travelled about 450 yards in little more than 10 minutes. During all of this activity, the covey remained on the ground and it eventually took refuge in dense honeysuckle. During the next morning the covey was located directly in the path of the advancing gallery. The covey divided permanently, with 1 portion of the covey abandoning the covey range and joining another covey that ranged off the field trial course. The residual segment of the covey remained within its original home range for another day, then moved off its established range and joined another covey southwest of the field trial course. This covey's original range was located near the starting point and ending point of the morning and afternoon courses, respectively. Thus, in addition to the disturbance caused by the gallery passing through their range, the quail were subjected to additional disruptions such as the loading of horses and gear, and heavy automobile traffic. The covey's response to disturbance of this magnitude was dramatic.

Table 1. Numbers of coveys and numbers of quail on the Ames Plantation study area during December, 1966 to March, 1972.

Period	Number of coveys			Number of quail		
	December	March	Percent decline	December	March	Percent decline
1966-67	90	76	15.6	1184	925	21.1
1967-68	101	81	19.8	1478	1073	27.4
1968-69	100	82	18.0	1394	1033	25.9
1969-70	73	66	9.6	1007	832	17.4
1970-71	89	77	13.5	1179	964	18.2
1971-72	111	95	14.4	1334	1269	4.9
Mean	94	80	15.4	1263	1016	19.5
Acres/covey	22.3	26.4	-	-	-	-
Acres/bird	-	-	-	1.7	2.1	-

Table 2. Number and proportion of coveys on the study area which were located on the field trial course.

Period	December		March	
	No. of coveys on field trial course	% of total coveys	No. of coveys on field trial course	% of total coveys
1966-67	49	54.4	40	52.6
1967-68	51	50.5	37	45.7
1968-69	54	50.0	39	47.6
1969-70	37	50.7	32	48.5
1970-71	47	52.8	45	58.4
1971-72	49	44.1	48	50.5

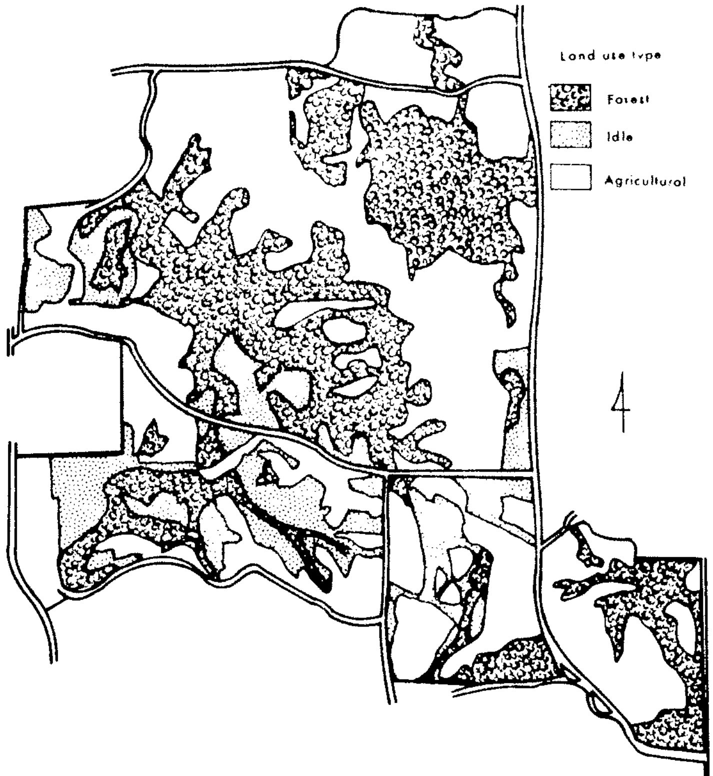

Fig. 1. The study area, a 2100 acre tract on Ames Plantation, Fayette and Hardeman counties, Tennessee.

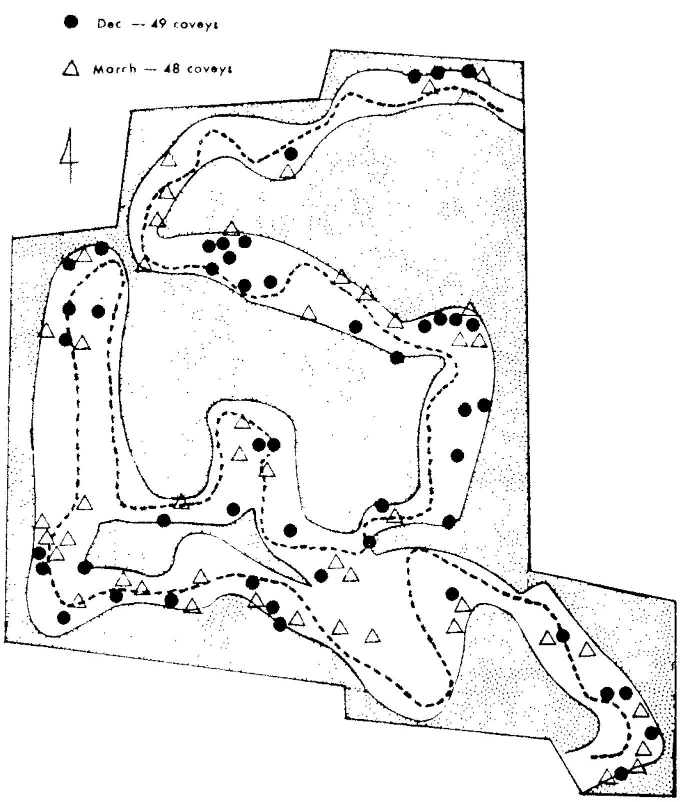

Fig. 2. Location of coveys on the morning field trial course during December, 1971 and March 1972.

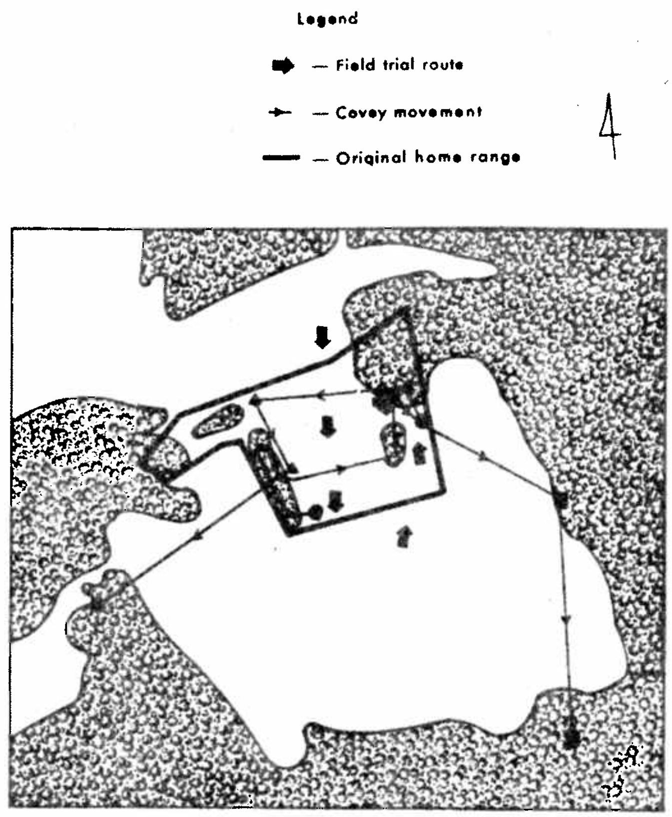

Fig. 3. Home range boundaries and movements of a covey disturbed by field trial activities Feb. 15–17, 1970.

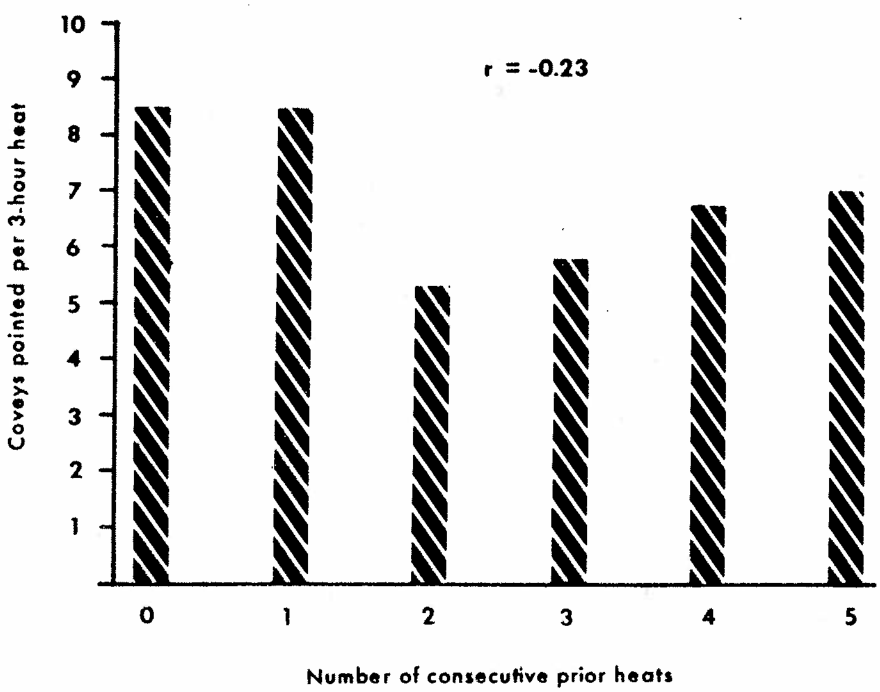

Fig. 4. Number of coveys pointed per 3-hour heat on the morning field trial course, 1967–72.

Performance of Bird Dogs

The performance of the competing dogs in locating coveys was considered a subjective index of the impact which the field trial exerted upon the availability of coveys. Over the 6 field trials studied, dogs averaged pointing 1.3 coveys per hour. The number of covey points per dog-hour varied only slightly between years; analysis of variance indicated that these minor differences were not statistically significant. It is likely that variations in quail density between years were not great enough to exert significant influence on the dogs' ability to locate coveys.

We used linear regression to measure the relationship between the number of coveys pointed during a 3-hour heat and the number of consecutive heats run prior to that heat. We assumed that if repeated disturbance of the area by the large gallery initiated egress of quail from the field trial course, we would detect a trend toward fewer covey points as the field trial progressed. We did not observe such a trend over the 6 trials. The greatest number of points occurred on days preceded by zero and 1 day of prior running, but no consistent trend was obvious (Fig. 4). The correlation was low (-0.23), and was not significant.

Conclusions

We draw 2 major conclusions from our study of field trial activities and quail behavior. First, we conclude that the rather traumatic experience of having their home range invaded by large numbers of mounted riders is sufficient disturbance to cause some coveys to demonstrate marked shifts in the location of their activity centers and home ranges. Telemetry data on 1 covey indicated clearly that coveys may disintegrate and abandon a well-established home range when these circumstances become prevalent.

Second, a point we believe to be more significant, the dramatic adjustment of home range was not universal among coveys on the study area. Covey distribution and density remained relatively unaltered, and the dogs' ability to locate and point coveys did not diminish as the trials progressed. Thus, it appears that minor, and occasionally major, shifts in covey ranges may be compensated for by 3 factors: (A) the moderately high density of quail maintained on the field trial course by good habitat management; (B) day-to-day variations in the specific areas searched by the dogs, and (C) the layout of the field trial course which enhanced the "interception" of displaced coveys.

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HABITAT UTILIZATION BY BOBWHITE QUAIL DURING WINTER

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Abstract:

This study was conducted on a 214-acre area of the Ames Plantation, Fayette County, Tennessee. Information on habitat utilization by bobwhite quail (Colinus virginianus) during winter was obtained by telemetering quail during January - March, 1970. The ranges of five coveys averaged 16.7 acres. Coveys spent little time in cultivated fields although this type of cover constituted much of the home ranges of 4 coveys. Cedar woods, hardwood forests, and old fields were used in proportion to their abundance for diurnal protective cover by the quail population, but presence of honeysuckle (Lonicera japonica) or other dense understory cover generally increased the attractiveness of a wooded area for quail. Honeysuckle was also the preferred ground cover for roosts.

The characteristic habitat or vegetative type most important to the bobwhite during winter varies widely among portions of its range in North America. The specific vegetative types quail utilize most frequently in a particular region reflect both their immediate needs for coping with environmental problems and the variety of vegetative types available to them. Typically, certain features of habitat exert significant influence on diurnal patterns of quail movement during winter. This is evidenced by the bobwhite's tendency to spend disproportionate amounts of its time in certain areas. Bobwhites in south-central Kansas, an area characterized by open herbaceous cover, show a strong inclination to establish "headquarters" in patches of brushy or woody cover when available (9). In Wisconsin, hedgerow of specified dimensions is the significant feature determining the quality of winter habitat for quail (5), and in

Missouri fencerow cover is important to the carrying capacity of farmland (8). In southern Illinois, however, bobwhite population densities show no significant correlation to total amounts of edge (including fencerows), but the number of coveys in fall is strongly correlated with the amount of specified types of edge, e.g., edge between cultivated fields and brushy pastures (4).

We made the present study to identify cover types or habitat features that are most important to bobwhites in west Tennessee. We analyzed the extent to which quail utilize various cover types and habitat features during winter, and we described characteristics of covey ranges and reactions of quail to habitat alterations within covey ranges.

The Study Area

The study area is located on the Ames Plantation, an 18,600-acre tract in Fayette and Hardeman Counties, Tennessee. Quail behavior was studied intensively on a 214-acre plot within a 2,100-acre unit intensively managed for bobwhites.

Soil materials in the plot consist of a 3-ft layer of loess overlying coastal plains material composed mostly of sand. Loring and Calloway soil series characterize the area (11). Drainage ranges from moderately good to restricted; topography is smooth. Elevation is about 600 ft (3). Several intermittent streams cut deeply into the underlying sand and meander away from the study area.

The climate is humid and temperate. A long growing season, averaging 209 days, and high annual rainfall, averaging 51.6 inches, favor such vegetational growth. Mean seasonal temperatures range from 42 F in winter to 78 F in summer.

Varied habitats exist on the study area. A red cedar (Juniperus virginiana) grove with an understory of broomsedge (Andropogon virginicus) occupies 33 acres in the southern portion of the area. North of these cedars lies a series of soybean (Glycine max) and cotton (Gossypium hirsutum) fields ranging in size from 1.2 to 40 acres. Idle ground and brushy cover patches encircle each field. Two strips of hardwoods run north and south through the 100-acre central portion of the study area. One strip halves the area while the other edges the western border.

The northern portion of the study area consists of 41 acres of idle land interspersed with hardwood stands consisting mostly of sapling and pole-sized oaks (Quercus spp.), sweetgum (Liquidambar styraciflua), and hickories (Carya spp.). Hardwood understories range from open to dense. Honeysuckle (Lonicera japonica) and blackberry (Rubus sp.) characterize dense understories.

In addition to agricultural usage, the study area is managed for quail by prescribed burning and maintaining cover strips. Twice annually, during December and March, the quail population is censused. The December census, immediately prior to this study, revealed a density of 1 quail per 2 acres. The March census, at the termination of the study, indicated the population had declined to 1 quail per 2.4 acres.

Methods and Materials

Quail were live-trapped on the study area to obtain birds for marking. Eight funnel traps, made of 0.5 inch nylon mesh sewn to steel-rod frames were used to capture quail. Traps were placed at the edges of merging cover types in areas frequented by quail. Traps were set early each morning and examined late in the morning and evening. Trapping continued for a maximum of 3 weeks at each site. Quail were aged, sexed, and banded; some were fitted with transmitters as described below.

The heaviest bird captured from each covey was harnessed with a transmitter. A second quail was retained, providing a second chance to telemeter a covey should the first transmitter fail to perform satisfactorily.

The telemetry system consisted of a battery-operated receiver, a directional, hand-held antenna, and 9 transmitters, each equipped with a 10-inch whip antenna. Transmitters emitted a continuous signal on frequencies ranging from 150.830 Mc. to 151.070 Mc. RM-625 Mallory batteries equipped with soldering tabs powered the transmitters. Weight of an assembled unit was 14 g. Brander and Cochran (2) concluded that transmitters on birds should constitute no more than 4% of body weight. The transmitter assembly used in this study averaged nearly 10% of body weight, but did not noticeably impair quail flight if properly balanced over the wings. Coveys containing telemetered quail were flushed 35 times; at each flush the telemetered bird flew with the covey. The trailing antenna dragging through vegetation, however, may have posed a problem to the telemetered bird.

Coveys containing telemetered birds were located at 2-hour intervals diurnally. Transmitter signals were detected by systematically searching covey ranges with the receiver. The bird was approached to within 30 to 70 yards, as indicated by signal intensity, and then circled to obtain bearings on the position of the covey.

Results and Discussion

Eleven telemetered quail provided data on 5 covey ranges for periods ranging from 8 to 27 days (Table 1 and Fig. 1-5). The home ranges of these 5 coveys, determined by 69 to 134 radio telemetry locations, averaged 16.7 acres. Home-range size on our study area was smaller than reported elsewhere. Bartholomew (1) estimated home ranges of 4 coveys in southern Illinois to average 38 acres, ranging from 30 to 46 acres. His data, like ours, were obtained by radio telemetry during the winter, and represented comparable periods of observation. Roseberry (10) tracked 3 coveys in heavy snow for about 6 weeks and reported that their average home range included 23.7 acres. Using mean dimensions reported by Lehman (7) we computed a mean home range of about 23 acres each for 10 coveys he studied during winter in Texas.

Utilization of Cover Types

The proportion of time a covey spent in each cover type during daylight hours was measured by the proportion of occasions it was located by telemetry in each type. These data were then compared with the proportion of the covey's home range occupied by each cover type to determine whether or not cover types were used randomly (Table 2). Chi-square tests of goodness of fit for single classification frequency distribution were used for statistical determinations.

Four of the 5 coveys showed nonrandom use of cover types in their home ranges. Coveys 1, 3, and 5 occupied ranges containing large percentages of cultivated land. Use of this cover type, however, was decidedly nonrandom. While an average of 31.5% of the ranges of these 3 coveys was in cultivated land, only 4.3% of 328 telemetry locations were in this cover type. Bartholomew's (1) observations on time bobwhites spent in cornfields corroborated ours.

A cornfield in the range of Covey 3 was the only cultivated field in which quail were located frequently (Fig. 3). Cornstalks and weeds remained standing in this field providing concealment for the covey. Protective cover was absent from other cultivated fields. Despite the limited amount of time spent there, however, cultivated land is obviously important to bobwhites. All coveys studied had ranges which included portions of a cornfield or soybean field, and these 2 cultivated grains composed the most important food of quail on the study area during winter (Eubanks, personal communication).

Covey 2 deviated from a pattern of random utilization of its range although its range included little cultivated land. The majority of this deviation resulted from the covey's heavy utilization of a small, densely vegetated, marshy area. The covey's use of this marsh was 6 times greater than random use would indicate.

The use of cover types by Covey 4 was random. This covey's range included only a small portion of cultivated land and contained no unique habitat type such as the marsh described previously.

Three vegetative types constituted the majority of uncultivated lands in the covey ranges studied; cedar woods, hardwoods, and old fields. The combined use of these three vegetative types by the 5 coveys was random (X^2 = 0.7922). However, 3 of the coveys showed preferential use for 1 or more of these types (Table 2). A major factor influencing use of the 2 forest types by coveys was the character of its understory vegetation. The presence of honeysuckle or other dense understory vegetation generally increased the attractiveness of a wooded area for quail.

Activity Centers

Within covey ranges, activity centers of about 50 sq yards or less were used intensively (Fig. 1-5). Each of the 5 ranges had 2 of these centers, arbitrarily defined as places where the covey was found 10 or more times during the study. With 1 exception, each was characterized by honeysuckle understory in a forested area adjacent to a grain or weed field. Honeysuckle is a very common understory species on our study area and many such sites were available.

Examination of flush data obtained during the population census further illustrated the usefulness of honeysuckle to quail during winter. Nearly 30% of 946 covey flushes were from sites at which the vine was a significant feature. Typically, these flush locations were patches of honeysuckle near an edge between a forest and a field. These data, while not strictly comparable to data obtained by telemetry, signify that honeysuckle plays an important role in providing protection to coveys during the winter period.

Roost-Site Selection

Of 107 roosts located by radio telemetry, 63 were in honeysuckle. Brushy and herbaceous vegetation were frequently interspersed in the honeysuckle patches selected for roosts. The extent to which honeysuckle was favored for roosting varied between coveys (Table 3). Of 37 roosts selected by coveys 1 and 5, 34 were in honeysuckle. Covey 4 selected only 3 of 21 roosts in honeysuckle.

Twelve roost sites were located under low-hanging cedar boughs. Eleven roost sites each were in mixed herbaceous vegetation and in blackberry briar patches. Ten roost sites were in broomsedge. The characteristic use of honeysuckle for roosting contrasted with roosting behavior of quail in other areas. Murray (8) indicated that luxuriant growths of Korean lespedeza (*Lespedeza stipulacea*) were favored for winter roosts in Missouri farmlands. In southern Illinois, in an agricultural region roughly similar to our study area, quail characteristically selected broomsedge for roosting (1,6). However, during a lengthy period of heavy snow cover in that same region, Roseberry (10) observed a shifting of roosting and loafing sites from open to woody cover, especially to clumps of Japanese honeysuckle.

The rather striking differences in roost-site selection by quail occupying generally similar environments indicates clearly the need for information on specific cover requirements and preferences of local quail populations if they are to be managed effectively.

Response of coveys to habitat alteration

Baiting or trapping within covey ranges did not noticeably influence movements of quail. Coveys utilized bait sites in passing but did not linger near bait.

Modification of areas 0.25 acre or larger, however, precipitated some changes in range utilization. Two covey ranges encompassed a cedar woods in which some mature trees were cut out during the study period. The coveys noticeably increased their use of this part of their ranges by feeding on ground disturbed by the tree cutting and taking refuge in the cedar tops left in the area. In another instance, several horses were stabled for a brief period in a covey's range. This covey quickly developed a new center of activity in this area, feeding in the soybean straw used as bedding for the horses. In both cases, quail recognized and responded rapidly to favorable changes in their habitat.

Summary

We observed the following characteristics of cover-type selection by quail on our study area:

1. The proportionate use of major cover types by a covey reflected certain characteristic features of its range. Coveys occupying ranges composed of significant amounts of cultivated land deviated from random usage of cover types, showing disproportionately heavy use of uncultivated portions of their ranges.

2. Within the uncultivated segment of a covey's range, utilization of major cover types, summed for all coveys, was random. Individual coveys, however, were strongly influenced by special vegetative features. Honeysuckle, for example, figured prominently in selection of daytime activity centers and night roosts. It also appeared to provide important escape or protective cover, as observed during population censuses.

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Table 1. Home Ranges of Five Coveys During Winter as Determined by Radiotelemetry

Covey number	Number of tele-metered quail employed	Period over which telemetry data was obtained	Number of days during which tele-metry loca-tions were made	Number of monitored locations	Covey range size in acres
1	2	Feb. 9 - Feb. 16	8	69	13.8
2	3	Jan. 28 - Mar. 17	27	94	10.0
3	1	Feb. 17 - Mar. 17	27	125	15.9
4	4	Jan. 14 - Feb. 18	25	109	14.6
5	1	Feb. 19 - Mar. 17	25	134	28.9
Average			23	106	16.7

Table 3. Ground Cover of 107 Roost Sites Selected by Five Radio-telemetered Coveys During Winter, 1970, Ames Plantation, Tennessee

	Covey number					
	1	2	3	4	5	Total
Honeysuckle	10	16	10	3	24	63
Broomsedge	-	1	6	1	2	10
Low-hanging cedar bough	-	5	7	-	-	12
Blackberry	-	-	4	7	-	11
Mixed herbaceous vegetation	1	-	-	10	-	11
Total	11	22	27	21	26	107

Table 2. Comparative Availability and Use of Vegetation Types by Five Coveys During January-March, 1970.

Covey number	Vegetative types in covey range	Acres of vegetative type in covey range	Percent of range composed of vegetative type	Percent of telemetry location in vegetative type	Number of telemetry locations in vegetative type	Chi-square comparison of relative use of all habitat types	Chi-square comparison of relative use of cedar, hardwood, & herbaceous habitat types
1	Cedar	.6	4.6	17.4	12	120.8834*	15.1081*
	Cultivated	8.2	59.1	4.4	3		
	Hardwood	3.6	26.1	39.1	27		
	Herbaceous	1.4	10.2	39.1	27		
2	Cedar	4.6	44.6	36.2	34	60.7629*	25.4622*
	Cultivated	.5	4.6	2.1	2		
	Hardwood	2.4	23.1	38.3	36		
	Herbaceous	2.5	24.6	6.4	6		
	Marsh	.3	3.1	17.0	16		
3	Cedar	.8	2.8	8.0	10	34.9732*	9.7422*
	Cultivated	7.8	26.9	8.0	10		
	Hardwood	15.8	54.5	60.0	75		
	Herbaceous	4.6	16.8	24.0	30		
4	Cedar	1.1	7.6	3.7	4	2.5743 NS	0.6781 NS
	Cultivated	.2	1.4	.9	1		
	Hardwood	4.3	29.4	32.1	35		
	Herbaceous	9.0	62.0	63.3	69		
5	Cedar	7.7	48.1	56.0	75	23.7060*	.6781 NS
	Cultivated	2.5	15.6	.8	1		
	Hardwood	1.4	8.6	9.0	12		
	Herbaceous	4.4	27.5	34.3	46		

*Use of habitat types was not random at the 0.05 level of probability, indicating a preference by coveys for certain habitat types.

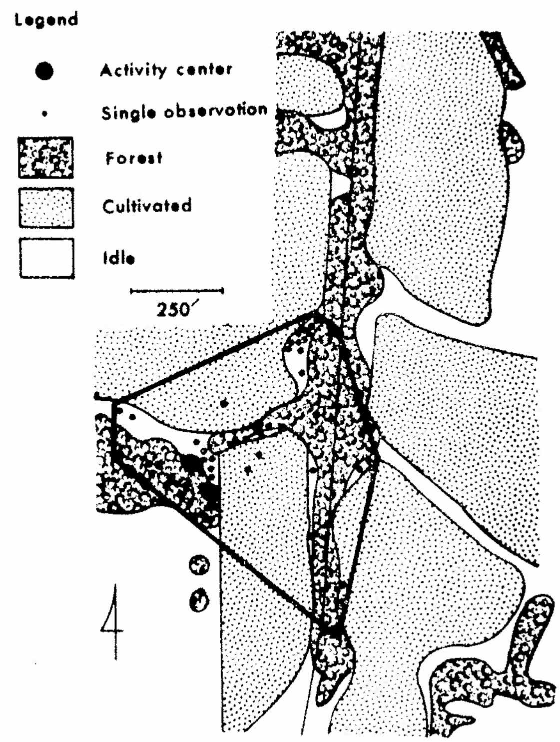

Fig. 1. Home range of covey 1, February 9–16, 69 locations.

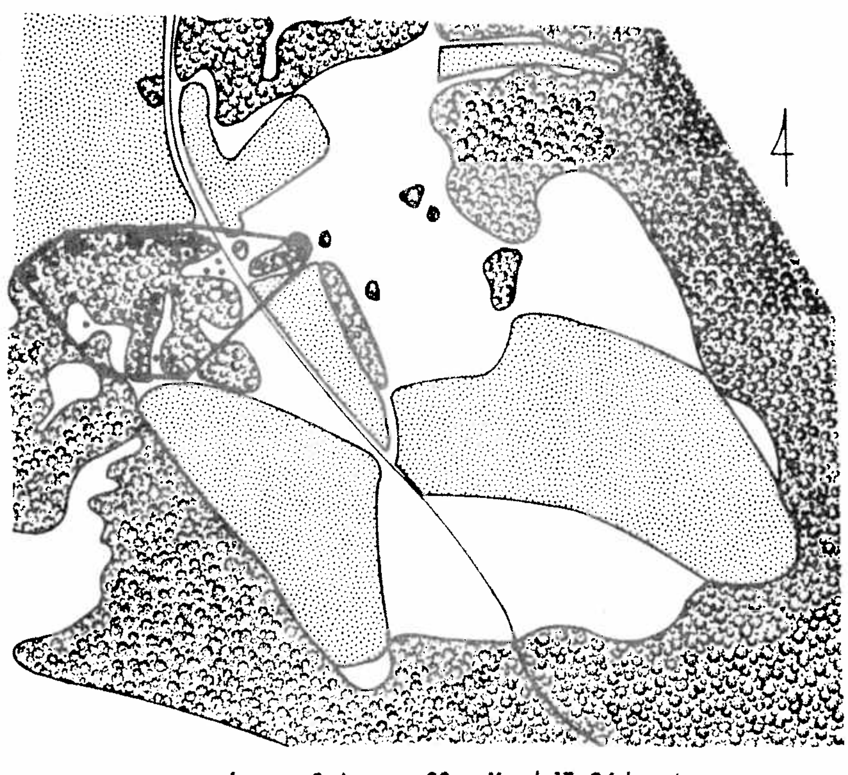

Fig. 2. Home range of covey 2, January 28 – March 17, 94 locations.

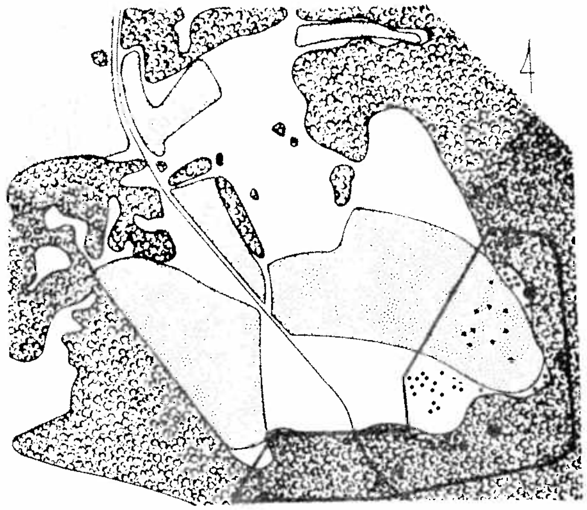

Fig. 3. Home range of covey 3, February 17 — March 17, 125 locations.

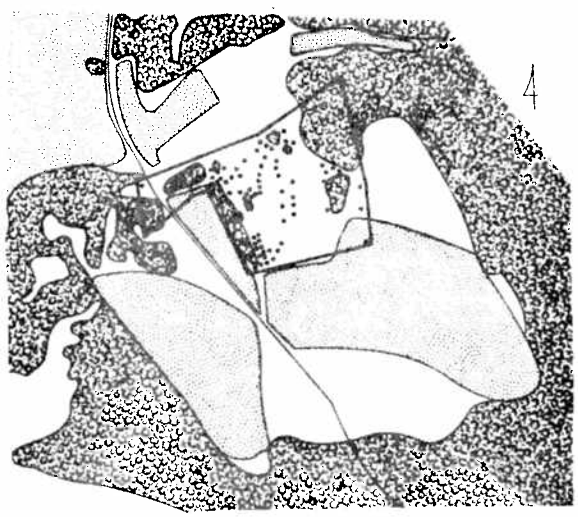

Fig. 4. Home range of covey 4. January 14 — February 18, 109 locations.

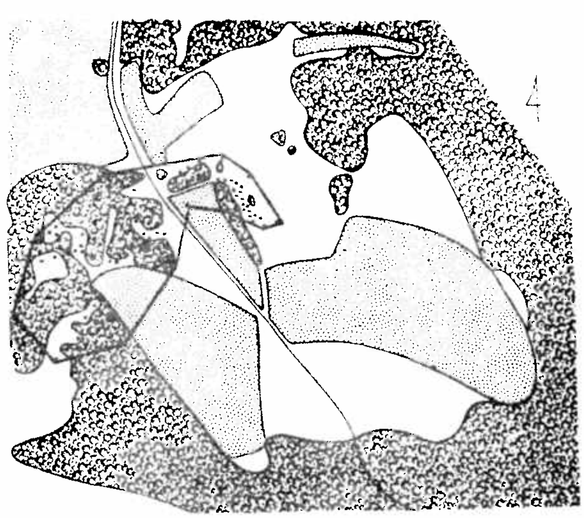

Fig. 5. Home range of covey 5, February 19 — March 17, 134 locations.

EARLY QUAIL HUNTING SEASON IN TENNESSEE: REASONS AND RESULTS

Chester A. McConnell, Tennessee Game and Fish Commission, Lawrenceburg

Abstract:

Bobwhite quail (Colinus virginianus) wings were collected and aged from 1952 through 1970. The wing age data indicated that Tennessee's quail hunting season could begin 20 days earlier than the traditional Thanksgiving Day opening, providing a larger quail harvest. A study involving a season opening date of 5 November was conducted on Laurel Hill Wildlife Management Area resulting in an 18% increase in quail kill over previous years. Only 18% of the quail bagged on Laurel Hill were <12 weeks of age, indicating that birds were sufficiently developed to provide good sport. Based on these earlier studies, the Commission opened the statewide quail season on 6 November 1971. A total of 5,270 quail wings were collected and aged during the early season. An estimated 180,000 additional quail were harvested as a result of the earlier season. Approximately 18 to 19% of the quail were <12 weeks of age. Based on data resulting from a questionnaire, approximately 80% of the quail hunters furnished information favorable to the early season. Weather conditions during the early season were unseasonably warm, but 64% of the hunters indicated that warm weather was only a minor problem. Landowners (87%) indicated that unharvested crops were only a minor problem. Hunters (80%) indicated that young quail presented only minor problems. Sportsmen responding to the questionnaire averaged 8.1 hunting trips and bagged an average of 5.0 quail per trip in November.

The purpose of this study was to test the hypothesis that a hunting season on bobwhite quail (Colinus virginianus) in early November would allow sportsmen to harvest a segment of the population that generally is lost to natural mortality.

The Tennessee quail season traditionally opened on Thanksgiving Day prior to 1960. From 1960 to 1969, opening dates fluctuated from 3 to 10 days earlier, then returned to Thanksgiving Day in 1970. Biologists have contended that the season could be opened approximately 15 to 20 days earlier, resulting in a larger harvest of quail in which both sporting quality and size of birds were acceptable to hunters.

Persons opposing the earlier hunting date believed that quail would be too small, the weather too warm for hunting, and that farmer's crops would not yet be harvested and would suffer damage from hunters.

This paper attempts to explain the reasons for and results of the early quail hunting season in Tennessee.

Seasons prior to 1960 were based on tradition and other nonbiological factors. This is basically true in much of the quail range, and efforts to establish quail hunting seasons based on sound biological data have failed in many states.

Studies of quail population dynamics (8,12,13,18,21) have indicated that more quail should be available for hunting during an earlier season. The Game Management Division wanted to determine: (A) whether an earlier season would permit hunters to harvest additional birds, (B) the age structure of the quail population during early November, and (C) hunter response to an earlier opening date.

The assistance of the many people who contributed to this project is gratefully acknowledged. Without the quail wings contributed by thousands of Tennessee hunters for the past 21 years, the study could not have been made. The assistance of the sportsmen who answered the questionnaire is also appreciated. Special thanks go to the dedicated biologists who have assisted in collecting and aging the quail wings during the study; to the Game and Fish Officers who provided hunter names and collected hunter success data; and especially to Eugene Legler who was the Wildlife Investigations Project Leader for 15 years.

Materials and Methods

Twenty-Year Quail Wing Study

Tennessee quail wing collections were begun in 1951 when biologists collected wings in 6 southwestern counties. The collection was expanded to other counties in 1952. Beginning in 1953, names of quail hunters from all 95 counties were provided by Game and Fish Officers. Hunters were sent letters describing the quail program along with 5 self-addressed, postage-paid envelopes . Hunters were requested to cooperate by contributing 1 wing from each quail bagged. They were instructed to place the wings from 1 day's hunt in an envelope, write the date, county of hunt, and their name and address on the envelope, and mail them to the Game Division. Additional hunters were included during the 20-year period.

Wings received were aged according to techniques described in the literature (3,7,14,17,20). Basically, the aging technique was to evaluate the color of greater primary covert feather tips and measure the progress of molt of the primary wing feathers. Wings were aged to determine: (A) the adult-juvenile ratio, (B) the percentage of various age groups of juvenile quail in the fall population, and (C) hatching periods.

Pilot Study (1970)

A pilot study was conducted in 1970 on 1,200 acres of quail habitat on Laurel Hill Wildlife Management Area to study the effects of opening the quail season earlier. This public area normally has very heavy hunting pressure. An opening date was selected for the hunting season by using an average cumulative hatching curve (Fig. 1). An average date was determined by which time 84% of the juvenile quail were hatched. Twelve weeks (84 days) for maturing were added to that date. The season was thus set to begin on 5 November 1970. All persons hunting on the area were required to check in and out at checking stations so that biological data could be collected. Records were made of numbers of hunters and quail bagged. One wing was collected from each quail shot from 5 through 24 November. All wings were aged and the data recorded. Climatological data were collected in the study area to determine the effect of weather on hunting activity and success during November. Hunters were questioned to determine their response to the early season. Locations from which hunters originated were also recorded.

State-wide Early Season (1971)

Based on results of the previous studies, the Commission established an early statewide quail season to begin on 6 November 1971. Quail wings were collected from 6 through 30 November as described above to assist in evaluating the early season. Quail hunters were checked in the field throughout the season by 130 Game and Fish Officers and Game Biologists to determine kill success.

State-wide climatological data were obtained from the U. S. Weather Bureau. This information was correlated with hunting activity and success.

Data obtained from the Tennessee Crop Reporting Service were reviewed to determine the percentage of agricultural crop acreage harvested by specific dates. This information was used to study the relationship of hunting to possible crop damage.

Quail Hunter Questionnaire

In February 1972, a questionnaire was sent to 282 quail-wing-survey cooperators. Questions concerning their hunting experiences and their feelings regarding various controversial aspects of the early season were asked. The questionnaire data were compiled and compared with other phases of the project.

Results

Twenty-Year Quail Wing Study

A total of 65,026 quail wings were contributed statewide by hunters from November 1951 through November 1970. Approximately 81% of these wings were from juvenile quail (<7 months of age) and 19% were from adult quail. The largest percentage of juvenile quail in the fall population was 84% in 1965 and the smallest percentage was 71% in 1952. An average of 3% of these quail were in the 4-to-10.5-week age class. Wing age data collected during the entire 20-year period are compiled in Table 1. A 20-year average cumulative hatching curve was developed based on the age data (Fig. 1). Quail wings collected during the first 2 weeks of each hunting season were used to develop age data in Fig. 1

Laurel Hill Study (1970)

The experimental season, restricted to Laurel Hill, began on 5 November 1970 and closed on 8 January 1971 with quail hunting permitted only on 24 days at regular intervals. Most of the sportsmen (390) hunted during the first 8 scheduled days and bagged 596 quail. Only 15 of the total 405 hunters utilized the area after the regular statewide season began on 26 November. No one hunted during 9 of the scheduled hunt dates. A total of 611 quail were bagged during the 15 days of actual hunting.

Overcrowded conditions on several hunt days caused some sportsmen to stop hunting soon after beginning, and for all practical purposes they did not hunt. Other persons utilized the area during the early portion of the season primarily to train dogs.

The 1970-71 quail-kill data are difficult to interpret due to the unexpectedly large number of hunters. The crowded situation resulted in hunter antagonism and caused poor hunting conditions. However, the number of quail bagged exceeds by approximately 18% the previous high of 503 quail bagged. There may be several possible causes for the increased harvest, but it is believed that at least a portion of it was because more birds were available earlier. Each year hunting pressure has been abnormally heavy on the 1,200 acres of quail habitat. Observations and quail population census attempts with bird dogs during October and February of each of the 3 years indicated only minor variations in the numbers of birds.

During the 1969-70 season 271 hunters bagged 490 quail. The season began on 22 November 1969 and closed on 17 January 1970 with 13 days of hunting permitted at regular intervals.

A total of 503 quail were bagged by 201 hunters during the 1968-69 season. This season began on 28 November 1968 and closed on 14 January 1969. Hunting was permitted on 11 days at regular intervals. Sportsmen utilized the area on all scheduled hunt days in 1968-69 and 1969-70.

Wings were removed and aged from 535 of the quail killed during the period of 5 through 24 November 1970 (Table 2). Approximately 18% of all quail bagged were <12 weeks of age. This percentage indicated that an average of 1 quail per each 8-bird bag limit could be recognized as a young bird by observing the primary covert feathers. The 18% was close to the predicted 16% based on an average-hatching curve.

Climatological data from 3 stations in the Laurel Hill vicinity indicated that weather conditions were favorable during November when 97% of the quail hunters used the area. Cool and drier-than-normal days prevailed during most of November. Only 2 warm days (28 and 30 Nov) were considered unfavorable for hunting. Dogs worked poorly and hunters were uncomfortable during these 2 days.

The number of persons hunting on Laurel Hill in 1970-71 increased 33% over 1969-70, the previous high. Reasons for the early quail season were discussed with hunters at the checking stations and they were questioned concerning their attitudes. All hunters questioned stated that they would favor an early season if it were possible to harvest additional game. Two hunters, who killed 4-to-7-week-old birds, stated at first that they were against an early season. It was explained to them that late-hatched quail may suffer a high mortality rate. When they learned that the young birds they had killed had a high probability of dying during the first severe weather, they also decided in favor of an early season.

Persons hunting on Laurel Hill during the early season came from 26 counties in Tennessee and 6 counties in Alabama. Local (Lawrence

County) persons constituted only 19% of the hunters. It was reasonable to assume that these hunters would not object to an early season or they would not have traveled long distances to hunt on Laurel Hill.

Available data from hunts on Laurel Hill indicated that an earlier season was biologically sound and that more quail could be harvested.

Statewide Early Season (1971-72).

The 1971-72 quail hunting season (6 Nov through 12 Feb) began earlier than any previous year in Tennessee and earlier than any other statewide season in the Southeast. A total of 5,270 quail wings were contributed by 282 hunters during the early part of the season (6 through 30 Nov). This is the second largest number of wings contributed in 21 years of collections. Wings were returned from 89 of the 95 counties in Tennessee.

The quail-wing age data indicate that the 1971 production was excellent, based on the 82% proportion of juveniles in the bag compared to lower proportions of juveniles in other years of the 20-year study. The data also indicate that the 1971 hatch was slightly later than the 20-year average (Fig. 1). Approximately 18 to 19% of the quail bagged were <12 weeks of age (Table 3). This is roughly 3 or 4% more than is considered desirable.

A total of 2,232 quail hunters were checked in the field during November. They had hunted 5,659 hours and killed 4,920 quail. This indicates that statewide hunting success in terms of kill per hour was 0.87, which is the fourth highest kill per hour on record (19 years). The average 18-year kill-per-hour rate for November is 0.77. Hunters killed 0.83 quail per hour in December, 0.81 per hour in January, and 0.74 per hour in February. The 1971-72 season was rated excellent based on the data collected.

Data obtained from the U. S. Weather Bureau indicate that the mean date of the first fall temperature of 32 F or lower occurs prior to 30 October in all but 2 small locations in Tennessee (Fig. 2). The normal maximum daily temperatures were plotted for November from data furnished by the Weather Bureau (1). The data indicate that, normally, the warmest temperatures during daylight hours in November range between 53 and 68 F (based on 1931-1960 data). The coldest temperatures were not recorded because cold weather does not affect hunting conditions as much as warm weather does during November. During the Laurel Hill study, the weather approximated normal November weather and provided comfortable hunting conditions. During the early statewide season in November 1971, statewide daily maximum temperatures indicated that approximately 15 days had temperatures above and 15 days below the normal maximum (Fig. 3).

Quail Hunter Questionnaire

Approximately 76% (216) of the hunters returned the quail hunting questionnaire. Most persons answered all questions on the form, but some indicated that they could not remember certain facts and left these spaces blank. Based on the questionnaire, approximately 80% of the hunters furnished information favorable to the early season. A total of

193 hunters recorded making an average of 8.1 trips and bagging an average of 5.0 quail per trip during November. Two hundred and sixteen sportsmen gave ratings to the season (1971-72). Approximately 12% rated the season excellent, 41% gave ratings of good, 36% rated the season fair, and 11% gave the season a poor rating. When these 216 hunters compared this season (1971-72) with the quail season of a year ago (1970-71), 30% indicated that the 1971-72 season was better, 49% about the same, and 21% worse. Landowners with quail hunting opportunities on their farms composed 47% of the persons answering the questionnaire.

Quail hunters rated 4 controversial situations according to how the situations affected their hunting during November (Table 5). The 4 situations included warm weather, unharvested crops, age of quail, and landowner opposition.

Weather Effects:

Temperatures during most of the 1971-72 quail hunting season were unseasonably warm. This was favorable to the quail population, but some hunters complained of unpleasant hunting conditions. Even with the abnormally warm weather, approximately 64% of the hunters responding to the questionnaire indicated that warm weather during November was only a minor or no problem (Table 5).

Age of Quail:

The quail hatch was later than normal in 1971 and this probably caused a 3 or 4% increase in the number of young birds bagged. Nevertheless, only a few (1.5%) were less than 8 or 9 weeks old (Table 3). Approximately 80% of the quail hunters answering the questionnaire indicated that young quail were only a minor or no problem during the early season. Prior to the early season, most sportsmen believed that the vast majority of the quail would be too young for hunting when the season opened.

Landowner Attitudes:

Prior to the early season, some farmers complained about the early quail season because they feared crop damage by hunters. Their primary concern was loss of soybeans due to hunting activity. They contended that dogs running through fields of mature soybeans awaiting harvest would cause substantial damage. During the past few years new varieties of soybeans that are practically shatter resistant have been developed and widely used.

The majority of the state's soybeans are grown in west Tennessee and these landowners indicated more of a problem than those in other sections. Rains during September caused rank growth of soybeans. Maturation of the crop was later than normal, causing a late harvest. Data from the Tennessee Crop Reporting Service (11) indicate that 74% of the corn, 70% of the cotton, and 55% of the soybeans were harvested by 10 November 1971 (Table 4). Approximately 89% of hunters responding to a questionnaire indicated that unharvested crops were only a minor or no problem. Landowners with quail hunting opportunities on their farms also indicated few problems with unharvested crops (58% - no problem, 28% - minor problem, 14% - severe problem).

Discussions and Conclusions

Scientific data collected during the 20-year quail-wing study and the Laurel Hill study indicated that a portion of Tennessee's harvestable quail crop was being wasted each year. The data showed that, normally, 85% of the quail in the fall population were of sufficient age to be harvested in early November.

During the first week of the 1954 and 1955 statewide quail wing study, the percentage of juveniles in the bag was larger than the percentage when data for several weeks of these seasons were compiled.

This indicates 2 possibilities: (A) juvenile quail have a higher mortality rate than do adults as the season progresses and they are not available to hunters, or (B) juvenile quail are more susceptible to being killed and a larger percentage are killed at the beginning of hunting seasons. Marsden and Baskett (15) concluded that there was no significant change in the age ratio of an unhunted quail population from October through July, indicating that young in their first winter were dying at the same rate as were adults. Bennitt (2) found a drop in the percent of young amounting to 0.6% per week over the 8-week hunting season in Missouri (November-December). He concluded that the change was ". . . enough to show that young birds, even if fully grown, are slightly more vulnerable to shooting than older birds." In any case the first weeks of the 1954 and 1955 seasons and the Laurel Hill study demonstrated that the earlier the birds can be hunted the more quail the hunter can harvest.

Quail Mortality Statistics

Normally about 75 to 85% of the statewide bobwhite quail population succumbs annually to some mortality factor. This is established by the age data in Tables 1, 2 and 3 which show that approximately 75 to 85% of the birds bagged each year are juveniles. Data from studies in other states confirm this (2,5,9,15). The rate at which the approximate 80% mortality occurs varies from year to year. Natural causes of mortality such as weather, disease, parasites, predation, and food-and-cover deficiencies also vary in severity at different locations and seasons. These data indicate an average monthly mortality rate of approximately 6 to 7% or an instantaneous mortality rate of 11 to 15%.

Rosene (18) reported that his combined data indicated a loss of juveniles of slightly over 3% a week from hatching to 16 weeks of age. Rosene's data also showed that from 52 to 63% of adult birds were lost from 1 March to 20 November on several southern quail plantations. These plantations have high-quality habitat, and losses on them may be lower there than on statewide situations. Fatora, Provost, and Jenkins (4) reported a mortality of approximately 50% from hatching to 15 weeks of age, with a mortality rate of 3% per week after the initial high mortality immediately after hatching. Kabat and Thompson (12) reported mortality rates on their study area (Wisconsin) for several ecological periods. Based on 100% at the start of each period the rates were 50% from 15 November to 31 March, 17% from 1 April to 14 July, and 63% from 15 July to 14 November.

Management Considerations

The maximum quail population normally exists in August near the close of the hatching period. The maximum harvest by hunting could be achieved by opening the hunting season in August before other mortality factors acted, but this would be undesirable for several reasons. A large number of quail would be too small and the weather and vegetation would be undesirable for enjoyable hunting.

Size of Quail:

Realistically, the quail hunting season should begin when approximately 84% of the juvenile quail attain a weight of 141 to 170 g (5 to 6 oz). It is wasteful if hunting seasons are opened too early because many quail are too small for sport hunting or food. Because of high mortality rates in quail, it is also wasteful to delay opening the season until all young quail have gained fully mature weight. Herndon (10) found that Tennessee quail 10.5 weeks old compared favorably in weight to older birds. Birds 10.5 to 14.5 weeks old averaged 5.58 oz. Birds 14.5 weeks to adult age averaged 5.97 oz, and fully adult birds averaged 6.01 oz. Herndon emphasized that weights of individuals in any age classification may vary drastically. His data showed one adult weighing less than 5 oz and one 16.5 week-old female weighing 8 oz. In Missouri, Stanford (19) noted that quail 11 to 12 weeks of age were of adult size and that their sex could be easily determined. Stoddard (20) found that quail 88 days of age weigh 125 to 150 g (4.4 to 5.3 oz). Haugen and Speake (8) noted that bobwhite quail in Alabama over 90 days of age are indistinguishable from old birds insofar as estimated weight is concerned. Their conclusion was based on the assumptions that the average hunter in the field may be able to distinguish a bagged quail of 10% or more below adult weight as an immature bird, and that bobwhites weighing more than 156 g (5.5 oz) are, for hunting purposes, fully grown. Rosene (18) noted that average weights of juveniles 100 days old are practically the same as average weights of adults. Gore, Holt, and Barron (6) contended that Texas quail hunters consider unacceptable any quail weighing less than 150 g (5.3 oz). Kabat and Thompson (12) reasoned that an early opening date results in some sacrifice of size in quail, but reduces the number of birds that would be lost through natural mortality occuring between 15 October and 15 November. They contended that the presence of many small quail in the population (in Wisconsin) on 15 October is not a problem because hunters readily pass up the squealers (quail 3 to 7 weeks of age). Also they stated that shooting extremely immature birds does not materially reduce the population because these are late-hatched birds having a very high winter mortality.

Based on a combination of these considerations it was concluded that quail 12 weeks of age and above should be suitable in all respects as game birds. It was assumed that the average hunter, in his daily limit of 8 birds, would not be opposed to bagging an average of 1 quail (15.6%) that was slightly smaller than normal, especially if he felt he would have the opportunity to bag additional birds.

Potential Harvest

The quail population in Tennessee has been estimated to number 4,400,000 near the end of October (16). Based on mortality rates reported by several investigators (4,12,18), the potential losses in the quail population were computed for the period of 6 to 27 November. The 1971 quail wing data (Table 3) were used in these computations with an assumed quail population of approximately 4,272,000 birds on 6 November 1971. The potential weekly losses computed for the period of 6 through 27 November averaged 3% per week for juveniles less than 16 weeks of age and 2% per week for subadults and adult birds. It must be emphasized that mortality rates are not well-established, particularly for the early fall season. However, these estimated mortality percentages seem reasonable when the population turnover rate of 82% during 1971 is considered. This would indicate an average mortality rate of 1.6% or an instantaneous mortality rate of 3.2% per week. Based on the available data, estimates indicated a potential loss of approximately 310,000 juveniles and 49,000 adults, a total potential loss of 359,000 quail during the 22-day period. Assuming that 50% of these birds could be harvested, approximately 180,000 additional quail could have been bagged by hunters. It is believed that, with present habitat conditions, the statewide quail kill could be increased more by opening the season earlier than by any other means.

Related Factors:

The fears expressed by some sportsmen and landowners concerning the early quail season were proved to be unwarranted. Sportsmen imagined that they would encounter many young quail and that the weather would be too hot for hunting. Based on contacts with numerous hunters, these beliefs have been mostly dispelled. Few hunters reported observing small quail and few wings were contributed that came from extremely young birds.

Weather during 0.5 the days of the early season was unseasonably warm. This factor did cause some unpleasant hunting, but sportsmen learned that this did not spoil their sport. Many persons in Tennessee hunt on shooting preserves where the season opens on October 1 and they enjoy their hunts. Sportsmen in the Gulf Coast Regions, especially Florida, have been hunting in warm weather for many years. Florida's temperatures normally range from approximately 66 to 72 F in November, and hunters there harvested approximately 2,423,500 quail in the 1971-72 season (personal communications). While weather that is slightly warmer than normal may not be desirable to some Tennessee sportsmen, it certainly did not prevent them from hunting.

Farmers were also pleasantly surprised to observe that their crops were not ruined. Not a single case of crop damage was reported as a result of the early quail season. All information indicated that crop damage was not a legitimate concern. It is fully realized that most hunting takes place on private land, and the Commission would not advocate any program that would possibly damage property. Most hunters use discretion in these matters and avoid potentially damaging situations.

Summary

One of the responsibilities of the Game and Fish Commission is to provide more sport hunting. The hunter is allowed to harvest a maximum

number of game animals without endangering the populations. This was the goal when setting the quail season 20 days earlier than the traditional Thanksgiving opening date.

When all factors are considered, it is believed that the quail hunting season opening in early November (A) allowed hunters to harvest many additional birds that would have been lost to a variety of natural mortality factors, (B) provided 20 additional days of hunting opportunity per hunter, (C) demonstrated that the vast majority of the quail are suitable from the standpoint of age, size, and sporting quality, (D) will normally have weather conditions suitable for pleasant hunting, (E) will cause insignificant damage to agricultural crops, and (F) will not be opposed by most of the landowners. The sportsmen answering the questionnaire represent the "silent majority" and have spoken in favor of the early season. The Tennessee Conservation League (statewide affiliate of sportsmen's clubs) passed a resolution favoring the early quail season, during their annual convention, in April 1972.

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Table 1. Tennessee Bobwhite quail population age structure based on wings collected statewide from November 1951 through November 1970.

Wing Collection Dates	Juvenile quail age in weeks									Juveniles[1]		Adults		Total wings
	4-7	7-8	8-9	9-10½	10½-14½	14½-17	17-19	19-21½	Over 21½	Total	Percent	Total	Percent	
11/22/51-12/9/52		3	3	11	53	28	26	54	129	307	83.7	60	16.3	367
11/27/52-1/12/53		2		10	22	37	33	71	169	344	71.1	140	28.9	484
11/26/53-1/15/54			1	6	68	191	171	369	880	1,686	77.2	499	22.8	2,185
11/25/54-1/25/55			5	15	116	363	310	705	1,653	3,167	75.4	1,031	24.6	4,198
11/24/55-1/21/56			3	49	147	175	146	336	803	1,659	82.1	363	17.9	2,022
11/22-30/56		1	4	20	139	166	309	115	667	1,464[2]	81.1	342	18.9	1,806
11/28-12/08/57		1	2	12	106	274	272	329	1,083	2,116[3]	80.5	511	19.5	2,627
11/27-12/07/58		1	4	51	303	214	194	572	1,541	2,880	81.8	640	18.2	3,520
11/26-12/06/59		2	7	78	532	360	226	697	1,893	3,795	82.6	798	17.4	4,593
11/21-27/60	1	4	32	111	581	408	267	718	1,593	3,715	77.8	1,060	22.2	4,775
11/20-26/61		3	5	127	467	357	247	577	1,103	2,886	81.3	675	18.7	3,561
11/19-25/62		5	22	65	255	165	262	459	919	2,152	79.9	541	20.1	2,693
11/18-30-63		6	30	246	599	358	276	769	1,618	3,902	83.9	751	16.1	4,653
11/23-30/64	2	5	33	98	362	273	188	403	1,085	2,449	80.5	595	19.5	3,044
11/22-30/65	3	7	16	83	524	370	282	710	1,680	3,675	83.9	705	16.1	4,380
11/21-30/66		3	16	116	407	351	306	777	1,981	3,957	81.1	878	18.2	4,835
11/20-30/67		3	23	102	554	322	289	688	1,413	3,394	82.7	708	17.3	4,102
11/18-30/68			14	81	431	317	445	1,030	1,968	4,286	79.4	1,115	20.6	5,401
11/17-30-69	4	14	44	130	394	221	222	486	1,058	2,633[4]	80.9	619	19.1	3,252
11/26-30/70	1	2	4	73	300	211	172	361	970	2,094	82.8	434	17.2	2,528
Total	11	62	268	1484	6360	5161	4643	10,226	24,206	52,561	81.3	12,465	18.7	65,026
Percent	0.02	0.10	0.41	2.28	9.78	7.94	7.14	15.73	37.23		80.83		19.17	

[1] Unclassified juvenile wings were entered on this summary sheet, therefore column totals will not balance.
[2] Includes 43 unclassified juvenile wings.
[3] Includes 37 unclassified juvenile wings.
[4] Includes 60 unclassified juvenile wings.

Table 2. Laurel Hill Bobwhite quail population age structure based on wings collected from 5 through 24 November 1970.

	Juvenile quail age in weeks											Juveniles total	Adults total	Total wings
	4-5	6-7	7-8	8-9	9-10½	10½-12½	12½-14½	14½-17	17-19	19-21½	Over 21½			
Number wings	1	3	11	11	31	37	39	54	71	23	141	422	133	535
Percent of all quail bagged	0.19	0.56	2.06	2.06	5.79	6.92	7.29	10.09	13.27	4.30	26.36	78.88	21.12	

Table 3. Tennessee Bobwhite quail population age structure based on wings collected statewide during the early season - 6 through 30 November 1971.

	Juvenile quail age in weeks										Juveniles		Adults		Total wings
	3½-5	6-7	7-8	8-9	9-10½	10½-14½	14½-17	17-19	19-21½	Over 21½	Total	Percent	Total	Percent	
Nov. 6-11															
East		3	13	23	56	111	29	37	84	100	456	83.98	87	16.02	543
Plateau			1	3	19	19	6	9	23	34	114	83.82	22	16.18	136
Middle	1	7	27	53	137	187	56	61	170	228	927	83.44	184	16.56	1,111
West		3	7	25	56	95	35	41	87	122	471	83.07	96	16.93	567
Total State	1	13	48	104	268	412	126	148	364	484	1,968	83.49	389	16.51	2,357
% of all Quail	0.04	0.55	2.03	4.41	11.37	17.48	5.35	6.28	15.44	20.53		83.49		16.51	
Nov. 12-17															
East			3	4	9	37	25	19	43	70	210	80.15	52	19.85	262
Plateau				8	8	10	13	7	19	28	93	83.04	19	16.96	112
Middle			3	7	27	63	21	22	38	99	280	78.21	78	21.79	358
West			3	9	15	38	25	21	39	58	208	78.49	57	21.51	265
Total State			9	28	59	148	84	69	139	255	791	79.34	206	20.66	997
% of all Quail			0.90	2.81	5.92	14.84	8.43	6.92	13.94	25.58		79.34		20.66	
Nov. 18-23															
East				3	6	24	12	9	21	51	126	86.90	19	13.10	145
Plateau				1	2	3	7	3	5	16	37	77.08	11	22.92	48
Middle			2	7	20	36	18	21	53	117	274	85.89	45	14.11	319
West			2	12	28	44	30	27	41	101	285	83.58	56	16.42	341
Total State			4	23	56	107	67	60	120	285	722	84.52	131	15.48	853
% of all Quail			0.47	2.69	6.56	12.54	7.85	7.03	14.07	33.41		84.52		15.48	
Nov. 24-30															
East			1	5	5	26	13	11	37	86	184	83.64	36	16.36	220
Plateau						1	1	4	4	9	19	79.17	5	20.83	24
Middle			1	5	8	46	23	28	61	161	333	80.43	81	19.57	414
West			1	6	5	40	32	18	67	147	316	78.02	89	21.98	405
Total State			3	16	18	113	69	61	169	403	852	80.15	211	19.85	1,063
% of all Quail			0.28	1.50	1.69	10.63	6.49	5.74	15.90	37.91					
Grand Total	1	13	64	171	401	780	346	338	792	1,427	4,333	82.22	937	17.78	5,270
% of All Quail	0.02	0.25	1.21	3.21	7.63	14.80	6.57	6.41	15.03	27.08		82.22		17.78	

Table 4. Percentage of crop acreage harvested by specific dates in Tennessee, 1969-1971.

Crop and year	September						October						November					
	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30
									Percent									
Cotton																		
1969	1	3	5	9	16	27	36	40	45	53	62	66	74	81	88	92	98	
1970		1	2	3	7	11	19	26	27	30	33	38	45	54	61	67	72	
1971				2	4	5	10	17	25	35	44	52	63	70	77	82	91	
									Percent									
Corn																		
1969		7	10	15	20	26	31	35	44	53	61	66	72	79	87	90	94	97
1970		10	14	18	23	31	39	46	50	55	60	65	70	74	79	85	86	87
1971		4	7	10	13	18	23	29	38	46	54	60	69	74	80	87	91	95
									Percent									
Soybeans[1]																		
1969							4	9	14	23	34	55	62	70	80	86	92	95
1970							4	6	9	13	15	18	28	38	47	56	66	75
1971							1	4	7	13	18	25	36	55	69	80	87	93

[1]Most soybeans are grown in West Tennessee

Table 5. Summary of question six of the questionnaire.

Question 6. Think carefully about your quail hunts during November and rate the following situations according to how they affected your quail hunting.

Situation	No problem		Minor problem		Severe problem		Total hunters responding
	Number	Percent	Number	Percent	Number	Percent	
Warm weather	23	10.7	116	53.7	77	35.7	216
Crops not harvested	112	55.5	67	33.2	23	11.4	202
Quail too young	100	48.3	66	31.9	41	19.8	207
Landowner opposition	129	62.9	47	22.9	29	14.2	205
Total all situations	364	43.8	296	35.7	170	20.5	830

Rating (Check (x) one rating for each situation)

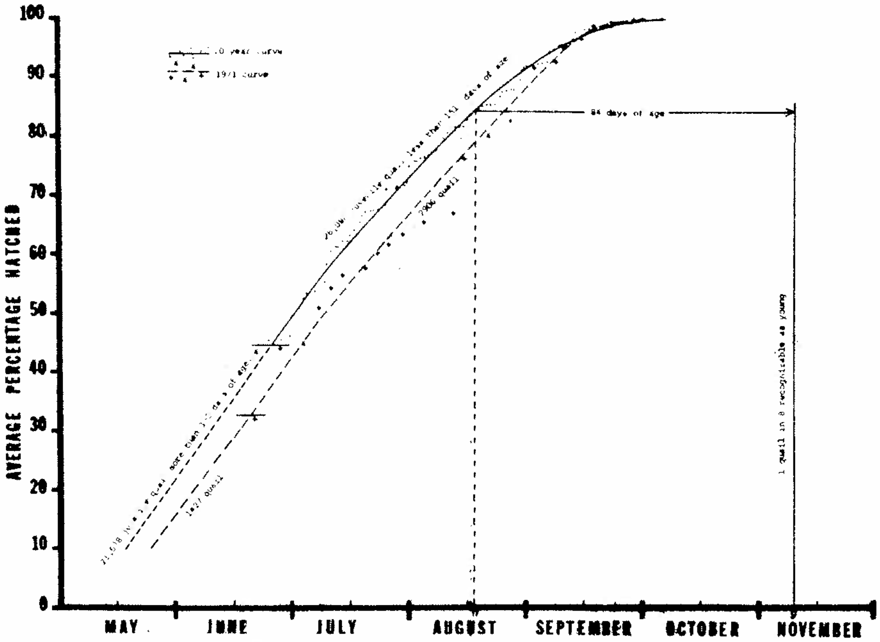

Figure 1. Twenty year (1951-1970) Bobwhite quail average cumulative hatching curve for Tennessee showing relationship of average hatching date to possible opening date for hunting season. (80% juvenile quail ratio is assumed). The 1971 quail hatching curve is plotted which shows the hatch was later than average.

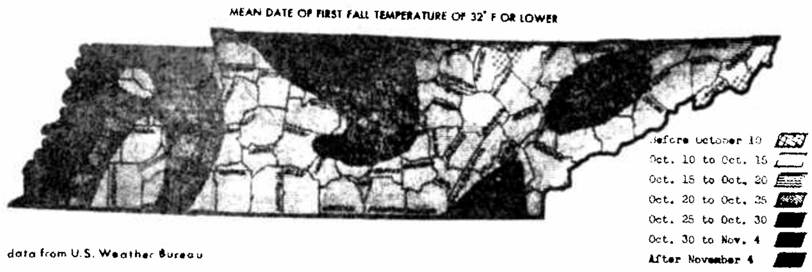

Figure 2. Map of Tennessee showing mean date of first fall temperature of 32 F or Lower.

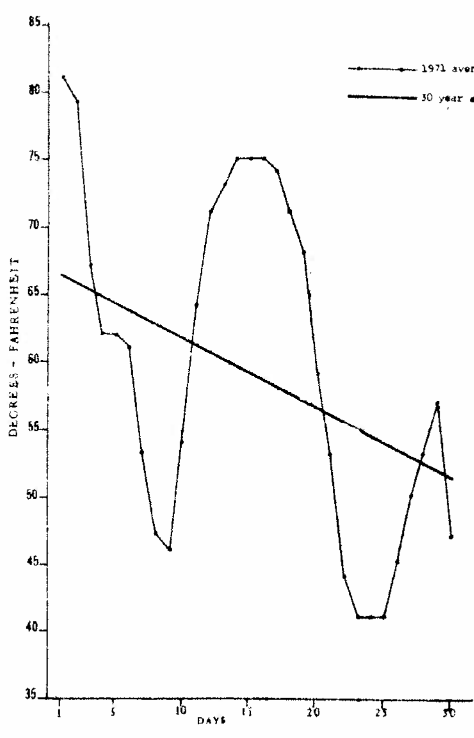

Figure 3. Average maximum daytime temperature for November 1971 and 30 year average (1931-1960) for Tennessee.

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BOBWHITE QUAIL POPULATION DYNAMICS: RELATIONSHIPS OF WEATHER, NESTING, PRODUCTION PATTERNS, FALL POPULATION CHARACTERISTICS, AND HARVEST IN MISSOURI QUAIL

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Abstract:

For 25 years Missouri has investigated bobwhite quail (Colinus virginianus) behavior, production, and population response to 4 major types of weather. Ten population parameters are examined annually to compare effects of Normal, Wet-Deluge, Snow-Cold and Drought weather years on quail populations.

Different types of weather are related to varying annual quail abundance by affecting productivity and survival and influencing relative levels of annual harvest and hunter interest. Normal and Wet-Deluge years yield favorable fall quail populations and satisfactory hunting. Years having winters of severe snow and cold have high breeder losses, low production, and reduced hunting success. In years having high temperature and drought in spring and summer, quail reproduction is inhibited, resulting in high losses of eggs and young, greatly reduced fall bird crops, and below-par hunting for many hunters. Recovery from weather-caused population lows usually occurs within 2 or 3 years after favorable weather conditions return.

Reliable techniques for sampling have been developed to yield indices of annual production and hunting success. Production curves show the value of data on the distribution of peaks in hatching for understanding annual production and fall population levels of quail in Missouri. Such data form the basis for setting annual hunting regulations of bobwhite harvest.

Successful management of bobwhite quail rests upon land-use and vegetation-manipulation practices that produce habitat capable of supporting abundant quail. An adjunct to this favorable habitat-game complex is a knowledgeable interpretation of the relationships between quail production, survival, weather, and effects of game harvest.

To learn these relationships, the annual collection of data on weather, game population dynamics, and game harvest becomes an important part of both applied and long-term research programs of many game departments. The data provide a growing understanding of species biology and serve as a basis for sound harvest regulations. These data usually represent the major information source for the managing organization and for the sporting public.

This paper presents data on the biology, population dynamics, and responses of bobwhite quail to weather in Missouri from 1948 through 1971. By extrapolation, much of the data relative to Missouri may apply to other locations in the more stable midcontinental bobwhite quail range.

Location, Topography, and Climate of Study Area

Missouri, embodying 69,420 square miles, lies between latitudes 36°30' N and 40°31' N in the basins of the Missouri and Mississippi Rivers. In longitude, the state lies between 89° E and 95°46' W.

Missouri includes portions of 4 major physiographic provinces. These provinces and the bobwhite harvest estimated for each in 1969 are: (A) The glacial or northern plain, an expanse of generally rolling-to-level land extending across the state, north of the Missouri River, in which land use is mainly for headgrains, beans, and cattle and hog farming (1,721,000 birds). (B) The Missouri Ozark highlands, bordered by the White, Missouri, and Mississippi River drainage basins, cover much land area south of the Missouri River; their rough-rolling, partly to heavily timbered uplands, and their cleared bottomlands now support grazing, limited small-grain farming, and woodland products (621,000 birds). (C) The western plain, a broad wedge-shaped prairie penetrating the central western portion of the state, has grazing and headgrain and bean farming as the major land-use practices (1,547,000 birds). (D) The southeastern corner of Missouri, with fertile flat, Mississippi River delta lands, supports intensive production of corn, headgrains, beans, and cotton (92,000 birds).

The climate of Missouri is similar to that of the cornbelt. Average temperatures in January range from 27 F in the northwest to 37 F in the southeast. Temperatures in July average 79 F in northern counties to 80 F in the southeast. Summer temperatures throughout the state often exceed 100 F. Extremely high temperatures and dryness, producing severe droughts harmful to agriculture and quail, have occurred about 8 times in the last 45 years. Prolonged snowfall, with low temperatures, prevailed in about 1 of 11 years. Severe drought or deep, prolonged snowfall rarely occur statewide.

Average annual snowfall ranges from 6 to 8 inches in the southeast counties, 12 to 16 inches in the Ozarks, 16 to 22 inches in the central counties bordering the Missouri River, and 22 to 26 inches in northern counties. Major snowfall months are December through February and occasionally through March. When prolonged, severe, March snowfall occurs, numbers of quail decline considerably (Fig. 1).

Averages of annual precipitation (rain-snowfall) in Missouri range from 50 inches in the southeast to 34 inches in the northwest. Rain is generally well distributed throughout the year with about 42% of it ocurring during the active crop-growing season of May through August. Spring-summer rains are frequent (except in drought periods) and often severe, delivering up to 10 inches within a 24-hour period. Table 1 presents normal or average monthly weather for Missouri's climatologic divisions (2).

Missouri bobwhite populations are relatively stable in accord with annual weather patterns, but both snow and drought adversely affect populations (15). Although periodic declines in quail numbers, through stress caused by severe weather, may be striking, they are short-term occurrences. Neither snow-cold nor drought occur as frequently or as severely in Missouri as in the fringe portions of the quail range: the northern heavy-snow states and the droughty western-southwestern areas.

Study Objectives

Beginning in 1946, Missouri developed a series of quail-research projects to obtain long-term information on reproduction and other biological characteristics. Project goals were:

1. To develop sampling surveys to provide annual indices of the relative abundance of bobwhite quail and to measure the related hunting success.
2. To study annually, regionally, and statewide the effects of weather upon bobwhite quail behavior, production, survival, and abundance.

3. To determine the relationship between hunter success and annual quail population levels, and the relationship between hunting effort and various annual levels of quail abundance.

4. To study nesting behavior, production chronology, fall population characteristics, and wing-molt progression of both young and adult birds.

5. In 1959 the project was expanded to include studies of nesting behavior and molt in quail collected (shot) in the wild and wild quail trapped and held as pairs in isolated field (ground) pens.

I am grateful to the research personnel, field men, rural-route mail carriers, and quail hunters who cooperated in field studies on bobwhite quail. Special acknowledgement is made of F. W. Sampson, biologist in charge of annual small game harvests.

Methods

A Bobwhite Quail Population Survey, including daily observation and recording by field observers, is operated on a 12-month basis by the Missouri Department of Conservation. Over 200 field personnel (Conservation Agents and special-area men) submit monthly survey forms summarizing daily recordings of prevailing weather conditions, quail numbers seen, and activities relative to covey breakup, pairing, mated pairs, singles, and nesting.

Production Season

A special Quail-Brood Population Index Survey is conducted during July and August as a portion of the year-round survey. This employs additional Department area personnel and 200 to 300 rural mail carriers. The ages of quail broods and field activities of adult birds are recorded.

Between 2,000 and 3,000 broods are normally observed and their ages estimated during the 60-day survey period. Data on broods whose ages have been determined are used in 2 ways:

1. To show nesting-hatching chronology from covey breakup until mid-July, and to pinpoint the first hatching peak. Fig. 2 presents typical quail production patterns based upon the average of data from 12 years. The first peak of hatching shown on the graph is based upon brood age data; the second peak is estimated from wing molt data from harvested quail.

2. To formulate an annual Production Index (PI) which is the average number of broods seen per observer during the survey period (Fig. 1, Table 2). PI's are developed on both a regional and a statewide basis.

Hunting Season

Traditional dates for the quail hunting season in Missouri were 10 November through 31 December from 1915 to 1962. Since then, the season has been extended through 15 January. During the hunting season, data are gathered on hours hunted, coveys flushed, birds taken, related information, and 10,000 to 20,000 hen wings. These data are collected statewide through the efforts of cooperating hunters who provide information on 5,000 to 6,000 hunts, 20,000 to 25,000 hunting hours, and 20,000 to 25,000 coveys flushed. Data are analyzed regionally and statewide. Wings are collected only during the November part of the hunting season (10-30 Nov.).

A Hunting Index (HI) figure (Fig. 1, Table 2) based upon hours hunted and coveys flushed is computed annually for regional and statewide use. This index is used in conjunction with PI figures for evaluating annual Production-Hunting success and in making comparisons with success of other years.

Early in this study large collections of wings from quail of both sexes were analyzed annually to determine age ratios of both males and females, and of hens only. Data on adult cocks per 100 adult hens were computed from samples of wings and from records on daily hunting forms.

It was concluded that:

1. the sex ratio of young birds in the fall is 50:50,

2. adult cocks outnumber hens (similar distortions of sex ratio in Missouri quail were found previously [1,2,10]),

3. hunters' records of harvested quail provide adult sex-ratio figures comparable to those computed from wing samples, and

4. hen wings alone provide, as suggested by Petrides (11), adequate information on the young-adult ratio.

Thus for the reasons listed, plus the obvious savings in manpower, time, and money, young-adult ratios are computed from about 10,000 hen wings per year. Age-ratio figures of 85% young to 15% adult serve as the normal base figure in describing age ratios of hens in this study. These percentages resemble the figures of 80%-20% cited in sex-age ratios, including both cocks and hens, in other areas.

An associated project of the Missouri quail survey is an annual January-February trapping of wild quail which are held as pairs in isolated ground pens. Since 1960, an average of 30 wild pairs per year (as many as 100 pairs) have been used in studies of reproductive behavior and primary molt in adults (mainly hens) and young (17). Data from this long-term project, and from birds collected in summer, have added materially to interpretations and conclusions.

Table 3 summarizes basic field data and lists parameters for which the data are used.

Results

Spring Behavior, Covey Breakup, Pairing, and Nesting

Bobwhite quail populations in Missouri exist as coveys during the period of January through March. Although field records show that occasionally a few birds pair and nest extremely early, in late February or early March, most birds remain in a covey until mid-April.

As days lengthen and warming occurs in late March or during April, the calling of male "bob-whiting" is heard in fields and woodlands. Such calling usually coincides with the blooming of yellow spring mustard (Brassica kaber var. pinnatifida) and announces the breakup of wintering coveys and onset of subsequent nesting activity. From then until mid-September, the abundance of whistling males indicates nesting-hatching chronology of the production season (16).

Spring reproductive activities begin in southern Missouri and progress northward; southern counties are usually 10 to 15 days ahead of northern Missouri. Many quail in Missouri establish pair bonds before the major covey breakup, as do quail in Texas (8). These pairs leave the covey and feed and loaf together during the day, but they return to roost with the covey at night.

Covey ties usually begin to weaken in mid-March, but chilling, wet days and cold nights cause regrouping of scattered birds. Generally, covey ties are completely broken and pair bonds are well established from 15 April through the first week in May.

If cold conditions prevail late in spring, covey bonds for some birds may continue until the end of April or even mid-May. When covey breakup is delayed, pairing is often concentrated in a brief time period. In 1 week birds are mainly in coveys while the following week, after 1 or 2 days of typical spring-like weather, covey breakup occurs and pairs form.

Actual pairing, nesting, and laying undoubtedly involve a photoperiod (length of daylight) affecting the bird's hormonal balance, but the time of covey breakup seems to depend mainly on a temperature-moisture relationship. Quail in Missouri follow a fairly predictable pattern of reproductive activity after covey breakup (15 April, day length of 12 hr 48 min). A few quail, however, begin nesting in early March (1 March, day length of 11 hr 20 min) and have young chicks flying in mid-April when other quail are still in coveys.

When adequate nesting cover is available near a covey's winter headquarters, many pairs may remain in that vicinity. If nesting vegetation is lacking, birds often move onto lands that lack winter survival cover but will support spring and summer reproductive activities. The population may occupy such areas during the summer and early fall then move to more secure, woody, wintering sites prior to the fall hunting season. Woody cover is emphasized because it is essential to good winter habitat.

In years having favorable spring weather, about 64% of the paired birds nest in April and May. These efforts result in a peak of hatching at about 15 June, the first of 2 major hatching periods in a typical production cycle. The second hatching peak occurs about 15 August.

Short-term weather factors that affect quail production and abundance are: (A) winter snowfall-temperature relationships involving the amount and duration of snowfall and extent and duration of low temperatures, which determine how many breeders survive; (B) spring moisture-temperature relationships (April-May) which control onset of nesting and early season production; and (C) summer moisture-temperature relationships in the nesting, hatching and rearing periods, which affect overall production and survival of young. Negative effects of 1 or more of the short-term weather factors produce noticeable to considerable fluctuations in annual quail populations. Low populations resulting from short-term adverse weather conditions are usually corrected within 2 or 3 years, unless adverse weather, such as drought, intervenes.

Arbitrary standards, based upon weather records, surveys of quail populations, and harvest records are used to classify weather conditions affecting annual production into 4 types of production seasons. The names and terms of types used in this paper are based upon United States Weather Bureau terms familiar to farmers and sportsmen. Major annual weather types affecting bobwhite quail are expressed simply: (A) Normal, (B) Wet-Deluge, (C) Snow-Cold, and (D) Drought.

Weather data for 25 years used in evaluating and distinguishing population parameters are averaged and grouped according to the 4 major types of weather in Table 4. Quail production and population parameters for the Normal year provide the basic data for comparing and evaluating changes in quail density occuring in adverse weather years.

Normal or Favorable Winter-Spring Production Year (10 Years)

In the Normal year, temperature and moisture, including snowfall, do not deviate greatly from the average of weather bureau records (Table 5). Snowfall varies from slightly above normal to average to very light amounts that, in extremely favorable years, persist briefly. While the winters of Normal years may often be stressful and cause considerable breeder mortality (when average snowfall is concentrated and accompanied by low temperatures), losses are never as great as in the severe, cold winters in which snowcover is prolonged into March.

In Normal years, as in some years having extremely wet springs, covey breakup usually occurs from mid to late April. The first hatching peak then occurs around 15 June, when about 64% of the annual bird crop is produced. A second peak in the hatching period usually occurs around 15 August when approximately 36% of the year's bird crop is produced. Fig. 2 shows the Normal-year hatching curve.

The typical covey breakup in April followed by hatching peaks on 15 June and 15 August, has happened in 15 or 25 years. These Normal years are essential for satisfactory fall quail populations in Missouri.

Ten population parameters are examined in evaluating and comparing the effects of Normal versus adverse weather years on quail (Table 4). The average of data from 10 Normal weather years serves as the base.

Fig. 3 presents a summary of annual production-season weather, distribution of hatching peaks, and some population parameters. PI's of Normal production years usually fall in the favorable to very favorable range (9-12+). The HI in Normal years ranges from 66% to 84%. The graphed relationship of PI's and HI's is shown in Fig. 1.

Primary feather molt and replacement in young quail indicate hatching chronology. In adult hens, wing molt progression often reflects the timing of nesting and production because most hens delay wing molt until after the young hatch. The delaying effects of adverse May-June weather on hen nesting and hatching will usually be shown by late wing molt in the hen.

Missouri quail studies (17) show that incomplete molt in mature hens may indicate: (A) no production in June, nesting delayed until late July or August; or (B) second nestings by hens (Fig. 2) (17). The incomplete primary molt pattern in young Missouri birds hatched during August or later in a Normal year averages 36%. An average of 66% of the adult hens shows an incomplete replacement of primaries, wherein primaries 10 and 9 (occasionally 8 also) are retained and not molted until the following fall. Wing aging of quail is based upon back-aging primary molt from 20 November, the midpoint in the November wing-gathering period.

Onset of molt of primary feathers in adult hens may occur from May through October, with the major period of initiation occurring from June through September. About 18% of hens nesting successfully molt shortly after the mid-June hatching peak, but in most of these early nesters, onset of molt is delayed until July or August. Fig. 2 shows periods of molt onset and duration of primary-feather replacement in hens during Normal years. Nonmolting hens in late July and August are potential nesters over a 4-month period; many of these hens are potential producers of second broods (17).

An analysis of hen wings collected in November gives age ratios of young to adult birds, and hunting records provide sex ratios among adults. In years when adult sex ratios approach the normal figure of 114 cocks to 100 hens, a high proportion of juveniles in the bag indicates good production (11 young per adult hen represents the normal or favorable production year). If, as occurs in some adverse years, the proportion of juveniles is high whereas the proportion of adult hens is low (interpreted as high losses of adult hens) we must be aware that the population may actually be down because the high proportions of young in the bag may be a function of low numbers of adult hens rather than of high productivity. Thus, when interpreted properly, the proportions of young per adult hen and of adult cocks per 100 adult hens are valuable parameters for evaluating relative success or failure of annual production.

Normal years usually provide good-to-excellent quail hunting because birds are in habitat capable of supporting good populations. The average HI of 75% (Table 4) shows that Normal years provide the highest hunting success of any type of weather year. Occasionally, as shown in Fig. 1, annual hunting success may be higher or lower than the harvest prospects indicated by the annual PI.

In the case of such higher success, the answer often lies in the fact that fall hunting conditions are exceptionally favorable for a high harvest, and many birds are taken in just a fair production year because only the best bird hunters are afield and working hard. Lower hunting success than expected often occurs in a good bird year when an exceptionally warm, dry fall or an early December onset of cold-snow weather may seriously restrict hunting success and cause many hunters to forsake the field.

Annual numbers of quail hunters fluctuate in accord with high and low bird years. In seasons having poor hunting prospects, many gunners may forsake the field until years having brighter harvest prospects occur. One may ask why?

Missouri quail hunters seem to include 2 types of individuals. Some men spend considerable time in developing good dogs, seeking hunting sites, and hunting often. These hunters possess the characteristics that cause them to be afield during any type of quail year; they hunt and work hard to find game and they usually find it.

Men in the second group enjoy bird hunting, but unfortunately their time is limited for working dogs, locating a variety of hunting sites, and actually hunting. These individuals usually do considerably less hunting in adverse game years, or they may not hunt at all, because they are "fringe hunters". The fact that many "fringe hunters" often forego hunting in seasons having reduced quail prospects leaves the game supply to fewer hunters. Thus, many men afield in the poorer bird years, while not having the best of success, do pretty well. Their results often show up as fairly good HI's in poor bird years.

The average kill per hunter further reflects the effects of production-season weather on annual bird abundance; this figure helps in evaluating and comparing hunting success over the years (Fig. 1).

Wet, Above-Normal Rainfall, Deluge Spring, Production Year (6 Years)

The Wet-Deluge seasons are usually characterized by having rainfall considerably above normal in April, May and June, and often in early July. Spring moisture may be near average, but prolonged May-June torrential rains may sheet-wash fields and flood out nesting sites. The normal schedule for harvesting crops, mowing, and haying is greatly altered, adding to early-season nest disturbances and losses. The presence of many paired quail in May and June, called "road walkers" in Missouri, gives ample evidence of disrupted nesting schedules.

Table 4 and Fig. 3 illustrate the population characteristics of quail during the Wet-Deluge years. Wet year production patterns may differ from those of Normal years in several ways:

1. The June hatching peak may occur around 15 June, but a lower percentage of young is produced. The second hatching peak usually occurs near 15 August, but the total hatch increases through compensatory nesting by many hens that lost their clutches or young earlier in the

rain-soaked hatching period of June.

2. The first hatching peak may be delayed until early July as a result of cool, wet spring, and be accompanied by a drop in overall production, although in some years production may be higher than normal. The second peak is usually a week or more later than the normal date of 15 August. In some wet years, the hatching percentage in the second peak is above the normal percentage, but in deluge years, the August peak may fail to make up the early-season production losses and the annual population shows a small-to-considerable decline. Fig. 4 compares the production pattern and percentage distribution averages between Normal and Wet-Deluge years and shows the shifting of hatching peaks that often occurs in Wet-Deluge years.

3. While PI's in Wet-Deluge years may occasionally fall in the favorable range, they will often be poor to fair (Table 2, Fig. 3). The average Wet-Deluge year PI is 8, compared to 12 for Normal years.

4. HI's of some Wet-Deluge years indicate good to satisfactory hunting, but low indices of extremely wet years show that occasionally fall quail populations may be low because of excessive moisture. The HI average for the Wet-Deluge years is 66% compared to 75% in Normal years (Table 4). Both PI and HI figures indicate accurately the relative population status of quail in the Wet-Deluge years. The average kill per hunter (Fig. 1) further shows that fair-to-favorable population levels of wet years provide success for hunters afield.

5. Young-old ratios in Wet-Deluge years average 83%-17% or only a 2-point departure from the proportion of 85% young to 15% adult in the Normal year. On the surface, a small percentage-point difference such as this appears of little consequence. If we compare the difference in young per 50 pairs of adults (Table 4), we see that quite a change in production has occurred because 488 young (83% young) in wet years is 14% below that of 567 young (85% young) in Normal years.

6. The ratio of young per adult hen averages 10, and there are 116 adult cocks to 100 adult hens. When compared with Normal-year figures, the Wet-year data indicate a slight drop in production occurring with some increase in hen mortality.

7. Increased percentages of incomplete molt over that of Normal years occur in August or afterward in the Wet years; the corollary to this is in a higher percentage of adult hens carrying incomplete primary molts. Such indications of compensatory nesting in hens undoubtedly lessens the impact of early season nesting losses and raises fall population levels. (Such late compensatory nesting does not occur in severe drought years).

Wet-Deluge years, as with other adverse weather years that may limit population, may occasionally encompass much of the state. Usually not more than one-half of the state, and in some cases only 1 or 2 regions, may be affected.

While Wet-Deluge years may negatively affect annual production-survival and fall population size, such years have always supplied adequate quail crops to assure a fair-to-satisfactory hunting season. Wet-Deluge years do not have an adverse effect on subsequent production as may happen in a sequence of severe drought years.

Snow-Cold Winter-Spring Production Year (4 Years)

In Normal weather years, average snowfall, low temperature, and occasionally icy conditions cause a portion of the annual quail mortality. Such losses are increased if snowfall is concentrated, covers the ground for long periods, and occurs in late winter. At this time, some stressed birds are existing in nearly marginal habitat. Considerable losses of birds ensue, whereas if similar conditions occur early in winter, losses are less because habitat at this period is more secure and birds are in prime, fall-fat condition.

Some exceptionally mild-to-open Missouri winters, having little or no snowfall, occur periodically and permit higher breeder survival and carryover than normal. Such winters often precede exceptionally fine quail crops.

A Snow-Cold year having considerable below-normal winter temperature, coinciding with above-average snowfall prolonged into March, is a time of high winter mortality, and quail populations in the subsequent fall show a serious decline.

Masses of huddled, starving quail and uncoordinated coveys move along rural roads after being forced from snow-blanketed, submarginal home ranges. Emaciated, nonflying, or frozen birds, easily collected by man or predator, mark the Snow-Cold winter. Stanford (15) and Roseberry (12) have described in detail the catastrophic effects of the 1960 "Big Snow" winter on midwestern bobwhite (Table 5).

Subnormal numbers of breeding birds in spring, greatly reduced fall populations, and a poorer hunting season are the aftermath of the Snow-Cold winter.

Quail production patterns and some population parameters for individual Snow-Cold years of 1947, 1948, 1960 and 1970 are shown in Fig. 3.

Although some statewide production and harvest parameters of 1970 fail to compare with those of other Snow-Cold years, 1970 is placed in this classification because southwest Missouri and much of the Ozarks had severe winter snow conditions resulting in population decline and extremely low hunting success. Statewide data tend to mask the effect of these high winter losses because of exceptionally high quail populations and hunting success in the rest of the state during 1970.

Effects of Snow-Cold are shown in Table 4. Quail populations of heavy snow years vary from Normal in the following respects:

1. A marked reduction in spring breeder carryover is caused by high bird mortality in late winter, resulting in a noticeable scarcity of birds in the nesting season. This condition is clearly reflected in a greatly reduced average PI of 5, compared to 12 for the Normal year (Table 4).

2. In Snow-Cold years (and often in years of cool, wet springs) quail behavior may include either normal onset of pairing and nesting, with the first hatching peak around 15 June, but with fewer hens nesting and contributing young to the first peak hatching period, or delayed covey breakup resulting in a first peak of hatch near 1 July or slightly later, with fewer chicks than normal being brought off. 1 July first-hatching peaks have occurred in 5 of 25 nesting seasons.

3. The second major hatching period in Snow-Cold years may peak around 15 August or as in Normal years it may be a week later or very much later as in 1947 (Fig. 3).

4. In Snow-Cold years, the first hatching peak produces fewer birds and the second hatching peak provides more young than in Normal quail years. Overall total production usually falls considerably below that of Normal years (Table 4).

5. The average of 82% young in the Snow-Cold years (Table 4) is only 3 percentage points from normal. But 456 young from 50 pairs shows more clearly a decline of 19%. The figure of 124 adult cocks per 100 adult hens (compared to a Normal of 114-100) indicates greater losses of hens in Snow-Cold years than in Normal seasons. In very severe years, high loss of hens may be paralleled by high losses of males. Statewide data averages (Table 4) may fail to show the true extent of high regional bird losses which occur in areas receiving the brunt of winter storms. Data for individual years provides a clearer understanding of the degree of quail decline.

An example is the Snow-Cold of late winter in 1960 when southern Ozark timber lands were snow blanketed and many areas suddenly became submarginal for birds. Regional data showed 77% young and only 335 young per 50 pair or 41% below Normal-year abundance.

Annual data for individual years can be misleading unless all parameters are carefully considered. For example, the "Big Snow" year of 1960 provided the best data on quail behavior on record. Careful field observations clearly indicated that Missouri's quail populations declined 50% to 75% in various regions. The state PI of 3 was the lowest on record and similar to that of drought year 1953. Yet, under such conditions, 1960 data showed favorable figures of 84% young, 11 young per adult hen, 525 young per 50 pair (nearly the normal of 567 young) and 114 adult cocks per 100 hens, the same as a Normal-year cock-hen ratio. The conclusion drawn is that high mortality served as a common leveler for both sexes. The results were Normal appearing but deceptive in some parameters.

The Snow-Cold conditions in years 1947 and 1948 were less severe on quail than were conditions in 1960. Yet data for these 2 years, while showing favorable figures for young-old ratios and young-per-adult-hen ratios, clearly revealed, through large distortion in adult cock-hen ratios, the high loss of hens. This distortion caused the deceptively favorable-appearing data on young.

The need for several parameters for ample interpretation of population data becomes evident.

6. The Snow-Cold data show a 24% increase over Normal in the size of the August peak hatch and in incomplete molt in birds hatched during August or later. Numbers of adult hens molting late show an 11% increase above Normal, indicating production losses in the early nesting season and compensatory nesting during the August hatching period.

In evaluating effects of the Snow-Cold weather on quail, bird losses often appear severe and similar to those of some drought years. Hunting success in the 1960 "Big Snow" year rated poorer than in severe drought years (Fig. 1).

Reduced bird populations in Snow-Cold years cause reduced hunting effort as many fringe hunters do not hunt. Hunters find the bird crop down and coveys sparse. Birds are gone from areas that support them in mild winters. Hunting efforts provide reduced bags, and the average kill sets a record low for all types of adverse-weather years.

Quail populations usually show rapid recovery to favorable levels within 2 or 3 years following a Snow-Cold year. One year's production is usually required for developing an ample supply of potential breeders; by the second year (sometimes the third) populations are at or near Normal. Numbers of hunters afield then increase with the growing quail population.

Drought Production Year (6 Years)

Of the 3 major types of weather effecting changes in the Normal production and survival curve of Missouri bobwhite, drought is undoubtedly the most dramatic. In Drought years, high prevailing ground temperatures and much-below-normal moisture prior to and throughout the production period affected quail behavior in various ways and at important stages of the production cycle. Such conditions have prevailed in 6 quail production seasons in 25 years. Oddly enough, these 6 Drought years occurred consecutively, during 1952-1957 inclusive, and this undoubtedly accentuated effects of drought on quail in the more stable portion of the bobwhite's range. These data clearly illustrate the more serious effects that drought can exert on quail populations in midcontinental United States.

Regional droughts of season duration occur periodically in Missouri. These are not considered here because such conditions usually affect only the fall behavior and movement of birds rather than significantly reduce populations. In such years, birds often forsake drought-seared and overgrazed areas and seek refuge in woodlands where they are usually unavailable to hunters. The effect of drought on bobwhite quail has been studied widely (3, 4, 5, 6, 7, 8, 9, 13, 14, 18, 19). Drought-caused effects and changes from Normal are as follows:

1. Onset of pairing, covey breakup, and nesting is delayed.

2. In a severe drought year in which spring moisture shows a cumulative deficiency (often from a previous drought year), many birds may fail to break coveys and to pair. Some covey units remain partially or nearly intact through June, July, and August.

3. Limited nesting occurs during May, June, July.

4. Many nests containing full clutches are abandoned.

5. Hens become emaciated and die on the nests.

6. Smaller clutches are incubated.

7. Eggs are prematurely incubated by high ground temperatures prior to incubation by the hen. Much egg spoilage occurs.

8. Unhatched chicks pip and partially ring their eggshells, but rapid desiccation traps them in half-opened eggs. Uneven hatching, with a few eggs hatching early, causes hens to leave nests with fewer young, often as few as 2-4 chicks.

9. Marked scarcity of broods during June and July.

10. Large numbers of adult pairs and single birds lack chicks from June through September.

11. An above-normal number of adult males, minus females, care for small clutches of young during the production season.

12. The most noticeable and important result of severe Drought years is few to no broods of extremely young chicks during August and September. The second, or August, hatching peak does not occur.

Overall effects of drought on production patterns, fall population levels, and hunting success are shown in Fig. 5 and by parameters for the individual Drought years shown in Fig. 1 and 3.

Average parameters for the 6 Drought years are compared with Normal years in Table 4. A PI of 4 falls 66% below the Normal PI of 12, and thus rates the Drought years as the most damaging to Missouri quail in the 25 years of study.

The record Drought year of 1953, with a low PI of 3, was 75% below Normal. This compares with the Snow-Cold PI of 3 during 1960.

In 4 of the 6 Drought years, the 15 June hatching period shifted 1 to 2 weeks later. These first hatching peaks, while averaging around 92% of the annual production, actually produced 50% to 75% fewer birds than the first peak hatch of a Normal year.

The second hatching peak of Normal weather years occurs around 15 August and contributes about 36% of the annual quail crop. In the severe drought years, this second peak of hatching may disappear or contribute only 5 to 6% of a Normal bird crop. A small percentage of hens in drought years may produce 2% to 15% of the year's quail crop in an August or later hatch, resulting in extremely young birds through mid-September, as shown in Fig. 3. As shown in Fig. 3, the hatching period of 1 July 1953 accounted for 98% of the annual production; hatching in August and later was nearly nonexistent.

The chronology and amount of production in drought years depart so far from the Normal that population levels and hunting success for many hunters reach a forecastable low.

Young-old ratios and young-per-adult-hen figures for the Drought years, as in other types of weather years, often fail to convey fully the degree of population decline. In fact, as in ratios of Snow-Cold years, these figures if evaluated alone, falsely indicate exceptional quail production. Young-hen ratios alone too often are believed to indicate excellent quail production and high populations. High young-hen ratios could occur in the last remaining 100 birds in an endangered population. Only by noting (A) actual population levels through a game survey (the PI), (B) ratios of adult cocks to 100 adult hens, and (C) numbers of young per 50 pairs of adults, and by comparing all with the Normal condition can we analyze a population and learn why young-hen ratios and young-per-adult figures appear so favorable. The high loss of hens marks the reality in such ratios. By considering distortion of adult cock-hen ratios, we can align our thinking more clearly, and hope that our interpretations are accurate.

The ratio of young per 50 pair of adults in drought years is 456, or only 19% below Normal. A similar decrease is noted for the Snow-Cold years. These figures may well represent the existing population that is present and being measured; they are deceptive when, as often occurs, they fail to reveal that a huge segment of a Normal population is absent. The actual degree of quail mortality and population loss in drought years must be discerned from other population parameters and from comparisons between years.

In Missouri's southern Ozark regions, where effects of drought are most severe, data from 1952 and 1953 show that the percentage of young dropped to 74% and 73%, with young-per-adult ratios of 5 to 1 and 6 to 1, respectively. Ratios of young per 50 pairs of adults for these 2 years were 285 and 270, respectively, a departure from Normal of 50% and 53% respectively. Thus in areas and years where drought is extremely severe, annual ratios for young per adults, young per adult hen, and young per 50 pairs of adults may reflect more realistically population characteristics during drought.

Data on incomplete molt in years of drought show that production of the second (August) hatching period, and presence of extremely late-hatched young, averages 9%, or 73% below Normal. During the severest drought year, 1953, molt figures dropped to 2%, or 91% below the Normal year. In such poor production years, production and hunting success rest solely on early-season production.

Total statewide kill and regional harvest in the most drought-ravished regions drops considerably, as fewer birds afford less harvest. Restrictions on season length and daily harvest, while saving some birds through direct harvest reductions, have greatest effect in restricting total kill by discouraging hunting effort, as shown by reduced hunting by avid hunters and no hunting by casual hunters.

A noticeable improvement in annual harvest, as shown by PI's, (Fig. 1) occurs with but the slightest rise in annual production in drought years. The slight rises in PI figures of drought years 1955, 1956, and 1957 imply that improvement in spring moisture improved habitat conditions. Many acres lacked grazing pressure after vast cattle sell-offs, and they gradually began to recover carrying capacity for birds through replacement of natural food and cover.

Following a short-term occurrence of adverse weather, Missouri bobwhite quickly respond to improved conditions of moisture and restoration of natural habitat where land-use practices permit it. After 1 or 2 seasons of breeder buildup, populations return to Normal-season bird densities, consistent with habitat quality and favorable production weather.

As shown in Fig. 1, drought-stricken quail populations returned to the very favorable PI of 10 by 1959, with a corresponding good bird harvest.

These data emphasize that annual quail abundance and satisfactory-to-good hunting success in Missouri are dependent upon a favorable June quail hatch and a near average or better August production peak.

Summary and Conclusions

Weather during 25 years of study on the biology and population dynamics of Missouri quail has been classified into 4 major types according to moisture-temperature characteristics. They are: the favorable normal years and the less-favorable years of Wet-Deluge, Snow-Cold, and Drought. Ten population parameters are measured to compare weather effects of the 4 types of years on quail production, fall population size and composition, and hunting success.

Although weather of the Wet-Deluge years often changes the times of hatching peaks and the percentages of hatch in each, and may cause some population decline, such years are not overly harmful to annual quail populations, and hunting success in these years is never a "bust".

Table 1. Missouri Climatography Normals by Climatological Division

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Aver.
						Temperature (F)							
Northwest Prairie Div.	27.7	31.6	40.6	53.8	64.0	73.7	78.7	76.9	68.7	57.8	42.1	31.9	54.0
Northeast Prairie Div.	29.8	33.0	41.5	54.2	64.4	74.1	78.5	76.8	69.0	58.1	43.1	33.1	54.6
West Central Plains Div.	32.2	35.7	43.7	55.9	65.3	74.8	79.5	78.3	70.3	59.6	44.8	35.6	56.3
West Ozarks Division	35.1	38.5	45.6	56.9	65.4	74.5	78.8	78.1	70.6	60.1	46.2	38.0	57.3
East Ozarks Division	34.8	37.9	45.4	56.9	65.4	74.3	78.2	77.3	69.7	59.0	45.5	37.0	56.8
Bootheel Division	37.5	40.3	48.0	59.1	68.2	77.0	80.3	79.1	71.9	61.2	47.8	39.3	59.1
						Precipitation (Inches)							
Northwest Prairie Div.	1.40	1.33	2.37	3.58	4.10	5.43	3.43	4.06	3.53	2.63	1.93	1.54	35.36
Northeast Prairie Div.	1.83	1.79	2.83	3.51	4.20	4.61	3.47	3.50	3.29	2.95	2.47	1.92	36.37
West Central Plains Div.	1.76	1.89	2.61	3.66	4.93	5.08	3.38	3.84	4.01	3.40	2.41	1.91	38.88
West Ozarks Division	2.15	2.39	3.05	4.14	5.41	4.95	3.56	3.19	3.91	3.65	2.82	2.27	41.49
East Ozarks Division	2.98	2.85	3.76	4.32	5.01	4.43	3.35	3.42	3.42	3.32	3.44	2.83	43.13
Bootheel Division	4.33	3.71	4.86	4.29	4.46	3.94	3.34	3.19	3.41	3.12	3.89	3.67	46.21

Table 2. Explanation and Rating Valves of Production Index (PI) and Hunting Index (HI)

PRODUCTION INDEX (P.I.)

Based on broods observed in 60 days-July-August

P. I.= AVERAGE BROODS PER OBSERVER PER REGION

P.I. RATINGS

(1) POOR-3-5 (3) FAVORABLE-9-11

(2) FAIR-6-8 (4) VERY FAVORABLE-12+

HUNTING INDEX (H.I.)

Based on ratings of coveys flushed per 8 hour hunting day

EXCELLENT	GOOD	FAIR	POOR
8 COVEY PER DAY 1-1.1 Hrs/covey or better	6 COVEY PER DAY 1.2-1.5 Hrs/covey	5 COVEY PER DAY 1.6-2.5 Hrs/covey	3 COVEY PER DAY 2.6+Hrs/covey

Expressed as the combined percentage of hunters rating Good to Excellent hunting success.

EXAMPLE: Hunters rating excellent hunting success 50%

Hunters rating Good hunting success 25%

HUNTING INDEX (H.I.) Equals 75%

Table 3. Bobwhite Quail Studies - Basic Field Data: Yield Parameters: 1948-1971

Production Survey – July-August

BROODS	69,000	Nesting Activity – Chronology Hatching Patterns – First Peak Indication of Second Hatching Peak Effects of Weather P. I. – Production Index

Hunting Season Survey – November-January

WINGS	222,000	Young – Old Ratios Young Per Adult Hen
Young Primary Feather Molt		Back Aging – Second Hatching Peak
Adult Primary Feather Molt		Nesting Pattern-Hens – Second Brood Indicator
COVEYS FLUSHED	255,000	Bird Abundance – H. I. Hunting Indexes
HOURS HUNTED	321,000	Bird Abundance – H. I. Hunting Indexes
KILL BY SEXES	396,000	Age Ratios – Young Per Adult Hen Adult Cocks Per 100 Adult Hens

Ten Month Field Survey – Quail Behavior-Activity

COVEYS	100,000	Covey Breakup – Shuffles – Nesting – Non-Nesting
PAIRS	100,000	Pairing – Nesting – Non-Nesting – Nest Losses – Desertions
SINGLES	100,000	Nesting – Non-Nesting (Road Walkers)

Table 4. Missouri Bobwhite Quail Population Parameters Averages by Type of Production Weather Year: 1947-1971

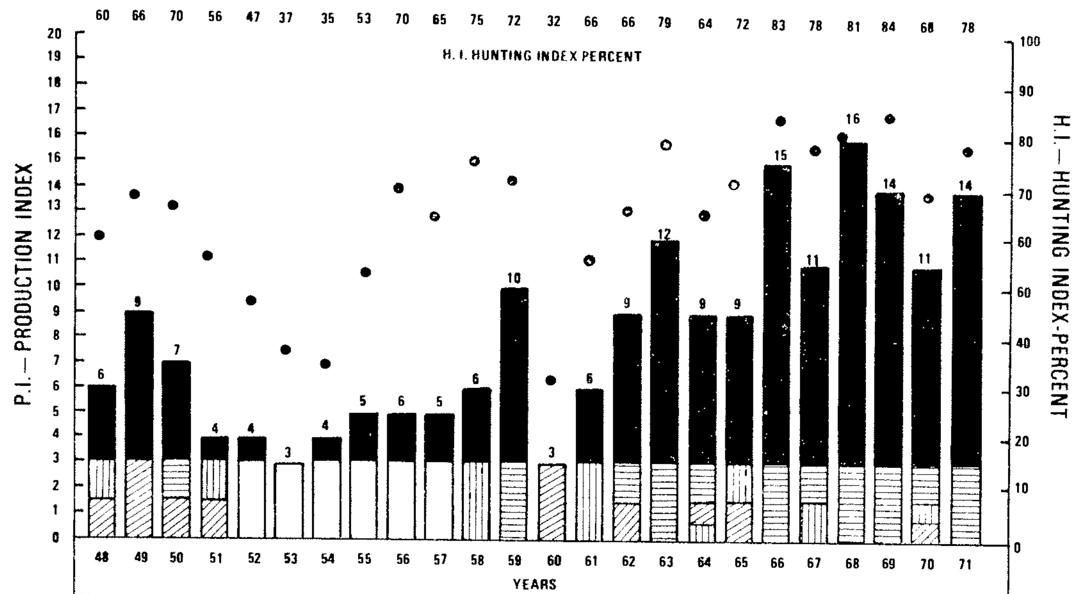
PARAMETERS	CHARACTERISTICS OF TYPE PRODUCTION YEAR			
	"NORMAL" OR FAVORABLE WINTER-SPRING -10 YEARS-	WET - DELUGE RAINFALL ABOVE NORMAL-SPRING SUMMER ** -6 YEARS-	SNOW-COLD WINTER-SPRING -4 YEARS-	DROUGHT RAINFALL MUCH BELOW AVERAGE PROLONGED HIGH TEMPERATURES ABOVE 100° -6 YEARS-
PRODUCTION INDEX	12	8	5	4
HUNTING INDEX %	75%	66%	53%	51%
% YOUNG - FIRST PEAK HATCH PERIOD	64%	55%	59%	92%
% YOUNG - SECOND PEAK HATCH PERIOD	36%	45%	41%	8%
YOUNG - OLD RATIO %	85% - 15%	83% - 17%	82% - 18%	82% - 18%*
YOUNG PER 50 PAIR (100 ADULTS)	567	488 (14% below normal year of 85% yg.)	456 (19% below normal year of 85% yg.)	456 (19% below normal year of 85% yg.)
YOUNG PER ADULT HEN	11	10	12	9
ADULT COCKS PER 100 ADULT HENS	114	116	124	130
% YOUNG WITH MOLT INCOMPLETE	33%	45%	41%	9%
% ADULT HENS WITH MOLT INCOMPLETE	66%	72%	73%	15%

*IN THE MOST SEVERE DROUGHT REGION OF SOUTHERN MISSOURI, YOUNG PERCENT DROPPED TO 73% WITH 5.4 YOUNG PER ADULT HEN AND 270 YOUNG PER 50 PAIR.

**1970 YEAR CLASSED AS BOTH A WET-DELUGE AND SNOW-COLD YEAR.

Table 5. Average Annual Winter Snowfall, Average Annual Temperatures for January, February and March; Snowfall and Winter Temperatures in 1960; According to Climatological Divisions in Missouri

Division	Averages: Winter snowfall (inches)	Averages: Temperatures (F) January	February	March	1960: Snowfall	1960 Temperature (F): January	February	March
Northwest Prairie	23.4	27.7	31.6	40.6	52.0 +19	27.9 -0.1	26.0 -6.1	26.8 -14.1
Northeast Prairie	19.7	29.8	33.0	41.5	45.0 +25	30.4 -0.3	28.2 -5.4	27.9 -14.1
West Central Plains	17.1	32.2	35.7	43.7	35.0 +18	32.8 -0.1	30.9 -5.5	31.4 -12.8
West Ozarks	12.6	35.5	38.5	45.6	28.0 +15	35.5 -0.0	33.0 -6.0	34.4 -11.7
East Ozarks	10.8	34.8	37.9	45.4	25.0 +14	35.4 -0.1	33.5 -5.0	32.5 -13.6
Bootheel	7.2	37.5	40.3	48.0	32.0 +25	38.6 -0.8	36.9 -3.9	35.2 -13.5



	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Average Kill	14	16	15	12	9	9	10	11	13	12	13	17	8	13	17	18	16	24	28	20	18	21	20	19
Hrs./Covey	1.5	1.3	1.6	1.4	1.5	1.9	1.7	1.4	1.3	2.8	2.9	1.2	2.1	2.6	2.9	1.2	1.1	1.2	1.0	1.1	1.0	1.0	1.2	1.1
Kill/Covey	1.3	2.3	2.5	2.8	2.6	2.5	2.4	2.4	2.9	1.3	2.9	2.7	2.5	2.6	2.5	2.3	2.6	2.8	2.6	2.6	2.5	2.7	2.7	2.6
Annual Kill-M	1,499	1,939	1,769	1,333	1,001	674	598	722	1,024	930	883	1,514	568	1,053	1,706	2,261	1,706	2,788	3,771	3,287	3,036	3,981	3,625	3,501
Hunters-M	105	115	115	105	101	72	60	62	78	72	66	84	81	78	98	124	103	112	135	161	168	186	176	185

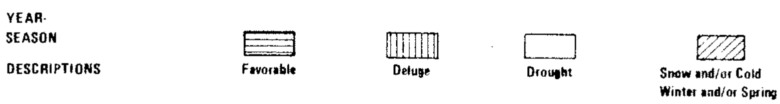


Figure 1. Missouri Bobwhite Quail Production Indexes (Bars) and Hunting Indexes (Dots) for years 1948-1971. Major Weather Type Affecting Populations and Production are Shown by Bar Cross-Hatching. Harvest Data Show Effects of Weather on Annual Production and Fall Bird Crop.

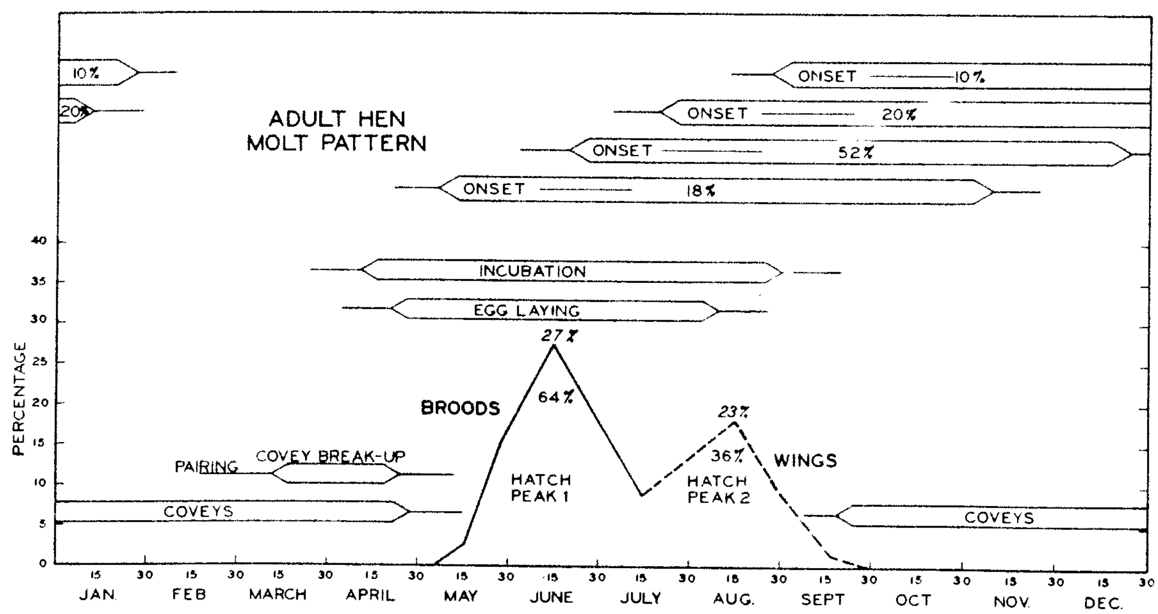


Figure 2. Missouri Bobwhite Quail Average Production Pattern: Peak Hatch Percentages (27%-23%), Hatch Distribution (64%-36%) and Adult Hen Molt Variations.

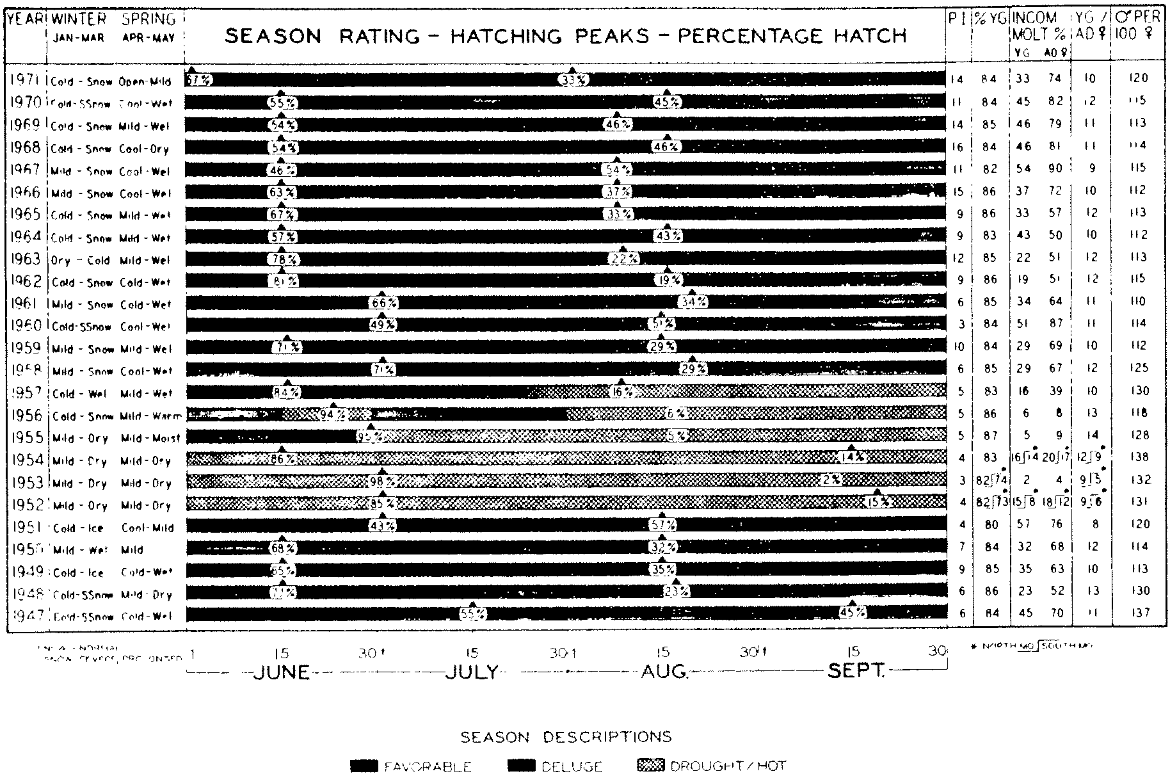


Figure 3. Bobwhite Quail Production Seasons - Population Composition - Missouri 1947-1971. (Terminology Used in Describing Winter-Spring Weather is from U. S. Weather Bureau).

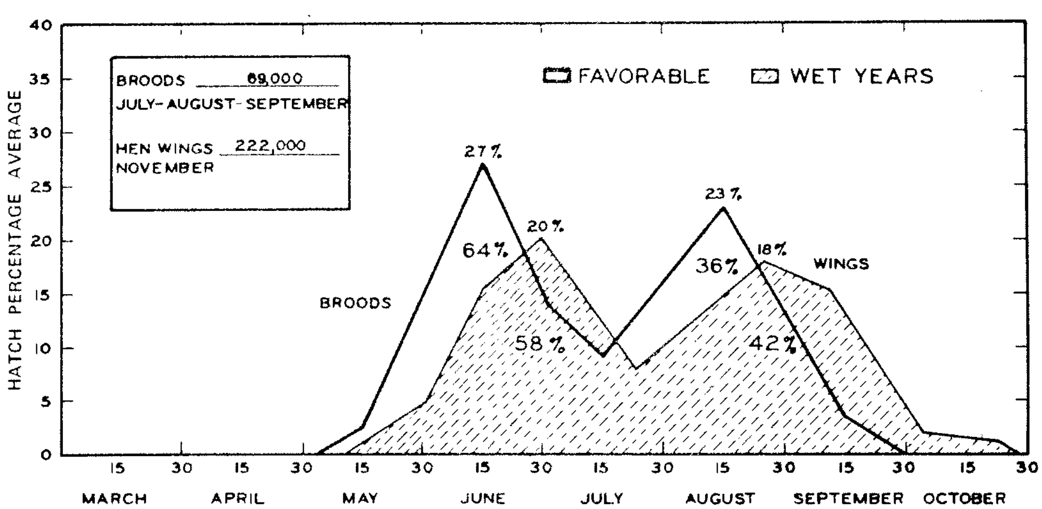


Figure 4. Bobwhite Quail Production Hatch Percentage Averages of Normal or Favorable Weather Years and Wet Years 1947-1971.

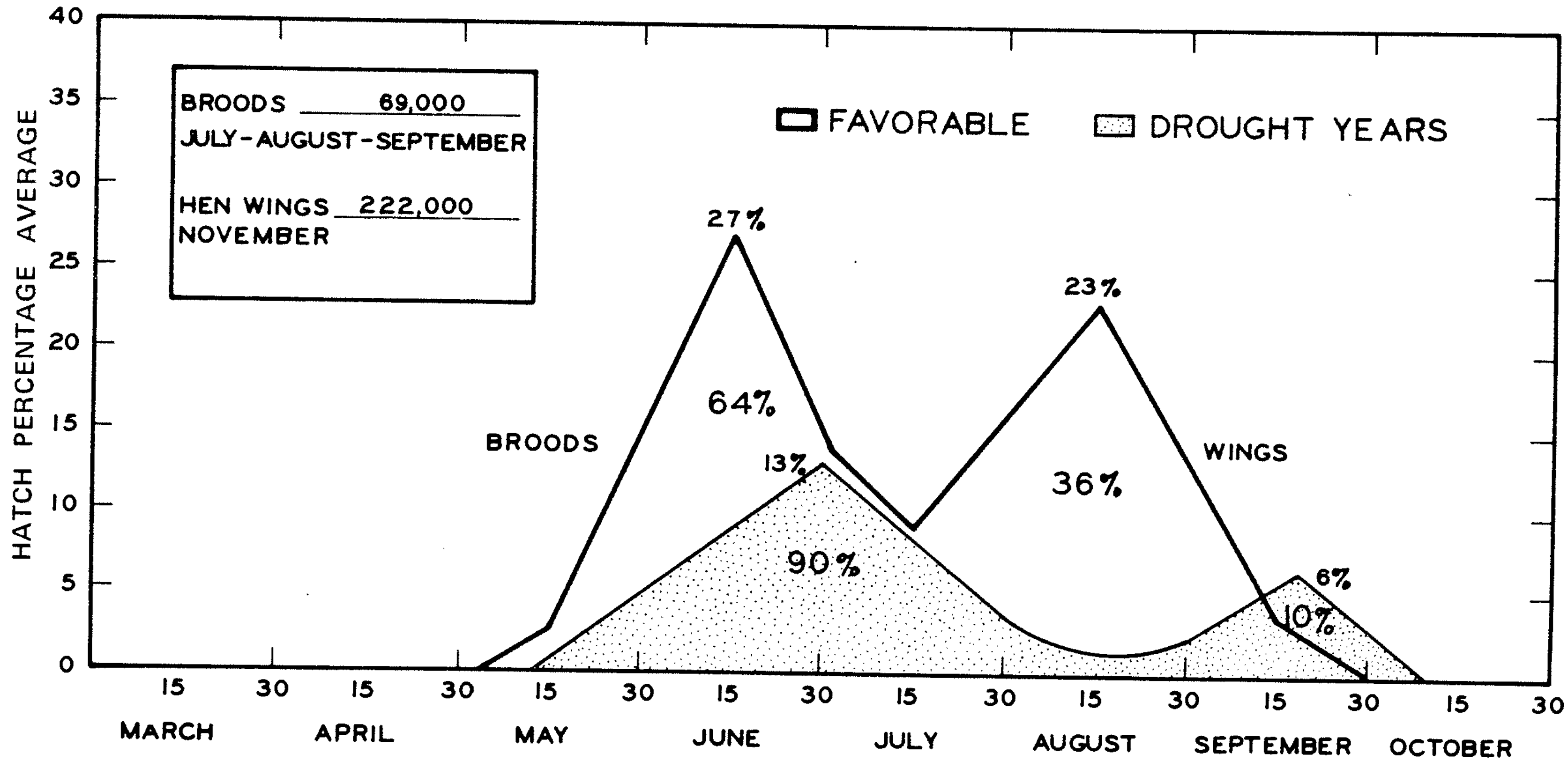


Figure 5. Bobwhite Quail Production Hatch Percentage Averages of Normal or Favorable Weather Years and Drought Years 1947-1971.

The Snow-Cold year seriously reduces annual bird abundance through a scarcity of breeders and reduced production. Both hunting pressure and rate of hunting success declines.

Severe drought with high temperatures is the type of weather most damaging to quail reproduction. Hatching peaks occur later than in Normal years; production in the first peak of hatching is strongly reduced; and production in the second hatching peak is either reduced or eliminated. Hunting success in such years is usually poor. The total effects of adverse weather is that the double hatching peak, typical of the Normal year, is disrupted to the extent that birds may be produced later and fewer in number from either the first or second hatching peak or from both.

Periodic bobwhite declines or "lows" so popularly referred to as "the quail cycle" are not regarded as cycles, but only as temporary fluctuations caused by short-term variations in weather. Such population lows are self-corrective (habitat permitting) with the return of 2 or 3 consecutive years of "normal" weather conducive to bird production and survival.

But the level to which quail can increase, even under favorable weather conditions, depends on the capacity of the habitat to support birds. If long-term trends of land use and vegetation succession are in or approaching a stage of negative value for quail, the chance for favorable production weather to provide bird abundance is definitely limited. In such situations, the negative trend of land-use must be corrected and directed in a positive direction that will produce favorable food-cover conditions for birds.

If sportsmen are to continue enjoying the sport of quail hunting in many localities, they must take a greater interest in the biology of the bird and derive added pleasure from understanding the annual problems encountered by quail under varying weather situations affecting production and survival. With fewer hunting areas in prospect, the effects of weather upon huntable quail populations will become more noticeable. To understand more fully the problem is to be better prepared to meet setbacks; and the quail problems of tomorrow will bring plenty of setbacks. Hunters should be aware that good hunting is impossible every year, and that because of the effects of weather on quail, in about 11 of 25, or 44% of the hunting years (as judged by the past) the bird harvest will fall below the average.

The only way to improve this situation is through good quail-land management designed to produce more bobwhite under all conditions of weather.

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BODY FAT CONTENT OF BOBWHITES IN RELATION TO FOOD PLANTINGS IN KANSAS

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Abstract:

A wildlife habitat improvement program was initiated on the Fort Riley Military Reservation in 1961 to increase winter food supplies for bobwhite quail (Colinus virginianus). As part of an ongoing evaluation of this program, 164 bobwhite quail were collected during the fall and winter of 1968-72 for fat analysis. Fat content in carcasses of birds collected <600 m from a food plot was compared with fat content of birds collected >900 m from a food plot.

During winter months, birds collected near a food plot were significantly ($P<0.10$ to $P<0.05$) heavier than birds not having access to a food plot. Fat content of birds close to a food plot was likewise greater ($P<0.10$ to $P<0.01$) than fat content in birds not using food plots. Calculations indicate that birds close to food plots have sufficient energy reserves to provide a 79% greater protection against brief periods of food deprivation than birds far from a food plot. Fat energy reserves alone in a quail close to a food plot could provide sufficient energy for 2.0 days of survival whereas quail far from food plots contained fat energy reserves sufficient for only 1.1 days of survival.

Reserve energy for animals is stored in the body mainly in the form of fatty acids. The quantity of stored reserve energy (fat) may be critical to the animal's survival during periods of food scarcity or extremely cold weather. Much work has been done on fat content, composition, and regulation in songbirds (8, 9, 10, 11, 12, 15, 16, 23, 24). Only recently has any attention been given to body fat reserves of wild gallinaceous birds under natural conditions. West and Meng (25) reported on the relationship of total fat and fatty acid composition to diet of willow ptarmigan (Lagopus lagopus) in Alaska while Moss and Lough (14) presented similar data for 3 species of grouse in Scotland.

Almost no attention has been given to fat reserves of bobwhite quail even though it is known that fat reserves may be essential for bird survival during periods of dietary stress (15, 23 and others). The most recent book on bobwhite quail (22) does not even discuss the importance of maintaining adequate fat reserves in quail for winter survival and spring breeding. In fact, not until only very recently has any attention been focused on basic energetics of bobwhite quail (3). Earlier I included a small amount of body-fat data in an evaluation of food plantings for bobwhite quail in Kansas (18). The purpose of the study described herein was to gather more extensive data on body fat content in bobwhite quail, especially as related to seasonal changes and food plantings in Kansas.

The interest, efforts and unlimited cooperation of Fort Riley military personnel, especially G. B. Joselyn and J. W. Dunlap, are gratefully acknowledged. Financial assistance was provided by the Wildlife Management Institute, Kansas Forestry, Fish and Game Commission, U. S. Department of the Army, National Science Foundation, and the Kansas Agricultural Experiment Station.

This paper is a contribution of the Division of Biology, Kansas Agricultural Experiment Station, Kansas State University, Manhattan.

Methods

This research was conducted on the Fort Riley Military Reservation in Riley County, 8 miles southwest of Manhattan, Kansas. The Reservation is on the western edge of the Kansas Flint Hills. Vegetation and topography of the area are described in Robel (18). A wildlife habitat improvement program was begun on the Reservation in 1961 mainly to benefit bobwhite quail and is still somewhat active. Early studies (21) disclosed a shortage of winter food (seeds) for wildlife, and therefore the primary purpose of the habitat improvement program on the Reservation was to increase the availability of seed sources for bobwhite quail and other granivorous wildlife.

Plantings of corn, wheat and sorghum were established on the Reservation by military personnel. Normally a food plot consisted of a combination of corn and sorghum, but sometimes corn, sorghum, and wheat were planted adjacent to each other. Early in the study, food patches were small (0.52 acres each) and scattered over the entire Reservation except for a central artillery impact area. During 1965 and 1966, several long narrow plots (up to 2 miles long) of corn and sorghum were established, in addition to the many small and isolated food patches, to utilize available large equipment more effectively. Total area producing cultivated grain for wildlife varied from year to year, ranging from 150 to 300 acres. All planted grain was left standing for the entire winter.

Beginning in 1961 bobwhite quail were collected regularly during fall, winter and spring. Birds collected prior to 1968 were used to determine food habits (18), weight dynamics (18,20), winter mortality (17, 19), and helminthic burdens (6). Birds collected after 1968 were used to provide body fat data in addition to the information listed above. Sporting firearms were used to kill the quail and bird dogs helped in locating coveys and retrieving cripples. Collecting was normally limited to late afternoon hours and no more than 2 quail were taken from any 1 covey on the same day. Time and location of kill plus sex and age were recorded for each bird collected. Exact kill locations were determined in the field by using military coordinates on contour maps having a scale of 4 inches per mile. Tip coloration of the greater upper primary feathers (13) and appearance of the seventh greater primary coverts (7) were used as criteria to distinguish juveniles from adults. Sex was determined by body plumage characteristics.

Bobwhites were weighed within 3 hr of the time they were killed. Crop contents were removed prior to weighing the bird to the nearest 0.1 g.

Carcasses were quick-frozen and stored at -20 C until analyzed for body fat. Each bird was analyzed individually. While frozen, birds were sawed lengthwise and processed through a universal No. 3 food chopper (fine cutter). The chopped material was then dried 24 hours at 60 C, again processed through the chopper and thoroughly blended. Moisture-free weight was determined after drying 2-g samples for 5 hr at 110 C under vacuum (28 inches of Hg). Fat was extracted from 2 2-g samples of each bird in a Goldfisch extraction apparatus for 16 hr using anhydrous diethyl ether as a solvent. Samples were then redried at 110 C for 5 hours under vacuum and reweighed. Ether-extractable fat was expressed as a percentage of dry tissue weight.

Weights (g) and fat content (%) are expressed as mean $\pm$ standard error.

Results and Discussion

Body fat determinations were made on 164 quail carcasses during the 1968-72 collecting period (Table 1). Of the 164 total, 79% were juveniles and 21% were adults. Males and females were represented equally in the sample but adult/juvenile ratios were not the same for each sex (Table 1). Because of small sample size in each month of each year (range 0 to 6), birds were pooled by month for the 4-year study. Although sample pooling masks year-to-year differences and also prevents detecting any age or sex differences, it does provide adequate sample sizes for meaningful analysis. Weights of bobwhites collected for fat analysis varied seasonally (Table 2). Birds collected in September weighed the least (178.2 $\pm$ 4.2 g) whereas those collected in December were heaviest (196.3 $\pm$ 3.3 g). These data are similar to more extensive quail weight data presented by Robel and Linderman (20) and Robel (18) for bobwhites collected on the same study area.

Content of ether-extractable fat in carcasses of bobwhites varied seasonally. Fat content was lowest in birds collected in September (7.29 $\pm$ 0.35%), gradually increased during October, November and December, and reached a peak in January (20.13 $\pm$ 1.69%). Fat content gradually decreased after January, to 16.75 $\pm$ 1.22% in February and 14.46 $\pm$ 2.46% in March. The highest amount of ether-extractable fat (37%) was found in a juvenile bobwhite collected in January 1969. Twenty quail contained more than 25% fat; 85% of these birds were collected during December and January. The least amount of fat (3.6%) was found in a juvenile male collected in December 1969. Fifteen quail contained less than 6% fat; 47% of these birds were collected in March whereas 20% each were collected during September and October, respectively.

The relationship between quail body weight and fat content was analyzed. No significant ($P>0.10$) relationship existed between the 2 parameters when weights and fat content of all birds collected between September and March were included. However, a significant ($P<0.01$) positive correlation was detected in birds collected only during the winter months (January-March).

Relationship with Food Plots

Earlier (18) it was determined from crop content that birds within 600 m of a food plot commonly utilized the plot as a food resource. Birds within 600 to 900 m of a food plot occasionally fed in the plot, whereas birds collected farther than 900 m from a food plot never used the plot as a food resource. Therefore, the effectiveness of food plots can be evaluated by comparing birds collected within 600 m of plots with those collected 900 m or more from plots. Birds killed in the 600-to-900 m distance class are omitted from the comparison since they occasionally utilized food plots.

Of the 164 birds collected and analyzed for fat content during this study, 78 were collected within 600 m of food plots and 76 were collected 900 m or more from plots. Weights of birds collected within 600 m of plots were not significantly different ($P>0.10$) from those of birds killed 900 m or more from plots during the September to December period; however, birds killed close (0.600 m) to plots in January, February and March weighed significantly more ($P<0.10$ to $P<0.05$) than birds killed far (>900 m) from plots (Table 1). The weight difference in January was 9.7 g, that for February was 6.4 g, and the weight difference in March was 10.8 g. The mean weight difference for the 3-month winter period was 9.0 g, i.e., on an average, birds killed close to food plots weighed 9.0 g more than birds killed farther than 900 m from plots.

The seasonal weight changes exhibited a quadratic relationship (Fig. 1). Weights of birds killed close to food plots reached a peak in January whereas weights of birds killed more than 900 m distant from plots peaked in December (Table 2). Although weights of birds collected close to and far from plots decreased during the winter, weights of birds killed close to plots decreased less than those of birds killed more than 900 m from plots (Fig. 1).

A comparison of the amount of ether-extractable fat contained in the bodies of birds killed close to and far from plots disclosed a relationship similar to that of the weight comparison described above. Fat content of birds killed within 600 m of plots was not significantly different ($P>0.10$) from fat content of birds killed more than 900 m from plots during the September-December period (Table 3). Birds killed close to plots during the January-March period all had a significantly greater ($P<0.10$ to $P<0.01$) amount of body fat than did birds killed more than 900 m from plots. Birds killed close to plots had an average of 20% body fat during January-March whereas birds killed far from plots during the same period contained only 13% body fat. Therefore, during winter, birds near plots had 1.5 times the fat content of birds killed more than 900 m away from plots.

Ether-extractable fat content of birds close to plots reached a peak in January while fat content of birds far from plots peaked in December (Table 3). As with bird weights, body fat of birds close to and far from plots decreased in late winter; however, the magnitude of the decrease was less among birds close to plots compared with birds far from plots (Fig. 2).

Since both bird weight and fat content exhibited a quadratic relationship with season, one would expect body weight and body fat content to be correlated. An analysis of these variables disclosed such a relationship, significant at the $P<0.01$ level, for all birds and for those killed within the 2 distance classes. During winter months (January-March), the slopes of the linear regressions were different ($P<0.01$) for birds killed close to plots and for those killed farther than 900 m from plots (Fig. 3). The steeper slope (and higher value) exhibited by birds killed close to plots might have resulted from the greater amount of fat contained in these birds. Minor day-to-day weight changes in birds close to plots could be accomplished by a fluctuation in fat content of that bird whereas changes in weight of a lean bird might not be possible by changes in fat content alone.

Importance of Fat Reserves

Fretwell (4) has shown that year-to-year survival of fat birds is greater than survival of lean birds. Such should not be surprising since fat is essentially reserve energy for a bird. Data collected during my study showed that birds living near food plots have more energy reserves during the critical winter months than birds living farther than 900 m from plots. By incorporating these field data with laboratory bioenergetics data for bobwhite quail (3), it is possible to evaluate the importance of these energy reserves to bobwhite quail. It is assumed that energy reserves will be of greatest value during winter months, therefore, I will compare the "starvation protection" afforded by fat reserves of bobwhites collected near food plots with that of bobwhites collected more than 900 m from a food plot. For this example, I will assume an ambient temperature of 5 C (representative of the January-March period in Knasas), a 190-g quail whose dry weight is 40% of its wet weight, a quail with a fat content of 15% of its dry weight, and an energy need 1.3 X the existence-energy requirement of a confined quail. This 190-g quail would require 60.74 kcal (46.72 kcal X 1.3) of energy per day (3). For this example, I am assuming further that only stored fat constitutes an energy reserve (not true in fact), that all but 3% of the fat in the bird is available for use as reserve energy, and that metabolism of 1 gram of fat by the quail produces 9.3 kcal of energy for the bird. Based on these conditions, this bird would be able to withstand complete starvation for approximately 1.4 days by existing on his stored fat energy alone. The calculations are shown below.

190 g quail X 0.40 dry wgt = 76 g dry wgt

76 g dry wgt X 0.12 fat = 9.12 g metabolizable fat reserves

9.12 g fat X 9.30 kcal/g = 84.82 kcal reserve energy

84.82 kcal ÷ 60.74 kcal/day = 1.40 days of reserve energy

By substituting actual field data obtained in this study wherever possible in the above calculations, the "starvation-protection" afforded wild bobwhite quail by food plots can be estimated.

Birds at <600 m from a food plot

193.2 g quail X 0.40 dry wgt = 77.3 g dry wgt

77.3 g dry wgt X 0.17 fat = 13.14 g metabolizable fat reserves

13.14 g fat X 9.30 kcal/g = 122.18 kcal reserve energy

122.18 kcal ÷ 60.74 kcal/day = 2.01 days of reserve energy

Birds at >900 m from a food plot

184.1 g quail X 0.40 dry wgt = 73.6 g dry wgt

73.6 g dry wgt X 0.10 fat = 7.36 g metabolizable fat reserves

7.36 g fat X 9.30 kcal/g = 68.48 kcal reserve energy

68.48 kcal ÷ 60.74 kcal/day = 1.13 days of reserve energy

Seldom do conditions exist in which quail can obtain no food whatsoever. Likewise, some energy can be obtained by the catalysis of proteins in the body, and energy can be conserved by reduced activity and covey formation (3). Disregarding these variables, or assuming they are constants for birds within 600 m of a food plot and birds 900 m or more distant from a food plot, it is possible to use the results of the above calculations to reflect the effectiveness of food plots for bobwhite quail on the Fort Riley Military Reservation. Regarding fat reserves alone (excluding 3% unavailable fat), quail close to a food plot during winter have 13.14 g of fat reserves while those far from a food plot have only 7.36 g. Therefore, birds close to food plots have more reserve energy, providing a potential "starvation protection" 79% greater than birds not having access to a food plot. These extra reserves of energy are no doubt extremely important for bird survival during periods of winter cold and food shortage.

Although the effect of low energy reserves on reproductive behavior has not been studied intensively in bobwhites, data from research on ring-necked pheasants (<u>Phasianus colchicus</u>) indicate possible effects. Breithenbach et al. (2), Gates and Woehler (5), and Barrett and Bailey (1) reported that food restrictions resulting in weight losses in late winter could retard the onset of egg-laying in ring-necked pheasants. Furthermore, Breitenbach et al. (2) and Gates and Woehler (5) reported a reduction in total egg production in ring-necked pheasants which were in poor condition due to a limited energy intake.

Obviously there is a need for controlled research on the influences of fat reserves on bobwhite quail survival and reproductive success. I hope results presented in this paper will stimulate work in this interest.

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Table 1. Monthly distribution by sex and age of 164 bobwhite quail analysed for body fat during this study.

Month	1968-69				1969-70				1970-71				1971-72				Entire study				Pooled
	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	Ad M	Juv M	Ad F	Juv F	
September	--	4	1	6	--	1	--	1	--	--	--	--	--	--	--	--	--	5	1	7	13
October	--	--	--	--	1	4	1	4	1	4	1	5	--	--	--	--	2	8	2	9	21
November	1	6	--	3	--	--	--	--	--	--	--	--	1	4	1	4	2	10	1	7	20
December	--	--	--	--	--	6	1	3	2	2	1	5	1	2	1	4	3	10	3	12	28
January	2	5	--	2	2	2	1	6	1	2	1	5	2	--	--	--	7	9	2	13	31
February	--	--	--	--	1	3	1	3	2	1	1	4	--	4	--	4	3	8	2	11	24
March	3	3	--	3	2	4	2	3	--	3	--	4	--	--	--	--	5	10	2	10	27
Totals	6	18	1	14	6	20	6	20	6	12	4	23	4	10	2	12	22	60	13	69	164

Table 2. Weights (grams) of all bobwhite quail analyzed for body fat; as well as those collected within 600 m of food plots, and those collected 900 m or more from food plots.

Collected	All Birds		Distance from food plots[1/]			
			0 to 600 m		>900 m	
	N	Weight ± S.E.	N	Weight ± S.E.	N	Weight ± S.E.
September	13	178.2 ± 4.2	1	162.3 ± --	8	176.1 ± 4.0
October	21	184.0 ± 2.5	15	183.9 ± 3.4	2	184.6 ± 2.2
November	20	191.2 ± 3.6	13	195.5 ± 4.2	7	187.3 ± 5.2
December	28	196.3 ± 3.3	11	192.8 ± 3.3	17	198.6 ± 5.0
January	31	191.9 ± 2.0	15	197.4 ± 3.6**	15	187.7 ± 3.1
February	24	193.8 ± 2.5	10	194.5 ± 2.3*	13	188.1 ± 2.6
March	27	183.1 ± 3.3	13	187.4 ± 3.1**	14	176.6 ± 3.6

1/ Birds killed between 600 and 900 m of a food plot excluded (see text).

* Significantly greater (P<0.10) than weight in other distance class.

**Significantly greater (P<0.05) than weight in other distance class.

Table 3. Content of ether extractable fat in carcasses of all bobwhite quail collected during this study as well as those collected within 600 m of a food plot and those collected farther than 900 m from a food plot.

	Ether extractable fat (percent dry weight)					
	All birds		Distance from food plots[1/]			
Month			0 to 600 m		>900 m	
collected	N	Percent ± S.E.	N	Percent ± S.E	N	Percent ± S.E.
September	13	7.29 ± 0.35	1	7.79 ± --	8	7.23 ± 0.47
October	21	9.45 ± 1.19	15	9.78 ± 1.50	2	7.01 ± 0.33
November	20	12.90 ± 0.98	13	13.63 ± 1.29	7	11.52 ± 1.43
December	28	17.30 ± 1.39	11	14.50 ± 2.11	17	19.12 ± 2.07
January	31	20.13 ± 1.69	15	24.43 ± 2.23**	15	16.37 ± 2.16
February	24	16.75 ± 1.22	10	19.35 ± 2.18*	13	14.75 ± 1.26
March	27	14.46 ± 2.46	13	15.40 ± 1.26***	14	9.37 ± 0.80

1/ Birds killed between 600 and 900 m of a food plot excluded (see text).

* Significantly greater (P<0.10) than fat content of comparable birds in other distance class.

** Significantly greater (P<0.05) than fat content of comparable birds in other distance class.

***Significantly greater (P<0.01) than fat content of comparable birds in other distance class.

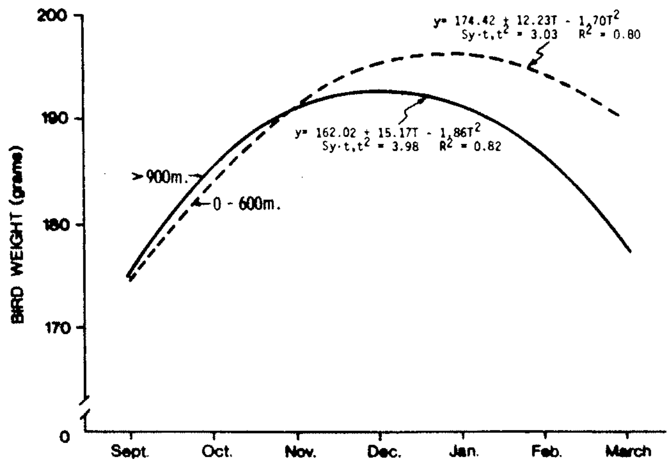


Fig. 1. Comparison between weights of 78 bobwhites collected within 600 m of a food plot and the weights of 76 birds collected more than 900 m from a food plot.

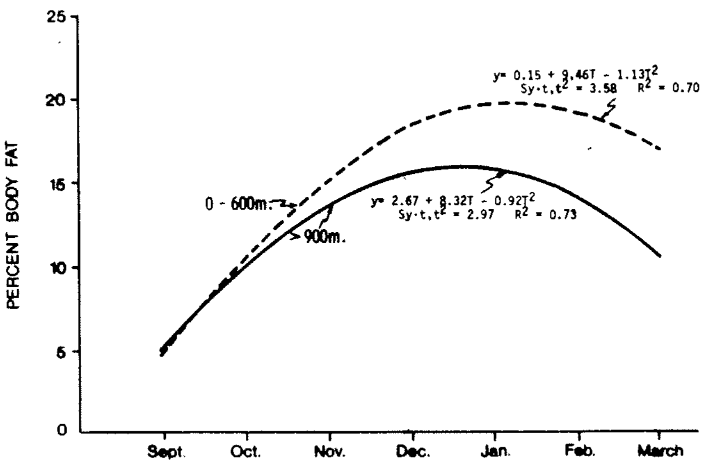


Fig. 2. Percent (dry weight) ether-extractable fat in carcasses of 78 bobwhites collected within 600 m of a food plot compared with fat content in 76 quail collected over 900 m from a food plot.

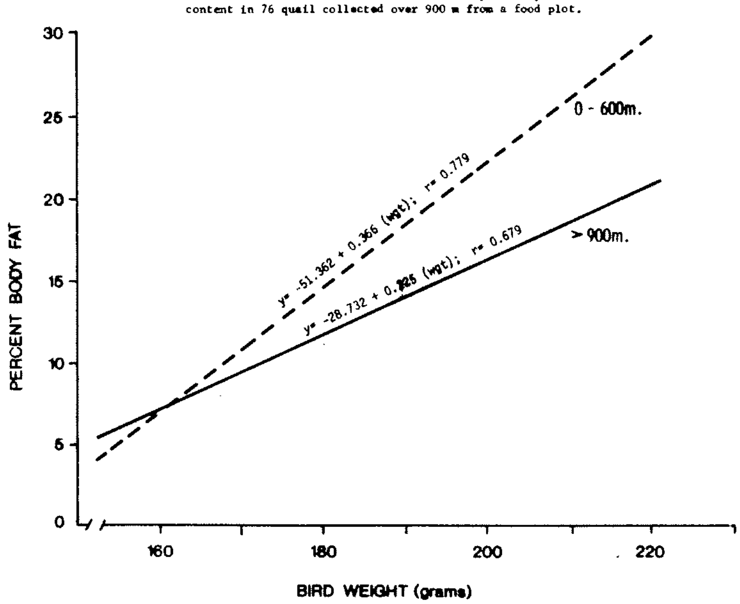


Fig. 3. Relationship between ether-extractable fat and weights of bobwhites collected during winter (January-March) within 600 m of a food plot and farther than 900 m from a food plot. Both correlation coefficients are significant ($P<0.01$).

RELATIONSHIP OF POSTBURN INTERVALS TO THE INCIDENCE AND SUCCESS OF BOBWHITE NESTING IN SOUTHWEST GEORGIA

Ronald C. Simpson, Georgia Game and Fish Commission, Albany, Georgia

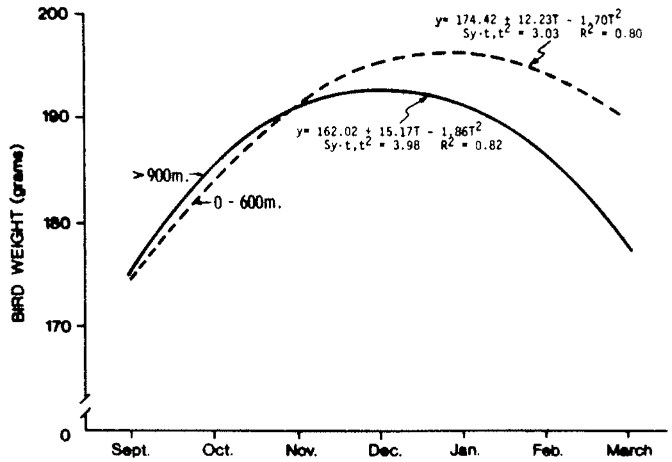
Abstract:

Data relating to the interval between the last prescribed burn and current nesting attempts were collected from 842 nests known to have contained eggs during the 1969-71 nesting seasons on a 1,262-acre area in southwest Georgia. The yearly habitat acreage per nest averaged 11.4 acres on areas burned during the current spring, 1.4 acres on areas 1 yr postburn, 2.3 acres on areas 2 yr postburn, and 1.8 acres on areas more than 2 yr postburn. One successful nest occurred per 32.0 acres on burned areas, 9.2 acres on areas 1 yr postburn, 14.5 acres on areas 2 yr postburn, and 38.0 acres on areas more than 2 yr postburn.

Initiation dates were known for 385 of the 842 nests. The occurrence of nests on burned areas was low prior to June 16. Nests on burned areas increased after June 15 (1 nest/30.1 acres/year) but the incidence was still lower than that on unburned areas (1 nest/11.1 acres/year). Data indicate that areas burned during the current spring are used by quail for nesting, but that maintenance of suitable cover conditions 1 and 2 yr postburn is the greatest benefit to nesting derived from prescribed burning.

Prescribed burning has long been used in managing land for bobwhite quail (*Colinus virginianus*). During the past few years, a number of studies have been conducted on prescribed burning done to maintain cover and food supplies important to quail (1,2,5,7,8,10,11,13,14).

Predictable changes in nesting effort and success, and in the seasonal timing of these in relation to changes in vegetational succession caused by prescribed burning, are also important in formulating sound quail habitat management programs. However, only a limited amount of data are available on the effect of prescribed burning on nest-site selection, initiation dates of nesting, and nesting success. Dimmick (3), in reporting on the influence of controlled burning on bobwhite nesting patterns in Tennessee, stated that there was no significant difference between nesting success or peak periods of nest construction on burned and unburned areas. He did find that unburned areas were utilized earlier in the nesting season than were burned areas. Eighty percent of the Tennessee nests were in unburned habitat and 21% in burned habitat. Stoddard (12) reported that in the Thomasville, Georgia - Tallahassee, Florida area 89% of the nests were in growth of the preceding season and only 8% on ground burned over during the preceding winter. Rosene (9) noted that over 80% of the nests he located were in unburned cover. Klimstra and Scott (6) found in Illinois that dead vegetation from only the previous or current year was used in virtually all nest construction. It was indicated that burning on their study area would have an undesirable effect on quail nesting.



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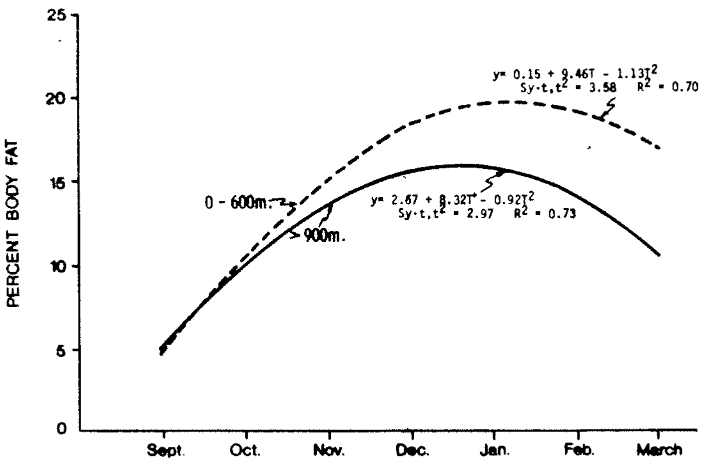

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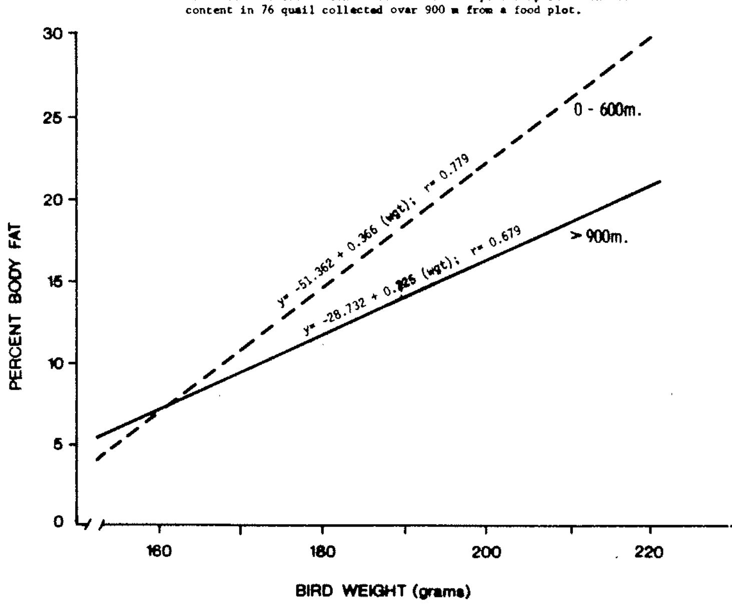

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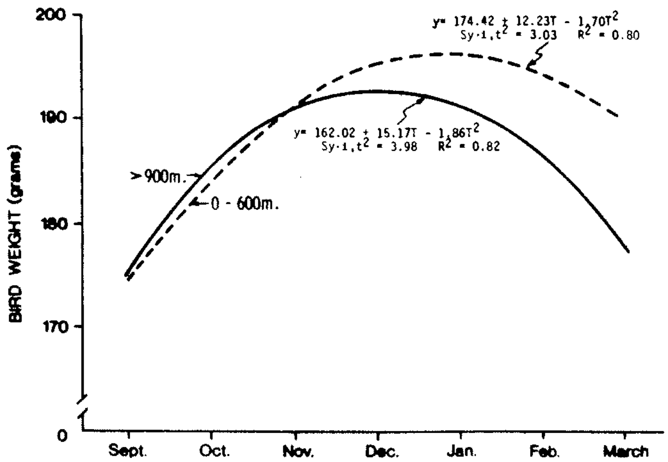

Fig. 1. Comparison between weights of 78 bobwhites collected within 600 m of a food plot and the weights of 76 birds collected more than 900 m from a food plot.

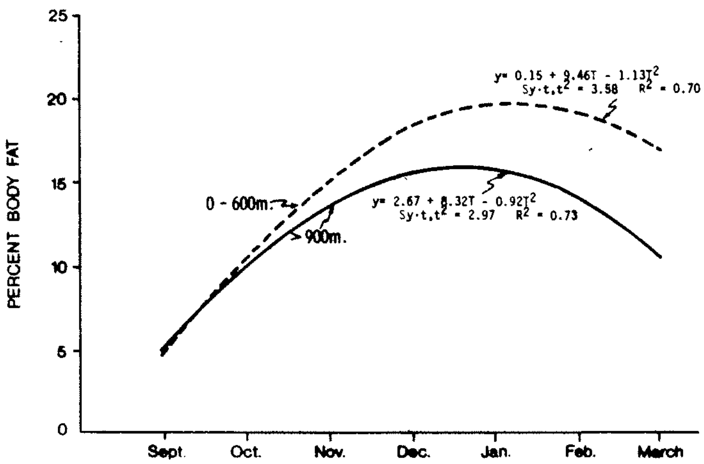

Fig. 2. Percent (dry weight) ether-extractable fat in carcasses of 78 bobwhites collected within 600 m of a food plot compared with fat content in 76 quail collected over 900 m from a food plot.

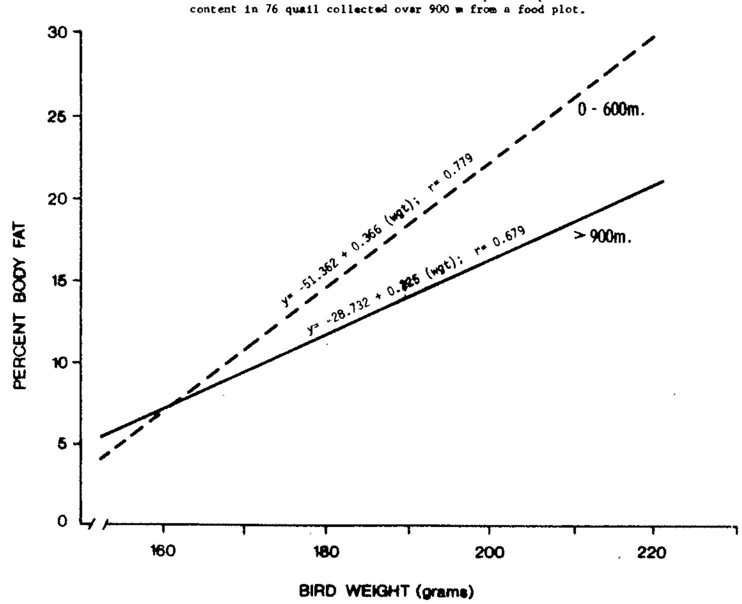

Fig. 3. Relationship between ether-extractable fat and weights of bobwhites collected during winter (January-March) within 600 m of a food plot and farther than 900 m from a food plot. Both correlation coefficients are significant (P<0.01).

RELATIONSHIP OF POSTBURN INTERVALS TO THE INCIDENCE AND SUCCESS OF BOBWHITE NESTING IN SOUTHWEST GEORGIA

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Abstract:

Data relating to the interval between the last prescribed burn and current nesting attempts were collected from 842 nests known to have contained eggs during the 1969-71 nesting seasons on a 1,262-acre area in southwest Georgia. The yearly habitat acreage per nest averaged 11.4 acres on areas burned during the current spring, 1.4 acres on areas 1 yr postburn, 2.3 acres on areas 2 yr postburn, and 1.8 acres on areas more than 2 yr postburn. One successful nest occurred per 32.0 acres on burned areas, 9.2 acres on areas 1 yr postburn, 14.5 acres on areas 2 yr postburn, and 38.0 acres on areas more than 2 yr postburn.

Initiation dates were known for 385 of the 842 nests. The occurrence of nests on burned areas was low prior to June 16. Nests on burned areas increased after June 15 (1 nest/30.1 acres/year) but the incidence was still lower than that on unburned areas (1 nest/11.1 acres/year). Data indicate that areas burned during the current spring are used by quail for nesting, but that maintenance of suitable cover conditions 1 and 2 yr postburn is the greatest benefit to nesting derived from prescribed burning.

Prescribed burning has long been used in managing land for bobwhite quail (*Colinus virginianus*). During the past few years, a number of studies have been conducted on prescribed burning done to maintain cover and food supplies important to quail (1,2,5,7,8,10,11,13,14).

Predictable changes in nesting effort and success, and in the seasonal timing of these in relation to changes in vegetational succession caused by prescribed burning, are also important in formulating sound quail habitat management programs. However, only a limited amount of data are available on the effect of prescribed burning on nest-site selection, initiation dates of nesting, and nesting success. Dimmick (3), in reporting on the influence of controlled burning on bobwhite nesting patterns in Tennessee, stated that there was no significant difference between nesting success or peak periods of nest construction on burned and unburned areas. He did find that unburned areas were utilized earlier in the nesting season than were burned areas. Eighty percent of the Tennessee nests were in unburned habitat and 21% in burned habitat. Stoddard (12) reported that in the Thomasville, Georgia - Tallahassee, Florida area 89% of the nests were in growth of the preceding season and only 8% on ground burned over during the preceding winter. Rosene (9) noted that over 80% of the nests he located were in unburned cover. Klimstra and Scott (6) found in Illinois that dead vegetation from only the previous or current year was used in virtually all nest construction. It was indicated that burning on their study area would have an undesirable effect on quail nesting.

The objective of this study was to determine the relative incidence of bobwhite nests and evaluate the chronological distribution of nests and nesting success in relation to postburn intervals after prescribed burns during 1969-1971 in southwest Georgia.

Special recognition is due to Mr. John M. Olin, owner of Nilo Plantation, for providing both financial assistance, through the Georgia Game and Fish Commission, and the area upon which the study was conducted.

Mr. Gratten Parker, manager of Nilo Plantation, provided valuable assistance and co-operation during the study.

The data presented is a portion of that gathered during the quail investigations study funded through the Federal Aid to Wildlife Restoration Act under Pittman-Robertson project W-41-R and the Georgia Game and Fish Commission.

Description of Study Area

The study area is a 1,262-acre tract on Nilo Plantation in Dougherty and Baker counties, southwest Georgia. Forested land, including planted pine rows, constitute 60% of the study area, croplands 10%, open areas and idle fields 20%; the remaining 10% consists of natural ponds.

The overstory is made up primarily of slash pine (*Pinus elliottii*), longleaf pine (*Pinus palustris*), live oak (*Quercus virginiana*), southern red oak (*Quercus falcata*), post oak (*Quercus stellata*), and water oak (*Quercus nigra*). Shrubs consist mainly of sassafras (*Sassafras albidum*), sumac (*Rhus* spp.), blackberry (*Rubus* spp.), and oak sprouts (*Quercus* spp.). Herbaceous plants consist primarily of broomsedge grass (*Andropogon* spp.), panic grass (*Panicum* spp.), Indian grass (Sorghastrum *secundum*), aster (*Chrysopsis* spp.), beardgrass (*Gymnopogon* spp.), partridge pea (*Cassia nictitans* and *C. fasciculata*), lespedeza (*Lespedeza* spp.), beggarweed (*Desmodium* spp.), dogfennel (*Eupatorium* spp.), and ragweed (*Ambrosia* spp.).

Since the initiation of this study, the fall population has exceeded 2 quail/acre. As evidenced by the high population density, the area is managed intensively for quail. Habitat management consists mainly of prescribed burning, planting food patches, and cultivating fields usually of no more than 5 acres. Supplemental feeding is conducted during winter and early spring. Predator control using steel traps was more intensive before 1969 than in 1969-71.

Within the 1,010 acres of nesting habitat present, during the 3 years of study, an annual average of 662 acres (66%) was burned each year; of the 348 acres (34%) of unburned habitat, 233 acres (23%) were at 1 yr, 77 acres (8%) at 2 yr, and 38 acres (3%) at more than 2 yr postburn. Unburned areas were small, having maximum sizes of 2 or 3 acres each in 1969 and 1970. In 1971, unburned areas, due to design and wet burning conditions, ranged up to 40 acres each, with 4 areas containing 20 acres or more. A considerable portion of these larger areas in 1971 were in pond areas that are excluded from nesting cover acreage.

Procedures

The study was conducted during the nesting seasons of 1969, 1970, and 1971. Personnel, consisting of 3 individuals, made daily searches for nests from May through August each year. They were each assigned a different section of the area and usually worked independently. All cover areas, whether considered prime nesting habitat or not, were searched on foot with the aid of a staff for parting vegetation. Two to 3 weeks were required to cover the entire study area once. When found, a nest was flagged with colored plastic surveying tape. Flags were placed far enough away from active nests to avoid attracting predators to the nest sites. Active nests were usually checked once a week. Some nests were visited more frequently near their estimated hatch dates. The area around active nests was disturbed as little as possible.

Initiation dates of nests were determined by back dating with the following criteria: 23 days for incubation, 1 day between cessation of laying and incubation, 1 day per egg deposited in a nest, 2 days between construction and laying, and 1 day for construction. The time intervals were obtained from data collected during this study. The interval per egg deposited in a nest is slightly greater than the mean (0.8 eggs per nest per day), but is approximately the same as the observed mode for egg production.

Prescribed burning was conducted in late March and early April by plantation personnel. Little effort was made to leave unburned areas of any certain size, particularly during 1969 and 1970.

Results and Discussion

Nesting and Nesting Success in Relation to Postburn Interval

The interval since the last prescribed burn was known for sites of 842 quail nests containing eggs during the 3 nesting seasons. Nests occurring on areas burned in the current spring totaled 174 (21%). Nests on unburned areas in relation to the interval since the last prescribed burn numbered 503 (60%) on areas 1 yr postburn, 101 (12%) on areas 2 yr postburn, and 64 (8%) on areas more than 2 yr postburn.

Areas left unburned for 1 year (Table 1) were the most preferred nesting habitat with 1 nest occurring per 1.4 acres. Areas burned in the current spring were least preferred, with 1 nest occurring per 11.4 acres; however, burned habitat became more favorable during the latter portion of the nesting season than it was during the early season. This will be discussed later in more detail.

Unsuccessful nests, those producing no chicks, made up 685 (81%) of the 842 nests. The distribution of these nests according to postburn intervals closely paralleled that of all nests (Table 1). Areas 1 yr postburn had the highest incidence of nests, containing 1 nest per 1.6 acres, and areas burned in the current spring had the lowest, with 1 nest per 17.8 acres.

Successful nests totaled 157 (19%) of the total nests observed. Nesting success was significantly greater on burned areas than on unburned (Chi-square, $P < 0.05$). Nesting success according to burn interval was 36% on areas burned in the current year, 15% on areas 1 yr postburn, 16% on areas 2 yr postburn, and 5% on areas more than 2 yr postburn.

Areas burned in the current spring were relatively unproductive in spite of the lower nesting effort per successful nest, from the standpoint of the amount of habitat per successful nest. The yearly average of the number of acres of habitat per successful nest was 32.0 for areas burned in the current spring, 9.2 on areas 1 yr postburn, 14.5 on areas 2 yr postburn, and 38.0 on areas more than 2 yr postburn (Table 1). Thus, it is evident that despite a smaller proportion of successful nests to total nests on areas 1 and 2 years postburn, when compared to that for areas burned the current spring, a higher number of successful nests occurred per unit of habitat.

It is also evident that the postburn interval (Table 1) did not have as much influence on the use of unburned areas for nesting as it did on nesting success. The incidence of successful nests on unburned areas having a 1-yr-postburn interval was about 58% higher than on areas 2 yr postburn and 318% higher than on areas more than 2 yr postburn.

Nest Initiation Dates and Burn Interval

Initiation dates and postburn intervals were known for 385 nests active when found. Eighty of the nests (21%) occurred on areas burned during the current spring and 305 nests (79%) on unburned areas.

A comparison of the distribution of initiation dates of all nests and of unsuccessful nests through the season, according to interval since the last burn, revealed little difference between the 3 unburned categories. The chronological distribution of successful nests did differ. This could be due, however, to the small number of successful nests in the 2- and more than 2-yr-postburn intervals. Because the initiation dates of nests occurring on the 3 categories of unburned areas corresponded so closely, the combined total of these were compared with the distribution of nest initiation dates on areas burned in the current spring.

The period of greatest nesting on areas burned during the current spring was later in the nesting season than the peak nesting period on unburned areas. A comparison of initiation dates for nests on areas burned during the current spring to those for nests on unburned areas indicated that burned habitat became desirable for nesting during the latter part of June (Table 2). Herbaceous cover had developed to a suitable density for screening of nests and quail movement. Also, pine needle cast, pine needles being a major nest material, had begun by this period. During this period prior to 16 June, unburned areas were utilized much more than burned areas. However, the use of unburned areas decreased after 15 June and the use of burned areas increased. Of the 225 nests begun prior to 16 June, 14 nests (6%) were on burned areas (66% of the study-area nesting cover) and 211 nests (94%) on unburned areas (34% of the study-area nesting cover). Nests initiated after 15 June totaled 160, of which 66 nests (41%) were on burned areas and 94 nests (59%) on unburned areas. The decline in nesting attempts after 15 June on unburned areas, particularly areas 1 yr postburn, was not necessarily due to these areas becoming less desirable but because the burned areas had become suitable nesting habitat and constituted a higher percentage of the nesting cover present.

Two peaks of nest initiation were evident on areas burned in the current spring and 1 peak on unburned areas. The first peak on burned areas was about 1 month later than the peak on unburned areas. The peaks of nest construction were 16 May - 15 June on unburned areas and 1-15 July and 1-15 August on burned areas. The overall peak period of construction of all nests, with initiation dates of nests on burned and unburned areas combined, was 1-15 June, after which there was a steady decline in nests initiated.

Additional information relating to prescribed burning and its effect on quail nesting was gained by determining nest initiation dates on the basis of nesting success. Of the 385 nests with known initiation dates, 107 nests were successful and 278 nests unsuccessful.

Initiation dates of unsuccessful nests on areas burned in the current spring and on unburned areas made up a large percentage of initiation dates for all nests, and thus paralleled initiation dates for all nests (Table 3). The nests started before 16 June totaled 192 of which 9 nests (5%) were on burned areas and 187 nests (95%) were on unburned. Of the 82 unsuccessful nests begun after 15 June, 29 nests (35%) were on burned areas and 53 nests (65%) were on unburned areas. Peaks of initiation occurred during the period 1-15 August on burned areas and 16-31 May on unburned areas.

No successful nests were initiated before June on areas burned in the current spring (Table 4). However, few nests were constructed on burned areas before this date. Of the successful nests initiated before 16 June, 17% were on burned areas and 83% on unburned areas. The percentage of the successful nests initiated after 15 June on areas burned in the current spring and on unburned areas was about even, 47% and 53% respectively.

The peaks of initiation of successful and of all nests on areas burned in the current spring were the same, 1-15 July and 1-15 August. Peaks of successful nest construction on unburned areas occurred 1-15 June and 1-15 July. However, the number of nests initiated for the periods 1-15 June, 16-30 June, 1-15 July, and 16-31 July were relatively constant.

Despite the increase in occurrence of successful nests with improvement of cover conditions as the nesting season progressed, the amount of habitat acreage per successful nest for areas burned in the current spring was still higher than that for unburned areas (Table 5). Of the successful nests initiated after 15 June, 1 nest occurred per 53.8

acres of nesting cover on burned areas as compared to 1 nest per 25.4 acres on unburned areas. It must be concluded that while successful nests on areas burned in the current spring compose a higher proportion of the successful nests during late season than during the early season, the most valuable nesting benefit derived from prescribed burning is in creating suitable nesting cover conditions that usually exist 1 and 2 years postburn (4).

The low success for nests initiated prior to June was due to nest predation. This was influenced partly by the burning design, i.e., percent of the area annually burned and the size of individual areas of unburned habitat. The bobwhites, along with cottontail rabbits (*Sylvilagus floridanus*) and various ground-nesting birds and rodents, were concentrated during their respective periods of breeding activity on the 34% of the cover area that was unburned. Predators heavily utilized the unburned cover as feeding areas because of this concentration. When cover on the burned areas became suitable for use, nesting attempts were spread over the entire area and made discovery by predators more difficult.

During the study period, the concentration of the majority of successful nests in late summer had no measurable adverse effects on fall population densities. However, in a year that had unfavorable environmental conditions for good nesting success or chick survival during August or September, the fall population density could be substantially reduced. Additional study of burning design is needed in order to be able to maintain habitat as near optimum as possible for quail and increase the success of nesting attempts initiated before mid-June.

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Table 1. Number of nests and the number of acres of habitat per nest in relation to postburn intervals.

Postburn interval	No. of acres	No. of nests			Average yearly amount of habitat/nest (acres)		
		Total	Unsucc.	Success.	Total	Unsucc.	Success.
None	662	174	112	62	11.4	17.8	32.0
1 Yr	233	503	427	76	1.4	1.6	9.2
2 Yr	77	101	85	16	2.3	2.7	14.5
>2 Yr	38	64	61	3	1.8	1.9	38.0

Table 2. Incidence of active nests according to initiation date and interval since prescribed burn.

Initiation dates	Burned in spring	Unburned in spring			Total
		1 yr.	2 yr.	>2 yr.	
March 16-31	-	-	1 (2.1%)	-	1 (.3%)
April 1-15	-	5 (2.2%)	1 (2.1%)	-	6 (2.0%)
April 16-30	3 (3.6%)	28(12.4%)	9 (18.8%)	5 (15.6%)	42 (13.8%)
May 1-15	2 (2.5%)	30(13.3%)	9 (18.8%)	7 (21.9%)	46 (15.1%)
May 16-31	3 (3.6%)	46(20.4%)	6 (12.5%)	6 (18.8%)	58 (19.0%)
June 1-15	6 (7.5%)	46(20.4%)	5 (10.4%)	7 (21.9%)	58 (19.0%)
June 16-30	14(17.5%)	26(11.6%)	7 (14.6%)	5 (15.6%)	38 (12.5%)
July 1-15	18(22.5%)	20 (8.9%)	2 (4.2%)	1 (3.1%)	23 (7.5%)
July 16-31	12(15.0%)	12 (5.3%)	4 (8.3%)	-	16 (5.2%)
August 1-15	18(22.5%)	6 (2.7%)	3 (6.3%)	1 (3.1%)	10 (3.3%)
August 16-31	4 (5.0%)	6 (2.7%)	1 (2.1%)	-	7 (2.3%)
Total	80(99.7%)	225(99.9%)	48(100.2%)	32(100.0%)	305(100.0%)

Table 3. Incidence of unsuccessful active nests according to initiation date and interval since prescribed burn.

Initiation dates	Burned in spring	Unburned in spring			Total
		1 yr.	2 yrs.	>2 yr.	
March 16-31	-	-	-	-	-
April 1-15	-	4 (2.3%)	1 (2.6%)	-	5 (2.1%)
April 16-30	3 (7.9%)	26(15.1%)	9 (23.7%)	5 (16.7%)	40 (16.7%)
May 1-15	2 (5.3%)	26(15.1%)	9 (23.7%(	7 (23.3%)	42 (17.5%)
May 16-31	3 (7.9%)	41(23.8%)	6 (15.8%)	6 (20.0%)	53 (22.1%)
June 1-15	1 (2.6%)	36(20.9%)	4 (10.5%)	7 (23.3%)	47 (19.6%)
June 16-30	5 (13.2%)	18(10.5%)	5 (13.2%)	5 (16.7%)	28 (11.7%)
July 1-15	6 (15.8%)	12 (7.0%)	-	-	12 (5.0%)
July 16-31	7 (18.4%)	4 (2.3%)	2 (5.3%)	-	6 (2.5%)
August 1-15	9 (23.7%)	4 (2.3%)	1 (2.6%)	-	5 (2.1%)
August 16-31	2 (5.3%)	1 (.6%)	1 (2.6%)	-	2 (.8%)
Total	38(100.1%)	172(99.9%)	38(100.0%)	30(100.0%)	240(100.1%)

Table 4. Incidence of successful active nests according to initiation dates and interval since prescribed burn.

Initiation dates	Burned in spring	Unburned in spring 1 yr.	2 yr.	>2 yr.	Total
March 16-31	-	-	1 (10.0%)	-	1 (1.5%)
April 1-15	-	1 (1.9%)	-	-	1 (1.5%)
April 16-30	-	2 (3.8%)	-	-	2 (3.1%)
May 1-15	-	4 (7.5%)	-	-	4 (6.2%)
May 16-31	-	5 (9.4%)	-	-	5 (7.7%)
June 1-15	5 (11.9%)	10 (18.9%)	1 (10.0%)	-	11 (16.9%)
June 16-30	9 (21.4%)	8 (15.1%)	2 (20.0%)	-	10 (15.4%)
July 1-15	12 (28.6%)	8 (15.1%)	2 (20.0%)	1 (50.0%)	11 (16.9%)
July 16-31	5 (11.9%)	8 (15.1%)	2 (20.0%)	-	10 (15.4%)
August 1-15	9 (21.4%)	2 (3.8%)	2 (20.0%)	1 (50.0%)	5 (7.7%)
August 16-31	2 (4.8%)	5 (9.4%)	-	-	5 (7.7%)
Total	42(100.0%)	53(100.0%)	10(100.0%)	2(100.0%)	65(100.0%)

Table 5. Acres of habitat per nest initiated before June 16 and after June 15 in relation to postburn interval.

Nest classification	Date initiated	Average yearly habitat (acres)/nest: Burned in spring	Unburned in spring 1yr.	2yr.	>2yr.	Total
Total	Before June 16	140.9	3.0	7.5	4.6	5.0
	After June 15	30.1	10.0	13.5	16.5	11.1
Unsuccessful	Before June 16	220.7	5.3	7.9	4.6	5.6
	After June 15	68.2	17.9	25.7	22.4	19.7
Successful	Before June 16	389.4	31.9	110.0*	--	45.2
	After June 15	53.8	22.6	28.5	54.3*	25.4

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THE INTERSPERSION INDEX AS A TECHNIQUE FOR EVALUATION OF BOBWHITE QUAIL HABITAT

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Abstract:

An index based on the interspersion of vegetative types proved useful in evaluating quail habitat. Application of the technique for related studies indicated that interspersion indices may find wider application for assessing habitat deficiencies, for evaluating land areas for production of a diversity of wildlife species, and for planning.

Over 40 years ago, the concept of habitat interspersion was advanced by Aldo Leopold (6). Indicating then that "we are only on the threshold of an understanding of the ecology of game species," Leopold went on to postulate his law of interspersion that recognized "game is a phenomenon of edges." Although the validity of Leopold's premises have been documented both directly and indirectly many times in the past 4 decades, the complexity and frustration in describing ecological diversity of game range has continued to pose a problem for wildlife managers.

On the basis of recognition and use alone, the terms interspersion and diversity were not commonly part of wildlife jargon for many years. Even though the concepts were recognized, they were undefined both quantitatively and qualitatively. The Wildlife Review, for example, carried neither of these terms in its index from 1935 to 1951. Hammerstrom, Mattson and Hammerstrom (3) were perhaps the earliest investigators to demonstrate the validity of Leopold's concepts in their work to maintain the prairie chicken in Wisconsin. They related the interspersion of habitat types to the mobility of prairie chickens, and investigated the tolerance of the species to variation in composition and interspersion of habitat. Kelker (5) rephrased Leopold's law, stating "the abundance of resident species requiring two or more cover types appears to depend on the interspersion of numerous small blocks of such types."

More recently, Pimlott (8) stated, "the message is clear that diversity of habitat is the life blood of the majority of species and the ramifications extend from the subsistance of an individual to the viability of a population and to the survival of the species." Assuming that most wildlife managers agree with this premise, the task of developing a method for evaluating habitat diversity is an important need.

That early wildlife investigators recognized deficiencies of habitat and of management steps needed to correct them is evident. Stoddard (9) in his monumental classic on bobwhite quail management, listed in detail the steps needed for transforming nonproductive quail cover to that capable of producing and carrying significant bobwhite densities. Leopold (6) and Errington and Hammerstrom (2) provided the basic approach to studying food and cover requirements for effective game management. Fundamental habitat concepts were delineated by Kabat and Thompson (4) as related to Wisconsin bobwhites. Their quail:hedgerow-mile index was a primary step in providing a usable descriptive tool for game managers. Leopold's interspersion concepts were finally "coming home."

Today's rapid change in land-use patterns coupled with ever-increasing human demands have placed an increasing burden on the contemporary wildlife manager. Faced with the need to optimize every environmental effect and to defend his decisions, the manager needs a definitive expression of habitat quality. This need, in recent years, has not been confined to wildlife interests alone. Resource planners, also, have encountered situations containing pressing needs to describe recreational land values and potentials for management. There is now an additional need to interface wildlife habitat values with highway corridors, urban and rural population shifts, and other land-use changes brought about by expanding technology and economic growth.

Because of the need to define habitat quality in Nebraska's quail management program, a study was initiated to empirically measure the quality of quail habitat and to determine if this could be related to quail population indices.

The study area consisted of 3 counties, containing some of Nebraska's best bobwhite habitat, located in the southeast portion of the State. From north to south, the area included Cass, Otoe, and Pawnee Counties.

Cass, Otoe, and Pawnee Counties are part of an eroded glacial drift plain capped with Loveland and Peorian loess, both being wind-deposited formations. The soils that developed under the influence of tall-grass vegetation are characterized by high organic matter, granular structure, and a comparatively uniform chemical composition.

The climate in this region is typical of areas situated near the center of a large continent in the temperate zone: warm summers, cold winters, and moderate precipitation. The mean annual temperature is approximately 51 F; the mean annual precipitation is 30 inches; and the mean relative humidity is 70%. The average growing season is 156 to 167 days.

Procedures

Preliminary studies, based on 3 previously established, 20-mile-long bobwhite audio-census routes, 1 in each county, were devised to quantitatively evaluate land use. Aerial photographs were examined in the county ASCS offices to measure existing land use along each route. Using a polar planimeter, habitat acreage was measured in 0.5-mile-wide transects along each side of the route based on the following classification:

1. Cropland (row crops, small grains, legumes)
2. Grassland (pastures, native prairie, grassed waterways, fence rows)
3. Woody vegetation
4. Farmsteads (parcels of land containing houses, outbuildings, etc.)
5. Miscellaneous (stock ponds, quarries, roadways)

Assuming that the audio census used in these counties provided an accurate index of the number of whistling males within 0.5 mile on either side of a census route, we measured the habitat within these limits along the length of each route. We located the audio-census route on aerial photographs (660 ft/inch scale) then superimposed the sample transect along the route, extending the width to 0.5 mile on each side (Fig. 1).

We derived the interspersion index by drawing lines diagonally across each quarter section of land bordering the audio-census routes (Fig. 1), then counting the number of times the established vegetation classifications changed along the course of each line. The number of changes in each line in each quarter section was summed (Fig. 2). The quarter-section totals were then summed to determine the total for each route.

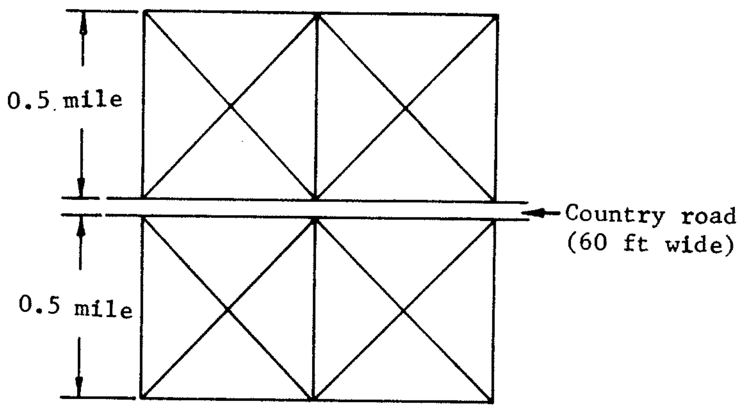
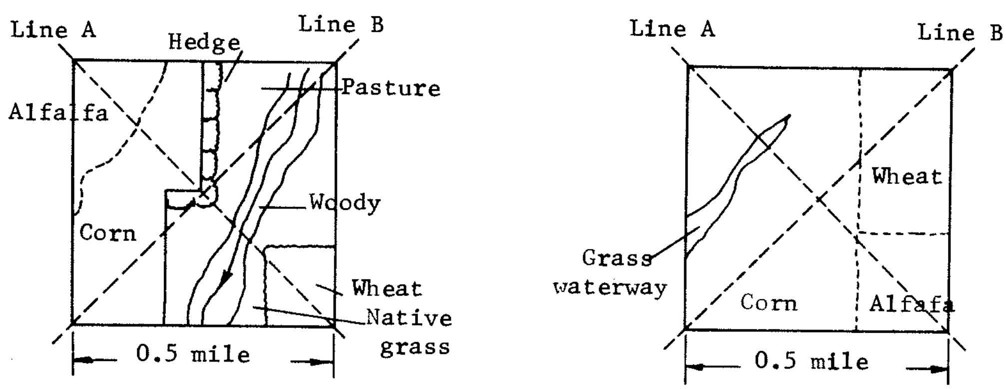


Figure 1. Diagram of diagonal lines used in calculating the interspersion index



Sample Calculation of Interspersion Index

Area 1	Area 2
Line A = 6	Line A = 3
Line B = 5	Line B = 1
I-index = 11	I-index = 4

Sample Calculation of Interspersion Index

Area 1	Area 2
Line A = 6	Line A = 3
Line B = 5	Line B = 1
I-index = 11	I=index = 4

Figure 2. Determination of interspersion index from simulated aerial photographs

The interspersion index simply represented the number of changes from 1 cover type to another. The relationship of the interspersion index to the audio-census data for each route was calculated by linear correlation.

Findings

Land use along the 3 quail-census routes as determined from aerial photographs is presented in Table 1.

Table 1. Comparative land-use patterns in Cass, Otoe, and Pawnee Counties

	Cass		Otoe		Pawnee	
Land-use	Acres	% Total acres	Acres	% Total acres	Acres	% Total acres
Cropland	10,828.5	83.81	9,685.8	78.21	5,801.3	43.69
Grassland	747.2	5.78	1,590.6	12.85	5,001.5	37.66
Woodland	1,111.0	8.60	981.9	7.93	2,298.7	17.31
Farmsteads	153.7	1.19	105.6	0.85	130.7	0.98
Miscellaneous	79.8	0.62	20.1	0.16	47.8	0.36
Total acres sampled	12,920.2	100.00	12,384.0	100.00	13,280.0	100.0

The number of acres sampled along the transects ranged from 12,384 in Otoe County to a high of 13,280 in Pawnee County. These data show that very noticeable land-use differences existed among the counties. The intensity of agricultural land use decreased from north to south. Approximately 84% of the land along the Cass County route was classified as cropland. In Pawnee County, slightly less than 44% of the land was in this category. Cropland constitutes 78% of the land along the Otoe County route.

The amount of grassland in the counties was inversely related to cropland. The percentage of grassland increased from north to south. Cass, the northernmost county, had approximately 0.5 as much grassland as Otoe County and 0.17 as much as Pawnee County, the southernmost county.

There were approximately twice as many acres of woody vegetation along the Pawnee County route as there were along either of the other routes, with the smallest acreage occurring in Otoe County. Because woody cover is an essential element of the bobwhite's habitat needs, we felt that a closer examination of woody cover characteristics was advisable.

We examined the woody cover in the northernmost and southernmost counties with respect to acreage and cover type according to the following classification:

1. Windbreaks (multiple-row tree plantings; usually associated with farm buildings)

2. Hedgerows

3. Woodland tracts less than 3 acres

4. Woodland tracts 3 to 5 acres

5. Woodland tracts 5 to 10 acres

6. Woodland tracts greater than 10 acres

Table 2 shows the distribution of woody cover areas by acreage and type in Cass and Pawnee Counties. Pawnee County exceeded Cass County in every category except windbreaks.

Table 2. Extent and distribution of woodland vegetation[a]

Woodland class	Cass		Pawnee	
	Acres	% Total woody	Acres	% Total woody
Windbreak	143.1	12.88	136.9	5.96
Hedgerow	64.9	5.84	332.0	14.44
<3 Acres	150.5	13.55	428.3	18.63
3-5 Acres	121.0	10.89	159.5	6.94
5-10 Acres	174.4	15.70	320.0	13.92
>10 Acres	457.1	41.14	922.0	40.11

[a]Data were not collected in Otoe County

The differences in categories such as hedgerows and plots up to 5 acres in size were of particular interest. Pawnee County had 5 times as many acres in the hedgerow category, 2.8 times as many tracts of woody cover less than 3 acres in size, and 1.3 times as many acres devoted to the 3- to 5- acre class.

The interspersion index values for the 3 counties were: Cass County - 404; Otoe County - 631; and Pawnee County - 984 (Table 3).

Preseason inventories of bobwhite quail populations are routinely conducted each year during July using a standardized audio-index or whistle count. Means from the Game Division's preseason inventories of bobwhite quail for the years 1964-1967 are shown in Table 3.

Table 3. Comparisons of preseason inventories of bobwhite quail (4-year average number of calls per stop) and interspersion indices.

Characteristics	Cass	Otoe	Pawnee
Mean number of calls per stop (1964-1967)	1.88	2.50	5.14
Interspersion index	404	631	984

The bobwhite quail is a species characteristically associated with edge. The interspersion indices indicated that Pawnee County had more junctions of plant communities per unit area than did Cass or Otoe Counties. Therefore, the higher preseason population inventories in Pawnee County were believed to be an expression of greater interspersion of habitat. The relationship between the interspersion and whistle-call indices was tested by linear correlation. The calculated r value of 0.976 indicated a significant correlation between quail numbers and the frequency of cover type change.

Modifications of this technique have been utilized by others within our agency as well as by other agencies. Game Division technicians have applied a field modification of this technique in most quail areas of the state. After completing the whistle-count route, the technician reverses direction and travels the route while visually recording all changes from any cover type to woody cover in or immediately adjacent to the road right-of-way. The number of cover-type changes recorded are used as an index to interspersion of woody cover in the counties. Correlation analysis of these data has indicated that a highly significant relationship exists between this index and the whistle-call index.

The interspersion index method was also used to assign wildlife values to each section of land in an 11-county ecological study conducted by our planning personnel (1). The goal of this study was to assemble information needed in the decision-making process for the conservation and enhancement of the environmental resources which have significant fish and wildlife, outdoor recreation, cultural, historic, scientific or educational values. As used in that study, the term "wildlife" meant upland game species and song birds.

Van Doren, Hazard, Stallings, and Schnacke (10), consulting engineers for the Nebraska State Department of Roads, used a highly detailed modification of the Interspersion Index to assign wildlife values to a corridor study for freeway bypasses at Lincoln, Nebraska. In determining the locations having the least social cost, 10 elements including wildlife were utilized in an overlay system similar to those utilized by McHarg (7).

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BOBWHITE POPULATIONS AND HUNTING ON ILLINOIS PUBLIC HUNTING AREAS

David Russel Vance, and Jack A. Ellis, Illinois Natural History Survey, Effingham

Abstract:

Bobwhite (*Colinus virginianus*) populations on 2 public hunting areas in Illinois have been intensely utilized by hunters since 1964. Hunting has removed an average of 60-70%, and as much as 81%, of fall bobwhite populations, with no apparent detrimental effect on subsequent population levels. Total harvest and hunting effort were both closely correlated with prehunt quail abundance. Average hunter success was low (1 bird bagged per trip). The most successful hunters were residents of the regions surrounding the areas. The highest hunting success occurred on weekdays during the first week of the season.

This paper describes some of the characteristics of quail hunting and the relationship between hunting and quail populations on 2 state-owned public hunting areas in Illinois during 1964-70. Bobwhites provide the bulk of game-bird hunting on state-owned conservation areas in southern Illinois.

We thank the personnel of the Illinois Department of Conservation's Division of Parks for their cooperation in obtaining hunting data. Paul Moore, G. C. Sanderson, W. R. Edwards, and H. C. Schultz were especially helpful in conducting and reporting the study. This paper is a contribution from Illinois Federal Aid Project W-66-R.

Methods

The study areas, Stephen A. Forbes State Park (now 2,930 acres) in Marion County and Sam Dale Lake Conservation Area (1,300 acres) in Wayne County, and the management programs on them have been described previously (3). Management of the areas has remained unchanged since 1967 with the exception of initiation of more sharecropping on Illinois Department of Conservation lands on Forbes (250-acre increase) in 1968 and on Dale (260-acre increase) in 1970.

State hunting regulations prevail on the areas (8-bird daily limit) except for shorter hunting hours and the compulsory checking procedures. Hunting hours are from 0800 to 1600 daily during the regular season which extends from mid-November to 31 December. Hunters are required to check in at the ranger station before hunting. Each hunter deposits his hunting license and receives a numbered back tag. Hunters must check out at the end of the hunt and declare all game taken. All hunting data are derived from hunter survey cards completed at the end of each hunt.

Quail censuses, using bird dogs, are conducted 3 times each year. We conduct a posthunt census in early January, a prebreeding census in March, and a prehunt census in early November. Population estimates are based on number, size, and location of individual coveys.

Results and Discussion

Hunting and Quail Populations

Results of the censuses and harvest data for 1964-1970 are presented in Table 1. Fall bobwhite populations on the Forbes and Dale Areas fluctuated throughout the study period. Population lows occurred on both areas in 1965, and both populations peaked in 1968. This trend conforms to reported statewide population trends (10).

Quail abundance determined the amount of hunting effort. Regressions of gunning pressure on prehunt quail abundance were significant ($P<0.05$) for both areas (Fig. 1). Hunting effort increased with increasing quail abundance and, as others have reported (5,7), hunter interest waned as populations decreased. Preno and Labisky (10), however, concluded that in Illinois "bobwhite hunters pursued their favorite game species with a predetermined level of effort that seemingly superseded changes in species abundance" (p. 57). This conclusion was based on a statewide sample, by mail questionnaire, of hunting license buyers and on counts of individual whistling-male bobwhites.

We also found significant ($P<0.01$) regressions (Fig. 2) of harvests on prehunt populations. Others have reported similar dependencies of harvest on abundance of bobwhites (4) and Gambel's quail (5). Preno and Labisky (10) found no relationship between indices of quail harvest and indices of quail abundance in Illinois. However, they were dealing with spring abundance rather than with fall abundance. We believe that their spring census methods could not produce an accurate index to fall populations, and that harvest does, in fact, depend on quail abundance. Fall abundance of bobwhites, rather than spring, indicates hunting opportunity. In effect, size of the quail populations on our study areas determined the amount of gunning pressure on these areas, much the same as reported for Texas (6).

Hunting removed from 32 to 74% ($\bar{x}$ = 59%) of fall quail populations on Forbes and 54 to 81% ($\bar{x}$ = 68%) on Dale. Bobwhite populations have remained markedly unaffected by this degree of utilization. We found no relationship between the proportionate harvest level of 1 year and fall population size in the subsequent year. Several other studies have shown that hunting has no effect on populations (1,5,8). As further substantiation, we found significant ($P<0.01$) negative correlations between harvest levels and additional winter losses (Fig. 3) for Forbes ($r = -0.967$) and for Dale ($r = -0.871$). Additional winter losses (expressed as a percent of prehunt densities) occurred between the opening of the quail season and the prebreeding census in March. Total fall and winter mortality averaged 79.5 $\pm$ 2.6 (SE) % of fall populations on Forbes and 76.7 + 1.9 (SE) % on Dale. The negative correlations indicate that low winter losses offset high harvests and, conversely, that high winter losses occurred after low harvests. Bobwhite populations declined to 15-30% of prehunt densities by the following spring, regardless of the harvest.

Quail harvests consistently exceeded 50% of fall populations on both the Forbes and Dale areas. Stoddard (12) proposed a 50% harvest of quail as a possible maximum. Rosene (11) concluded that a 45% harvest was safe if it included crippling loss in the South and crippling and winter losses for the North. Our data for harvests do not include crippling loss. Such losses could not be adequately determined and were considered as part of the winter losses. We can only conclude that, under existing environmental conditions and hunting regulations in Illinois, annual harvest of bobwhites may safely remove 70% of fall populations on similar public hunting areas. This harvest level should be safe in areas having winter conditions no more severe than southern Illinois. We also believe that this high level of harvest will not occur in years of low quail abundance because lack of hunter interest will preclude such a high proportinate reduction.

Hunting Characteristics

Hunting effort and quail harvest for the Forbes and Dale Areas, 1964-70, are summarized in Table 2. Forbes, with about twice the acreage of Dale, sustained a greater total of hunter trips and gun hours and a greater total harvest than Dale. However, Dale received 39% greater gunning pressure and produced 77% greater harvest per unit area than did Forbes. We believe the greater effort and harvest on Dale to be primarily the result of consistently higher quail densities.

The "average" hunter on both the Dale and Forbes areas flushed about 1 covey per trip and killed 1 bird out of the covey (Table 3). The kill per hunter-trip on our areas was lower than that reported in several other studies. A mean of 2.75 bobwhites were killed annually per hunter trip during 1956-69 in Illinois (10). Harvests of 6.9 bobwhites per hunter trip for the 1950-51 season and 5.4 bobwhites per hunter trip for the 1951-52 season were reported in Texas (8). Hunter success on our study areas may be low due to proportionately fewer experienced quail hunters using public hunting areas. Inexperienced quail hunters killed 1.31 and 1.45 birds per hunter trip on private lands in Ohio during 1959 and 1960, respectively (2). Hunter success may also seem low on Forbes and Dale because biases inherent in using mail questionnaires were not factors in our study.

On the average, hunters on Forbes spent about 40 min more in the field and took 40 min longer to bag a quail than did hunters on Dale, although the time required to find a covey was similar on the 2 areas. Either quail were more vulnerable on Dale or hunters on the Dale Area were better shots than those on the Forbes Area. Data on home counties of hunters may substantiate the latter explanation. On the Dale Area, 58% of the hunters were local residents (within a 6-county area) and only 14% were from the metropolitan areas of East St. Louis, Illinois (2-county area) and Chicago, Illinois (4-county area). On the Forbes Area, 42% of the hunters were local residents (6-county area) and 22% were from the metropolitan areas. Hunters from the East St. Louis area killed only 0.43 and 0.59 birds per trip on the Forbes and Dale areas, respectively. Hunters from the Chicago area killed 0.39 birds per trip on Forbes and 0.85 birds per trip on Dale. Peterle (9) found a negative correlation between the characteristic of residing in a big city and the amount of game killed. The greater success attained by hunters on the Dale Area may also indicate that quail were more vulnerable to hunting on Dale.

On Dale, local hunters bagged 1.13 birds per trip compared with 1.00 birds per trip for all other hunters. On Forbes, the difference was much greater with local hunters killing 1.44 birds per trip and all other hunters killing only 0.76 birds per trip. These findings tend to refute the statement of Preno and Labisky (10) that "the tenacity for hunting, and hence, often success, might be greatest among hunters who travel a considerable distance from their homes in pursuit of their recreation" (p. 33).

Although quail abundance influenced the amount of hunting and harvest in a season, decreasing quail abundance within the season did not steadily reduce effort and harvest. On the Forbes Area, effort and harvest declined through the first 4 weeks of the season then increased slightly from the fifth to seventh weeks. The same trend occurred on the Dale Area but with a considerably greater increase during the last 2 weeks of the season. The kill per gun-hour for weeks of the season (1964-70) is shown for both areas in Fig. 4.

Hunting on weekends was less productive than hunting on weekdays. On Forbes, 54.9% of the gun-hours were expended on weekends and accounted for only 43.9% of the kill. On Dale, 52.7% of the gun-hours were expended on weekends with a resultant 42.4% of the kill. Kill per gun-hour on Forbes was 0.23 on weekends and 0.35 on weekdays and on Dale was 0.29 on weekends and 0.44 on weekdays. The higher success on weekdays was probably the result of less competition between hunters and a higher proportion of local hunters on these days.

Conclusions

Studies of quail populations and hunting on the Forbes and Dale areas for 7 years have shown that the most successful hunters were local residents who hunted on weekdays during the first week of quail season. Although individual hunter success was not great, extremely large proportions of the bobwhite populations were harvested. Evidence indicates that harvests of 70% of fall bobwhite populations were not excessive on these two public hunting areas.

Annual effort of hunters and the harvest of quail depend directly on quail abundance. This dependency indicates that merely providing the land and opening the season does not provide hunting opportunity. Hunting opportunity can be increased on existing public hunting areas by providing more game through effective habitat management.

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Table 1. Bobwhite population densities and harvests and hunting effort on the Forbes and Dale Areas, 1964-1970.

	1964	1965	1966	1967	1968	1969	1970	1971
Forbes								
Prehunt population (quail per 100 acres)	18.2	9.4	14.2	27.1	33.3	26.1	23.3	
Harvest (quail bagged per 100 acres)	11.5	4.5	10.5	17.9	23.4	15.8	7.5	
Hunting effort (gun hours per 100 acres)	49.5	18.6	29.1	52.6	60.1	60.8	51.0	
Posthunt population (quail per 100 acres)		6.7	2.4	3.7	9.2	9.9	7.6	6.0
Prebreeding population (quail per 100 acres)		3.4	1.9	4.9	4.8	7.3	4.6	3.1
Dale								
Prehunt population (quail per 100 acres)	26.9	18.5	29.7	36.4	49.7	41.7	37.1	
Harvest (quail bagged per 100 acres)	21.7	11.4	22.4	22.0	32.2	32.7	20.1	
Hunting effort (gun hours per 100 acres)	60.8	58.4	60.5	60.5	73.4	73.3	64.2	
Posthunt population (quail per 100 acres)		10.5	5.5	10.6	18.1	17.6	9.0	
Prebreeding population (quail per 100 acres)		3.8	3.5	7.8	9.4	12.7	10.0	10.5

Table 2. Hunter efforts and quail harvests on Forbes and Dale Areas, 1964-1970.

	Hunter trips		Gun hours			Harvest		
	Total	Mean	Total	Mean	Per 100 A.	Total	Mean	Per 100 A.
Forbes	2,000	286	7,395	1,056	46	2,096	299	13
Dale	1,657	237	4,939	706	64	1,780	254	23

Table 3. Characteristics of quail hunting on Forbes and Dale Areas, 1964-1970 averages.

	Gun Hours/ hunter trip	Kill/ hunter trip	Gun hours/ kill	Coveys/ hunter trip	Gun hours/ covey
Forbes	3.7	1.0	3.5	1.4	2.7
Dale	3.0	1.1	2.8	1.1	2.7

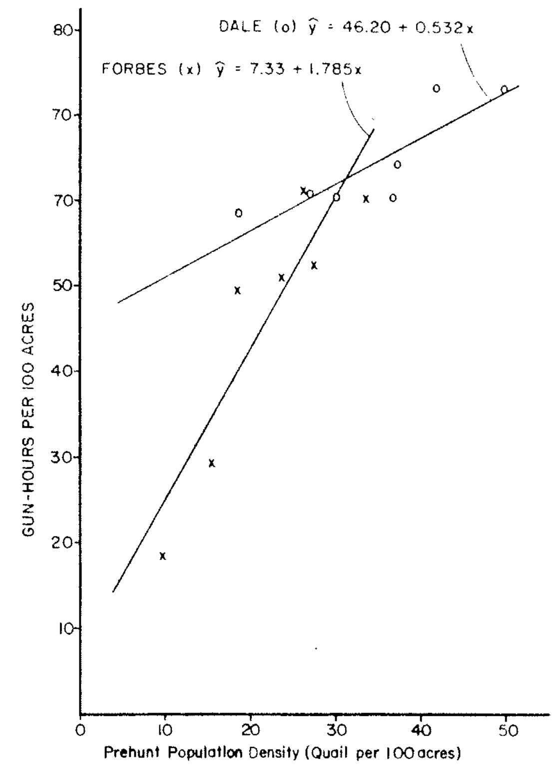

Fig. 1. Regressions of Hunting Effort on Prehunt Bobwhite Abundance, Forbes and Dale Areas, 1964-70.

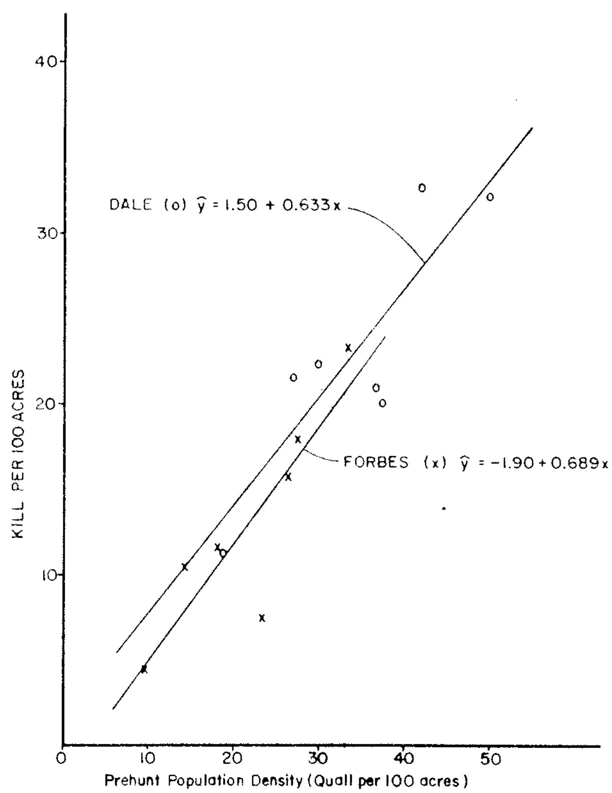

Fig. 2. Regressions of Harvest on Prehunt Bobwhite Abundance, Forbes and Dale Areas, 1964-70.

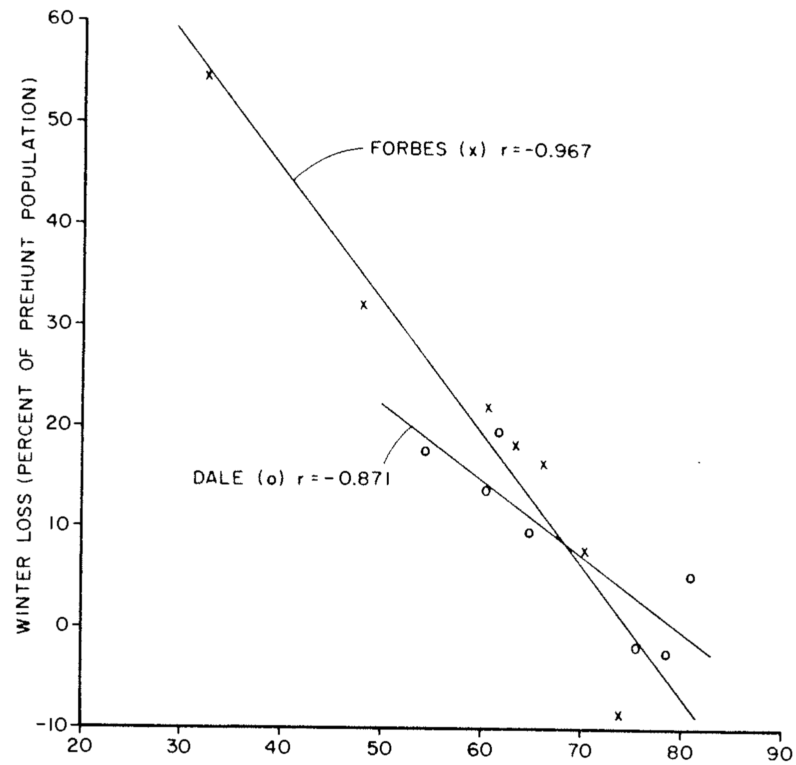

Fig.3. Relationship of Harvests and Winter Losses of Bobwhite Populations, Forbes and Dale Areas, 1964-70.

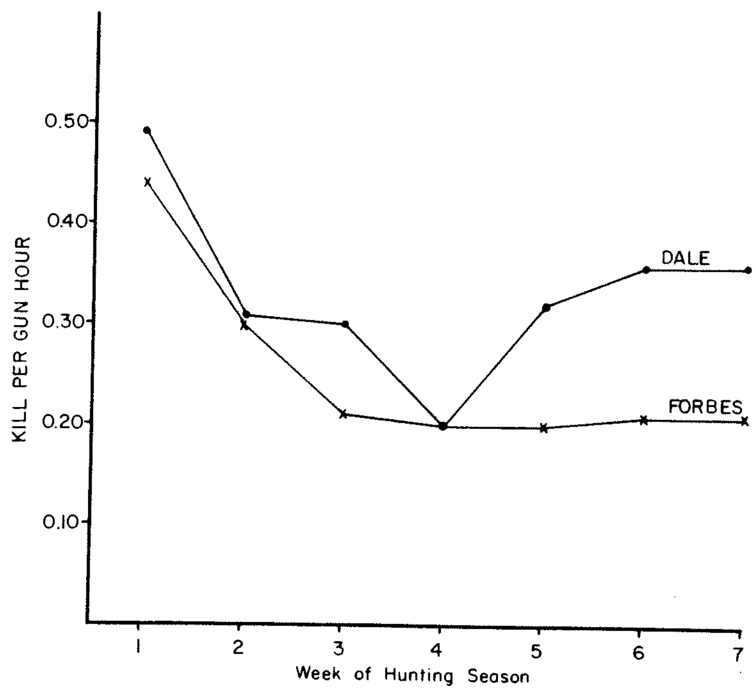

Fig. 4. Hunting Success During Successive Weeks of the Hunting Season, Forbes and Dale Areas, 1964-70.

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QUAIL, LAND USE, AND WEATHER IN ILLINOIS, 1956-70

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Abstract:

Bobwhite quail (Colinus virginianus) populations were at a 15-year high in 1968 and 1969 in Illinois. Analysis indicated that quail abundance over the years from 1956 through 1970 was significantly correlated with changes in land use and weather. Adverse effects associated with increased acreages of row crops and reduced acreages of oats appeared to be offset by aspects of land use, favorable to quail, that were associated with reduced acreages of harvested hay. Quail also appeared to be adversely affected by heavy snow, above-normal rainfall in late winter and spring, heavy summer rains, and drought in summer and fall.

The objective of this analysis was to use stepwise and multiple correlation techniques to identify some of the population, land-use, and weather parameters associated with fluctuations in the abundance and harvest of bobwhites in Illinois during the years from 1956 through 1970. This paper represents a preliminary examination of highly complex relationships.

The concept of the analysis was that abundance and harvest reflect the quality of the environment for quail and that changes in abundance and harvest reflect changes in the environment. Environmental effects were categorized under 2 primary headings: (A) population fluctuations resulting from man's changing use of the land and (B) the modifying influences of weather on the biotic community.

This analysis was made possible by the recent publication of 15 years of data on the abundance and harvest of upland game in Illinois. W. L. Preno, who directed the collection of data for the Department of Conservation, Department personnel who assisted the project, and R. L Labisky, who wrote the report and supervised its publication, are to be congratulated for their fine work. I express my appreciation to Glen C. Sanderson and Helen C. Schultz for editing this manuscript.

Methods

Data on the relative abundance and harvest of bobwhites used in this analysis were those of Preno and Labisky (1). These data include: (A) the mean number of bobwhites per 1,000 acres as determined by censuses conducted on 8 selected study areas with pointing dogs during January and February; (B) the mean number of individual male bobwhites heard whistling during 20, 2-min periods along 39, 20-mile census routes (20 stops per route) run twice annually during late May and June; and (C) the calculated statewide quail harvest for Illinois as determined from annual mail surveys of 8,000 to 12,000 resident small-game licensees.

One may question the accuracy of estimates based on hunter questionnaires, particularly county estimates. However, when findings from hunter questionnaires are viewed as indices to statewide harvest, the problem of possible effect of bias on accuracy is reduced. The fact remains that Preno and Labisky (1) provide 1 of the best long-term series of data on upland game currently available. Until better data become available, it remains the responsibility of those of us concerned with the dynamics of game abundance to use the data that are available.

Statistics on land use were obtained from Illinois Agricultural Statistics (2), Bulletins 56-1 through 71-1 (1956-71 inclusive). Preliminary analysis revealed possibly significant correlations with the quail population data for only 3 land-use parameters: (A) harvested acreage of corn, (B) harvested acreage of oats, and (C) total acreage of hay. The total acreage of hay represents a summing of the acreages of harvested hay and the acreages of legumes and grasses harvested for seed.

Weather data were compiled from Climatological Data Illinois (3), Vols. 60 through 75 (1955-70 inclusive). Parameters considered in this analysis were (A) mean monthly temperature, (B) mean monthly precipitation, (C) mean monthly snowfall, and (D) an index of monthly precipitation effectiveness derived according to Setzer (4). This index (Q) is obtained from the equation: $Q=P/1.07^t$, where P is the monthly precipitation in mm, t is the monthly mean temperature in degrees (C), and 1.07 is a constant derived by Setzer (4).

Weather data used in these analyses are statewide averages. These averages were used because the quail data were believed related to trends in harvest and abundance of the statewide quail population.

Testing and modeling of the data were severely restricted because the population data spanned just 15 years. A minimum of 30 years of data is desirable to obtain valid estimates of variability and response. Stepwise correlation was used to screen the environmental data to identify parameters closely associated with abundance and harvest. Variables that were considered to be associated with fluctuations in the population data were combined for multiple correlation. Analysis was performed by computer facilities of the University of Illinois, Urbana.

Several problems are inherent with an analysis of this type using only 15 years of census data. First there is the problem of relationships that would be recognized as significant if the data were more precise or if they spanned a longer period of years. Because of this problem it seems pointless to hold strictly to an arbitrary rule that a probability of less than 5% is necessary for rejection of hypotheses. I am more impressed with the nature and consistency of relationships than with the size of a particular test statistic. A closely related problem is that if enough parameters are examined, several will be found that are closely correlated simply on the basis of chance. There is no basis for eliminating these other than the rather arbitrary view of the worker as to whether they make sense and are consistent with other findings. There are also instances where the correlation coefficient between a particular independent variable and the dependent variable has 1 sign while the coefficient of regression from multiple correlation for that particular independent variable has the opposite sign. This difference in signs makes it risky to attribute a positive effect to a variable on the basis of the beta value when the correlation coefficient is negative.

A desirable objective is to combine apparently significant population, land use, and weather factors into 1 analysis that gives some idea of the relative importance of the factors and provides a model for predicting relative quail abundance. We have a problem here in that with only 15 years of data we can expect at best only 4 or 5 variables to produce test statistics significant at the 5% level. In reality, several times that number of variables are undoubtedly significant. At the same time, merely adding enough vectors of random numbers as predictors would reduce criterion variance to a very low level giving an inflated and misleading R^2.

Attempting to evaluate the relationships between weather and quail abundance and harvest using only 15 years of data has proved difficult. The analyses were complicated by the fact that weather unfavorable to quail may reflect either above or below normal conditions and may develop at any time during the year. For example, drought in July or August might be a problem at 1 time and torrential summer rains and flooding could be critical at another time.

The question can be raised as to what constitutes a <u>high</u> or <u>low</u> value for a given weather factor. The answer here undoubtedly relates to the normal climatic conditions to which the species is genetically adapted and to those prevailing weather conditions to which the individual has become acclimated. In the long run, thermoregulation and bioenergetics of organisms become critical. Conditions that create less favorable energy relations are undoubtedly less advantageous for the population than conditions that create a more desirable energy situation.

Findings

Preno and Labisky (1:25) concluded that the abundance of bobwhites in Illinois was markedly greater in 1968 and 1969 than at any other time during the 15 years of their data (Fig. 1, Table 1). However, they pointed out that this high was evident throughout western and southern Illinois, but was not noted in intensively farmed counties in east-central and northern Illinois.

The first phase of this analysis was to determine possible relationships with the abundance of quail, as indicated by a particular census, with quail abundance during previous census periods. In general, the relative abundance of quail as indicated by a given census was poorly correlated with trends in abundance evidenced by the census that preceded it. For example, only about 10% of the annual fluctuations in quail harvest could be associated with changes apparent in the 4 censuses that immediately preceded.

The conclusion drawn from this phase of the analysis is that we cannot satisfactorily predict changes in the abundance or harvest of quail on a statewide basis simply by using trends in abundance indicated by previous censuses. Two hypothesis can be drawn from this conclusion: (A) the censuses are not useful predictors of harvest, and (B) the statewide quail population or harvest is responding sharply to changing patterns of landuse, or weather, or both.

Land Use

The magnitude and rate of change in land use and man's effect on the environment over the past 15 years are difficult if not impossible to conceive. Some idea of the changes in land use can be obtained from the agricultural statistics for Illinois (Tables 2 and 3). Many potentially significant parameters of land use remain unmeasured. To name a few, these parameters include use of insecticides and herbicides, fall and winter plowing, mowing for weed control, stubble shredding, shifting from corn pickers to combines, and removing fences and fencerows.

The impression gained from agricultural statistics and from the changing appearance of farmland is that the carrying capacity of Illinois for quail should have been greatly reduced since 1955. With the possible exception of the intensively farmed counties in east-central and northern Illinois, this impression does not fit with the available data on quail abundance and harvest.

Of the land-use parameters for which data were available for the 15 years, only corn, oats, and hay demonstrated relatively high correlations with the quail harvest. Of these 3 crops, it appeared that quail abundance was most closely associated with the acreage of hay and least well correlated with corn. The test statistics indicate the relationships for both hay and oats with quail abundance to be significant.

The regression coefficients suggest that the decline in the acreages of oats over the last 15 years has been associated with conditions making the environment less favorable for quail. At the same time, the negative regression coefficient for hay suggests that the reduction in haying was somehow associated with habitat conditions more favorable for quail. However, we are undoubtedly dealing with very complex relationships, and at this time I will not attempt to speculate on what might be involved.

Weather

Snowfall

Snowfall data were examined on the basis of monthly averages for (A) the individual months of November through April, (B) early winter--total snowfall for November through January, C) late winter--total snowfall for February through April, and (D) total snowfall for the winter.

The analysis of the snowfall data indicates that quail harvest was negatively correlated with total snowfall during the months of February through April (r_{14} = -0.718; t_{13} =-3.721). This finding suggests that above-normal snowfall in late winter and early spring is related to reduced quail harvest in the succeeding fall. This information, coupled with the absence of a strong correlation between snowfall and whistle counts, suggests further that effect of snowfall was somehow manifested through reproduction or survival of juveniles rather than survival of adults.

Rainfall

Although tests of correlation of rainfall with indices of the population and harvest were not highly significant, a pattern did emerge from the analyses that suggested a positive relationship between rainfall in fall and early winter and quail abundance.

The strongest correlation between monthly rainfall and quail per 1000 acres on study areas in February was for the month of December (r = 0.496; t = 3.134). The maximum monthly precipitation for November through January was also positive and was ranked high by step-wise analysis using both quail per 1000 acres and whistle counts as dependent variables. Rainfall in October prior to hunting and the maximum monthly precipitation in early winter of the previous year were ranked first and third, respectively, in step-wise analyses of rainfall with estimated harvest of quail. Again, both of these relationships were positive.

A positive correlation between rainfall in fall and early winter and quail abundance is logical in that we would expect delayed harvest of corn and soybeans and delayed or reduced fall plowing to be associated with increased rainfall. Thus, improved habitat conditions would be associated with increased rainfall in fall and early winter. A second possibility would be that an increase in rainfall in fall and early winter would decrease hunting and thereby quail mortality thus resulting in more birds on areas in February and more whistling birds (potential breeders) in June and thus more quail the following hunting season.

Temperature

Correlation of quail population indices and harvest estimates with mean monthly temperatures failed to indicate any consistent pattern for the 15 years. Although temperatures may have been a contributing factor in fluctuations of abundance and harvest of quail, the evidence does not indicate that temperature in itself was critical during 1956-70.

Precipitation Effectiveness (PE)

Because of the generally weak correlation of temperature and precipitation with the indices of quail abundance and harvest, the next step in the evaluation of the effects of weather on the statewide Illinois quail population was an attempt to account for the combined effects of monthly mean temperature and precipitation. Setzer (4) provided an index that combines those 2 primary weather parameters into a single number. This PE index is positive with respect to precipitation and negative with respect to temperature.

Correlations of indices of abundance and harvest of quail with PE values were in general agreement with the interpretation of the analyses of the precipitation data except that the PE values generally indicated higher correlations. The analyses suggested that low precipitation or high temperatures, or both, in summer, fall, and early winter were related to low populations and harvests as were high precipitation or low temperatures, or both, in late winter and early spring.

Discussion

Several tentative conclusions may be drawn from the analyses presented above. The first is that changes in the abundance and harvest of quail in Illinois over the past 15 years were associated with changes in land use and with weather.

It appears that adverse effects on quail, associated with reduced acreages of oats and other small grains and increased acreages of corn and row crops, were somehow offset by favorable conditions associated with decreased acreages of hay. These changes in land use, plus favorable weather conditions, were apparently related to the generally high quail populations over much of Illinois during the late 1960's.

In general, it appears that a reduced quail population index can be expected with some combination of (A) heavy winter snowfall, (B) a combination of low temperatures and high precipitation in winter and spring, (C) a combination of high temperatures and low precipitation in summer, and (D) heavy summer rains. Although 15 years are not enough to evaluate fully the effects of weather, the above conditions could logically occur--and affect quail--with a relatively high frequency. However, the factors studied by no means cover the full range of weather conditions that could be expected to affect quail in Illinois.

The major conclusion to be drawn from this attempt to analyze the effects of weather on bobwhites in Illinois is that we must not expect to find a single key weather parameter or a particularly critical time in the annual cycle. In the final accounting, we will certainly find significance of intensity, frequency, duration, and timing of events. I am certain that weather is favorable or unfavorable depending on whether it places quail in a favorable or unfavorable position with respect to bioenergetics and thermoregulation. Weather effects may involve the population directly through metabolic responses of individual animals or indirectly through the variety, quantity, and quality of quail food and cover or the availability of food and cover. Any departure from normal climatic conditions is potentially limiting.

Even though weather and changes in land use are largely unpredictable, the biologist possessing data on current land use, recent quail populations, and prevailing weather conditions may soon be able to predict harvest and offer sound theories on the causes of fluctuations in quail abundance. The key to prediction will be continuity in a long-term series of quail population data.

Changes in land use in Illinois have been so great over the past 15 years that it does not seem possible that quail could be as abundant today as they were in 1955. The high quail populations of 1968 and 1969 may have been induced by particularly favorable climatic conditions or by whatever factors trigger a cyclic high (if such exists for quail). My personal view is that we will never again see quail as abundant in Illinois as they were in 1968 and 1969. Only time and more years of data can tell us if this appraisal of the effects of land use and weather is essentially correct.

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Table 1. Indices of abundance and estimated harvest of bobwhites in Illinois, 1956-70 (1:26-27).

Year	Quail per 1,000 acres in february	Current index as percent of previous index	Mean number of whistling cocks per 20, 2-minute stops	Current index as percent of previous index	Quail harvest in 100 thousands	Current index as percent of previous index
1956	60	---	24.5	---	2503	---
1957	62	103	23.6	96	2350	94
1958	59	95	26.1	111	2846	121
1959	56	95	32.9	126	2360	83
1960	59	105	28.2	86	1502	64
1961	38	64	25.8	91	1652	110
1962	43	113	24.2	94	2359	143
1963	48	111	27.0	112	2619	111
1964	62	129	25.9	96	1730	66
1965	64	103	29.5	114	1360	79
1966	62	97	23.5	80	2087	153
1967	77	124	28.5	121	1726	83
1968	82	106	32.7	115	2436	141
1969	.80	98	42.3	129	2388	98
1970*	76	95	33.6	79	2218	93

*Personal communication, W. L. Preno

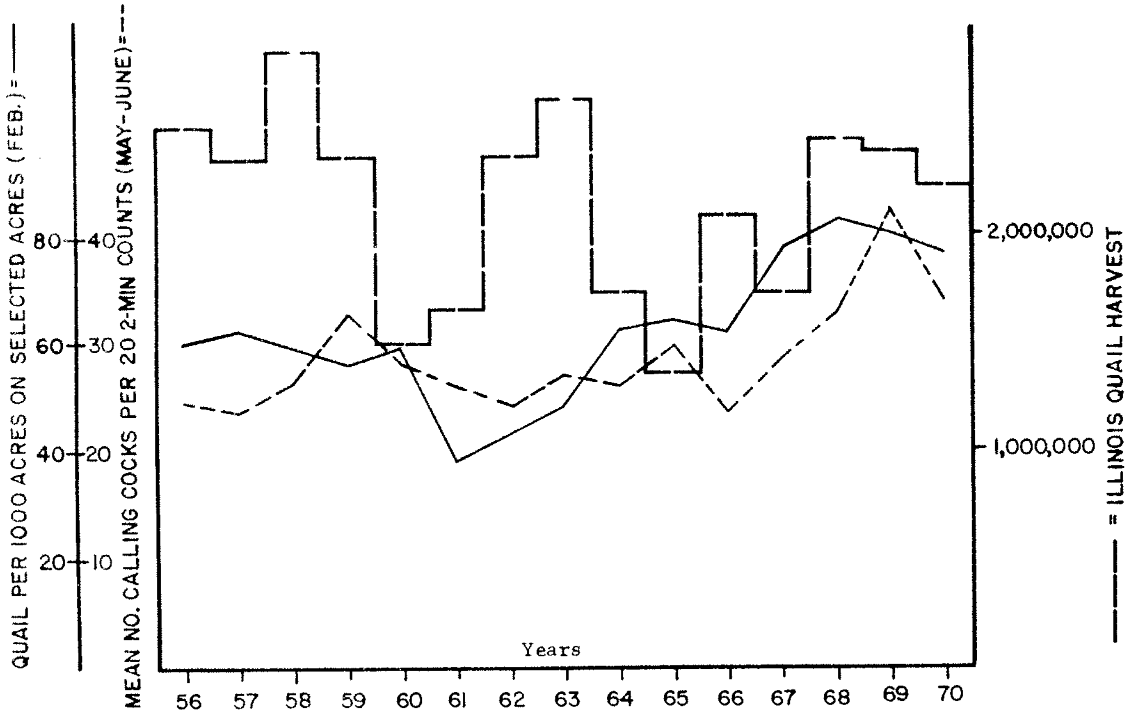

Fig. 1. Indices of Abundance and Estimated Harvest of Bobwhite in Illinois, 1956-1957 (1)

Table 2. Changes in selected agricultural statistics for Illinois, 1955-69 (2).

Item	1955	1970	Change
1. Average farm acreage	176	234	+33%
2. Thousands of farms	178	126	-29%
3. Thousands of cattle	4,028	3,278	-29%
4. Thousands of sheep	528	295	-46%
5. Thousands of acres total cropland	21,222	20,412	- 4%
6. Corn	9,171	9,940	+ 8%
7. Soybeans	4,328	6,865	+59%
8. Oats	3,168	612	-81%
9. Wheat, rye & barley	1,839	1,033	-44%
10. All hay	2,520	1,260	-50%
11. Grass & Legumes for seed	229	100	-56%

Table 3. Harvested acreages (in thousands) of corn, oats, and hay in Illinois, 1955-70 (2).

Year	Corn	Oats	Hay
1955	9171	3168	2749
1956	8712	3057	2865
1957	8189	2568	2695
1958	8517	2427	2667
1959	10050	2233	2525
1960	9985	1867	2423
1961	8188	1634	2226
1962	8270	1503	2261
1963	8849	1386	2186
1964	9114	1123	2090
1965	9777	889	1921
1966	10342	907	1704
1967	10788	756	1523
1968	10088	756	1425
1969	9698	703	1341
1970	9940	612	1360

TECHNICAL SESSION II

CURRENT RESEARCH ON BOBWHITE LIFE HISTORY

Chairman
Ralph W. Dimmick
Assoc. Professor of Forestry
University of Tennessee

Discussion Leader
Willard D. Klimstra, Director
Wildlife Research Laboratory
Southern Illinois University

THE BOBWHITE QUAIL OF CRANE NAVAL AMMUNITION DEPOT, INDIANA--25 YEARS OF PROTECTION AND PLANT SUCCESSION

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Abstract:

A low-density bobwhite quail population was studied to determine its status after 25 years of plant succession and protection from hunting on Crane Naval Ammunition Depot. The summer breeding population on the study area was approximately one-fifth of that around the periphery of CNAD. The winter population was approximately 1 bird per 50 acres. The subadult to adult ratio was normal (83:17) but the corresponding sex ratio of 60M:40F was unbalanced. Coveys retained their identity and, with the exception of 1 covey, maintained their numbers during winter. The major habitat limitation occurred during the nesting and brooding season. The low density of bobwhites was concluded to be primarily the combined result of poor nesting cover and above-normal loss of mature females during the breeding season.

The objectives of this study were to identify the dynamics of a low-density bobwhite population and the importance to it of available cover types on an area where the major cultural land-management practice was right-of-way mowing for 25 years, excepting recent timber management practices.

Southern Indiana is near the southern boundary of the area where extended periods of cold temperatures and snow may limit bobwhite quail populations. Bobwhites are generally abundant in this area of Indiana, however, and provide a significant contribution to sport hunting. Previous studies of bobwhite quail in Indiana include Reeves' (15) state-wide investigation in which he studied in detail a population in the farm habitat of adjoining Daviess County. Madden (11) reported the fall foods of southern Indiana bobwhites.

We wish to thank the commanding officers of Crane Naval Ammunition Depot for their permission to use this area for study. Many employees of CNAD helped in collecting information or supported the study in a variety of other ways. Michael Donahue and Roy Raider were especially helpful during the summers they worked with us. Journal Paper No. 4744

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from Purdue University Agricultural Experiment Station in cooperation with the Indiana Division of Fish and Wildlife and the Crane Naval Ammunition Depot.

Study Area

Crane Naval Ammunition Depot (CNAD) occupies most of the northern 0.33 of Martin County in southwestern Indiana. The original oak-hickory forests are currently considered to be in a sensitive balance with beech-maple and western mesophytic forest types (9,14). Farms began to break up the forests during the 1800's and by 1900 most ridge-tops and flood plain terraces were tilled. Hillsides that remained forested during the agricultural era were frequently grazed. Farming declined rapidly after 1900 (13).

Since its formation in 1940, CNAD has been an effective wildlife refuge because of military security and the resultant limitation of public access to the area. During this study, 56,160 of a total 62,780 acres were in some stage of forest succession. In addition, 4,660 acres were maintained by annual mowing as roadside, ammunition magazine, and powerline openings. The remaining 2,960 acres were in roads, buildings, and other man-made structures. Land cleared for farming during the 1800's left the most obvious impression on the original wooded landscape. Since the cessation of farming at least 25 years ago, various seral stages from grass-herb to brush communities have developed. Many of the areas appear savannah-like, with shrub growth scattered throughout a dense grass-herb ground cover. Forested areas were relatively undisturbed from establishment of CNAD until about 1959 when timber management practices began (3).

Within CNAD, 4 sq miles were selected for intensive study along Boggs Creek. The main cultural practice on the study area consisted of mowing at ammunition magazines, powerlines, and roadsides; although some scattered, selective logging and timber-stand improvement was performed.

Methods

A census of whistling males was conducted at weekly intervals on the study area and along the southern and western perimeter of CNAD during the breeding seasons of 1966 and 1967. The procedure was the same used by Bennitt (4) except that stops were made at 0.5-mile intervals.

Two types of trapping techniques were used in this study. Cock-and-hen traps were effective for the April-through-August breeding season (19). Bait trapping was used during the fall-to-spring period.

Birds captured in traps were banded, sexed, aged, and released at the trap site. Back tags and colored dyes were used to mark some birds for individual recognition.

Methods employed in the quantitative vegetation sampling have been described previously (6) except for the determination of cover types in bobwhite activity centers. A revised map of the vegetation cover types on the study area was prepared from a U. S. Forest Service map drawn in 1959 based on 1953 aerial photographs. The acreage of cover types was determined from these maps with fixed-radius plots around the activity center of 12 bobwhite quail and compared to the cover-type acreage in an equal number of randomly located plots. The 340-yard radius of the sample plots was an average of the activity radii of birds recaptured 3 or more times (5).

Findings

Habitat Studies

The forest was predominantly oak-hickory with a combined importance for all oak and hickory species of 62%. Hard maple ranked fourth and American beech ninth among all species found; combined, these species had an importance of only 14%.

The most important woody plants greater than 1 ft tall and less than 4-inches dbh are listed in Table 1. Potentially valuable fruit-producing species occurred in this vegetation layer, particularly in abandoned fields.

Woody plants, including seedlings and vines less than 1 ft tall, are listed in Table 1. Greenbriar and trumpet creeper tangles were the only species dense enough to provide shelter in some areas. Wild grape, blueberry, dewberry, and posion ivy all produced potentially valuable fruit.

Mowed openings were maintained in a predominantly grass-herb community, and grasses found there in descending importance, were blue-grass, fescue, panic grass, andropogons, cheat, sedge, red-top, tall purpletop, timothy, triple-awn grass, wild oats, and foxtail.

Nineteen woody plants occurred in mowed openings but only the vines survived the repeated mowing. A valuable fruit producer, dewberry, was the most important woody species in mowed openings. Wild rose was the only other woody plant known to produce fruit in the mowed areas.

Seeds of legumes and composites have been reported as important items in the diet of bobwhites of Indiana (15), Illinois (2,8), Kentucky (1), and Missouri (7). Korean lespedeza was the most important herbaceous plant in mowed openings on CNAD, and it has been found in a larger percent of Indiana quail crops than any other food item (Table 2). Reeves (15) ranked it third in percent volume behind corn and sassafras. Field observations made on feeding coveys in fall and winter confirmed that the abundance of Korean lespedeza in mowed openings of CNAD attracted quail during the winter.

Sweet clover produced abundant seed crops in mowed openings; however, it is a species that has been insignificant in the diet of quail in Indiana (15), Illinois (8), and Missouri (7). Tick trefoil, beggartick, ragweeds, and trailing wild bean in CNAD abandoned fields produced seeds that were potential fall and winter food sources. Seeds of wood sorrel, tick trefoil, and trailing wild bean were common foods in woodlands.

The density of plants in the ground layer has been recognized as an important variable in the selection and use of areas by bobwhites (17,19). In general, woodlands had the least dense ground layer of woody and herbaceous plants (206 plants per m^2) on CNAD, abandoned fields had slightly more (218 plants per m^2). The density of plants in mowed openings was more than twice that in other community types (464 plants per m^2). Thirty-three % of the ground-layer plants in woodlands were woody, whereas woody plants composed 10% of the plants in abandoned fields. Mowed areas had less than 10% woody-plant composition. Plant density and the rank growth of herbaceous plants in abandoned fields may reduce the late-winter value of these areas for providing food because much of the plant material covers the ground surface, and needed food supplies are not readily available. In addition, grass is considerably more dense in abandoned fields than in woodlands.

Bobwhite Studies

A survey of whistling (calling) males was conducted weekly during May through July, 1966 and 1967, to identify the annual size of the breeding male population and to determine the peak date of calling intensity. For both years the average calling index was 0.23 during the third week of July. The calling index along the farmland perimeter of CNAD during this same period averaged 1.2 calls, indicating a considerably higher population of breeding birds. Comparison of the call index value in this study to the call index values of 2.64 and 2.05 reported by Reeves (15) for the same soil types in adjacent areas of southern Indiana indicates a relatively low density of bobwhites on the study area. Reeves (15) conducted the whistling survey during the third week of July, but recommended the last of June as the best time for Indiana.

The peak calling index on the study area occurred in the last week of June in 1966 (0.62) and the second week of June in 1967 (0.85). The highest calling index on the perimeter of CNAD occurred in the third week of June both years (3.65 in 1966 and 2.31 in 1967). A calling index was obtained each week and found to be cyclic with highest values at approximately 4-week intervals and low values at approximately the midpoint in time between high records. This suggested that nesting began uniformly and renesting attempts may have occurred at greatest frequency on successive 4-week intervals. Speake and Haugen (18) reported that bobwhite whistling activity fluctuated with nesting activity and that sharp declines in calling followed peaks of hatching. Rosene (17) considered the peak in calling to coincide with the maximum in nesting activity. Small secondary calling peaks occurred in late July and early August in Kansas (16).

The low calling index and low breeding population it represented on CNAD probably reflected 2 basic factors: low reproduction and/or high annual losses in the population. Rosene (17) considered the whistling male census to reflect the quality of nesting cover; therefore, the low calling index on CNAD suggests that poor nesting conditions were present. It should be recognized that if losses were high during the fall and winter, the population remaining until the next breeding season could be small even though nesting cover was excellent.

The average turnover rate in a bobwhite population is reported to be 70-80% of the population each year with the highest rate in the northern ranges (17). Reeves (15) reported that 84.9% of juvenile birds were taken during the 1947-1951 hunting seasons in Indiana. The average age composition of 59 bobwhites captured on CNAD was 83% subadults and 17% adults (Table 3). Comparison of the number of individuals captured and recaptured indicates that a large proportion of the population was handled.

We consider the average age structure for the population of bobwhites on CNAD to be normal in terms of recruitment of young individuals. The year-to-year variation in our results could be expected from a low-density population in which a small variation in the number of individuals captured in either age class would cause a relatively large change in the age ratio.

A representative sex ratio of CNAD bobwhites was obtained only during the period when they were in coveys. During the breeding season, trapping was selective for males, and females were not readily observed. The sex ratio of 5 coveys (51 birds) which occupied the 4-sq-mile study area in 1965-66 and 2 coveys (19 birds) immediately adjacent to the study area within CNAD was 59M:41F. Females were never observed in greater number than males in any covey, and were equal in number in 2 coveys. The normal sex ratio in juvenile and subadult age classes is 50M:50F but the male portion will normally average 60% of the adult age class (17). Mortality of female bobwhites on CNAD was somewhat greater than would typically be expected for an age distribution which had a normal high subadult composition. Rosene (17) reported the proportion of males increased after the onset of nesting activity, which suggests a time of the year when female bobwhites on CNAD may be unusually vulnerable. In the 5 coveys on the study area between November 1965 and April 1966, the number of females declined less than the number of males in 2 coveys, both sexes remained stable in 2 coveys, and the sex ratio was not determined in 1 covey. These ratios indicate that female mortality was less than or equal to that for males within the coveys on the study area during the winter season.

Bobwhites typically have small home ranges (10,12,17). Forty-four individuals were captured during the summer trapping seasons of 1965-1967 of which 21 individuals were recaptured. Of 20 birds recaptured in the same summer that they were banded, 14 (70%) were recaptured within 0.5 mile, 19 (95%) moved less than 1 mile, and 1 bird moved more than 1 mile.

Males that move > 1 mile during the summer are unusual and presumably are not mated. An example on CNAD involved a subadult male that moved down the Boggs Creek Valley 2,530 yards in 8 days and 2,470 yards back up the valley 7 days later. He was recaptured a third time, 15 days later, 770 yards south of the previous capture site.

Movement records for more than 1 summer season were obtained from 3 individuals. Two birds recaptured on the study area after 2 years had moved an average of 8,950 yards from the last capture site. One bird, recovered after 3 years, moved off the study area and at least 1,760 yards from the previous capture site. No birds were found to move to or from the study areas or the southern perimeter of the depot during a single summer trapping period.

The average summer activity radius determined for 12 bobwhites captured 3 or more times was approximately 340 yards (range 60 to 710 yards). Individuals that had unusually long movement records were not included in these calculations.

To evaluate the relationship of bobwhite centers of activity to vegetation cover types in the summer, we compared the cover-type vegetation acreages around the activity centers of 12 bobwhites to a random sample of the cover-type acreages present on the entire study area. The results of an analysis of variance test of the variation within the 2 types of samples indicated that mowed openings were a smaller but more consistent acreage in both samples than other vegetation cover types. Mowed openings averaged 13 acres (20%) in both types of sample areas. By comparison, abandoned fields and woodlands were larger than mowed openings, and much more variable in size. An average of 18 acres (27%, range 5-43 acres) of the 66-acre plot taken around bobwhite activity centers was in the abandoned field cover type, whereas abandoned fields averaged 15 acres (23%, range 0-50 acres) at randomly selected plots elsewhere. Woodland acreage was the most variable of the 3 cover types and averaged 35 acres (53%, range 6-60 acres) in plots around activity centers compared to 38 acres (57%, range 2-56 acres) in randomly located plots.

The dominant plant species were recorded at 118 sites used by bobwhite coveys during the winter season. This information provided a percent frequency occurrence of species at feeding, loading, and roosting sites (Table 4) and is the basis for comparing the composition of winter habitat used by bobwhites against other available areas.

The ubiquity of goldenrod and broomsedge precluded their use as indicators of any selectivity by bobwhites. Korean lespedeza, wild carrot, tall purpletop, and bluegrass found at winter feeding sites (Table 4) were important constituents of mowed-opening vegetation (Table 2). Blackberry and common persimmon found at feeding sites are representative of the shrub borders of abandoned fields, situations where bobwhites were more often found loafing than feeding, as is indicated by the frequency of blackberry, serecia lespedeza, and sassafras at loafing sites. Bobwhite roosts were most often found in abandoned fields, and the plant species commonly found at roost sites agrees accordingly (Tables 2 and 4). The frequency of roosts found in pines increased during periods of snowy cover, indicating a need for more substantial cover during severe weather.

Conclusions

The purpose of this study was to identify the characteristics of a low-density, nonhunted bobwhite population that occupied an area that had undergone 25 years of plant succession. The whistling male index indicated that the breeding male population on the study area was less than 0.20 of that around the farmland perimeter of CNAD. The winter population on the study area was found to be 5 coveys or 51 birds (gross density approximately 1 bird/50 acres).

The sex and age characteristics of this population indicate how it has responded to the limited amount of suitable habitat and still remained viable. The age ratio indicates that the recruitment of young is similar to that normally found in populations of bobwhites at this latitude. The 60M:40F sex ratio, however, was found to be slightly unbalanced for a young population; it probably reduced the reproductive potential of this population. No evidence was obtained during this study to explain why the sex ratio favored males; however, it has been shown elsewhere that females are subject to greater mortality than males during the breeding season. The fact that fewer females than males were found in winter coveys and that the number of females was more stable than the number of males supports the conclusion that females are likely lost in greater proportion than males during the breeding season. During the remainder of the year, mortality probably is non-selective and the males and females die at a rate commensurate with their numbers in the population.

Comparison of the vegetation conditions on CNAD and those reported used by nesting bobwhites indicates that the edge of abandoned fields adjacent to mowed openings had the best potentiality. However, nesting bobwhites also prefer a low to medium density of ground vegetation and a minimum of plant litter. Since abandoned fields had dense ground vegetation (218 stems per m^2) and an abundance of plant litter, nesting conditions were suboptimal. Dry upland abandoned fields were predominantly in dense old stands of broomsedge, which are also reported to be suboptimum nesting conditions (17).

There was no evidence that nonmated birds moved off the study area during the breeding season. Evidence from birds recaptured in more than a single season, however, suggests that bobwhites may move long distances at other times of the year, possibly during the fall.

The number of coveys remained stable during the fall to spring period; 4 of 5 coveys maintained a relatively stable size.

The relationship between vegetation and bobwhite coveys indicates that areas used for feeding and loafing in the edge between abandoned fields and woodlands had a limited amount of plant litter on the ground surface. Coveys fed in mowed openings and roosted in abandoned fields in the latter part of the winter when much of the plant material had lodged. In light of these results we have concluded that winter food and cover on CNAD was adequate for the population present in the winter of 1965-66 and that the major factors controlling the numbers of bobwhites occurred during the breeding season as a result of suboptimum nesting conditions and disproportionate adult female mortality.

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Table 1. The important woody plants identified from three layers in the abandoned field and woodland communities of CNAD[1]

Species	Abandoned Field 0-1 ft. (%)[2]	Abandoned Field 1-5 ft. (%)	Abandoned Field > 5 ft. (%)	Woodland 0-1 ft. (%)	Woodland 1-5 ft. (%)	Woodland > 5 ft. (%)
Elm	--	4.0	20.9	--	--	--
Sycamore	--	3.4	17.4	--	--	--
Persimmon	--	13.5	16.2	--	--	--
Sassafras	--	--	14.0	8.0	14.5	12.0
Boxelder	--	--	11.8	--	--	--
Dwarf sumac	7.2	15.4	10.0	--	--	--
Flowering dogwood	--	10.0	5.0	--	14.3	21.8
Red maple	11.5	4.8	5.0	--	2.3	3.9
Hard maple	--	--	--	5.8	3.0	19.9
Hickory	--	--	--	--	6.6	7.1
Ironwood	--	--	--	--	7.7	6.2
Black gum	--	--	--	--	--	5.6
Oak	--	--	--	5.6	9.2	5.6
Ash	--	--	--	4.2	4.9	3.9
Tulip poplar	--	--	--	4.2	--	3.3
Trumpet creeper	7.4	18.1	--	--	--	--
Wild rose	6.5	9.6	--	--	--	--
Willow	--	8.2	--	--	--	--
Indian currant	--	3.8	--	--	--	--
Greenbriar	--	--	--	6.1	17.0	--
Blueberry	--	--	--	5.1	1.7	--
Dewberry	27.8	--	--	--	--	--
Poison ivy	24.7	--	--	8.3	--	--
Virginia creeper	10.0	--	--	12.3	--	--
Black cherry	5.1	--	--	--	--	--
Wild grape	--	--	--	5.2	--	--

[1]Excludes stems over 4 inches dbh.

[2]Importance = (relative density + relative frequency)/2 for each plant species.

Table 2. The important herbaceous plants identified from three communities on CNAD[1]

Species	Mowed opening (%)	Abandoned field (%)	Woodland (%)
Korean lespedeza	33.4	2.1	--
Goldenrod	7.7	18.3	5.7
Plantain	6.7	--	--
Sweet clover	6.0	--	--
Wild carrot	5.1	--	--
Cinquefoil	4.7	5.9	6.4
Ox-eye daisy	2.3	--	--
White clover	2.1	--	--
Black medic	2.0	--	--
Wood Sorrel	1.8	2.1	4.8
Tick trefoil	0.6	9.9	7.2
Yarrow	--	9.1	--
Beggar ticks	--	8.9	--
Ragweed	--	6.4	--
Violet	--	5.5	6.8
Pennyroyal mint	--	4.7	4.5
Agrimony	--	4.6	--
Trailing wild bean	--	3.0	9.6
Bedstraw	--	--	12.0
Pussy toes	--	--	10.6
<u>Eupatorium</u> spp.	--	--	3.9

[1]Importance = (relative density + relative frequency)/2 for each plant species.

Table 3. Number of bobwhite quail captured and recaptured on CNAD (1965-1967). The number of previously uncaptured individuals in parentheses.

Year Age class	Months Jan.	Feb.	May	June	July	August	Total
1965							
Adult	--	--	--	2(2)	5(1)	--	7(3)
Subadult	--	--	--	5(4)	19(5)	11(2)	35(11)
1966							
Adult	1(1)	2(0)	3(2)	5(1)	--	--	11(4)
Subadult	11(11)	10(3)	5(4)	8(5)	5(4)	--	39(27)
1967							
Adult	--	--	--	1(1)	3(1)	2(1)	6(3)
Subadult	--	--	--	8(7)	9(3)	5(1)	22(11)
Total							
Adult	1(1)	2(0)	3(2)	8(4)	8(2)	2(1)	24(10)
Subadult	11(11)	10(3)	5(4)	21(16)	33(12)	16(3)	96(49)

Table 4. Plant species with 10 highest percentage frequency occurrence values at winter bobwhite activity sites on CNAD.

Species	Feeding[1] (62) (%)	Species	Loafing (25) (%)	Species	Roosting (31) (%)
Goldenrod	65	Blackberry	44	Goldenrod	77
Broomsedge	57	Broomsedge	40	Broomsedge	65
Korean lespedeza	48	Goldenrod	36	Aster	48
Tall purpletop	40	Serecia lespedeza	32	Beggarticks	36
Bluegrass	33	Bluegrass	24	Bluegrass	36
Blackberry	31	Sassafras	20	Pine	32
Serecia lespedeza	24	Aster	20	Foxtail	32
Panic grass	24	Pussytoes	20	Cinquefoil	32
Wild carrot	23	Korean lespedeza	0	Selfheal	32
Common persimmon	21	Fescue	16	Common persimmon	26
		Panic grass	16	Flowering dogwood	26
		Tick trefoil	16		

[1]Number of sites examined.

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ASPECTS OF BOBWHITE QUAIL MOBILITY DURING SPRING THROUGH FALL MONTHS

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Abstract:

The mobility of bobwhite quail was studied on an 1160-acre nonhunted area in southern Illinois during March through November. Seventy-eight quail (39 adult males, 29 adult females and 9 young of the year) were radio instrumented. Radio locations totaled 2,302 during 1,726 days in which quail were radio marked. Increase in average monthly range from March to April was attributed to change in habitat preference. Considerable variation in monthly ranges during the period of June through August were noted and attributed to variations in breeding status of individual birds. An increase in monthly ranges during October was associated with covey formation.

Past research on mobility of bobwhite quail has produced conflicting data. Although some studies have shown bobwhite to be quite sedentary (4,10), others have shown them to be capable of moving considerable distances (2,3,5,7,11).

In an attempt to clarify mobility during the spring-through-fall months, several authors have tried to relate movements to a particular time of the year. Loveless (7) concluded that there was no special increase in movement during the spring, but that bobwhite were highly mobile during the summer months. In contrast, Lewis (6) and Murphy and Baskett (8) in Missouri found movement in the spring to exceed that of summer. Movements in the fall are also exemplified by conflicting data. Agee (1) found that coveys often established their winter ranges within 100 yards of their hatching point. Duck (3), Lehman (5), and Loveless (7) on the other hand showed a definite shift from fall to winter ranges. Duck (3) attributed this shift from summer to winter ranges to differences in habitat preference. Lehman (5) and Loveless (7) found no such correlation.

This study was initiated to clarify some of the aspects of bobwhite mobility during the spring-through-fall months and to indicate some of the reasons for increased mobility.

Study Area

A single 1,160-acre tract of Southern Illinois University farmland, which was not subjected to hunting and was not managed for quail, located in Jackson County, Illinois, served as the study area.

Twenty-seven % of the study area consisted of idle land (12% woods, 11% brushy areas and 4% weedy areas). Corn was grown on 45% of the area. Virtually all corn was mowed or plowed in the fall.

Populations of quail on the area were extremely low during the study. Spring populations varied from 65 to 99 birds, and fall populations from 96 to 274 birds.

The author acknowledges W. D. Klimstra and J. L. Roseberry for their supervision and encouragement during the course of the study. This publication is a contribution of Project No. 1: Cooperative Wildlife Research Laboratory and the Illinois Natural History Survey, cooperating; included are certain data being gathered for a doctoral dissertation, Department of Zoology, Southern Illinois University.

Methods and Materials

Quail were captured in wire traps (10, p. 447) baited with cracked corn in the fall and spring and with decoy hens during the summer. To determine movements, 78 quail (39 adult males, 29 adult females and 9 young-of-the-year) were equipped with radio transmitters. Radio locations totaled 2,302 during 1,726 days that quail were radio marked.

Locations of instrumented quail were determined by triangulation with the aid of a Model LA-11 AVM receiver and a Model 28 Hi-gain antenna. Locations were usually taken once daily at random periods, except during the period of 28 July to 30 September 1969, at which time radio locations were recorded at hourly intervals over a 4-hr period each day.

To determine monthly ranges, radio locations of each marked quail were plotted according to month. The area encompassed by a line connecting the least number of outermost fixes, but which still included all the other fixes of an animal, was defined as that animal's monthly range. Only those quail which were radio-tracked for 7 or more days were included. Radio locations were grouped according to the type of habitat in which the birds were found for an index of habitat usage.

Breeding status was determined by observing each marked quail at least twice weekly. Thus quail were categorized as to being in a covey, mated, or unmated; mated quail were further categorized as to nesting or with a brood.

To determine significant differences between means, we employed the t test for independent sample means.

Results and Discussion

Early Spring Period

The ranges in March ($\overline{X}$ = 14.3 acres) were significantly smaller ($P<.05$) than ranges in April ($\overline{X}$ = 32.6 acres). The increase in mean size of range from March to April was not attributed to covey breakup but to a shifting or expanding of March covey ranges during April. This in turn was related to a change in habitat utilization. There was a noticeable decrease in use of wood and brush cover and a corresponding increase in use of weed cover from March to April (Table 1). Coveys whose March ranges consisted only of fencerows or wood and brush areas shifted ranges completely in April. Coveys that had sizeable weed areas in their March ranges simply used the weed area within their range and did not shift.

It must be emphasized that a sizeable weed area was necessary to prevent shifting of ranges. Although data were too few to determine actual size of weed areas needed, it was noted that weed fencerows bordered on both sides by cropland, power line right of ways, and isolated patches of weed areas in brush cover were not adequate to prevent shifting, while weed areas of approximately 5 acres or more did. This is in accord with Roseberry's study (unpubl. manuscript) of the habitat surrounding nest sites. He found isolated weed areas were seldom used for nesting.

The fact that mobility of the bobwhite during the spring was closely related to habitat quality may in part explain previous conflicting data in regard to spring movement. Loveless (1958) noted little mobility on an area managed specifically for quail, while Murphy and Baskett (1952) reported a great deal of mobility on an area that was not the best quail range.

Late Spring and Summer Period

Considerable variation in monthly ranges occurred during May through August and was attributed to breeding status of individual birds (Table 2). The average monthly range of mated cocks (22.9 acres) was significantly less ($P<.05$) than that of unmated cocks (41.0 acres). These differences were also reflected in hourly movements as mated cocks moved significantly less ($P<.01$) per hr (178 ft/hr) than unmated cocks (320 ft/hr). It must be emphasized, however, that high mobility was not limited to unmated males. On 3 occasions mated males were known to move more than 0.5 mile from their center of activity. Two of these movements were to decoy hens in cock-and-hen traps. In all instances, the male's mate was believed to be incubating.

Slight differences in monthly ranges were noted between females, but data were too few to provide definite conclusions (Table 2). During the nesting period, monthly ranges of females averaged 16.0 acres. Distribution of their radio locations did not occur randomly throughout their range. In each case at least 50% of the radio locations could be included within a 3-acre area.

Two hens moved considerably after their nests were terminated prematurely. One moved more than 1.25 miles from her nest site and encompassed 115 acres during the 30 days after her nest was destroyed. The other hen shifted her range slightly after abandoning what was believed to be her second nest attempt.

Fall Period

Sixteen quail in 10 coveys were radio tracked from August through November. Data did not indicate a major dispersal. Only 2 of 8 coveys showed a complete shift in ranges from 1 month to the next although the maximum distance between any 2 radio locations for a covey averaged over 0.5 mile during this period. The other coveys only expanded their ranges; this expansion came during October in virtually every case, followed by a contraction in November (Table 3). The reason for the increase in October did not appear to be related to change in habitat utilization or to crop harvest. This expansion seemed to be a behavioral mechanism with which coveys expanded their ranges to associate with neighboring coveys. Only 1 of 8 coveys radio tracked during October failed to exhibit this type of behavior; this was a brood that did not hatch until late September.

Conclusions

There were a number of variables that contributed to increased movement of bobwhite during the spring-through-fall months. Coveys that had interspersed heavy and open cover within their range utilized significantly smaller ranges in the spring than did other coveys.

Mated cocks had significantly smaller ranges than unmated cocks. Nesting females showed smaller ranges than those females whose nests were terminated prematurely.

The increase in area utilized during fall was possibly related to low population levels. If coveys expand their ranges during the fall simply to meet other coveys, this increase might be less pronounced in areas of high population density.

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Table 1. Habitat types utilized by bobwhite quail during March and April, Southern Illinois University Farm.

	Percent utilization					
	Wooded areas	Brush	Weed areas	Pasture	Grass fencerows	Wooded fencerows
March	17	21	19	13	14	15
April	12	8	52	14	10	4

Table 2. Mean size of bobwhite quail monthly ranges in relation to breeding status, May through September, Southern Illinois University Farm.

	$\bar{X}$ Acres	N	SD
Mated males	18.7	11	12.5
Unmated males	41.2	9	23.5
Nesting females	15.8	5	9.5
Post nesting females	38.5	4	22.6

Table 3. Mean size of bobwhite quail monthly covey ranges, August through November, Southern Illinois University Farm.

	August	September	October	November
	Acres			
$\bar{X}$	21.1	22.9	41.0	22.6
N	4	7	11	7
SD	14.9	16.9	17.6	4.2

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A STUDY OF BOBWHITE QUAIL NEST INITIATION DATES, CLUTCH SIZES, AND HATCH SIZES IN SOUTHWEST GEORGIA

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Abstract:

Nest initiation dates, size of clutches, and proportion of eggs hatching are presented for a high-density bobwhite quail (Colinus virginianus) population studied from 1967 through 1971 in southwest Georgia. Initiation dates were known for 680 nests that were active when found; of these, 379 nests (56%) were initiated before 16 June. Nesting success (percentage of all nests producing chicks) was low for these nests. Of 171 successful active nests with known initiation dates, only 38 (22%) were initiated before 16 June.

Mean monthly clutch size decreased from March (25.0) to August (9.4). The mean clutch size for all nests was 12.0. The number of eggs hatching per nest also decreased from March (20.0) to August (8.4) with a mean of 9.9 eggs hatching for all nests.

A search of literature on the life history of the bobwhite reveals scant information concerning the chronological distribution of nest initiation dates, clutch sizes, and hatch sizes. The majority of available information deals with generalities or extremes of occurrence. The purpose of this paper is to provide quantitative information on these aspects of the bobwhite's life history.

Special recognition is due to John M. Olin, owner of Nilo Plantation, for financial assistance, through the Georgia Game and Fish Commission, and for use of the study area, and to Gratten Parker, manager of Nilo Plantation, for his valuable assistance. Funds for the study were provided through Pittman-Robertson project W-41-R, Georgia Game and Fish Commission.

Study Area and Procedures

This study was conducted during the nesting seasons of 1967-1971 on Nilo Plantation in Dougherty and Baker counties, southwest Georgia. A detailed description of the study area and procedures for locating and studying nests are described elsewhere in these proceedings (6). All data pertaining to clutch size were based on nests known to have been incubated.

Results and Discussion

Nest Initiation Dates

Initiation dates were known for 680 nests that were active when found (Table 1). The earliest nest observed was initiated 22 March, 1969, and the latest on 26 August, 1971. Some nests were probably initiated later than is indicated because searches for nests were terminated on 31 August each year. The peak of nest initiation occurred during the periods 16-31 May and 1-15 June, with 113 nests (17%) and 110 nests (16%), respectively, initiated during these intervals. A slight decline occurred in nest building during 16-30 June, with 80 nests (12%) being initiated during this period. A second peak, although not as great as the first, was indicated for 1-15 July when 88 (13%) nests were initiated. The 16 May - 15 June peak occurred each year with one exception in 1970. The second peak, 1-15 July occurred in 3 of the 5 years (1967-69).

Few past studies of bobwhite nesting present detailed information concerning the chronology of nesting beyond describing the onset and cessation of nest building and hatching. Dimmick (2) reported on initiation dates of 127 nests found during 1967-71 on Ames Plantation, Tennessee. Peaks of nest initiation occurred during the periods of 1-15 June and 1-15 July. Earliest nests were started during 16-30 April and latest during 1-15 August. Lehmann (4) reported on the initiation dates of 64 nests found in southwestern Texas during 1943. The earliest nesting date was 11 April. Peak nest construction occurred about 13 June. The peaks of nest initiation indicated in Tennessee corresponded to those I found in Georgia. Also, the main initiation peak in Texas fell within the period having the largest number of nests initiated on Nilo Plantation. The onset of nest construction was the same as was found in 4 of the 5 years in this study.

Of the 680 active nests, 171 (25%) were successful. The distribution of initiation dates of successful nests differed from that of all nests due to a high incidence of predation on the early season nests. Lowest nesting success occurred for nests initiated during the period 16-30 April and 1-15 May, when only 5% of the nests started during each period successfully hatched (Table 2). Highest nesting success (excluding the period of 16-31 March which involved only 1 nest) occurred in nests initiated during 1-15 July. Forty-five of 88 nests (51%) started during this period were successful. Nests initiated during 16-31 July were similarly successful, 31 of 62 nests (50%). It should be pointed out again that these estimates of nesting success are for nests that were active when found. Therefore, they may not accurately represent overall nesting success.

The peak of initiation for successful nests occurred during 1-15 July, when 45 nests (26%) were constructed. This period corresponds with the second peak of initiation based on data from all nests. Nests initiated during 16-31 May and 1-15 June, the first and highest peak of initiation for all nests, constituted only 6% and 11%, respectively, of successful nests. Nests initiated before 16 June made up 56% of all nests, yet constituted only 22% of successful nests. Nests initiated after 15 June constituted only 44% of all nests, but constituted 77% of successful nests.

Initiation dates were also estimated for 47 successful nests that had hatched shortly before being found. Combining data from these nests with those from nests active when found did not markedly alter the pattern of successful nest initiation described above (Table 3).

Clutch and Hatch Size

The mean size of 326 clutches that entered incubation was 12.0 eggs (range 5-33) (Table 4). Nest initiation dates were known for 296 of the clutches. Mean clutch size, in relation to month of initiation of the nest, decreased gradually during the nesting season from a high of 25.0 in March to 9.4 in August.

Of the 326 nests having known clutch size, 219 were successful (Table 4). Mean clutch size of successful nests was 11.2 eggs (range 5-30). The date of initiation was known for 211 of these nests. Mean clutch size declined from 25.0 in March to 9.5 in August.

The mean number of eggs hatched was 9.9 (range 2-24) for 211 of the 219 successful nests (Table 4). Initiation dates were also known for 206 of these nests. As would be expected, the number of eggs hatching per nest decreased in relation to the reduction in clutch size. Mean hatch size ranged from 20.0 in March to 8.4 in August.

Stoddard (7) reported an average clutch size of 14.4 eggs for bobwhites in the Tallahassee, Florida-Thomasville, Georgia area. In 1926, the first 25 clutches averaged 15.0 and the last 25 clutches averaged 13.9. In 1927, the first 50 clutches averaged 16.3 and the last 50 clutches averaged 12.8. Using Stoddard's data, I calculated the mean size of successful clutches to be 13.6 with an average of 11.7 eggs hatching. Lehmann (4) reported clutch sizes of bobwhites in southwest Texas as follows: 14.8 eggs in early spring clutches, 11.5 in midsummer clutches, and 10.5 in late summer clutches. From Lehmann's data, the mean hatch was calculated to be 9.9. Parmalee (5) reported a mean clutch size of 12.9 eggs for successful nests and a mean hatch of 11.9 in east-central Texas. Dimmick (1) reported mean clutch sizes of 11.4 in 1967 and 11.5 in 1968 for bobwhites in Tennessee. In a study by Klimstra (3) in Illinois, the average clutch size was 13.2 eggs and the average hatch was 11.7 chicks.

The mean clutch size and number of eggs hatching per nest found in this study were somewhat smaller than those reported for bobwhites in most of the studies cited. This difference was due mainly to the low success of the early nests and the resulting higher proportion of late nesting attempts with smaller clutches.

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Table 1. The chronological distribution of nest initiation on the Nilo Plantation, Georgia, during the nesting seasons of 1967-1971.

Initiation period	Number of nests 1967	1968	1969	1970	1971	Total
March 16-31	--	--	1	--	--	1 (0.1%)
April 1-15	--	--	5	--	1	6 (0.9%)
" 16-30	5	14	21	20	6	66 (9.7%)
May 1-15	6	28	15	27	7	83(12.2%)
" 16-31	21	31	20	15	26	113(16.6%)
June 1-15	17	28	19	21	25	110(16.2%)
" 16-30	13	15	13	20	19	80(11.8%)
July 1-15	16	30	16	13	13	88(12.9%)
" 16-31	5	28	8	12	9	62 (9.1%)
August 1-15	8	17	11	8	7	51 (7.5%)
" 16-31	3	4	3	6	4	20 (2.9%)
Total	94	195	132	142	117	680(99.9%)

Table 2. The relationship of initiation date to proportion of nests hatching on Nilo Plantation, Georgia, 1967-1971.

Initiation period	Total nests		Successful nests		Percent of nests successful
	No.	%	No.	%	
March 16-31	1	0.1	1	0.6	100.0
April 1-15	6	0.9	1	0.6	16.7
" 16-30	66	9.7	3	1.8	4.5
May 1-15	83	12.2	4	2.3	4.8
" 16-31	113	16.6	10	5.8	8.8
June 1-15	110	16.2	19	11.1	17.3
" 16-30	80	11.8	25	14.6	31.3
July 1-15	88	12.9	45	26.3	51.1
" 16-31	62	9.1	31	18.1	50.0
August 1-15	51	7.5	24	14.0	47.1
" 16-31	20	2.9	8	4.7	40.0
Total or average	680	99.9	171	99.9	25.1

Table 3. The dates of initiation for all successful nests during 1967-1971 on Nilo Plantation, Georgia.

Initiation period	Number of nests: Active	Number of nests: Hatched when found	Total
March 16-31	1	1	2 (0.9%)
April 1-15	1	2	3 (1.4%)
" 16-30	3	1	4 (1.8%)
May 1-15	4	4	8 (3.7%)
" 16-31	10	4	14 (6.4%)
June 1-15	19	5	24 (11.0%)
" 16-30	25	17	42 (19.2%)
July 1-15	45	8	53 (24.2%)
" 16-31	31	4	35 (16.0%)
August 1-15	24	1	25 (11.4%)
" 16-31	8	1	9 (4.1%)
Total	171	48	219(100.1%)

Table 4. Mean number of eggs per clutch and chicks per successful nest during each month of the nesting season on Nilo Plantation, 1967-1971. Numbers in parenthesis are the number of eggs and number of nests.

Month of Initiation	Clutch size: All nests	Clutch size: Successful nests	Hatch size
March	25.0 (50/2)	25.0 (50/2)	20.0 (40/2)
April	16.0 (353/22)	16.2 (81/5)	13.4 (67/5)
May	13.9 (707/51)	14.2 (327/23)	12.4 (286/23)
June	11.6 (926/80)	11.4 (660/58)	9.8 (569/58)
July	10.2 (991/97)	10.3 (904/88)	9.3 (794/85)
August	9.4 (415/44)	9.5 (331/35)	8.4 (276/33)
Total[1]	11.6 (3441/296)	11.2 (2353/211)	9.9 (2032/206)
Total[2]	12.0 (3896/326)	11.2 (2445/219)	9.9 (2085/211)

[1]Total for nests with known initiation dates.

[2]Total for all nests with complete clutches.

ENERGETIC REQUIREMENTS FOR EGG-LAYING BOBWHITES

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Abstract:

As part of an extensive bioenergetics study of bobwhite quail (Colinus virginianus), energy requirements for egg laying were determined. Caloric values for eggs averaged 5.489 kcal/g. Net energetic efficiency of converting productive energy into eggs was conservatively estimated to be 54% for quail laying at a rate of 0.45 egg/bird-day at 25 C. Assuming that those values were the same for quail laying a 10-g egg at a rate of 1 egg/bird-day resulted in an energy requirement of 69.645 kcal/bird-day. This is an energy demand equivalent to that of existence alone at about -3.3 C.

Bioenergetic studies of a species contribute to the understanding of factors limiting the number of individuals on a given area and the species' geographic distribution. They also contribute to a broader knowledge, namely, the flow of energy through an ecosystem. The primary objective of this study was to quantify energy expended by bobwhites for laying eggs. These data will supplement knowledge of basic energy requirements of bobwhites (2) and energy conserved by huddling (3). When integrated with field data on food habits, weight dynamics, and mortality (15,16,17,18), it may be possible to determine the critical season for the regulation of numbers of bobwhites.

I am grateful to R. J. Robel for his advice during this experiment and for his comments on earlier drafts of this paper. The Kansas Forestry, Fish, and Game Commission supplied the quail. Financial support was provided by NSF Grant GB-16010 and P-R Project W-30-R by the Kansas Forestry, Fish, and Game Commission to R. J. Robel. I thank R. W. Dimmick and W. D. Klimstra for their critical review of the manuscript.

Materials and Methods

Ten adult, game-farm-raised, females were placed in individual, polypropylene, 48 X 25 X 13 cm cages with 0.5-inch mesh bottoms and sliding, 0.25-inch mesh, hardware cloth tops. Caged birds were kept in a walk-in environmental chamber under controlled temperature, photoperiod, and relative humidity and were provided ad libitum feed (a balanced mash of 20.5% protein, 2.7% fat, and 3.6% crude fiber) having a caloric value of 4.250 ± 0.030 kcal/g (mean ± SE), and water.

Data were collected at 3-day intervals for a 12-day period at each temperature treatment. Feed and feces were separated and oven-dried at 65 C to a constant weight. Weight of birds, feed, and excreta were to the nearest 0.1 g.

Feed and excreta were prepared for calorimetric analysis by

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grinding in a Wiley Model micro mill. Samples were weighed to the nearest 0.1 mg before being analyzed in a Parr oxygen-bomb calorimeter.

Energy requirements were determined using the feeding method, i.e., calculating gross energy intake, excretory energy, and metabolized energy (see Cox (4) for definitions) for each bird. If constant body weight were maintained (weight change of 1% or less), metabolized energy was termed existence energy for nonlaying birds--the energy required by quail to subsist under caged conditions.

Birds were previously kept under a 10-hr photoperiod and it was desired to have all of them in reproductive condition before the start of this 15-hr photoperiod experiment. From results of others (7,8,11) I decided to allow a minimum of 60 days for acclimation, and actually allowed 83 days.

Temperature treatments were at 10-C increments from 5 to 35 C. A minimum of 2 weeks of acclimation was allowed after conditions were changed. Eggs were punctured with a dissecting needle and oven-dried at 65 C to a constant weight. They were analyzed calorimetrically by the same method used for excreta and feed, except they were ground by hand in a mortar after drying. See Case (2) for greater detail on methods.

Results and Discussion

Gross energy intake, metabolized energy, and excretory energy varied significantly ($P<0.005$) at different temperatures. Figure 1 depicts the significant ($P<0.005$) quadratic effect of temperature on those variables.

Case (2) reported that body weight differences accounted for less than 1% of the total variation about energy variables in male and female bobwhites under a 10-hr photoperiod. Also, a significant difference was not detected for existence requirements neither between males and females under a 10-hr photoperiod nor between males and nonlaying females under a 15-hr photoperiod. Thus, assuming that egg-laying females had the same existence requirement as males and nonlaying females, it was possible to determine the productive energy (Figure 1). Productive energy is the difference, in kcal/bird day, between metabolized energy and existence energy.

Eggs from birds maintained at 25 C were heaviest and had greatest caloric value (Table 1). Greatest caloric value/g and ash-free caloric value/g were for eggs laid at 35 C. Ash percentage was lowest at 35 C.

Productive energy and egg calories/bird-day were 13.800 and 7.438 kcal/bird-day, respectively, at 25 C, and those were highest of the 4 temperature treatments (Table 2). The highest egg-laying rate (0.452 egg/bird-day) was at 15 C.

Wilson (24) found that egg production of domestic chickens declined above 26.5 C, that some hens quit laying at 38 C, and that shell thickness decreased as temperature increased above 21 C. Although caloric value of eggs did not decrease significantly at 35 C in my experiment, rate of laying decreased drastically.

At temperatures higher than 25 C, excessive body heat may be generated by a high level of feeding. This hypothesis seems to account for the following observations: (A) energy intake and productive energy decreased at temperatures warmer than 25 C, (B) ash percentage of eggs decreased with increasing temperature, and (C) 2 birds laid eggs at 35 C with shells so thin they broke and could not be collected. DeWitt, Nestler and Derby (5) concluded that bobwhites required 2.3% calcium in their diet for egg production. The feed I used had sufficient calcium for egg laying below 35 C. It was either deficient or not used at 35 C, as evidenced by thin-shelled eggs. Payne (14) observed that when feed consumption is low, higher concentration of minerals in the diet may be necessary to sustain egg production in domestic hens.

Net efficiency of egg laying was maximum at 5 C. Wilson (25), using temperatures ranging from 5 to 40 C, reported lowest conversion of feed to eggs at 5 C for domestic hens. Net efficiency for egg formation in the zebra finch (Taeniopygia castanotis) was 49% at 14.5 C and 77% at 34.4 C (6). The high net efficiency at 5 C in my experiment seems spurious. This may be due, in part, to the small number of eggs (8 from 4 birds for 48 possible bird days). My other net efficiencies were comparable to those of El-Wailly (6) and Brody (1).

If existence energy of laying birds is equal to that of nonlaying birds, and caloric value, percent dry weight, and net energetic efficiencies remain the same as egg size and rate of laying increase, then it is possible to calculate the energy requirement for egg laying in bobwhites. Using the data from Tables 1 and 2 and assuming a 10-g egg is laid each day at 25 C, then 5.489 kcal/g X 10 g X 0.3371 = 18.503 kcal/egg. Since the net efficiency of egg formation is 54%, a productive energy (18.503 kcal/0.54) of 34.265 kcal/bird day is required to form a 10-g egg. Adding productive energy to existence energy at 25 C (35.380 kcal/bird-day), it is then possible to calculate the temperature-equivalent existence energy. That is, from Figure 1, laying an egg at 25 C requires as much metabolized energy as existence alone at -3.3 C (65.630 - 1.210T = 69.645; T = -3.3 C).

It must be stressed that this is probably an overestimate. For example, a net efficiency of egg formation of 70% (commensurate with values in literature and my data at other temperatures) results in a temperature-equivalent existence energy of about 3 C. Smaller eggs (representative bobwhite egg weights: 9 g, (21); 9.6 g (20); 8.8 g, this study) and possibly still higher efficiencies (perhaps as great as 77%) would lower the energy requirement further.

Speculation

There exists considerable evidence that food resources limit bird populations. In bobwhites, this seemingly would be in late winter when seed abundance has diminished and low temperatures are maintaining a high demand for food. Lack (12) and Fretwell (9) have discussed the role of dominance in winter survival of birds when food may be limiting. Perhaps a similar explanation exists for the low survival rate of juvenile bobwhites from September to April noted by Robel (16) and by Robel and Fretwell (19). The latter study showed a significant decrease in the proportion of juvenile bobwhites from fall to late winter and early spring over an 8-year period. Indirect evidence for food limitation of bobwhites in late winter is provided by decreased weights from December-January through March (10,18). One must also consider the importance of weather, namely snow cover, on limiting food availability (22).

Could food also account for differential sex mortality? Sex ratios of juvenile bobwhites are about equal (10,13), but that of adults is generally in favor of males. This differential sex ratio is usually attributed to high mortality of females during the nesting season. Rosene (23) suggested that possibly the physical strain imposed on females during egg laying and incubating is greater than that on males and thus females may die faster because they are weaker. My data on energy demands for egg laying indicate that at 25 C the productive energy required for egg formation (34.265 kcal/bird day) is nearly equal to that required for existence (35.380 kcal/bird day) at the same temperature. Apparently those data could be interpreted as supporting Rosene's hypothesis. I think that is not true. Adult quail weights increase in April and this is attributed to the increased weight of females (18). One could surmise that food must not be critical at this time because body weights increase, and the increased food is probably due to the increased availability of animal food. This is supported by Robel (17) finding an increase in volume of animal matter of 15% or more in bobwhite crops in April over that for December-March. An elevated metabolism, necessitated by egg laying, is not deemed to impose a physical strain on females. Since both males and females can readily sustain themselves at an equivalent winter-level of existence (about -3.3 C), strain could result only if food is in short supply.

If there is an energetic basis for a differential sex ratio it would probably be effective in late winter. Robel (1965) did find a difference in females:males from 1.28:1 in September-December to 0.96:1 in January-April, although this difference was not statistically significant. Regressions of existence energy on temperature for male and female bobwhites at 10 hr, not statistically different from each other, do indicate a steeper slope and a higher intercept for females (2). If this divergence is not due to random scatter and if it continued at colder temperatures (females requiring more energy), then energy demands may influence the sex-related survival of bobwhites during late winter when food is in short supply.

Two major gaps in information are brought out in regard to those statements, 1) existence energy requirements of quail of each sex at colder temperatures and 2) the availability of food in late winter and early spring. Especially lacking is information on the abundance and utilization (foraging and metabolic efficiency) of animal food by bobwhites in the wild.

Conclusion

Using estimates obtained in this experiment on metabolized energy, productive energy, caloric value of eggs, and efficiency of converting metabolized energy into eggs, it was possible to estimate the energy requirement for producing a 10-g egg at the rate of 1 egg/bird day at 25 C. This resulted in an energy requirement of 34.265 kcal/bird day, nearly equal to that of existence alone (35.380 kcal/bird day) at 25 C. This was judged to be a maximal estimate since average egg weights may be less and conversion efficiencies are likely higher.

The energy requirement for egg laying plus existence at 25 C is about equal to that for existence alone at -3.3 C. This was not judged to impose a physical strain on females. The observed increase in body weight prior to egg laying must reflect adequate food (at least calories) availability.

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Table 1. Weight, caloric content, and ash percentage of eggs laid during four indicated temperature treatments.

Temp (C)	N	Fresh weight (g)	Dry weight (g)	Percent dry weight	Caloric value (kcal/g)	Ash-free caloric value (kcal/g)	Total kcal/egg	Percent ash
		MEAN ± SE						
5	8	8.19 ± 0.21	2.74 ± 0.08	33.42 + 0.31	5.429 ± 0.056	6.610 ± 0.037	14.882 ± 0.477	17.87 ± 0.44
15	38	8.69 ± 0.10	2.94 ± 0.04	33.81 ± 0.15	5.442 ± 0.027	6.578 ± 0.018	16.054 ± 0.233	17.28 ± 0.22
25	43	8.79 ± 0.09	2.97 ± 0.04	33.71 ± 0.14	5.489 ± 0.025	6.585 ± 0.016	16.379 ± 0.210	16.67 ± 0.19
35	11	8.32 ± 0.19	2.77 ± 0.07	33.23 ± 0.28	5.862 ± 0.050	6.730 ± 0.033	16.200 ± 0.429	12.99 ± 0.40

Table 2. Productive energy, efficiency of egg production, and rate of lay at indicated temperature treatments.

Temp C	N[a]	Metabolized[b] energy (a)	Existence[b,c] energy (b)	Productive[b] energy (a-b=c)	Egg kcal/ bird-day (d)	Net energetic efficiency (d/c) x 100	Rate of egg Laying (egg/bird-day)
5	4	62.406	59.581	2.825	2.802	99.2	0.167
15	7	60.380	47.484	12.896	7.304	56.6	0.452
25	8	49.180	35.380	13.800	7.438	53.9	0.448
35	5	28.804	23.290	5.514	4.149	75.2	0.250

[a] n is the number of birds laying eggs at each treatment.

[b] values in kcal/bird-day.

[c] existence requirement of males, see text for rationale.

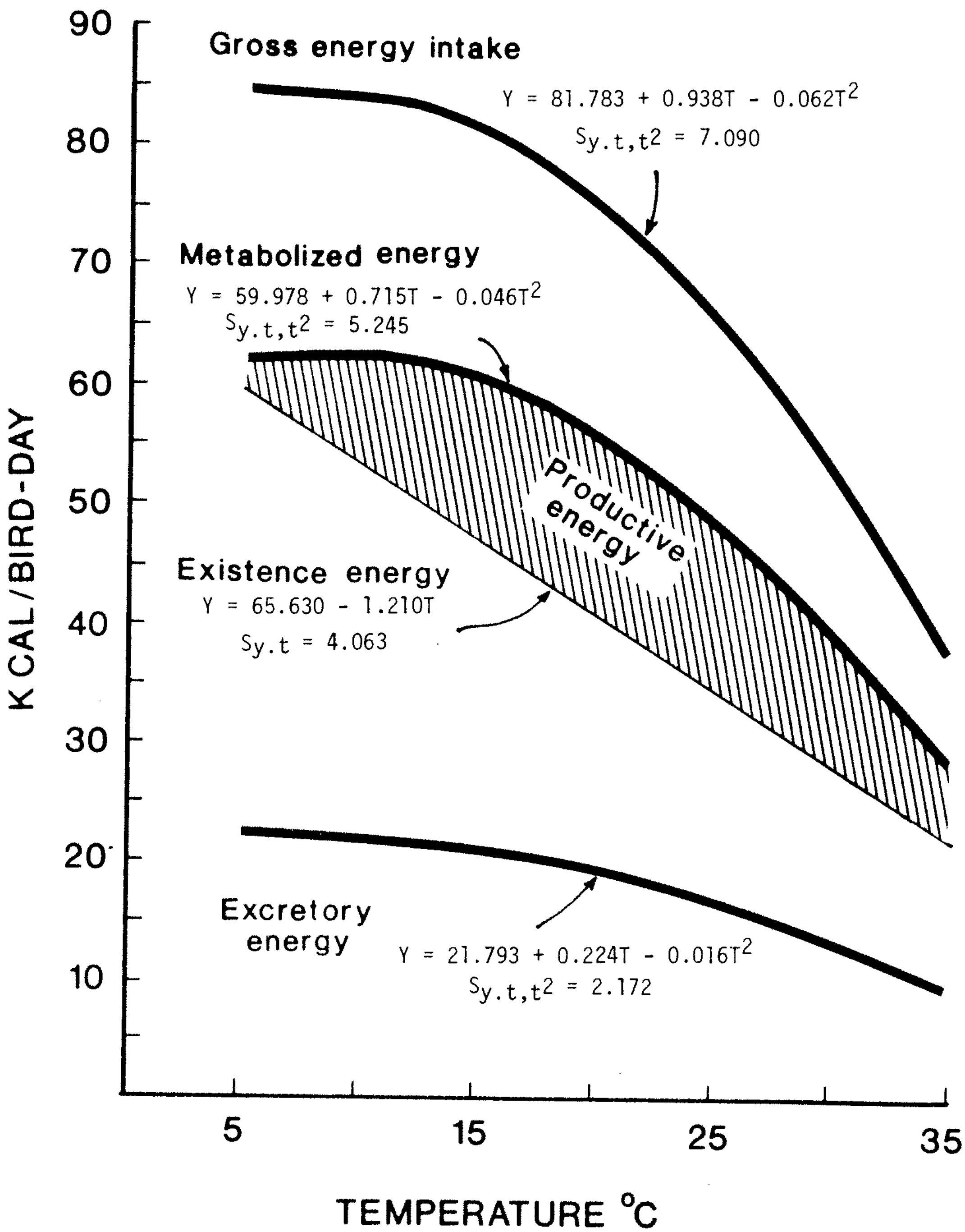

Figure 1. Gross energy intake, metabolized energy, productive energy, existence energy, and excretory energy as a function of ambient temperature for egg-laying bobwhites under a 15-hour photoperiod.

EFFECTS OF DDT ON STEROID METABOLISM AND ENERGETICS IN BOBWHITE QUAIL (COLINUS VIRGINIANUS)

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Abstract:

Female bobwhite quail (*Colinus virginianus*) fed low levels (5 ppm) of DDT in their diets showed increased enzyme induction in the liver and consequently a significant increase in steroid (progesterone) metabolism (a mean of 54% conversion of progesterone to its more polar metabolite in experimentals compared to a mean of 24.1% conversion in controls). The mean conversion of testosterone to its polar metabolite (25.1%) in experimental males was greater than in the controls (mean 18.1%) but was only significantly greater in certain males. There was a correlation ($r = 0.7$ $P<0.01$) between percent body weight of testes and percent conversion of testosterone to its metabolites (the smaller the testes the greater the conversion). A correlation ($r = 0.66$ $P<0.02$) was also found between circulating levels of DDE, DDT, and testes size (the higher the pesticide level the smaller the testes).

Dietary levels of DDT (10,50,100,150 ppm) affected the energetics (oxygen consumption) of bobwhite quail. All DDT-treated birds had a higher metabolic rate than the controls at all ambient temperatures tested except 30 C. After acclimation to an ambient temperature of 5 C for 10-13 weeks, birds on 100-ppm DDT diets had a significantly ($P<0.01$) higher metabolic rate than controls. After one week of exposure to -18 C there was a significant ($P<0.02$) increase in thyroid weight in the birds on 100-ppm diets. Birds on 100-ppm diet exposed to extreme cold for 1 week died of DDT toxicity.

Data on tissue residue levels, weight changes, I^{131} uptake by the thyroid, and adrenal changes are also presented. The ecological significance of the synergistic effect of DDT and cold stress on the bobwhite quail is discussed.

Numerous studies have been carried out on the toxicity of various pesticides based on gross biological phenomena observed in living organisms. Only in recent years has attention been focused on the effect of pesticides on metabolic functions that can be examined at the enzyme level. The administration of organochlorine insecticides to animals of various species stimulates both the hepatic microsomal oxidation of drugs and the microsomal hydroxylation of steroids including progesterone and testosterone (7,14,24).

Widespread and severe decreases in populations of several avian species have been noted throughout the world in the past 15 years (5,11,26,33). Correlations between these decreases in populations and the increased use of (DDT) pesticides were observed, but the concentration of pesticide residues found in these species was low compared with a toxic dose (28). There is also evidence that gross blockage of the reproductive systems does not occur except at concentrations approaching toxic doses (1,18). Decreased populations might result from more subtle effects on the breeding cycle (in social dominance) caused by changes in hormone levels and behavior. Peakall (24) stated "that if normal regulation of populations depends on a subtle balance of hormone concentrations and related feedback mechanisms associated with population density, it would not be surprising to find that agents affecting this balance cause declining populations." Conney et al. (8) suggested that the stimulating effect of halogenated hydrocarbon insecticides on steroid hydroxylation possibly explained the effect of these pesticides as exemplified by decreased fertility in experimental animals. DDT not only affects reproduction by altering steroid metabolism but Welch et al. (32) suggested that DDT could act directly as an estrogen. Ecobichon and Saschenbrecker (10) demonstrated that DDT-treated white leghorn cockerels 5 weeks old showed a marked reduction in both comb and testicular development when compared to control birds after 32 weeks of treatment. Once again these results could be taken to indicate that DDT has an estrogenic effect (masking the testosterone in juvenile birds with low testosterone levels).

Since DDT and its metabolites are stored in the fats, any factor increasing the energy requirement of the bird (cold stress) could result in higher circulating levels of DDT and its metabolites. Therefore, not only is it important to know the effects of DDT on steroid metabolism but it is equally important to know the effects of DDT and cold stress on the energetics of the bobwhite quail.

This study was concerned with: (A) the effect of low doses of DDT (5 ppm technical grade--Diamond Shamrock Chemical Co., Texas) on steroid function and metabolism (progesterone and testosterone) in bobwhite quail, (B) the effect of DDT on the reproductive capabilities of bobwhite quail, and (C) a comparison of the effects of cold stress on DDT-fed and control quail by studying their metabolism (oxygen consumption) over a wide range of ambient temperatures.

This research was supported by the Bureau of Sport Fisheries and Wildlife, through the Patuxent Wildlife Research Center, Laurel, Maryland. We wish also to thank Jacob W. Lehman and Denise Deschenes Lustick for their technical assistance.

Methods and Materials

DDT and Steroid Metabolism

Twenty-eight yearling pen-raised quail with a mean weight of 167.2 g were divided into groups (3 females and 7 males fed the control diet, 4 females and 14 males fed the experimental diet containing 5 ppm DDT). All diets consisted of Purina Game Bird Startena either mixed with corn oil only (Mazola Brand, control diet) or with DDT dissolved in corn oil. The birds were maintained on the diet from 30 to 70 days starting 30 June 1969. Except for 2 birds that were sacrificed in December (when the testes were regressed) all birds were sacrificed during the 70-day period. The procedure used for enzyme extraction was essentially that of Conney and Klutch (7), while that for steroid analysis was that of Peakall (24).

The testes from each of the male birds were weighed to the nearest 0.01 g. Residue levels were determined in the liver by gas chromatography (20).

DDT and Energetics

Methods for determining oxygen consumption and thermal conductance are described by Voss (31). The birds used in the different metabolic experiments consisted of 2 groups which were then further divided into subgroups.

Group 1 consisted of 1-month-old male and female bobwhites hatched on 2 June 1970. The birds were kept indoors for 10 days, then transferred outside into 5 wire cages of 6.1 m x 6.1 m x 11.2 m each. In mid-September the quail were placed in 5 cages of 9.2 m x 10.7 m x 14.3 m, 7 quail to a cage. Each of these cages contained a box with an opening so that the quail could escape inclement weather. Except for the first 10 days after purchase, the birds were outside and, therefore, acclimated to ambient conditions of temperature and photoperiod.

On 1 August, each of the 5 subgroups was placed on a diet containing different amounts of technical grade DDT purchased from Diamond Shamrock Chemical Corp. (0,10,50,100, and 150 ppm DDT). Technical grade DDT was dissolved in 100% pure Mazola brand corn oil.

All birds were sacrificed following the metabolic tests, there being no fatalities in any of the subgroups over the 211- to 242-day period. The livers and brains were weighed and enough fat tissue removed to be used for residue analysis by gas chromatography. These tissues from 4 birds from each subgroup were analyzed for DDT and its metabolites by the method proposed by Nauman (20).

Group 2 consisted of 21 4-month-old quail of both sexes. On the first of September 1971 these birds were divided into 3 subgroups of 7 birds each. The birds were then placed in individual cages (18 x 41 x 23 cm) inside a Sherer Dual Jet Model 810 environmental room capable of maintaining an ambient temperature ± 1.0 C of the desired temperature over an ambient temperature range of from -20 to 60 C. The birds were allowed to adjust to the chamber for 1 month. During this adjustment period the birds were maintained at an ambient temperature of 20 C and on a 12-hr photoperiod between 0830 and 2030 hr. On 2 October 1971, the ambient temperature in the environmental room was dropped to 5 C, and 2 of the 3 subgroups were placed on DDT diets of 10 ppm and 100 ppm respectively; the other subgroup was maintained as a control. The diets were mixed as previously described. The birds were maintained under these experimental conditions until 31 January 1972. The oxygen consumption at 5 C for all 3 subgroups was determined between the 2nd and 3rd week and again between the 10th and 13th week to determine what effect DDT and long-term acclimation to low ambient temperature might have had on the energetics of bobwhite quail. All birds were weighed periodically during the test period to determine if there were significant differences in ability to maintain weight between the 3 subgroups.

The potential effect of extreme cold stress was tested. On 31 January 1972, the temperature in the environmental room was dropped to -18 C, and 5 control birds, 5 birds on the 10-ppm-DDT diet, and 4 birds on the 100-ppm diet were injected intraperitoneally with 1μc of iodine (I^{131}) in physiological saline. The birds were maintained at this ambient temperature for 1 week; surviving birds were then sacrificed and thyroid weights and activity (I^{131} incorporation) determined. Brain levels of DDT and its metabolites were determined for 4 birds from each of the subgroups (control, 10, and 100 ppm DDT) by the method mentioned previously. The thyroid samples were prepared for analysis in the liquid scintillation spectrometer as described by Nauman (20). All iodine uptake values were adjusted so that they were based on a 28-hr exposure (time when first bird died). This enabled us to compare all birds.

Two LD_{50} tests were conducted on yearling birds by exposing them to diets ranging from 500 to 1500 ppm. In the first test, concentrations of 500, 600, 700, and 800 ppm DDT in the diet were used.

Results

DDT and Steroid Metabolism

Liver microsomal enzyme extracts from DDT-treated females all induced significantly ($P<0.001$) greater conversion of progesterone to its more polar metabolites than did extracts from control females (54.0% conversion in experimental females compared to 24.1% in the control females, Table 1). The mean conversion of testosterone in control males (18.8%) to its more polar metabolite was less than in the experimental males (25.4%) but there was no significant difference. Liver enzyme extracts from certain DDT-treated individuals showed a greater conversion of testosterone to its more polar metabolites than the control (Table 1). In males there was a correlation ($r = 0.7$, $P<0.01$) between testes weight and percent conversion of testosterone to its metabolites (both polar and less polar). Increased conversion of testosterone to its metabolites was inversely related to testes weight (Fig. 1).

The major pesticide residues in the liver, and thus circulating in the blood, were p,p' DDT (♂ 0.09 ppm, ♀ 0.10 ppm) and p,p' DDE (♂ 0.59, ♀ 0.26) though there were traces of o,p' DDE, o,p' DDT and p,p' DDD.

When 2 male birds with extreme values are omitted from the least squares analysis, a correlation ($r = 0.66$, $P<0.02$) between p,p' DDT in the liver and percent body weight of the testes (Fig. 2) was obtained. The greater the residue levels the smaller the testes. A similar correlation was found between o,p' DDT in the liver and percent body weight of the testes.

DDT and Energetics

The oxygen test results over a range of ambient temperatures (5 - 40 C) (Group 1) in the quail fed DDT varied from the control birds at all ambient temperatures except 30 C (Fig. 3). At the lower temperatures the differences in metabolic rate (O_2 consumption) of the five subgroups were significant only in that the experimentals were all higher than the controls (Fig. 3). As the thermoneutral zone (30 - 40 C) was approached the lines converged, with little difference among the dietary groups. The differences were greatest at the low ambient temperatures.

Above the upper critical temperature there is a considerable divergence of the means. One control bird tested at 45 C became hyperactive after only 15 min in the chamber, and over the next 5 min changed from using 126 cc/hr to 330 cc/hr of oxygen. Forty degrees centigrade seemed too severe for the experimental birds because 5 collapsed in the chamber and had to be removed before any readings were taken. Repeated tests were made on these birds and oxygen consumptions were obtained at 40 C; however, the time these bobwhites spent in the chamber ranged from only 30 to 75 min. None of the controls collapsed at 40 C. At the lower test temperatures all quail could spend an indefinite time in the test chamber, that is, until starvation or dehydration. All groups exhibited gular flutter and loss of moisture (collecting in the outlet tube from the chamber) at 40 C, indicating the humidity in the chamber was high since dry air was entering the chamber. Despite gular flutter and moisture loss, oxygen consumption of the control birds (mean of 1.17 $\pm$ 0.099 cc O_2/g/hr) at 40 C was of the same order as that of the control birds at 30 C (1.12 $\pm$ 0.103 cc O_2/g/hr) and 35 C (1.08 $\pm$ 0.048 cc O_2/g/hr) indicating that they were still within their zone of thermoneutrality at 40 C. The experimental birds on 10-, 50-, 100-, and 150-ppm-DDT diets used 1.39 $\pm$ 0.227, 1.40 $\pm$ 0.214, 1.30 $\pm$ 0.237, and 1.40 $\pm$ 0.524 cc O_2/g/hr respectively at 40 C. These values are not only higher than the controls at 40 C but also higher than the experimentals at 30 and 35 C, indicating that the upper critical temperature had been decreased. A greater variation in the oxygen consumption of the experimentals at 40 C than in the controls also suggested a lowering of the upper critical temperature in the DDT-treated birds; in thermal neutrality variation is at a minimum (19). The thermoneutral zone of the control birds was over a 10 C range, approximately between 30 and 40 C, while in the DDT-fed quail the thermoneutral zone was within a 5 C range, approximately from 30 to 35 C for all the treated groups. The body temperature of all quail remained relatively constant between ambient temperatures of 10 and 35 C. At 40 C the body temperature of all birds increased though that of the controls increased the greatest amount, whereas, at an ambient temperature of 5 C only the body temperature of the controls dropped significantly.

Thermal conductance (cc O_2/g/hr/C) was not significantly different among the 5 subgroups at any ambient temperatures except 40 and 35 C. At 40 C the thermal conductances of birds on diets of 10 (0.44 cc O_2), 100 (0.46 cc O_2), and 150 (0.52 cc O_2) ppm DDT are significantly different ($P<0.05$) from controls (0.34 cc O_2). Though the subgroup on 50 ppm DDT had a mean thermal conductance higher than the controls, it is not significant ($P>0.05$). At an ambient temperature of 35 C the only experimental group significantly different ($P<0.05$) from the controls (0.16 cc O_2) with regard to thermal conductance was the subgroup on the 150-ppm-DDT diet (0.20 cc O_2). There were no apparent trends among the experimental birds except at 40 C where increased DDT in the diet was correlated with increased thermal conductance.

In an attempt to determine if there were synergistic effects between long-term exposure to a moderately low ambient temperature (5 C) and DDT, we compared the oxygen consumption (at 5 C) of Group 1 quail on the control, 10-ppm, and 100-ppm-DDT diets to the oxygen consumption of Group 2 quail (on similar diets) which were acclimated to ambient temperatures of 5 C and tested at 5 C. Several differences and similarities between energetics of Group 1 and Group 2 quail at 5 C are apparent in Figure 4:

1. The birds on 10- and 100-ppm diets, whether acclimated or not, had a higher metabolic rate than the controls.

2. There was no significant difference in oxygen consumption between the acclimated (Group 2) and nonacclimated (Group 1) controls.

3. There was no significant difference in oxygen consumption between Group 1 and Group 2 quail on 10-ppm diets.

4. Group 2 quail on a 100-ppm-DDT diet had a significantly higher ($P<0.01$) oxygen consumption at 5 C than did Group 1 quail on the same diet and at the same temperature.

5. Group 2 birds on the 100-ppm-DDT diet had a significantly higher ($P<0.01$) oxygen consumption than did Group 2 and Group 1 controls at 5 C.

6. There was no significant difference in oxygen consumption between Group 2 birds (acclimated 2-3 weeks) and Group 1 birds on any of the diets.

Because the Group 2 quail on the 100-ppm DDT diet had a higher oxygen consumption than either Group 1 or Group 2 quail on any of the other diets, and increased oxygen consumption (metabolic rate) can sometimes be correlated to increased thyroid activity, thyroid activity (I^{131}) incorporation was determined at extremely low ambient temperatures (-18 C) (Table 2). All test birds, though given ad libitum food and water, lost weight over the 1-week test period. Controls dropped from a mean weight 197.3 $\pm$ 7.7 g at the start of the low-temperature test to a mean weight of 159.9 $\pm$ 13.3 g at the end of the test period, while those on 10- and 100-ppm-DDT diets dropped from 203.1 $\pm$ 5.5 g to 170.8 $\pm$ 8.2 g and 203.3 $\pm$ 3.6 g to 170.3 $\pm$ 2.6 g respectively. The weight change in the 100-ppm-DDT subgroup was at a mean rate of 12.1 g per day while in the controls and 10-ppm birds it was 5.3 and 4.6 g per day respectively.

In the 100-ppm-DDT subgroup, there was a significant ($P<0.02$) increase in thyroid weight expressed either directly in grams or indirectly as percent body weight as compared to the controls and

10-ppm-DDT subgroups (Table 2). No significant difference in thyroid weight was evident between the controls and 10-ppm-DDT subgroups. Iodine (I^{131}) activity expressed either as counts per minute or as percent of initial injection in the thyroid after 28 hr increased significantly ($P<0.01$) in the birds on 100-ppm-DDT diets over those on control and 10-ppm-DDT diets. There was no significant ($P>0.05$) difference between any of the groups when percent of initial injection of iodine incorporated into the thyroid per gram of thyroid was considered, though incorporation per gram was greatest in the birds on 10-ppm DDT, medium in the 100-ppm-DDT subgroup, and lowest in the control subgroup. During the 1-week low-temperature test period all birds sat in their cages with their feathers fluffed in order to minimize heat loss. Considerable shivering was noticed in all birds; shivering being especially prominent in the birds on 100-ppm-DDT diets 1 day prior to death. This may also have been related to DDT intoxication.

Mean hematocrits for the 5 subgroups (control; 10-, 50-, 100-, and 150-ppm-DDT diets) in Group 1 were found to be 38.6, 42.1, 42.1, 42.6, 41.5% respectively. This 3 to 4% increase of the experimentals over the controls was significant ($P<0.05$).

Trends in adrenal histology were apparent:

1. Control female adrenals were heavier than control male adrenals; whereas experimental females had lighter adrenals than male experimentals on every diet but 150-ppm DDT.

2. Control males had a higher percent cortical tissue (60.4%) and lighter adrenals than experimental males (53.1%).

3. Control female adrenals are heavier and have a greater percent cortex (67.9%) than experimental females (55.8%).

In Group 1, analysis of fat, brain, and liver tissue by gas chromatography showed that the metabolite most prominent in these tissues was DDE (Table 3). DDT was not detected in the 50-ppm sub-groups fat tissue in measurable amounts. The fat residues for the 50-ppm subgroup may not be representative because of the small amounts of fat which were removed from each bird. No traces of DDT were found in the control birds. DDD appeared only in liver tissue of birds fed 150 ppm DDT. Brain tissue levels of DDE were low in all subgroups in Group 1. Fat DDE levels increased in substantial amounts with the increasing concentrations of DDT in the diet.

A quail that died after 17 days on 800-ppm-DDT diet was dissected for tissue analysis. Fat residues were 18.23 ppm DDT, 12.7 ppm DDE, and 3.92 ppm DDD. The liver contained 77.6 ppm DDD and 103.0 ppm DDE. Brain levels registered 51.9 ppm DDT and 29.5 ppm DDE. Only brain levels showed a great increase compared to the figures for the 4 experimental subgroups in Group 1 on lower concentrations. In Group-2 quail the brain levels of p,p'DDE increased from a mean of 0.551 ppm in controls to a mean of 2.43 and 73.93 ppm in the 10- and 100-ppm subgroups respectively, while p,p' DDT increased from not detectable in controls to a mean of 0.355 and 19.25 ppm in the 10- and 100-ppm-DDT diet subgroups respectively.

The liver weights expressed as percent total body weight were higher in all Group 1 experimental birds (10-, 50-, 100-, and 150-ppm-DDT diets, Table 4). There was no significant difference in percent body weight of the liver between the controls and birds on 10-ppm-DDT diets, whereas in the subgroups on 50-, 100-, and 150-ppm-DDT diets it was significantly ($P>0.05$) heavier than in either the controls or 10-ppm-DDT birds. The brain weight expressed as percent total body weight for all subgroups within Group 1 remained relatively constant for all birds.

The LD_{50} for bobwhite dying within a period of 4 days was 1150 ppm DDT in their diet.

Discussion

DDT and Steroid Metabolism

Significant information on effect of insecticides and other compounds on rate of metabolism of in vitro steroids, compared with biological activity of in vivo steroids, is only preliminary. Little is known about the effect of DDT on steroid metabolism and enzyme induction in birds and especially game birds; Peakall (23,24) having made the only published reports. The effect of environmental doses of DDT on bird behavior (especially reproductive behavior) is virtually unknown.

The results suggest that in bobwhite quail, testes size may be related to the rate of induction of liver enzymes by DDT. DDT-treated males with smaller testes (which may indicate subordinate males with lower testosterone levels) showed the greatest conversion of testosterone to its more polar metabolites. DDT may have an estrogenic effect (3,25,32), thus converting subordinate-male (low testosterone levels) to female-type responses and explaining somewhat the similarity in response (in steroid metabolism) between females and males with regressed testes. Juvenile male quail and male quail with regressed testes during refractory period may be converted to and maintained in a female-like state due to low testosterone levels and the possible estrogenic effect of DDT. Concomitant with this is the increased enzyme induction (increased conversion of progesterone and testosterone to their more polar metabolites) due to DDT in females and subordinate males suggesting lower circulating levels of these hormones.

Peakall (23) has demonstrated in ring doves that DDT caused a decrease in circulating estrogen levels, a thinning of egg shells, and a delay in egg laying. Though it is unlikely that bobwhite quail would encounter high environmental levels of DDT in their diet, our study suggested that low environmental doses of DDT could be stored in the fats during the summer months when the birds are feeding partially on insects. During the winter months when the birds metabolize fats (see section on quail energetics) circulating levels of DDT and its metabolites could be high enough to enhance enzyme induction and thus steroid metabolism. This would be especially true during the winter months since the testes are in a regressed state. The smaller the testes the greater the conversion of testosterone to its metabolites. The decreased testosterone combined with the estrogenic effect of DDT could maintain the males in a female state, while the increased metabolism of estrogen and progesterone could account for delayed or complete lack of egg laying. This could explain why some adult birds with high tissue residues of DDT fail to breed.

DDT and Energetics

Quail are widely distributed in North America, from southwestern Wyoming south to eastern Mexico (2) and over most of the continent to the east, and are faced with many natural environmental stresses, especially a wide range in ambient temperature. The bobwhite (a relatively good homeotherm) maintains a relatively constant body temperature demonstrating a remarkable control and coordination over the mechanisms of heat production and heat loss. According to Scholander's et al. (27) adaptation of Newton's law of cooling ($MR = C [T_B - T_A]$) heat production can be equated to metabolic rate (oxygen consumption) and heat loss to thermal conductance (C) times the body temperature minus the ambient temperature. Therefore, by studying the energetics (oxygen consumption) of an animal it is possible to get some insight into how this animal adapts to ambient temperature stress and what effect DDT might have on its ability to survive under various ambient temperatures.

As indicated by the measurement of body temperatures over an ambient temperature range of 10 - 35 C the bobwhite can maintain a mean body temperature of 41.5 C. At ambient temperatures of 5 C the birds undergo a slight hypothermia (T_B 40.6) whereas at an ambient temperature of 40 C body temperature becomes hyperthermic (43.4 C). The zone of thermal neutrality ($\approx$30 - 40 C) for a bobwhite approximates that found by Brush (4) for the California quail, (Lophortyx californicus, 27 - 37.5 C). The mean oxygen consumption (1.12 cc O_2/g/hr) agrees closely with the value predicted by the Lasiewski-Dawson (16) equation for a 200-g nonpasserine bird (23 Kcal/day); the equation is $M = \log 78.3 + 0.723 \log W$; where M equals metabolic rate and W equals weight (15). The zone of thermal neutrality, therefore, extends over approximately 10 C (30 - 40 C) and is high when compared to most other birds. A high zone of thermal neutrality is usually assumed to be an adaptation to high ambient temperature and supports Darlington's (9) theory that bobwhite quail evolved in the warm climate of southern North America.

The most generally employed model for describing the metabolic response of homeotherms at rest to ambient temperatures is based on ideas related to Newton's law of cooling, with thermal conductance being minimal and uniform below the thermal neutral zone, with body temperature remaining uniform over a very wide range of ambient temperatures and with clearly defined upper and lower critical temperatures. By comparing the shape of the curve relating oxygen consumption to ambient temperature (Fig. 3) to the values for thermal conductance, it is evident that below an ambient temperature of 20 C the thermal conductance (mean of 0.064 cc O_2/g/hr/C) remains relatively constant and the regulation of body temperature is due to increased chemical thermogenesis. The mean thermal conductance of quail below 20 C approximates that predicted by Lasiewski et al. (15) for a 200-g bird (0.06 cc O_2/g/hr/C). The increased thermogenesis in the bobwhite was presumably due entirely to shivering because non-shivering thermogenesis has not yet been demonstrated in birds (19). The increasing values for thermal conductance and oxygen consumption between ambient temperatures of 20 C and 30 C (the lower critical temperature) indicated that the maintenance of a constant body temperature over this temperature range is accomplished by both increased thermogenesis and insulative changes in the shell (peripheral heterothermy, feather arrangement, tucking beak under feathers, and sitting on unfeathered legs). Thus, the bobwhite does not follow Newton's law of cooling (constant thermal conductance below thermal neutrality). In the bobwhite quail there is a gradual transition from regulation of body temperature primarily through control of insulative changes (thermal conductance) to regulation primarily through thermogenesis. As the ambient temperature approached the body temperature there were increasing amounts of moisture in the air leaving the metabolic chamber (determined by the rate of color change in drierite). As Brush (1965) pointed out in the California quail, as the T_A increased above the lower critical temperature, evaporation was responsible for progressively greater amounts of heat dissipation, whereas at ambient temperatures below the lower critical temperature it accounted for only about 5% of the total heat loss. The mechanism for evaporative water loss in the bobwhite is through a combination of panting and gular flutter which Lasiewski et al. (15) have found to be an extremely efficient means of heat loss; birds can lose better than 100% of the heat produced or gained from the environment by this method. At an ambient temperature of 40 C the bobwhite quail underwent a slight hyperthermia (T_B 43.4 C). This ability to withstand a slight hyperthermia aids the bird in heat loss since the temperature gradient from the bird to the environment is greater and heat dissipation can occur by conduction and convection rather than by the energy-requiring panting and gular flutter. This hyperthermia accounts somewhat for the high upper critical temperature of the bobwhite.

Below the zone of thermal neutrality (30 - 40 C) the maintenance of a constant body temperature is an energy-requiring process and anything that would increase this energy requirement would be detrimental to the birds, especially if food were scarce.

In this study the oxygen consumption of all the experimental birds (10-,50-,100-,150-ppm-DDT diets) was higher than that of the controls at all test temperatures except 30 C. Ozburn and Morrison (22) working with white mice, and Jefferies and French (13) working with pigeons, also found that DDT in the diet increased the oxygen consumption of these animals.

By comparing the oxygen consumption of the controls to that of the birds on various DDT diets over an ambient temperature range of 5 C to 40 C it becomes obvious that the greatest differences exist at the extreme ambient temperatures of 5 and 40 C. In fact, it is at an ambient temperature of 40 C that the greatest differences in oxygen consumption occur. Not only was the oxygen consumption of experimentals higher at 40 C than that of the controls but it was also higher than the experimentals at 35 C, suggesting that the upper end of the zone of thermal neutrality was shifted down at least 5 C (to 35 C). This was evident because the experimental birds collapsed in the test chamber at 40 C. The lowered upper critical temperature in the DDT-fed quail might well be a result of the greater heat production within the bird due to the increased metabolic rate combined with the inability to withstand as great hyperthermia as did the controls. Though metabolic rate was higher in the DDT-fed birds, body temperature was less, indicating that the experimental birds were losing heat faster. As mentioned previously, the major means of heat loss at high ambient temperatures is evaporative water loss (panting and gular flutter). Calder and Schmidt-Nielsen (6) have shown that increased oxygen consumption with panting and gular flutter in pigeons results in alkalosis of these birds under heat stress. Perhaps increased alkalosis was causing the experimental quail to collapse in the metabolic chamber.

At an ambient temperature of 5 C the control birds had lower body temperatures ($\bar{X}$ = 40.6 C) than the experimentals ($\bar{X}$ = 41.5 C). Below an ambient temperature of 20 C the thermal conductance of all the birds was minimized (maximum insulation). Because all the birds had the same insulating capacity, thermal conductance was the same. Therefore, a lower metabolic rate (lower heat production) in the control birds would result in a lower body temperature.

The increased hematocrit in all experimental birds can be correlated to increased oxygen requirement. It is obvious from the metabolic results that there is a threshold level of DDT in the diet that brings about the increased metabolic rate, and the metabolic rate does not increase with increased dietary levels of DDT above the threshold level in unacclimated birds.

Several hypotheses for increased oxygen consumption have been set forth:

1. Increased enzyme induction in the liver brought about by chlorinated hydrocarbons (24) could cause an increased oxygen consumption in the experimental quail. We found increased induction of liver enzyme on dietary levels of DDT as low as 5 ppm and significant increases in liver weight in dietary levels of 50 ppm or better. If the increased O_2 consumption was due to the enzyme, induction increase should be constant at all ambient temperatures. Our results show that the increase in O_2 consumption was not constant at all ambient temperatures thus rejecting the increased enzyme induction hypothesis.

2. Since DDT's introduction as a poison, it has been known to act on the nervous system (30). Thus, the oxygen increase could also result from increased nervous activity caused by sublethal amounts of DDT. Our birds were tested in a dark chamber (birds sit still) so increased nervous activity was unlikely. Liver levels can be used to indicate the amount of pesticide circulating through the body and hence available to enter the central nervous system (10). The residue levels in the livers of the treated birds were low except for the 150-ppm birds.

3. The third hypothesis is that DDT causes an increased thyroid activity which in turn brings about an increased metabolic rate. It is also known that exposure to low temperature causes increased thyroid activity in birds (29).

To test this we acclimated Group 2 birds (control; 10- and 100-ppm diets) for at least 10 weeks to a moderately low ambient temperature (5 C) and once again measured their metabolic rate at 5 C. We now found that the birds on 100-ppm DDT had significantly higher O_2 consumption than the controls, whereas O_2 consumption in the acclimated controls was no different than in the unacclimated controls. This supports the hypothesis that it is DDT and not just cold stress that enhanced thyroid activity. The birds on either of the diets did not lose significant amounts of weight over the 4-month test period, suggesting that survivability was the same.

To test this hypothesis further we injected I^{131} into the Group 2 birds and lowered the T_A to -18 C for 1 week, at the end of which the birds were sacrificed and thyroid activity determined. The significantly greater weight of the thyroid of 100-ppm DDT birds combined with the fact that I^{131} activity per gram was only slightly higher than the controls suggests greater secretion of thyroxine. Our results agree with that of Jefferies and French (13) who found a significantly increased O_2 consumption correlated with increased thyroid weight in pigeons after 11 weeks on the various DDT diets. Their lowest dietary level of DDT was as high as our highest. Of the 3 hypotheses set forth the latter is the most acceptable, though it is possible that the increased oxygen consumption is due to a combination of all 3 (increased enzyme induction, nervousness, and thyroid activity).

In the present study, the only birds dying of DDT poisoning were those used in the LD_{50} test and the Group 2 birds on 100-ppm DDT diets exposed to -18 C. We found an LD_{50} of 1150 ppm for 1-year-old bobwhite quail fed over a 4-day period. This values agrees closely with that found by Hill et al. (12) (1170 ppm DDT) for subadult (weight 158.0 g) quail.

Considering the high p,p' DDT and p,p' DDE residues in fat tissue of birds on a 100-ppm-DDT diet for several months (238.1 ppm and 924.5 ppm respectively), the large weight loss (12 g/day) of 100-ppm-DDT birds at ambient temperature of -18 C and the high metabolic rate of these birds, it becomes apparent why these birds died of DDT poisoning. The mobilization of these fat stores in response to low temperature and elevated metabolism due to DDT, increased the circulating amount of p,p' DDT and p,p' DDE to lethal levels. All of the birds on a 100 ppm DDT diet and low temperature (-18 C) that died had between 21.6 and 26.3 ppm DDT in the brain, and the 1 bird surviving the test had only 6.1 ppm DDT in the brain. This supports the findings of other investigators that approximately 20-30 ppm DDT in the brain is a toxic level. Since all 4 of the birds on 100-ppm-DDT diets and low temperature (including the surviving bird) had relatively high levels of p,p' DDE in the brain it would seem that p,p' DDT was the more important residue causing death.

The study of the effects of DDT on the energetics of bobwhite suggested that low dietary levels of DDT could have detrimental effects on quail survival in their natural environment. The slight increase in metabolic rate concomitant with the downward shift (40 C to at least 35 C) in the upper end of the zone of thermal neutrality and a decreased ability to withstand hyperthermia, decrease the chances of survival when quail are exposed to high ambient temperatures. This becomes extremely important because the bobwhite is typically a bird of southern North America.

At first thought, it would seem that at low ambient temperatures the increased metabolism due to DDT would be beneficial, enabling the bird to maintain its body temperature. At 5 C the body temperature of experimentals was not significantly lower than at 10 C while in the controls it was lower. At low ambient temperature there is usually a scarcity of food. Assuming a respiratory quotient of 0.75 (fasted bird oxidizing fats) 1 cc of oxygen consumed/g/hr can be equated to 4.7 cal/g/hr. Based on this figure, nonacclimated bobwhite quail on a 10 - 150 ppm diet would have an increased metabolic requirement of 2.5 Kcal/day at an ambient temperature of 5 C. In the acclimated quail on 100-ppm-DDT diet the increased metabolic requirement due to DDT was 9 Kcal/day at ambient temperature of 5 C. The increased metabolic expenditure must be met either by increased food intake or increased metabolism of stored fat. The scarcity of food, especially in the northern range of the bobwhite during the winter months, would mean that the birds would probably have to metabolize stored fats which would further influence the bird's life by increasing circulating levels of DDT and its metabolites.

As pointed out in our study, if residue levels in the fats are high enough, the bird could die of DDT toxicity. Even without DDT poisoning, weight losses could be high enough in DDT-fed birds (due to the increased energy requirement) to decrease survival. Our results support the findings of Neave and Wright (21) on the effects of weather and DDT spraying on 2 ruffed grouse (Bonasa umbellus) populations. They stated that a synergistic effect between DDT spraying and temperature resulted in increased egg loss. The synergistic effect might develop because the DDT birds have a higher metabolic rate than the controls (even though controls had an elevated metabolic rate due to cold stress). Therefore, a laying bird (due to a much higher metabolism than a bird without DDT and cold stress) would metabolize more fat, which in turn would increase circulating levels of DDE which would affect egg development.

The quail in our tests were in individual cages and could not covey during extreme-cold stress experiments. When the temperature in the environmental room was lowered, the quail gave the covey call. It is possible then, that coveying is a form of behavioral temperature regulation and at -18 C the energy requirement might be less in quail that covey than in our experimental birds.

Table 1. Conversion of progesterone and testosterone to their metabolites by control and DDT fed quail, 1969. BW = body weight; TP = testosterone polar metabolite; T4 =testosterone; LTP = less testosterone polar metabolite; PP = progesterone polar metabolite; P4 = progesterone; MO = control male; FO = control female; FX = experimental female; MX = experimental male.

Date, sex and treatment*	% TP or PP	% T4 or P4	% LTP	% BW of the testes
718 FO	15.6	84.4		
729 FO	24.8	75.2		
730 FO	32.0	68.0		
715 MO	25.8	69.0	4.75	0.70
724 MO	7.77	89.0	3.14	1.0
716 MO	3.45	54.5	10.4	0.55
729 MO	7.31	83.1	9.5	1.15
730 MO	3.67	92.7	3.55	0.65
1217 MOA	29.5	61.8	8.4	0.023
1217 MOB	23.1	45.7	31.5	0.01
729 FX	47.0	53.0		
730 FX	50.5	49.5		
81 FXA	42.8	57.2		
81 FXB	67.3	32.7		
717 MX	23.2	70.06	5.9	0.69
724 MX	23.2	68.8	7.96	0.64
1218 MX	39.4	53.6	6.89	0.02
729 MX	7.58	84.7	7.7	0.55
730 MX	8.5	87.7	3.75	0.54
812 MXA	37.58	58.82	3.6	0.188
99 MXA	37.1	59.8	2.89	0.44
99 MXB	21.6	68.0	10.6	0.645
99 MXC	20.8	75.6	3.85	0.50
99 MXD	12.7	81.0	6.3	0.41
911 MXA	29.8	65.5	4.64	0.13
911 MXB	21.0	74.6	4.9	0.32
911 MXC	56.0	38.0	5.74	0.03
911 MXD	18.3	64.8	4.9	0.37

*Prefix numeral indicates month and date (718 = July 18); suffix letter (A, B, C, D) indicates different birds on same date.

Table 2. Results from low temperature stress. CF = control female; CM = control male; TF = 10 ppm DDT female; TM = 10 ppm DDT male; HF = 100 ppm DDT female; HM = 100 ppm DDT male; * = birds not tested for brain residues. Means are ± one standard deviation.

Bird and diet	Survival time (hours)	Body weight (grams)	Thyroid weight (grams)	I^{131} activity after 28 hrs. counts/min.	% I^{131} activity per gram	Brain weight (grams)	% Brain lipid	Brain levels of p,p' DDE	Brain levels of p,p' DDT (ppm)
1CF	168.58	129.8	0.0135	21,600	308	0.7536	3.65	1.88	---
2CM	169.33	149.9	0.0096	22,300	446	0.9807	5.81	0.06	---
3CM	169.83	203.9	0.0219	22,000	193	0.9485	6.01	0.06	
4CM*	170.50	176.0	0.0068	---	-	---	--	---	---
6CF	172.00	140.2	0.0146	28,200	370	0.9603	5.83	0.20	---
Means		159.9 ± 29.9	0.0132 ± 0.005		329 ± 92				
9TF	172.50	146.7	0.0160	46,100	550	0.8289	4.89	2.96	0.66
10TM*	173.08	199.6	0.0179	---	-	---	--	---	---
11TF*	174.00	173.9	0.0118	---	-	---	--	---	---
12TF	174.50	150.1	0.0076	34,250	870	1.0843	5.81	3.8	0.32
13TM	175.16	184.1	0.0088	21,400	467	0.9096	5.88	1.96	0.21
14TM	175.83	171.2	0.0129	31,200	466	1.1611	5.77	1.0	0.23
Means		170.8 ± 20	0.0125 ± 0.0036		588 ± 166				
18HF	50.50	177.3	0.0251	44,900	344	1.0759	5.34	88.0	23.0
21HM	73.75	166.2	0.0270	52,500	374	1.0913	5.82	102.0	21.6
22HF	168.00	166.1	0.0246	44,900	351	1.1000	5.55	42.7	6.10
23HM	28.00	171.8	0.0167	63,400	720	1.0758	5.34	63.0	26.3
Means		170.3 ± 5.3	0.0233 ± 0.0039		447 ± 157				

Table 3. Mean residues of DDT and its metabolites for 4 quail from each group. Feeding period was 211-242 days. Residues are given in parts per million (ppm) wet weight. Dash (-) indicates no detectable residues.

Group	Tissue	ppm DDT	ppm DDT	ppm DDE
control N = 4	Fat	-	-	1.5
	Brain	-	-	-
	Liver	-	-	0.3
10 ppm N = 4	Fat	11.12	-	41.37
	Brain	-	-	0.33
	Liver	-	-	2.96
50 ppm N = 4	Fat	-	-	283.0
	Brain	-	-	7.5
	Liver	-	-	17.5
100 ppm N = 4	Fat	238.1	-	929.5
	Brain	-	-	8.89
	Liver	-	-	17.9
150 ppm N = 4	Fat	791.25	-	1877.50
	Brain	3.07	-	10.87
	Liver	-	11.75	90.12

*All residues were p,p' isomers except for the brain residue in the controls which was o,p' DDE. Recovery levels averaged 73%.

Table 4. Results of dissections giving mean body and liver weights in grams of birds used in the oxygen consumption tests.

Group 1	Mean body weight	Mean liver weight	Mean % total body weight of liver
Controls	201.7 ± 3.6	3.5	1.74 ± 0.22
10 ppm	196.0 ± 18.6	3.5	1.77 ± 0.18
50 ppm	179.8 ± 14.5	4.3	2.38 ± 0.31
100 ppm	201.1 ± 11.3	5.1	2.54 ± 0.20
150 ppm	191.2 ± 12.4	4.2	2.22 ± 0.06

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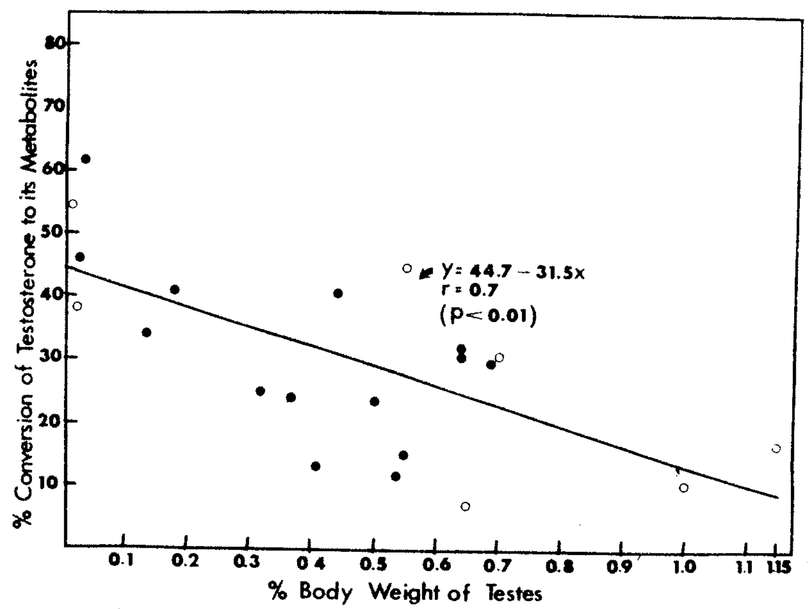

Figure 1. Relationship between testes weight and percent conversion of testosterone to its metabolites. The regression line is fitted by the method of least squares and has a correlation coefficient of r = 0.7 (P <0.01). Shaded circles represent experimental males, unshaded circles represent control males.

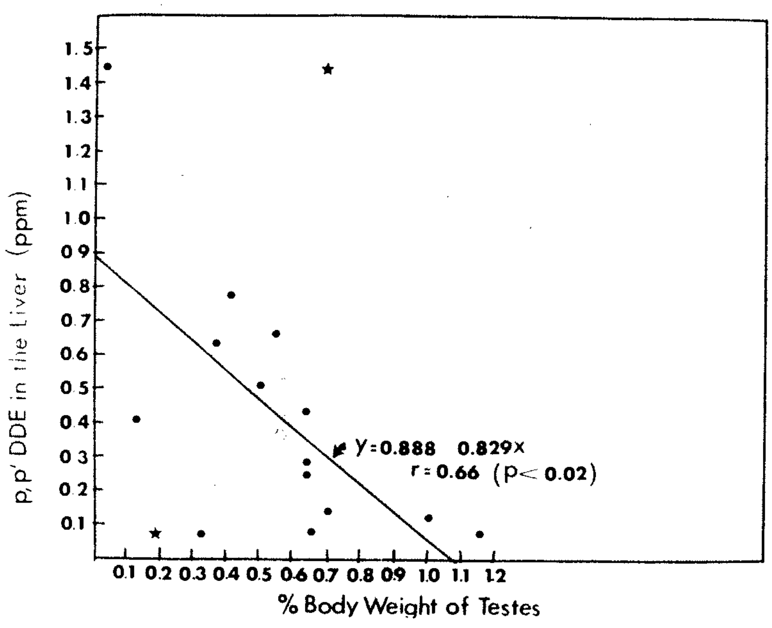

Figure 2. Relationship between percent body weight of testes and p,p' DDE in the liver, in experimental male bobwhite quail. The regression line is fitted by the method of least squares to the shaded circles and has a correlation coefficient of r = 0.66, P<0.02. The stars represent experimental birds not included in regression analysis.

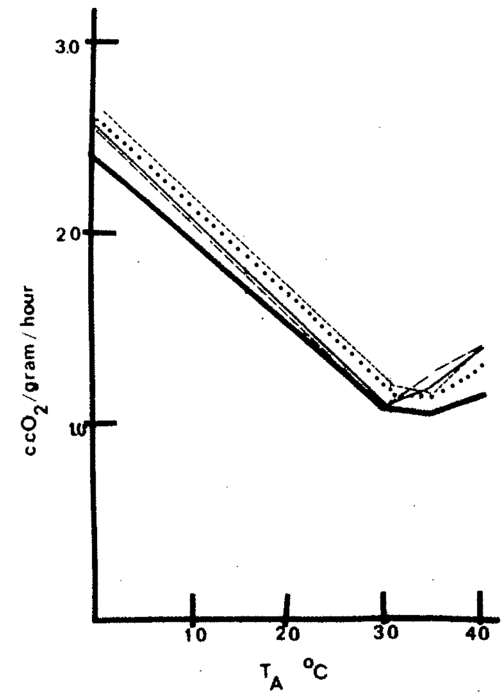

Figure 3. The slopes of the metabolic curves of the control group and 4 experimental groups below the lower critical temperature (~30° C). Means of the 5 groups are plotted at 35 and 40° C. n = 5. Using the least squares method to fit the standard metabolic curves to the lines, (Y = MX + b), the following results were obtained:

for control	2.4163 = (-0.0493)x + b	heavy solid line
10 ppm	2.5735 = (-0.0493)x + b	thin solid line
50 ppm	2.6885 = (-0.0494)x + b	dashed (short) line
100 ppm	2.6287 = (-0.0475)x + b	dotted line
150 ppm	2.5446 = (-0.0493)x + b	dashed (long) line

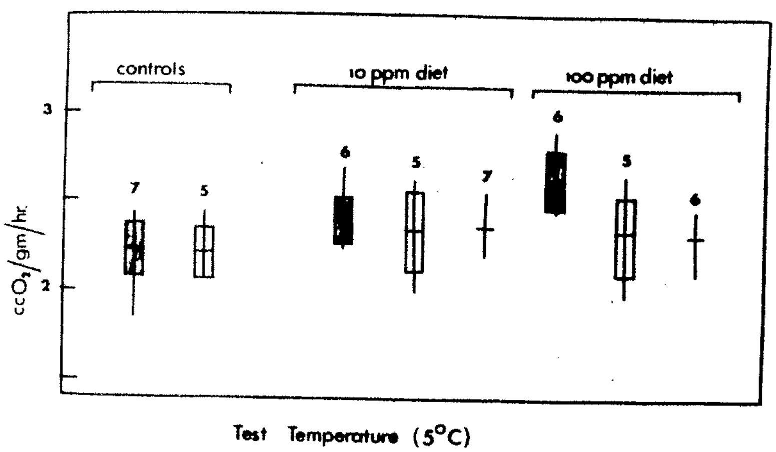

Figure 4. Comparison of the oxygen consumption at an ambient temperature of 5° C of quail acclimated for at least 10 weeks (shaded boxes), unacclimated quail (unshaded boxes), and quail acclimated for only 2 to 3 weeks (crosses) on three different diets (control, 10 and 100 ppm DDT). Vertical lines represent range, horizontal lines the mean and boxes the 95 percent confidence limits.

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DISEASES AND PARASITES OF THE BOBWHITE

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Abstract:

The authors' experiences with disease and parasite problems of wild and pen-raised bobwhites are given. Information extrapolated from an extensive literature review is presented in tabular form. Diseases and parasites of bobwhites, location in the bird of the lesion or parasite, and geographic areas of occurrence are note.

A variety of information concerning diseases and parasites of the bobwhite is available in the technical literature. The majority of mortality reports deal with pen-raised birds, but limited information is available concerning wild bobwhites. Basic publications related to diseases and parasites of bobwhites include: Biester and Schwarte's (1965) Diseases of Poultry; Davis, Anderson, Karstad, and Trainer's (1971) Infectious and Parasitic Diseases of Wild Birds; the section in Stoddard's (1931) book concerning diseases and parasites of the bobwhite; and Kellogg and Calpin's (1971) checklist of diseases and parasites reported from the bobwhite.

Today, 40 years after Stoddard's (1931) initial disclosure of diseases and parasites affecting quail, there is still little information as to the role diseases and parasites play in the high annual losses sustained by wild bobwhite populations. Blackhead, tularemia, and ulcerative enteritis (Stoddard 1961, Green and Wate 1929, Shillinger and Morley 1937) have been reported to cause death in wild bobwhites. This paucity of information probably is due to the small number of wild bobwhites that are submitted to diagnostic laboratories.

Only 16 wild bobwhites have been submitted to the Southeastern Cooperative Wildlife Disease Study (SCWDS) for diagnosis during the last 5 years. Deaths were attributed to the following causes: trauma (6), e.g. flying into solid objects; egg yolk peritonitis (3), i.e. the ovum had dropped into the body cavity rather than the oviduct and caused fatal peritonitis; pesticide poisoning (3); aortic rupture (1); proliferation of the "horny" lining of the gizzard (1); fowl pox (1); and fungus infection in the lungs, kidneys, and body cavity (1).

During various research studies we have examined hundreds of wild bobwhites, which were shot or trapped, and have noted only 2 parasite problems. Severe distention of the small intestine by tapeworms has been observed, and proventriculitis caused by large numbers of nematodes (*Tetrameres* sp.) has been encountered rarely. The proventricular wall in such cases was thickened to the extent that the lumen was almost occluded. Whether or not these problems would have caused death is speculative.

Many disease and parasite problems are associated with pen-raised bobwhites. In our experience the most common problems causing death of pen-raised bobwhites are: quail bronchitis, ulcerative enteritis, blackhead, and infection of the crop by the nematode *Capillaria contorta*. Problems occasionally occur with the proventricular nematode *Dispharynx nasuta* and with coccidia, but seldom do these entities alone cause death.

The diseases and parasites of wild and pen-raised bobwhites are presented in Tables 1-4. Location in the bird of lesion or parasite and geographic area of occurrence are given. A few older reports of diseases and parasites listed in the tables are now considered erroneous. The chicken coccidia *Eimeria acervulina*, *E. mitis*, and *E. tenella* have been reported from the bobwhite, but these records are in error (Pellerdy 1965). *Eimeria dispersa* is the only specific coccidium reported from the bobwhite in recent literature. At least 2 additional species of coccidia, as yet undescribed in the literature, infect the bobwhite (SCWDS, unpublished data). A blood parasite, *Plasmodium elongatum*, was erroneously reported as *Plasmodium praecox* in earlier literature (Cram et al. 1931, Wetmore 1941) and an acanthocephalan referred to as *Disteganius colini* was reported but never described (Lehmann 1953).

The tables and references listed should prove useful to laymen and technical personnel as well. Diagnosticians often lack familiarity with bobwhite diseases and therefore prefer not to examine them. The information included here should help alleviate this problem.

Table 1. Tabulation of viral, bacterial, and mycotic diseases reported from the bobwhite.

Disease (organism)	Location or lesion area	Type of report and geographical location if given*	Refer. No.
VIRAL DISEASES			
Equine encephalitis	brain	exp. inf.	137
		sp. rev.	75
		exp. inf.	156
		exp. inf.	146
Fowl pox	head, under wings, legs, feet, and inside mouth and esophagus	case rept.-Mexico	67
		case rept.-Ga., S.C.	133
		gen. rev.	98
		gen. rev.-southern U.S.	129
Newcastle disease	no lesions, but developed anti-bodies	gen. rev., exp. inf.	65
Quail bronchitis	respiratory tract	case rept.-W.Va.	105
		case rept.-Texas	58
		gen. rev.	132
		exp. inf.	57
		exp. inf.-Texas	59
		sp. rev.	77
		gen. rev.	70
		exp. inf., case rept.-Va.	55
		sp. rev.	56
BACTERIAL DISEASES			
Avian tuberculosis (*Mycobacterium avium*)	viscera	gen. rev.	129
		gen. rev.	127
Botulism (*Clostridium botulinum*)	nervous system	exp. inf.-N.Y.	15

Table 1. (continued)

Disease (organism)	Location or lesion area	Type of report and geographical location if given*	Refer. No.
BACTERIAL DISEASES (continued)			
Chronic respiratory disease (*Mycoplasma gallisepticum*)	lungs and air sacs	unsuccessful exp. inf.	159
		case rept.	95
Erysipelas (*Erysipelothrix rhusiopathiae*) (= *E. insidiosa*)	heart and liver	case rept.-Iowa	142
Escherichia freundii	lower intestine	case rept.	61
Fowl cholera (*Pasteurella multocida*)	heart and liver	gen. rev.	129
		unsuccessful exp. inf.	17
Fowl typhoid (*Salmonella gallinarum*)	heart and liver	gen. rev.	129
Paratyphoids			
Salmonella bareilly	lower intestine	case rept.-Ill.	122
Salmonella bredney	lower intestine	case rept.	47
		case rept.	48
Salmonella newport	lower intestine	case rept.-Ill.	71
Salmonella oranienburg	liver	case rept.-Ky.	62
Pseudotuberculosis (*Pasteurella pseudotuberculosis*)	viscera	case rept.-England	24
		sp. rev.	132
Pullorum (*Salmonella pullorum*)	liver and lungs	case rept.	64
		exp. inf.	129
Tularemia (*Pasteurella tularensis*) (= *P. tularense*) (= *Bacterium tularense*) (= *Fransicella tularensis*)	lungs, liver, and spleen	case rept.-Minn.	73
		exp. inf.	108
		gen. rev.	72
		sp. rev., case rept.-Mo.(?)	109
		gen. rev.	129

Table 1. (continued)

Disease (organism)	Location or lesion area	Type of report and geographical location if given*	Refer. No.
BACTERIAL DISEASES (continued)			
Ulcerative enteritis	lower intestine and liver	sp. rev.-Ala., D.C., Kan., Mass., Pa., Va., Nova Scotia	103
		sp. rev.-Va.	68
		case rept.-Ga.	133
		case rept.-Md.	120
		gen. rev.	126
		gen. rev.	98
		gen. rev.	106
		case rept.-Ill. (?)	3
		sp. rev., exp. inf.	128
		gen. rev.-southern U.S.	99
		sp. rev.	100
		exp. inf.	101
		gen. rev.	129
		sp. rev.	6
		gen. rev.	127
		exp. inf.	7
		sp. rev., exp. inf.	60
		exp. inf.	23
		exp. inf., case rept.-Md.	102
		exp. inf. (drug study)	87
		exp. inf. (drug study)	88
		exp. inf. (drug study)	89
		exp. inf. (drug study)	86
		exp. inf.	112
		exp. inf.	113
		exp. inf. (drug study)	116
		gen. rev.-Wis.	81
		gen. rev.	70

Table 1. (continued)

Disease (organism)	Location or lesion area	Type of report and geographical location if given*	Refer. No.
BACTERIAL DISEASES (continued)			
Ulcerative enteritis	lower intestine and liver	sp. rev.	114
		case rept.-S.C.	84
		exp. inf.-Ga.	18
		gen. rev.	141
		exp. inf.-Ga.	51
		gen. rev.	115
		gen. rev.	139
MYCOTIC DISEASES			
Aspergillosis (*Aspergillus fumigatus*)	respiratory tract	gen. rev.	72
		case rept.-Va.	133
		gen. rev.	98
Crop mycosis (*Candida albicans*) (= *Oidium albicans*)	esophagus and crop	gen. rev.	129
		gen. rev.	132

*Abbreviations used: gen. rev. = mentioned in a general review of diseases; sp. rev. = review of that specific disease or a specific parasite description; exp. inf. = experimental infection; case rept. = case report or survey.

Table 2. Tabulation of protozoan diseases reported from the bobwhite.

Organism	Location or lesion area	Type of report and geographical location if given*	Refer. No.
Chilomastix sp.	lower intestine	case rept.-Ga.	50
Eimeria acervulina (?)	small intestine	case rept.-Ohio	155
		case rept.-Ohio	140
		gen. rev.	129
		gen. rev.	127
		gen. rev.	74
Eimeria dispersa	small intestine and ceca	exp. inf.	136
		gen. rev.	138
		case rept.-Ohio	155
		case rept.-Ohio	140
		gen. rev.	129
		gen. rev.	16
		gen. rev.	127
		gen. rev.	74
		case rept.-Okla.	130
		gen. rev., sp. rev.	91
		gen. rev., sp. rev.	117
Eimeria mitis (?)	small intestine and ceca	gen. rev.	129
		gen. rev.	127
Eimeria tenella (?)	ceca	case rept.-Ohio	155
		case rept.-Ohio	140
		gen. rev.	129
		gen. rev.	127
		gen. rev.	74
Eimeria spp.	lower intestine	case rept.-Fla., Ga., Miss., N.C., S.C., Tenn.	45
		gen. rev.	98

Table 2. (continued)

Organism	Location or lesion area	Type of report and geographical location if given*	Refer. No.
Eimeria spp. (continued)	lower intestine	case rept.-Miss.	145
		gen. rev., sp. rev.	91
		gen. rev., sp. rev.	117
		gen. rev.	141
Haemoproteus sp.	erythrocytes	case rept.-Md.	154
		sp. rev. (survey in N.Mex. neg.)	21
		sp. rev. (survey in Iowa neg.)	123
Hexamita sp.	ceca	gen. rev.	132
Histomonas meleagridis	ceca and liver	gen. rev.	45
		gen. rev.	126
		gen. rev.	98
		gen. rev.	99
		gen. rev.	129
		gen. rev.	127
		case rept.	134
		case rept.-Ga., S.C.	84
		sp. rev., exp. inf.-Ga.	85
		sp. rev., exp. inf.-Md.	94
Plasmodium elongatum (= Plasmodium praecox of Cram et al. 1931)	erythrocytes	case rept.-Ga.	45
		case rept.-Ga., Md.	154
Plasmodium sp.	erythrocytes	exp. inf.	153
		sp. rev. (survey in N.Mex. neg.)	21
		sp. rev. (survey in Iowa neg.)	123
Trichomonas gallinae	esophagus and crop	exp. inf.	92
Trichomonas sp.	ceca	case rept.-Va.	1
		gen. rev., case rept.-Va.	45

Table 2. (continued)

Organism	Location or lesion area	Type of report and geographical location if given*	Refer. No.
Trichomonas sp. (continued)	ceca	gen. rev.	98
		gen. rev.	129
		gen. rev.	127

*Abbreviations used: gen. rev. = mentioned in a general review of diseases; sp. rev. = review of that specific disease or a specific parasite description; exp. inf. = experimental infection; case rept. = case report or survey.

Table 3. Tabulation of helminths reported from the bobwhite.

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
TREMATODES			
Harmostomum sp. (= Brachylaema sp.)	small intestine	case rept.-Md., N.C.	45
CESTODES			
Davainea sp.	small intestine	case rept.-Texas	90
Hymenolepis cantaniana (= Staphylepis cantaniana)	small intestine	case rept.-Md.	79
		sp. rev., case rept.-Md.	45
		exp. inf.	80
Hymenolepis carioca (= Echinolepis carioca)	small intestine	exp. inf., case rept.	44
		sp. rev., case rept.-Fla., Ga., Va.	45
		case rept.-Miss.	144
		case rept.-Miss.	145
		case rept.-Ga.	84
Hymenolepis sp.	small intestine	case rept.-Ohio	155
		case rept.-Ohio	140
		case rept.-Texas	110
Paricterotaenia sp.	small intestine	case rept.-Texas	151
		case rept.-Texas	148
		case rept.-Texas	90
Raillietina cesticillus (= Davainea cesticillus)	small intestine	exp. inf., case rept.	44
		case rept.-Fla.	135
		sp. rev., case rept.-Fla., Ga., Miss., Tenn.	45
		case rept.-Texas	147
		case rept.-Miss.	145

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
CESTODES			
Raillietina cesticillus (continued)	small intestine	case rept.-Texas	151
		case rept.-Fla., Ga.	84
		case rept.-Tenn.	14
Raillietina colini	small intestine	sp. rev., case rept.-Texas	147
		case rept.-Texas	151
		case rept.-Texas	148
		sp. rev.	125
Raillietina klebergi	small intestine	sp. rev., case rept.-Texas	148
		case rept.-Texas	150
		case rept.-Texas	90
		sp. rev.	125
Raillietina minuta	small intestine	sp. rev., case rept.-Texas	148
		case rept.-Texas	150
		case rept.-Texas	90
		sp. rev.	124
Raillietina tetragona	small intestine	sp. rev., case rept.-Fla., Ga., S.C., Va.	45
		case rept.-Texas	148
		case rept.-Texas	110
		case rept.-Texas	90
Raillietina sp.	small intestine	case rept.-Texas	110
		case rept.-Fla., Ga., S.C.	84
		case rept.-Tenn.	14
Rhabdometra odiosa	small intestine	sp. rev., case rept.-Fla., Ga.	78
		sp. rev., case rept.-Fla., Ga.	45

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
CESTODES (continued)			
Rhabdometra odiosa (continued)	small intestine	case rept.-Miss.	144
		case rept.-Miss.	145
		case rept.-Texas	151
		case rept.-Texas	148
		case rept.-N.C.	104
		case rept.-Texas	90
		case rept.-Ill.	19
		case rept.-Tenn.	14
Rhabdometra spp.	small intestine	case rept.-Ga.	84
		case rept.-Tenn.	14
ACANTHOCEPHALANS			
Mediorhynchus bakeri	small intestine	case rept.-Fla.	20
Mediorhynchus colini (= Disteganius colini)	small intestine	sp. rev., case rept.-Texas	149
		case rept.-Texas	110
		case rept.-Texas	90
Onicola canis	immature worms encysted in connective tissue outside crop and esophagus	case rept.-N.C., Mexico	37
NEMATODES			
Aproctella stoddardi	free in body cavity	sp. rev., case rept.-Fla., Ga.	45
		sp. rev., case rept.-Fla., Ga., S.C.	43
		sp. rev.	2

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Ascaridia compar	small intestine	sp. rev.	29
		case rept.-Fla.	193
Ascaridia lineata	small intestine	case rept.-Ga.	45
Aulonocephalus guaricensis	ceca	sp. rev., case rept.-Cuba	4
		sp. rev., case rept.-Cuba	5
Aulonocephalus lindquisti	ceca	case rept.-Texas	151
		case rept.-Texas	148
		case rept.-Texas	90
Capillaria annulata	crop	case rept.-Fla.	135
		case rept.-Va.	45
		gen. rev.	106
		gen. rev., sp. rev.	42
Capillaria contorta	crop	gen. rev., case rept.-N.J.	34
		exp. inf.	45
		gen. rev., sp.rev.-N.C.	42
		sp. rev.	152
		case rept. (drug study)-N.Y.	26
		case rept. (drug study)-N.Y.	27
		case rept.-Ga., S.C.	84
		case rept. (drug study)-Ga.	52
		case rept. (drug study)-Ga.	53
Capillaria obsignata	small intestine and ceca	exp. inf.	45
(= *C. retusa* of Cram et al. 1931)		exp. inf.	93
		sp. rev.	121
(= *C. columbae* of Levine 1938)		case rept. (drug study)-Ga.	53

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Capillaria spp.	crop	gen. rev.	141
Cheilospirura spinosa (= Acuaria spinosa)	under horny gizzard lining	exp. inf.	31
		sp. rev., exp. inf.	36
		sp. rev., case rept.-Tenn., Va.	45
		gen. rev.	129
		case rept.-Fla.	84
		case rept.-Tenn.	14
Cyrnea colini (= Seurocyrnea colini)	proventricular-gizzard junction	sp. rev., case rept.-Ga.	29
		case rept.-Pa. (zoo)	22
		case rept.-N.J.	8
		sp. rev., case rept.-Ala., Fla., Ga., Miss., N.C., S.C.	45
		sp. rev., exp. inf.	36
		case rept.-Ohio	155
		case rept.-Ohio	140
		sp. rev., exp. inf.	41
		case rept.-Miss.	145
		sp. rev., case rept.-Cuba	4
		case rept.-Fla., Ga., S.C.	84
		sp. rev., case rept.-Cuba	5
Cyrnea sp. (= Seurocyrnea sp.)	proventricular-gizzard junction	case rept.-Texas	90
		case rept.-Texas	151
		case rept.-La.	107
Diplotriaenoides minutus	body cavity	case rept.-Fla.	143
Dispharynx nasuta (= Dispharynx spiralis)	proventriculus	case rept.-N.J.	8
		exp. inf.	35

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Dispharynx nasuta (continued) (= Dispharynx spiralis)	proventriculus	sp. rev., exp. inf.	36
		gen. rev., case rept.-N.J.	37
		exp. inf.	38
		case rept.-Ohio	155
		gen. rev., case rept.-N.C.	97
		case rept.-Ohio	140
		gen. rev.	129
		gen. rev., case rept.-N.Y.	69
		case rept.-Ill.	19
		case rept.-Fla., Ga.	84
		case rept.-La.	107
Gongylonema ingluvicola	esophagus and crop	sp. rev., case rept.-Ga.	45
		gen. rev.-Cuba	118
		sp. rev.-Cuba	4
Habronema bialatum (= Spiroptera bialata) (= S. tenuis)	proventriculus	case rept.-Fla.	143
Habronema pileata	proventriculus	sp. rev., case rept.-Ga.	45
		case rept.-Miss.	144
		case rept.-Miss.	145
Heterakis bonasae	ceca	sp. rev., case rept.-Ala., Fla., Ga., Mass., Miss., N.C., S.C.	45
		case rept.-Ohio	155
		case rept.-Ohio	140
		case rept.-Miss.	145
		case rept.-Ill.	19
		case rept.-Fla., Ga.	84
		case rept.-Tenn.	14

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Heterakis gallinae (= H. gallinarum)	ceca	sp. rev.	29
		case rept.-Pa. (zoo)	22
		sp. rev., case rept.-Va.	45
		case rept.-Ohio	155
		case rept.-Ohio	140
		gen. rev.	129
		case rept.-Miss.	144
		case rept.-Miss.	145
		case rept.-Texas	110
		case rept.-Ill.	19
		sp. rev., case rept.-Cuba	4
		case rept.-Ga., S.C.	84
		sp. rev.-Cuba	5
		case rept. (drug study)-Ga.	53
		sp. rev., exp. inf.-Ga.	85
		sp. rev., exp. inf.-Md.	94
Heterakis vesicularis (= H. papillosa)	ceca	case rept.-Fla.	143
Oxyspirura mansoni	eyes	sp. rev., case rept.-Cuba	4
		sp. rev., case rept.-Cuba	5
Oxyspirura matogrosensis	eyes	case rept.-La.	107
Physaloptera sp.	immature worms encysted in breast muscle	case rept.-Wis.	37
		case rept.-La.	54
Strongyloides avium	ceca and small intestine	sp. rev., exp. inf.	32
		gen. rev.	33
		sp. rev.	45

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Subulura brumpti	ceca	case rept.-Pa. (zoo)	22
		case rept.-Miss.	144
		case rept.-Miss.	145
		case rept.-Texas	110
Subulura strongylina	ceca	sp. rev., case rept.-Ga., N.C.	45
		case rept.-Ohio	155
		case rept.-Ohio	140
Syngamus americana(?)	trachea	checklist	158
Syngamus trachea	trachea	gen. rev.	34
		sp. rev., case rept.-Va.	45
		gen. rev.	129
		case rept.-Miss.	144
		case rept.-Miss.	145
		case rept.-Texas	151
		case rept.-Texas	90
Tetrameres americana (= Tropisurus americanus)	glands of proventriculus	sp. rev., exp. inf.	36
		sp. rev., case rept.-Ga., Va.	45
		case rept.-Fla.	84
Tetrameres pattersoni (= Tropisurus pattersoni)	glands of proventriculus	sp. rev., case rept.-Md., N.C.	39
		sp. rev., exp. inf.	40
Tetrameres sp.	glands of proventriculus	gen. rev., case rept.-N.C.	37
Trichostrongylus tenuis (= T. pergracilis)	ceca	case rept.-Ga.	28
		sp. rev., case rept.-Ga.	29
		gen. rev.	30

Table 3. (continued)

Helminth	Location or lesion area	Type of report and geographical location if given*	Refer. No.
NEMATODES (continued)			
Trichostrongylus tenuis (continued) (= *T. pergracilis*)	ceca	sp. rev., case rept.-Ala., Fla., Ga., Miss., S.C., Tenn.	45
		sp. rev.	46
		gen. rev.	129
		case rept.-Miss.	145
		case rept.-Fla., Ga., S.C.	84
		case rept.-La.	107

*Abbreviations used: gen. rev. = mentioned in a general review of diseases; sp. rev. = review of that specific disease or a specific parasite description; exp. inf. = experimental infection; case rept. = case report or survey.

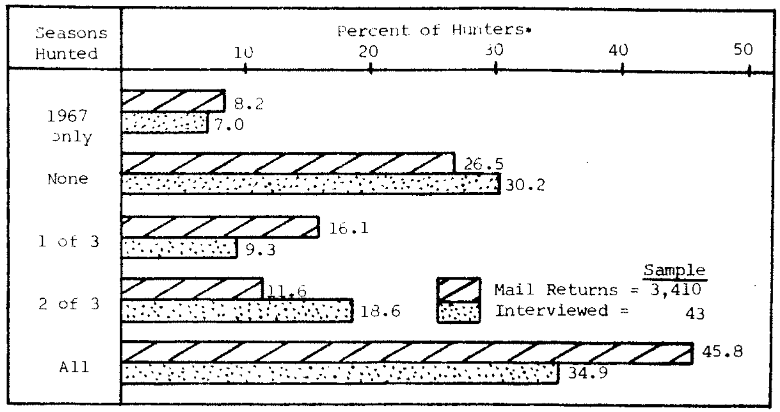

Fig. 3. Persons hunting quail in Oklahoma, 1965-1967.

* Includes non-quail hunters

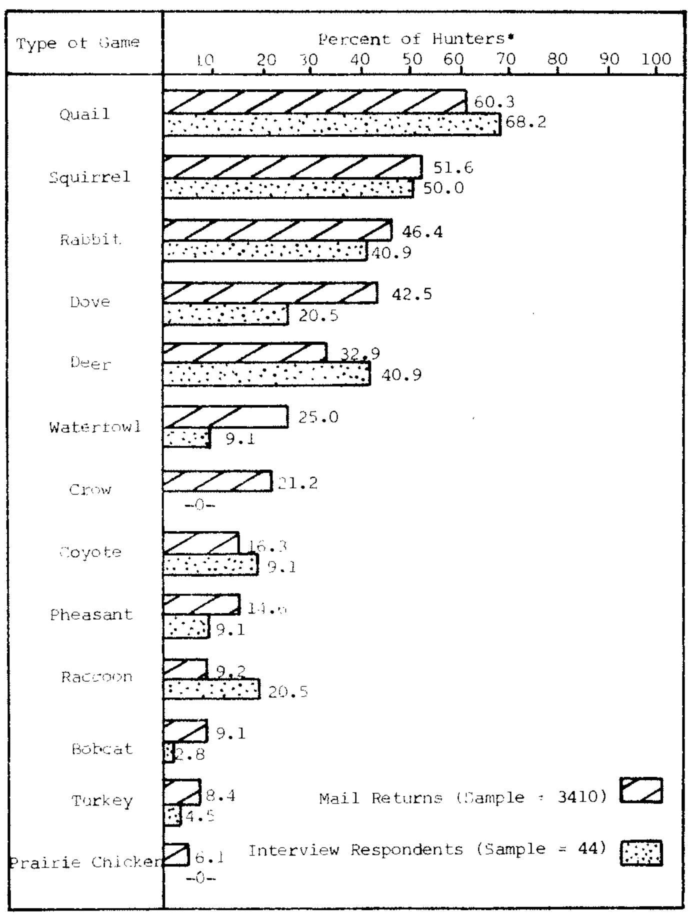

Fig. 4. Percent of all hunters hunting 13 kinds of game.

* Includes non-quail hunters

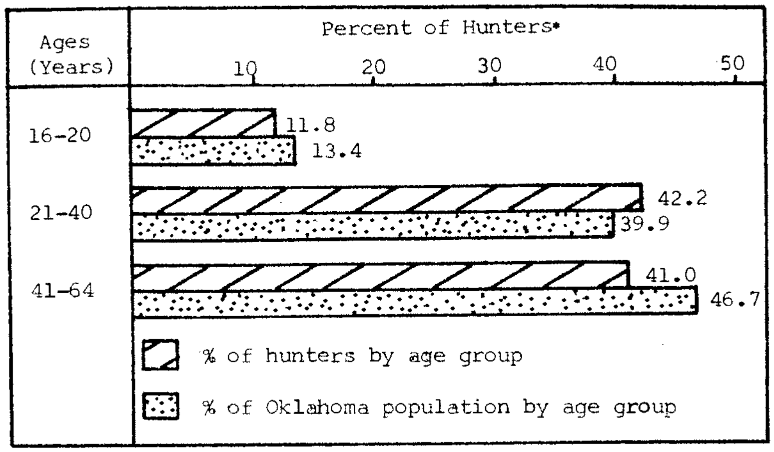

Fig. 5. Percent of Oklahoma residents and hunters by age groups.

* Includes non-quail hunters

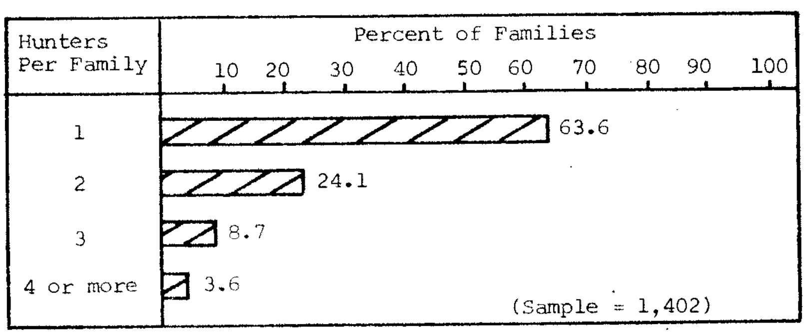

Fig. 6. Percent of hunter's families containing different numbers of hunters.

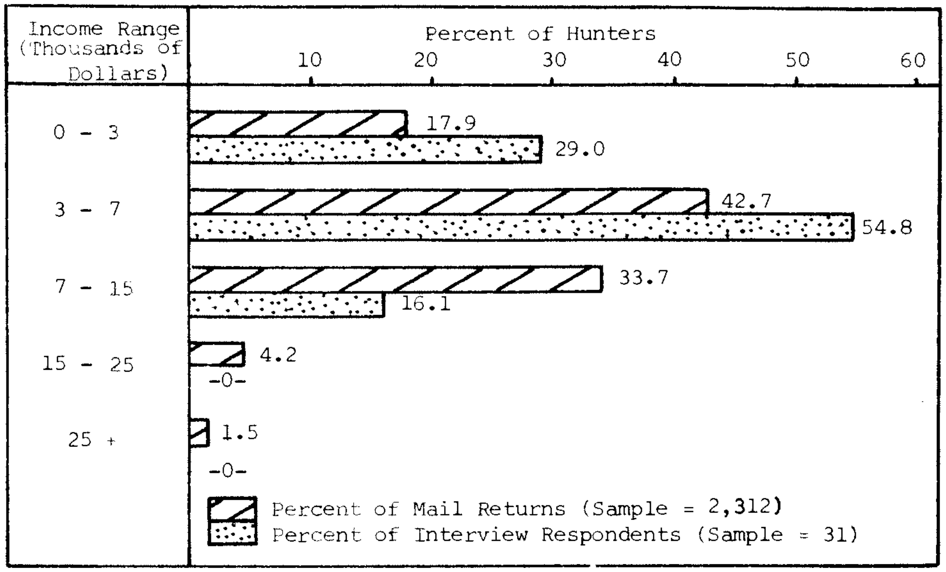

Fig. 7. Percent of quail hunters with different incomes.

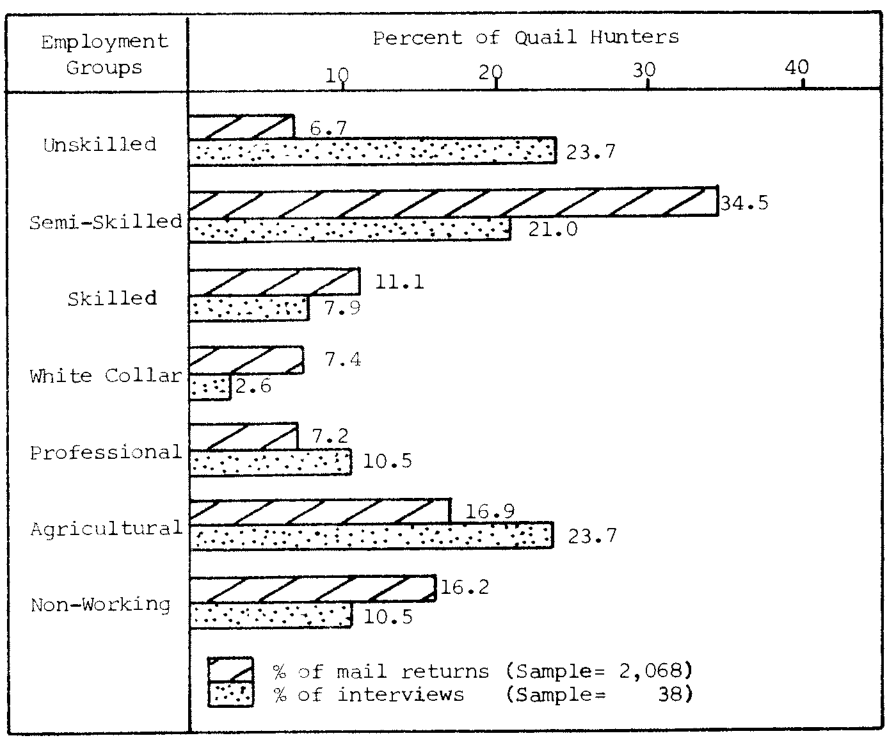

Fig. 8. Percent of quail hunters by employment group.

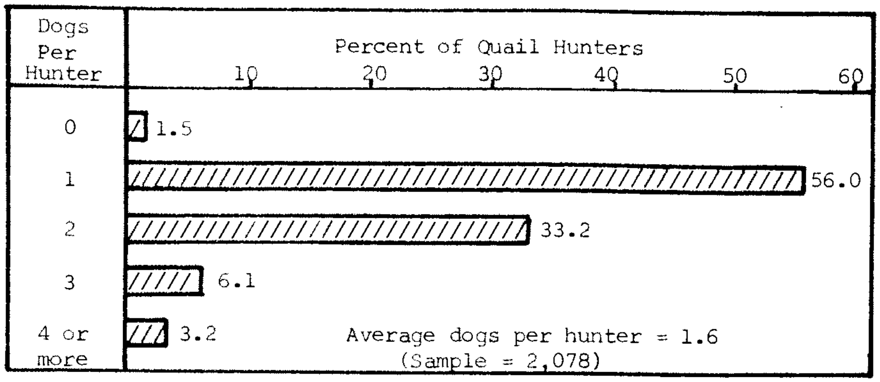

Fig. 9. Percent of quail hunters owning bird **dogs.**

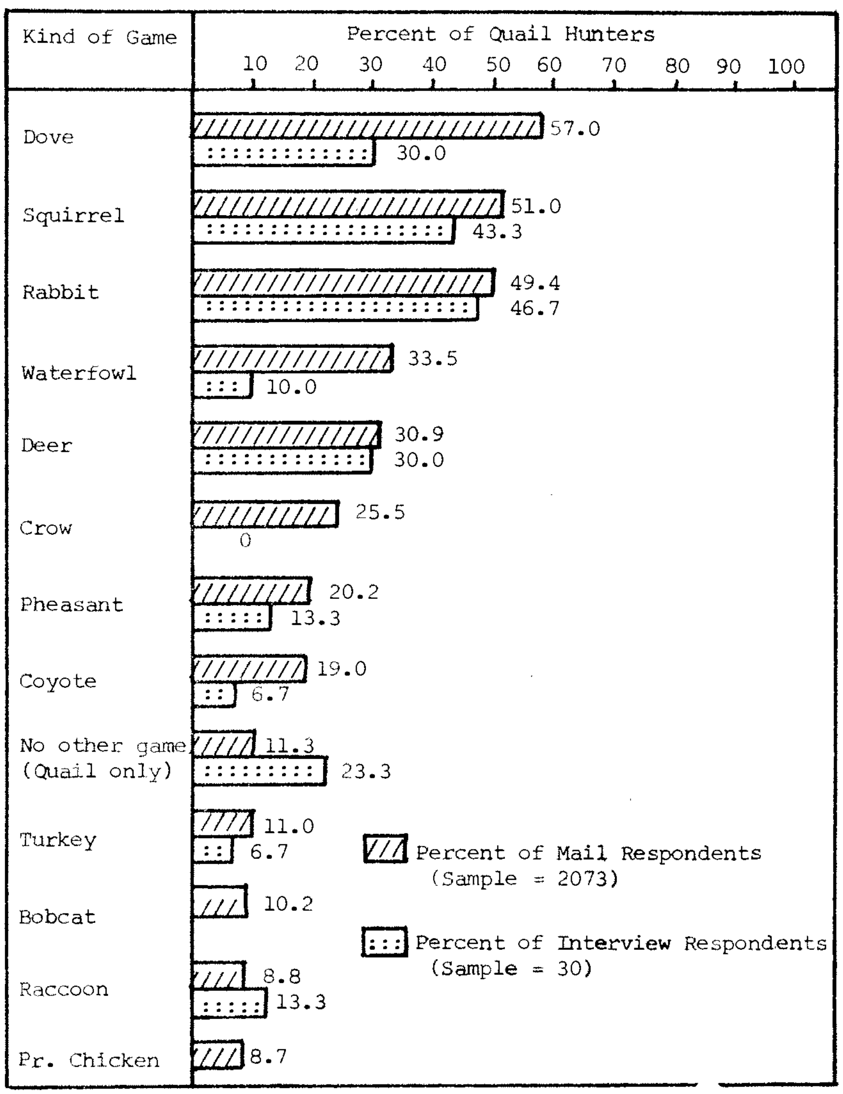

Fig. 10. Percent of quail hunters hunting **different kinds of game.**

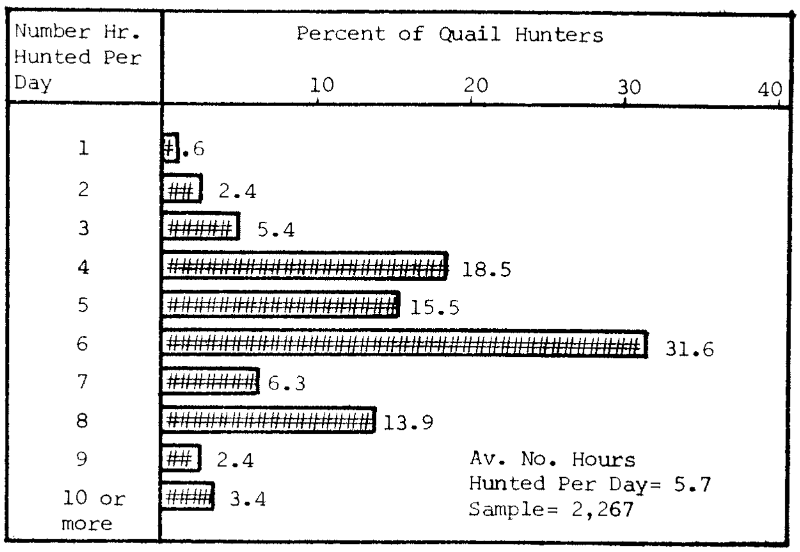

Fig. 11. Percent of quail hunters hunting different numbers of **hours per day.**

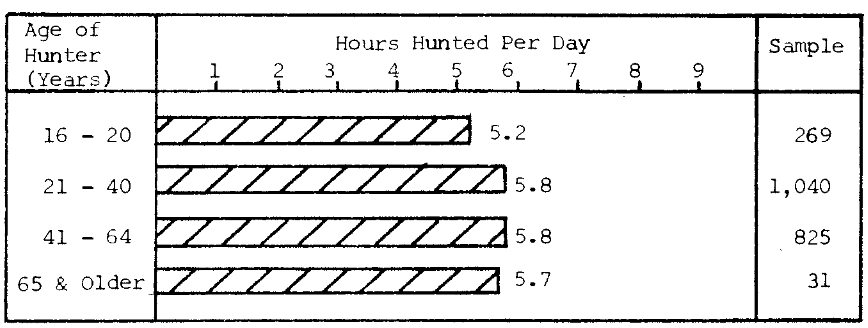

Fig. 12. Hours per day hunted by different age groups.

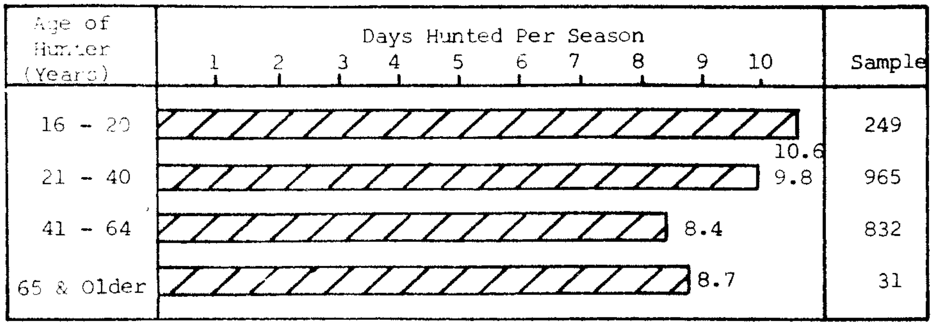

Fig. 13. Days per season hunted by different age groups.

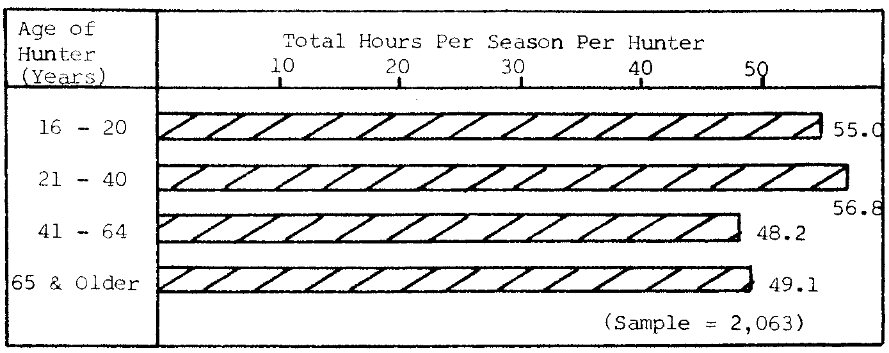

Fig. 14. Total hours per season hunted by different age groups.

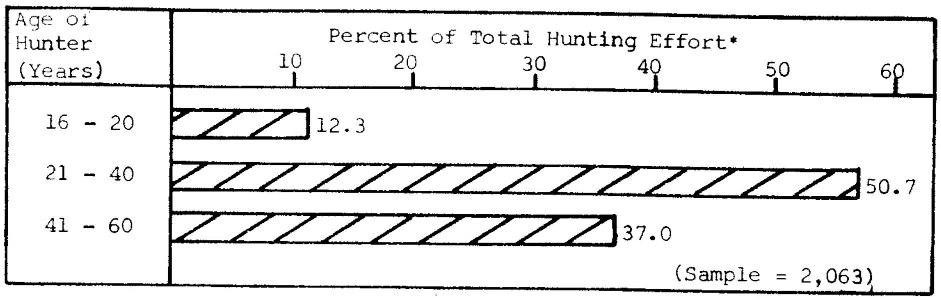

Fig. 15. **Percent of total hunting effort exerted by different age groups.**

***No. hunters x hr. per hunter (excludes non-licensed hunters)**

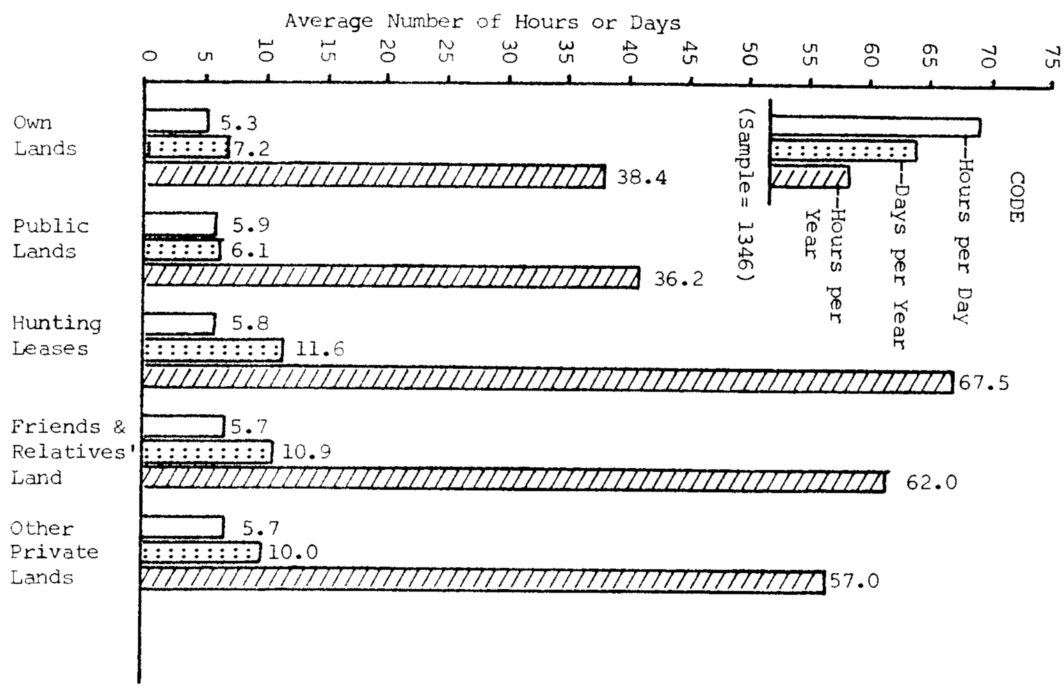

Fig. 16. Hours and days hunted by quail hunters on different kinds of hunting lands.

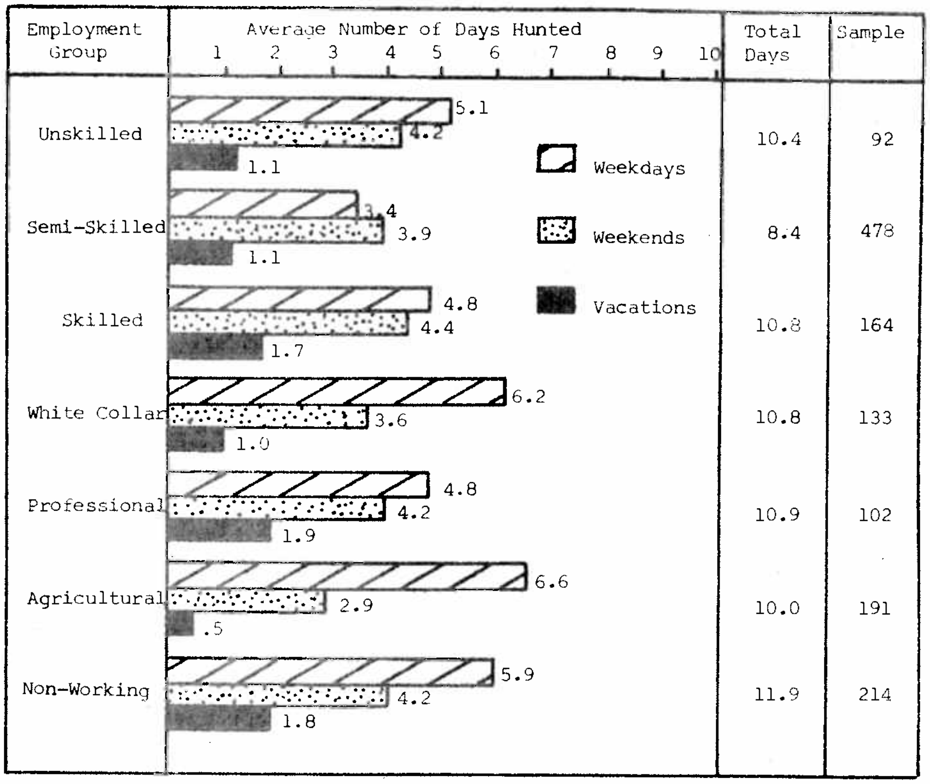

Fig. 17. Days hunted per season on weekdays, weekends and vacations by different employment groups.

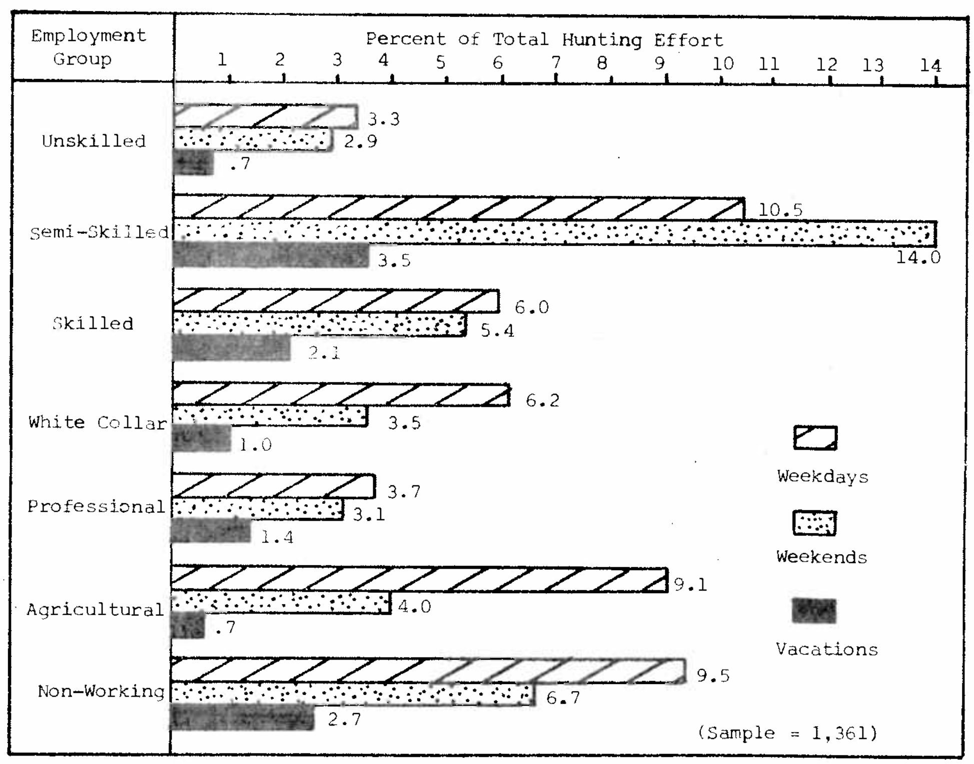

Fig. 18. Percent of total hunting effort done by different employment groups.

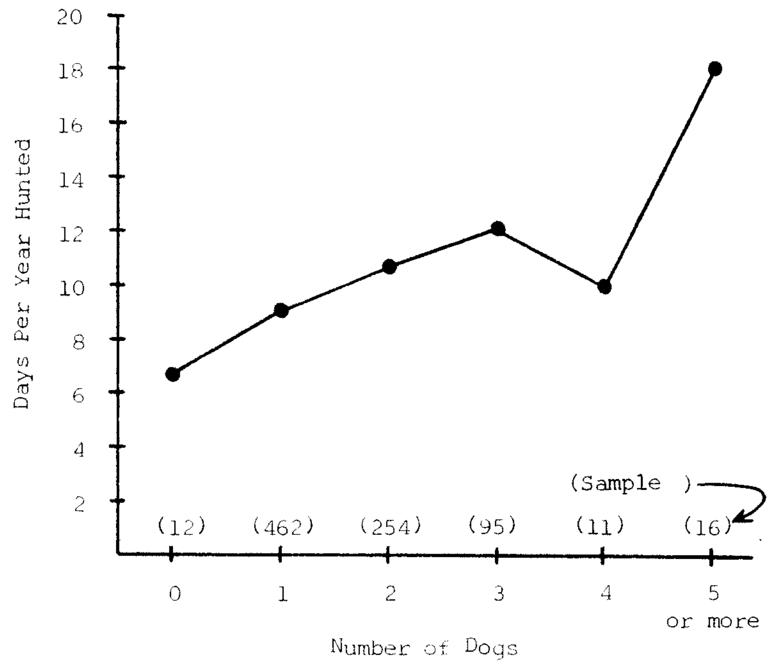

Fig. 19. Days hunted by persons owning different numbers of bird dogs.

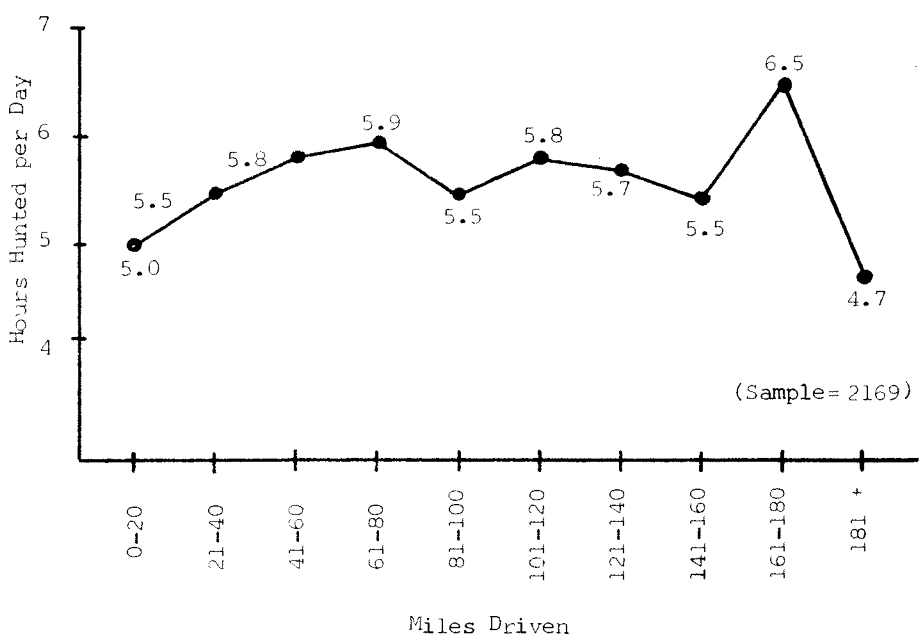

Fig. 20. Hours per day hunted by hunters driving different distances to hunting areas.

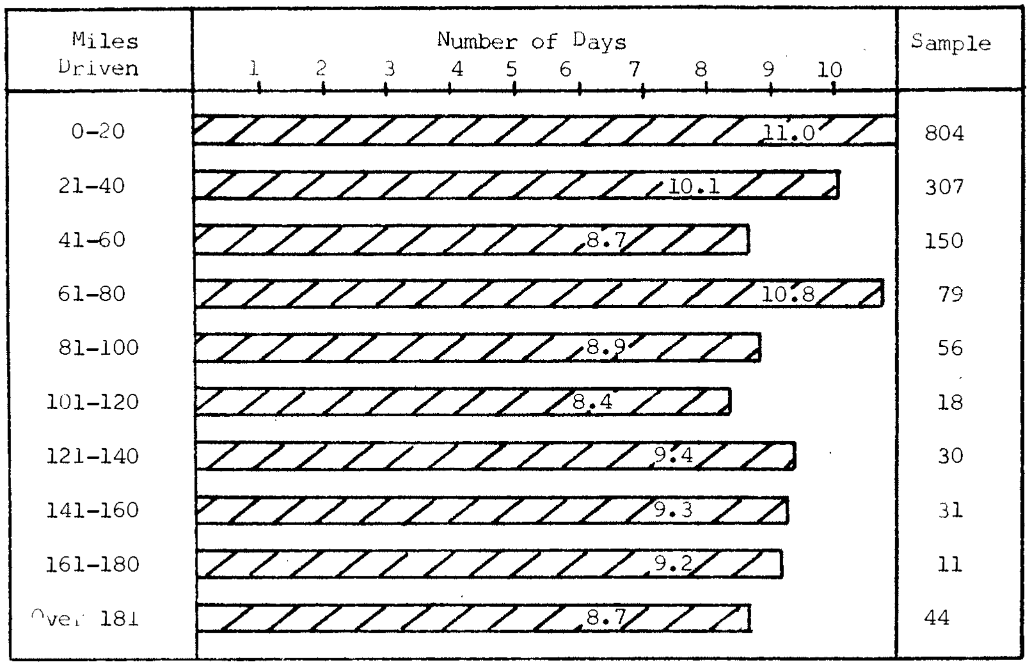

Fig. 21. Days hunted by hunters driving different distances to hunting areas.

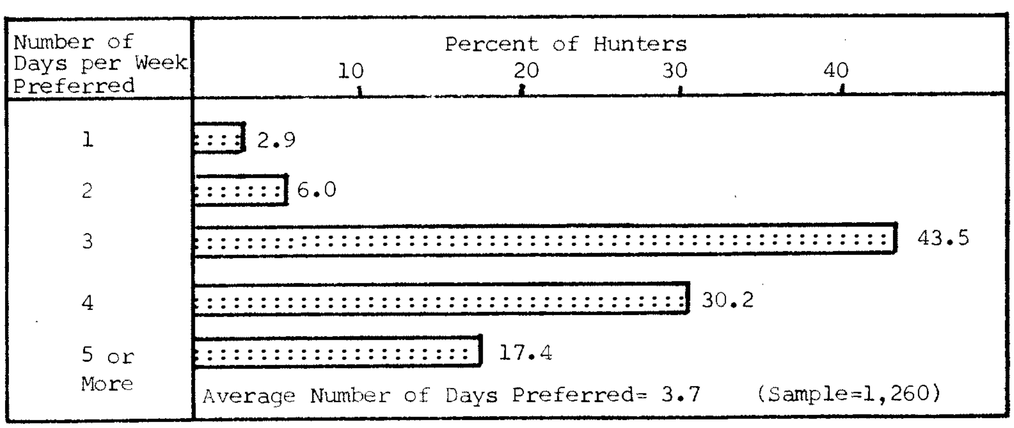

Fig. 22. Percent of hunters indicating preferences for specific numbers of days per week to be open for quail hunting.

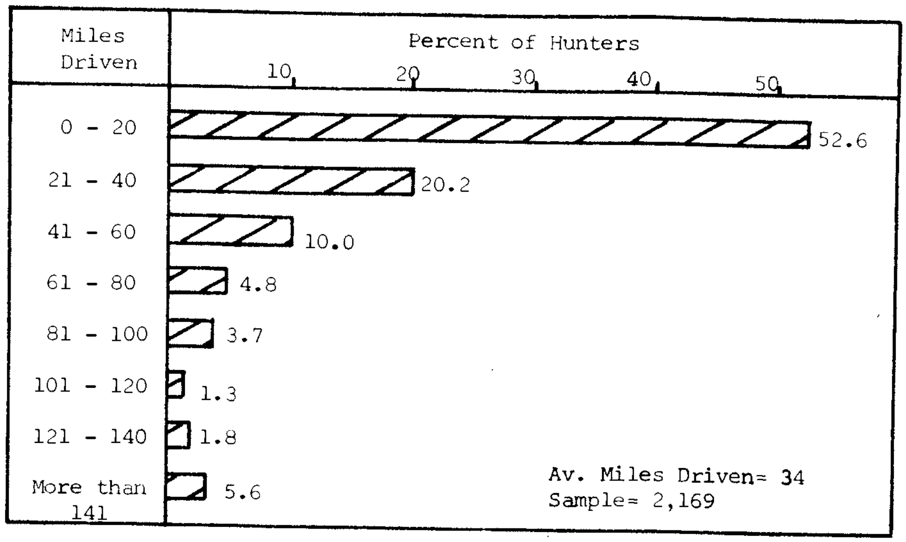

Fig. 23. Percent of hunters driving different distances (one day) to hunt quail.

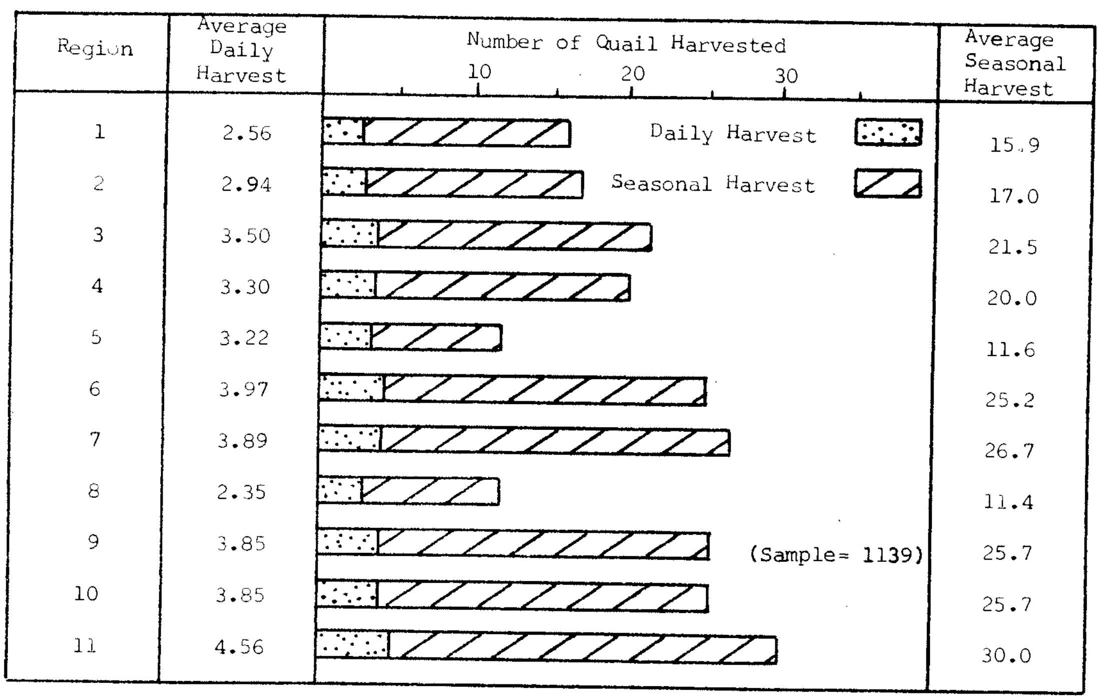

Fig. 24. Quail harvested per hunter in different planning regions.

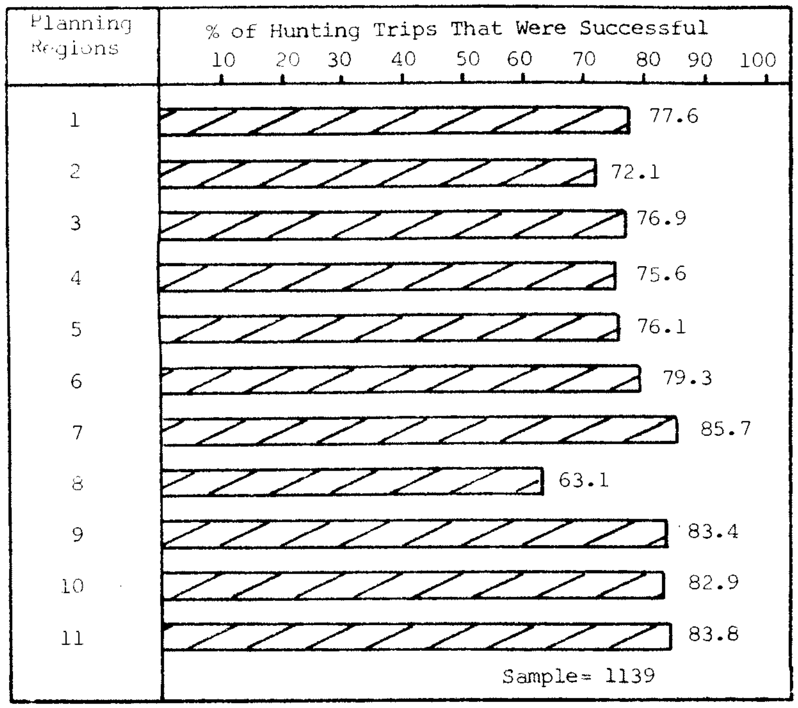

Fig. 25. Percent of quail hunting trips that were successful in different planning regions.

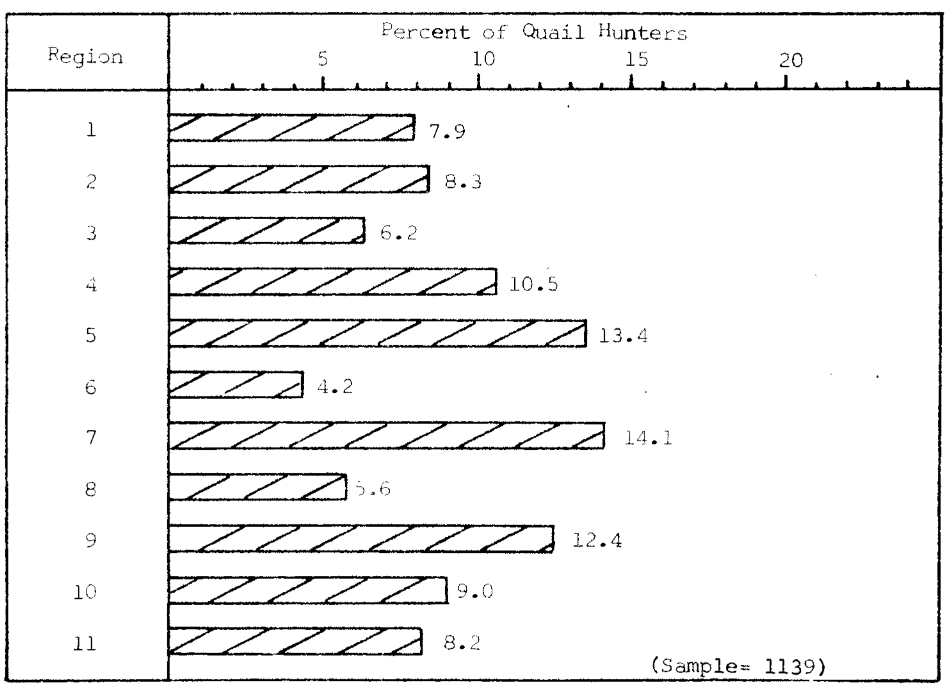

Fig. 26. Percent of quail hunters hunting in different planning regions.

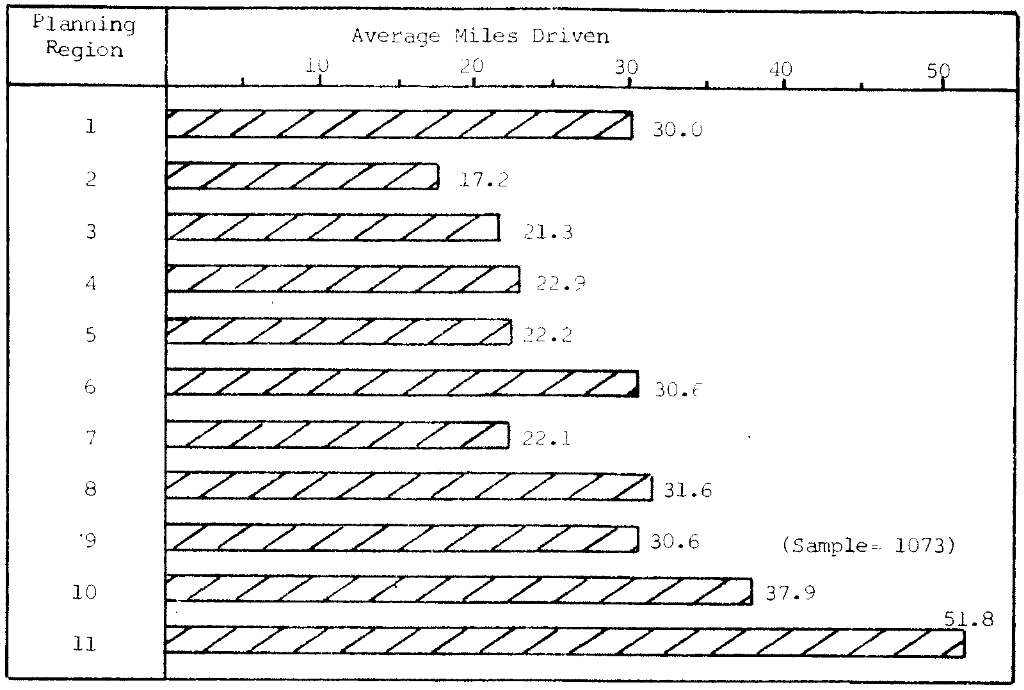

Fig. 27. Average miles driven to hunting area by persons hunting quail in different planning regions.

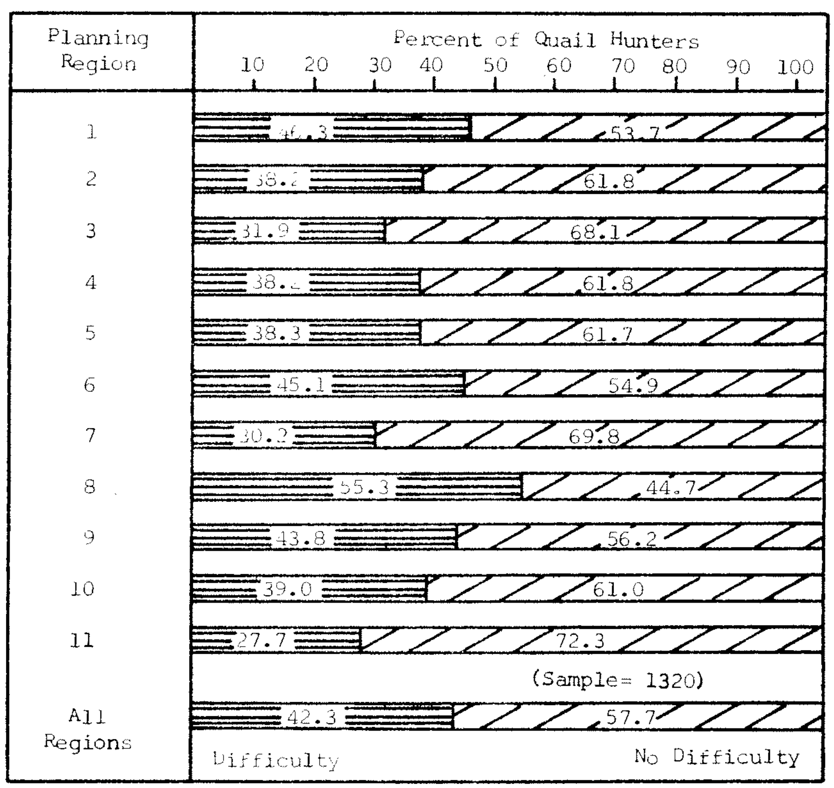

Fig. 28. Percent of hunters having difficulty and not having difficulty obtaining access for quail hunting in different planning regions.

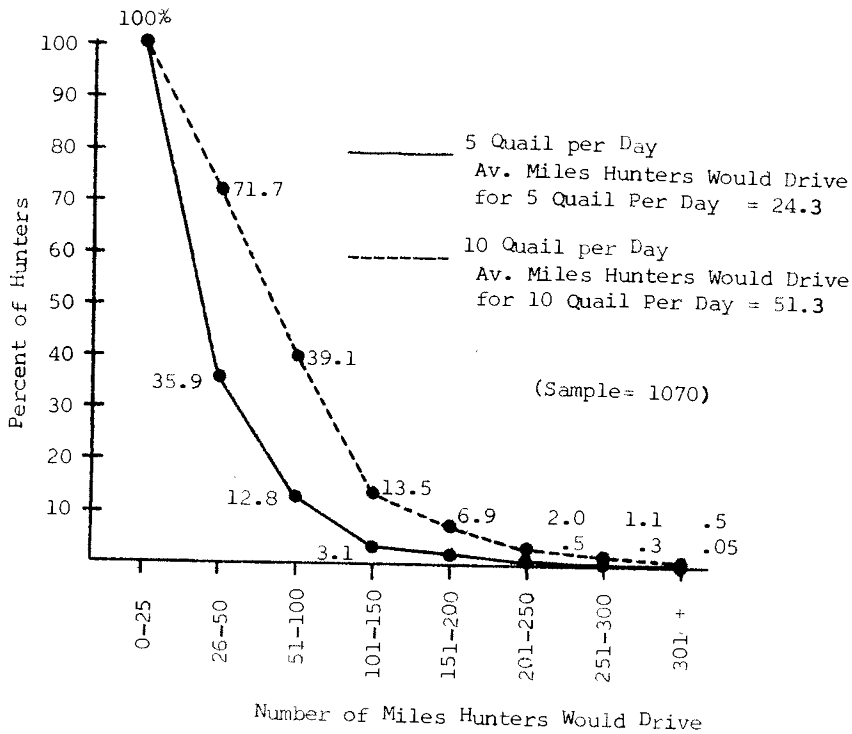

Fig. 29. Percent of hunters who would drive different distances for 5 and 10 quail per day.

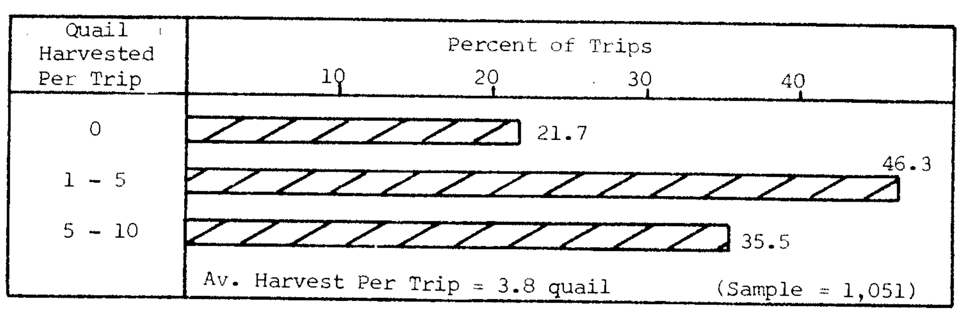

Fig. 30. Percent of hunting trips when average quail hunter took 1-5, 5-10 and no quail.

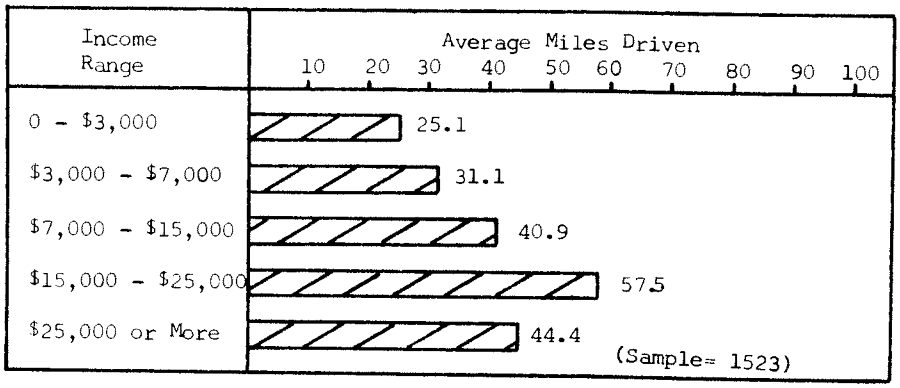

Fig. 31. Average distances driven (one way) to hunt quail by hunters with different annual incomes.

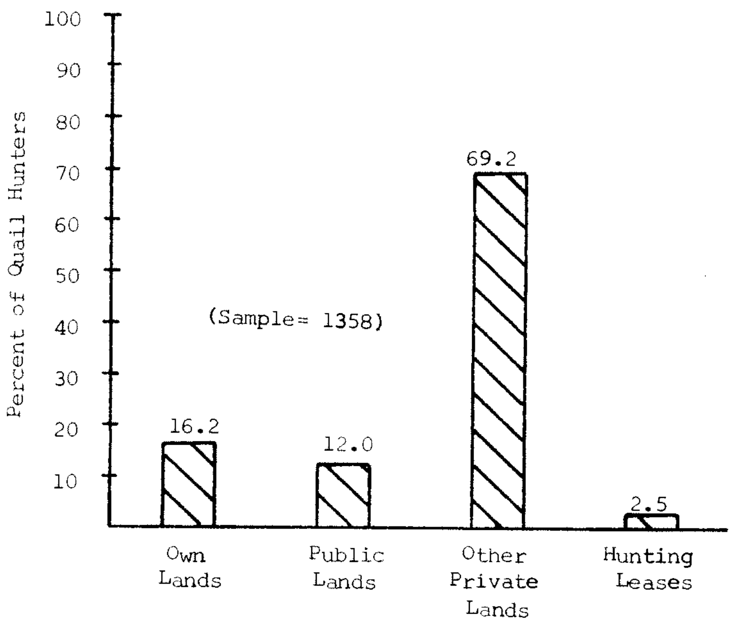

Fig. 32. Percent of hunters who hunted quail most on each of 4 kinds of hunting lands.

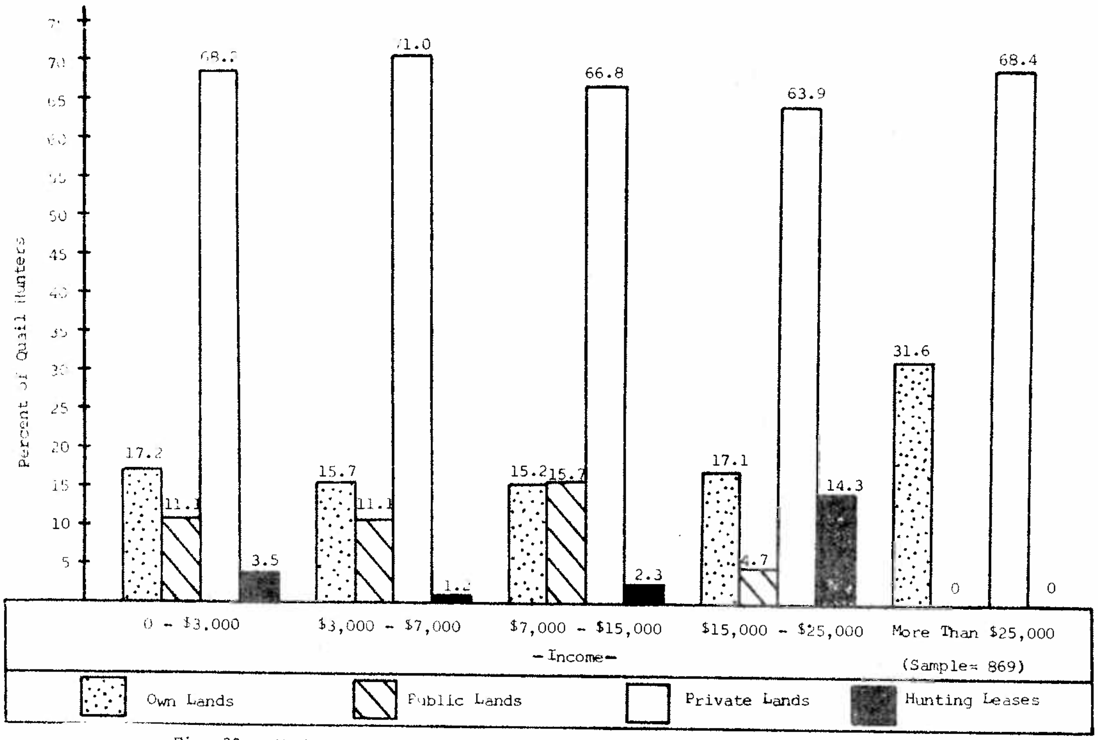

Fig. 33. Kinds of lands hunted by quail **hunters with different** incomes, expressed as % of each income group who hunted each type of land most.

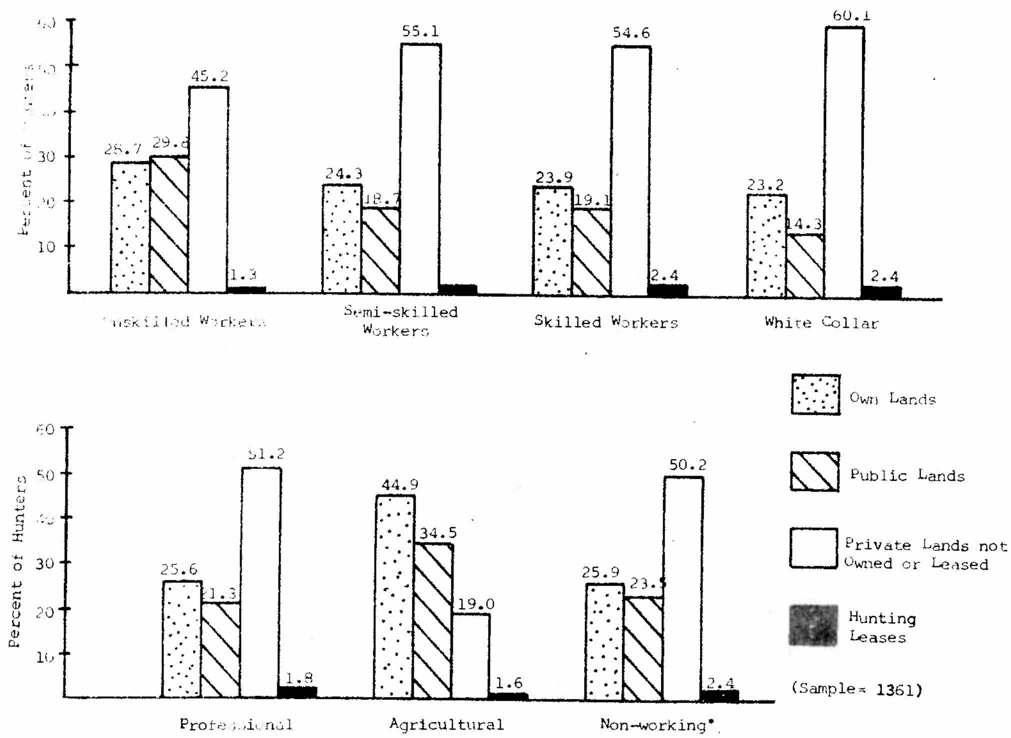

Fig. 34. Percent of quail hunters in each of 7 employment groups who hunted most on 4 kinds of hunting lands.

* Unemployed, students, retired, disabled

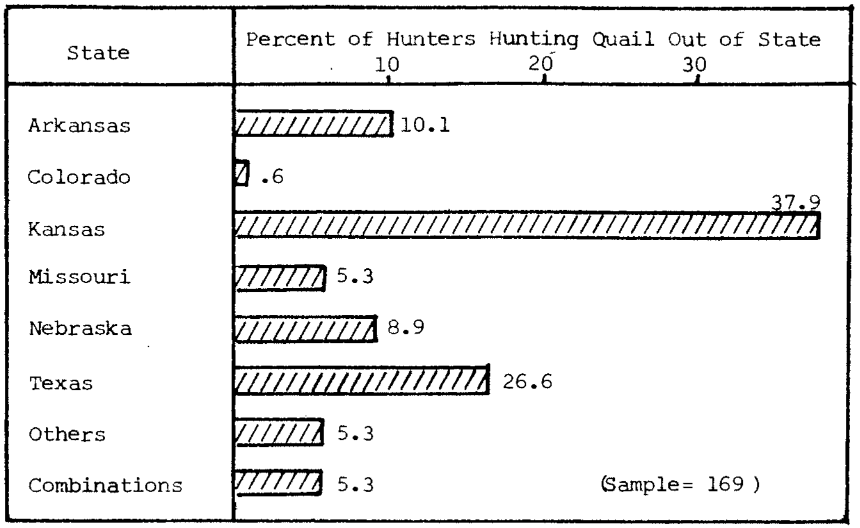

Fig. 35. States where Oklahoma hunters hunted quail.

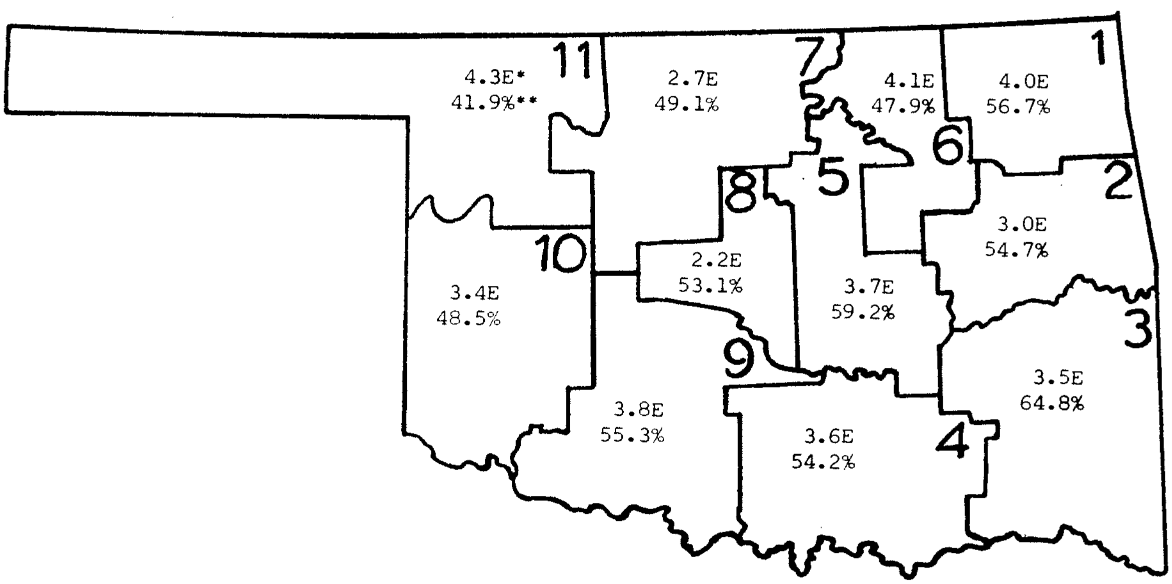

Fig. 36. Percent of quail hunters in each planning region who encountered other hunters while hunting.

* Aver. number of encounters by those encountering others
**% of quail hunters in district who encountered others

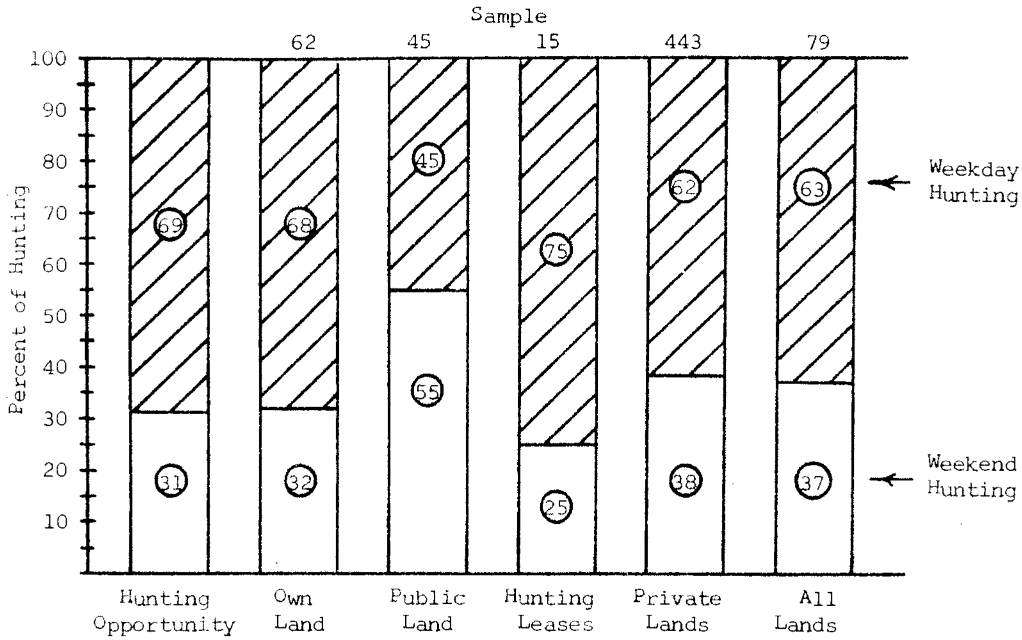

Fig. 37. Time of week when quail hunting occurred on 4 kinds of hunting lands.

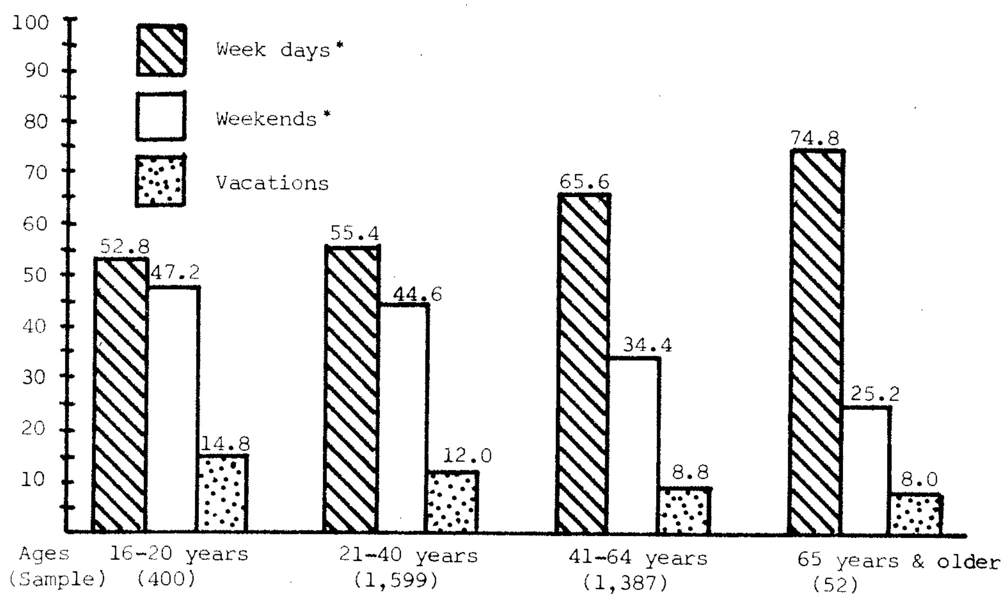

Fig. 38. Percent of hunters hunting on weekdays, weekends and vacations by age group.

* Includes vacation days

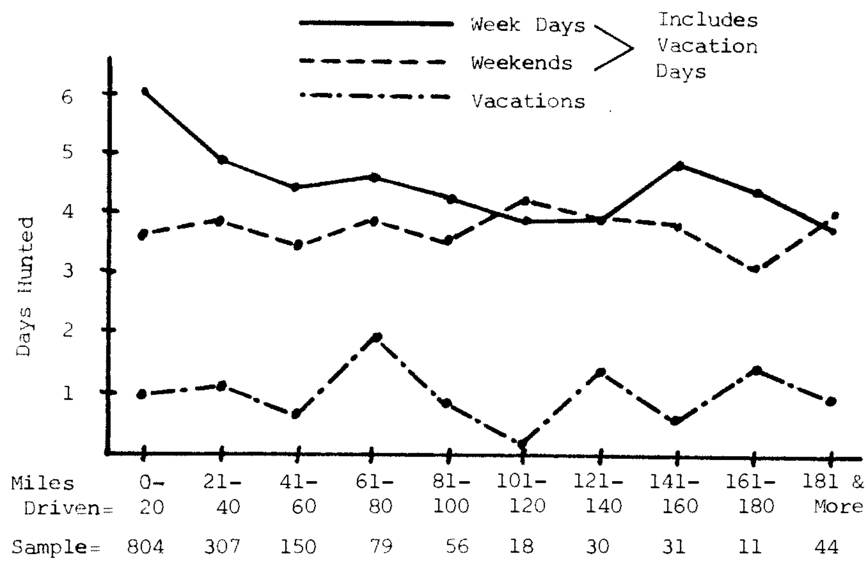

Fig. 39. Days hunted per season by quail hunters driving different distances to hunting areas.

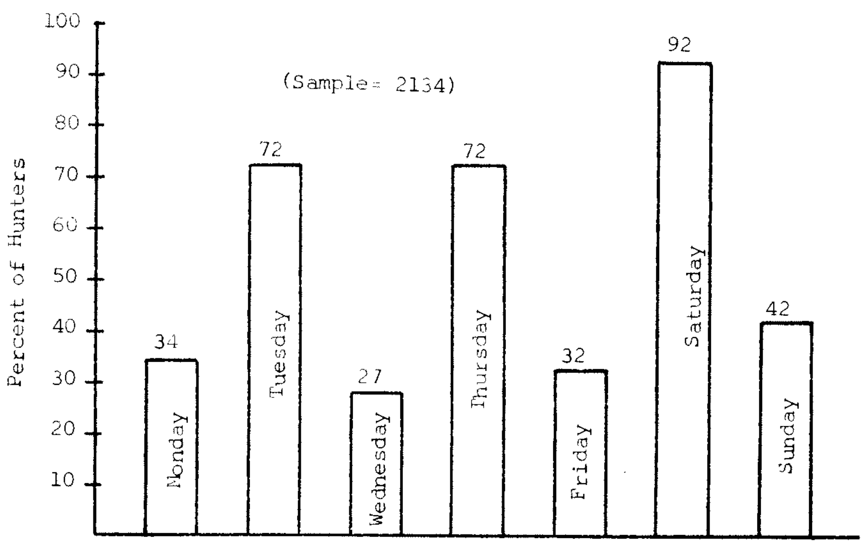

Fig. 40. Percent of hunters preferring legal hunting of quail on individual days of the week.

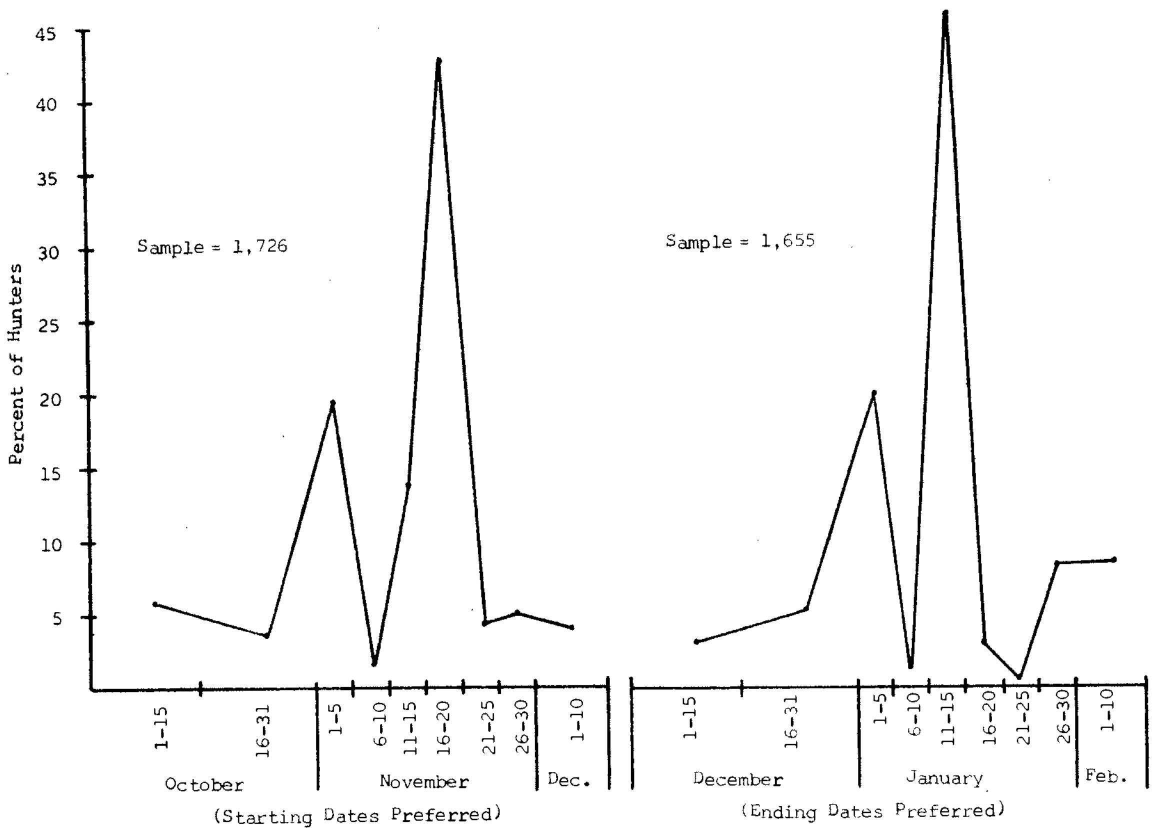

Fig. 41. Starting and ending dates for quail season preferred by quail hunters.

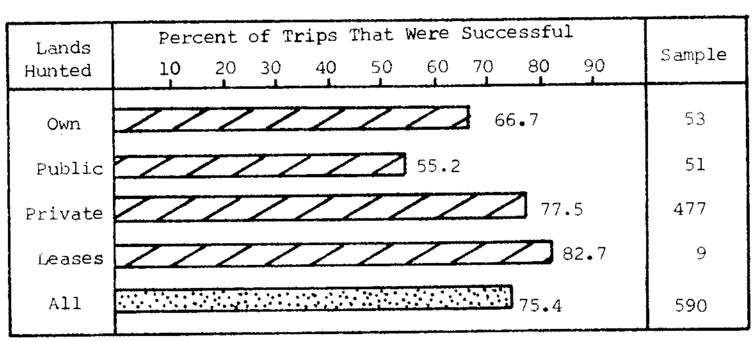

Fig. 42. Percent of hunting trips when quail were harvested on 4 kinds of lands.

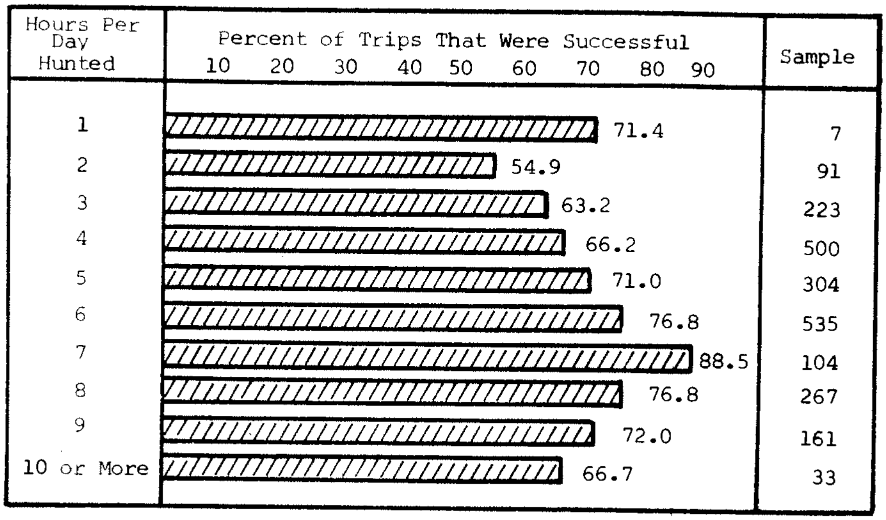

Fig. 43. Percent of trips when quail hunters hunting different numbers of hours per day were successful.

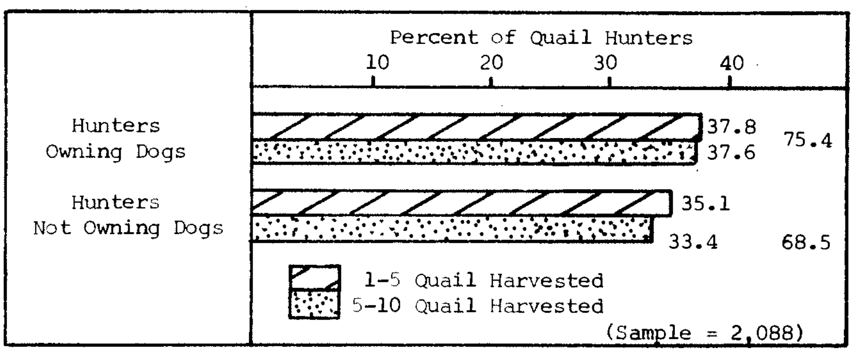

Fig. 44. Percent of trips when quail were harvested by hunters owning and not owning dogs.

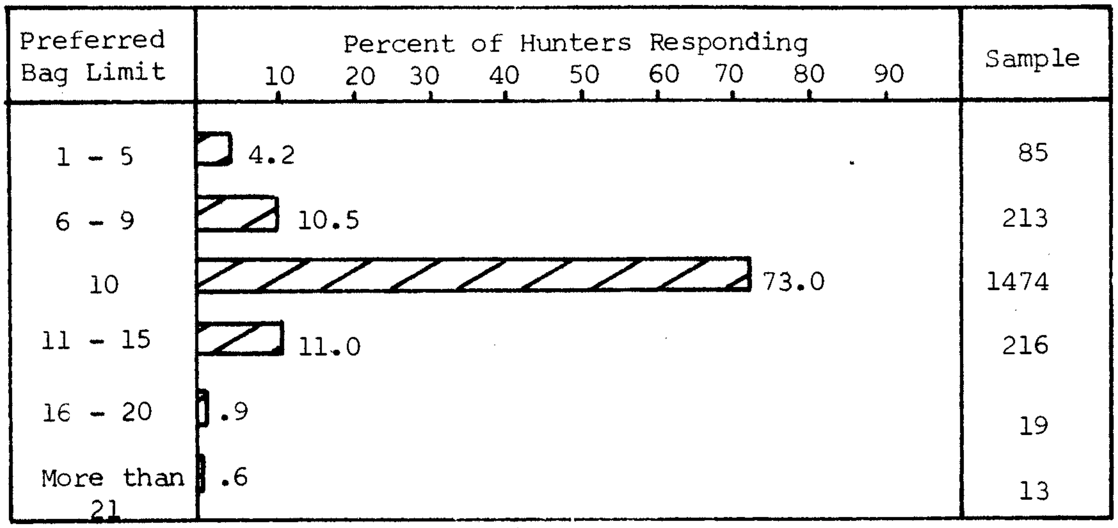

Fig. 45. Preferred number of quail in the daily bag limit

3. Leopold, A. 1928, 1929, 1930. American Game Policy and Its Development, 1928-1930 (Reprinted in facsimile from Proc. of Am. Game Conf., Vol. 15, 16 and 17, by the Wildl. Manage. Inst. 1971).

4. Robinson, J. L., and T. D. Curtis. 1969. Oklahoma Data Book, 1968. Bur. Business Res., Univ. of Okla., Norman.

5. U. S. Weather Bureau, Okla. City. (Personal Communications).

SIMULATION STUDIES OF QUAIL HUNTING SUCCESS ASSOCIATED WITH ECOLOGICAL SUCCESSION OF PLANTED PINE STANDS

John D. Gavitt and Robert H. Giles, Jr., Division of Forestry and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg

Abstract:

A concept paper of a methodology is presented for explaining past populations and predicting future populations of bobwhite quail (*Colinus virginianus*), as a function of forest changes. The methodology is applicable to large landholdings, regions, and states. It relates, using computer technology, the number of potential covey flushes per 100 acres per day to the age of forest stands or ecological succession curves. By summing quail flush curves over a large area, area-wide yields may be obtained. Flushes are modified by a shooting-quality factor and birds per covey. The computer-generated output tables provide an inventory, a historical overview, and projected populations. The results are useful for making forestry-wildlife tradeoffs, for explaining quail declines or increases as a result of forestry operations, and for improvements in allocating money to wildlife or forestry. The method is based on a similar system for big-game forage in the Pacific Northwest (2) and is now being developed.

The primary wildlife management action is decision making (1). Highly effective rational decision making relies upon increasingly sophisticated tools of explanations and prediction. The quality of management of large land areas for wildlife is largely a function of the managers' predictive ability. The probability of being right when a manager of bobwhite quail populations says "If I expend these dollars, I will get these birds" is a measure of managerial skill and knowledge. Similarly, it is a measure of such skill for a manager to say with justified confidence: "Within the next 10 yr, the quail population will have declined 35%?" Such inputs are essential for improved decision making about changing practices or allocating management funds.

One aspect of this general problem is the need to predict bobwhite quail populations over broad areas such as regions, counties, or private landholdings of greater than 10,000 acres. One obvious need for such prediction is to help bring sportsmen's expectations in line with their satisfactions. Other needs are to aid in formulating management action programs, to provide the basis for interagency policy formulation, and even to provide the basis for an agency's appeal to a court for an injunction against certain land-use practices.

The need for better prediction has become increasingly evident as more areas throughout the southern and southeastern United States have come under intensive use--whether for pulpwood or peanuts. In Virginia alone, 750,000 acres are reported to have been converted to pines. The South's Third Forest (3) documents plans for similar work elsewnere. These changes occur over thousands of acres, annually, in different soil types, having different growth potentials. In addition to the complexity, great size, and economic interest in such systems, they are very dynamic. Prediction in such a system is essential if the bobwhite quail manager is to be any more than a spectator. This paper presents the basis for and the methodology for a solution to a major aspect of this problem. We concentrate on the quail-timber interaction.

Planting pine in the East has become a large-scale business with private timber companies. The upward trend leaves much potential for recreational opportunities. So far, this potential has barely been tapped in terms of offering quality sport for the quail hunter. Many sportsmen think of pine plantations as "biological deserts," when, in reality, certain stages in the development of the latter can provide sufficient food and cover to greatly benefit the bobwhite quail (Colinus virginianus). By understanding which stages in the maturation of pine stands are associated with high populations of quail, the number of potential successful hunting man-days can be determined. Since quail hunting on small farms is rapidly becoming rare due to land consolidation, intensive farming, and posting lands, hunting in young pine stands owned by large timber companies and in public land may become the areas for opportunity of success for the majority of bird hunters. The purpose of this paper is to introduce the rationale for a computer simulations technique for evaluating pine stands for quail hunting quality in terms of past, present, and future potential. Such an evaluation was done for big game forage production in various habitats in Idaho (2). The approach used is a modification of their technique now developed as a computer program.

The first few yr of succession in a planted pine stand usually most important for quail production. The young trees have not completely shaded the ground, and competition for total available nutrients and water is not high. The available food for quail during these years is great. As the stand moves into the 10- to 20-yr-age class, quail food and cover production is curtailed greatly. We assume that potential quail populations are largely a function of cover and food, neither being in limiting supply during the early yr of the stand. Since cover and food production relates directly to the age of the stand, it can further be stated that the potential quail population is a function of the age of the stand. This study deals with the pine stand stages involved in producing quail populations, and not the specific environmental characteristics of each stage.

Development

A "unit" may be defined as a particular pine stand of a relatively uniform age. Each unit is assumed to have a potentiality for producing quail. A quail population curve exists for each unit and is expressed in the number of covey flushes per 100 acres per day. Such curves are dependent on factors such as pine seedling spacing, method of planting, and site preparation methods. Such factors will vary with the area involved and its location. The greater the research investment, the more precisely the curves can be determined (See Fig. 1). By summing these flush curves, the quail potential of an entire pine plantation with multiple units may be described historically, in the present, and for the future (Fig. 2 and 3). Production of these covey flush curves is accomplished by (A) determining which factors in an area (e.g. spacing) will tend to produce decidedly different curves and defining lands containing these factors as "units," and (B) censusing the different units to produce flush curves that will relate to age. The amount of censusing done will depend on the accuracy needed for the curves and the forest age classes available. In general, if the area is characterized by rapid early, pine seedling growth, then the quail populations will, in turn, rapidly decline. In this case, extensive censusing (e.g. with bird dog along transects) will be done in stands that are from 1 to 4 yr old. If seedling growth is slower, the censusing can be done less frequently and throughout more age classes.

Stands that have reached certain peak age will have their covey flush counts level off from that age until the end of the rotation period. The canopy blocks out the available sunlight and cover, decreasing food production for quail. The covey-flush curve then remains static in a plantation from 15 to 20 yr (approximately) until it is cut. It is generally useless to census quail populations in older stands. In older stands, the flushing curve of a unit could be changed to a flushes-near-edge curve, whereby covey flushes are measured in a zone along the edge of the stand. The width of that zone can be determined by the quail behavior (Fig. 4).

Having identified on an aerial photo a number of units, each having a particular covey flush curve associated with their growth, quail populations can be projected. The data needed for such projections are as follows: (A) acres in the stand, (B) yr stand originated, (C) flush curve that best fits the stand, (D) shooting-quality factor, and (E) covey-quality factor. The first 3 pieces of data are selfexplanatory. Numbers 4 and 5 are adjustment factors needed to determine the potential quality of shooting taking place in particular stands.

The shooting quailty factor is the time during which a covey may be shot. The time is a function of the cover. The factor could be based on the following: (These will be used as a first approximation).

1)	4 sec or over	1.00
2)	1 to 3 sec	0.75
3)	No shots can be fired	0.40

The quality factor could also be placed on a "singles found" index:

1)	3 or more singles found	1.00
2)	1 to 2 singles found	0.75
3)	No singles found	0.50

The above values are subjective ranks. Such values can be used to attempt to balance or better quantify such situations as those in which many birds are sometimes found in extremely dense cover, decreasing the chance of sport greatly. For example, a covey flushed in a stand where 4 sec were available to shoot but only 1 single was found would be equal to 1.00 x 0.75 = 0.75 flushes per acre instead of 1.00. This would indicate that the shooting would not be as good as the flushes per acre indicate.

The second quality factor is dependent on the number of birds in the covey. This factor ranks those areas that can support the most birds per covey, and thus, the most hunting pressure and success. However, such an adjustment factor should be made before the hunting season. As in all cases, this factor could be eliminated when available research time is limited.

The above information, then, will be recorded on a standard form and keypunched. Other information to be recorded for reference purposes is (A) extent of canopy, (B) type of vegetation, (C) type of last disturbance, and (D) food types available. Codes for such data sheets may be taken from the Wildlife Surveys Handbook, FS# 2609.2, Region I, and additional information on coding procedures may be taken from Giles and Snyder (2).

Output

From the above data certain valuable output values can be computed. Total flushes per acre can be projected over an entire rotation period in a particular stand. From aerial photos, a flush curve for an entire plantation can be produced by the summation of these particular stand curves as shown in Fig. 3. By using the adjustment factors in the input, the quality of the hunting in an area can be determined in terms of adjusted flushes per acre. This, in turn, will provide information for improved decision making for the wildlife manager.

It should be evident that predicting quail populations in a particular year is not the objective of this concept. However, the general trends of quality-ranked quail activity will be extremely valuable to statewide management planning. In the past, such planning has been the product of human judgment, which is limited and often greatly biased. Using a sophisticated computer model, the planner will have a general working plan from which he can base his activities, compare alternatives, and make better informed decisions and explanations.

An example may provide better understanding of the concept. Weyerhaeuser Corporation has a 40,000-acre tract which it wishes to lease to Virginia sportsmen for bird-hunting rights. Sportsmen want to know whether the $5.00 fee charged to them is worth the hunting opportunity now, and they will want to know the same in years to come. The Commission of Game and Inland Fisheries finds out the following about the area:

1) 20,000 acres is characterized by 6 x 6 spacing which will be designated as Unit A.

2) 20,000 acres is characterized by 8 x 8 spacing which will be designated as Unit B.

The procedure is then as follows:

1) The Commission either has or develops quail flush curves for the 2 units.

2) By aerial photos, tracts are divided on the 2 units according to year of origin (age).

3) The acreage is measured in each age-class tract.

4) Samples are taken from each of these tracts to obtain an adjusted flush count per acre to determine the quailty of the hunting.

5) The data are then processed and a projected overall yearly flush count is printed by the computer for each unit. These flush counts are summed to get an estimate of the future amount of quality-ranked quail activity, plantation wide.

Thus, quail hunting success over huge acreages of land could be predicted well within the limits of confidence and precision needed by managers without them taking actual direct census counts. Past the initial cost of developing flush curves, the economics of this simulation method are minimal based on the amount of information produced. The system is being implemented at Virginia Polytechnic Institute and State University to provide insight into quail management for the future.

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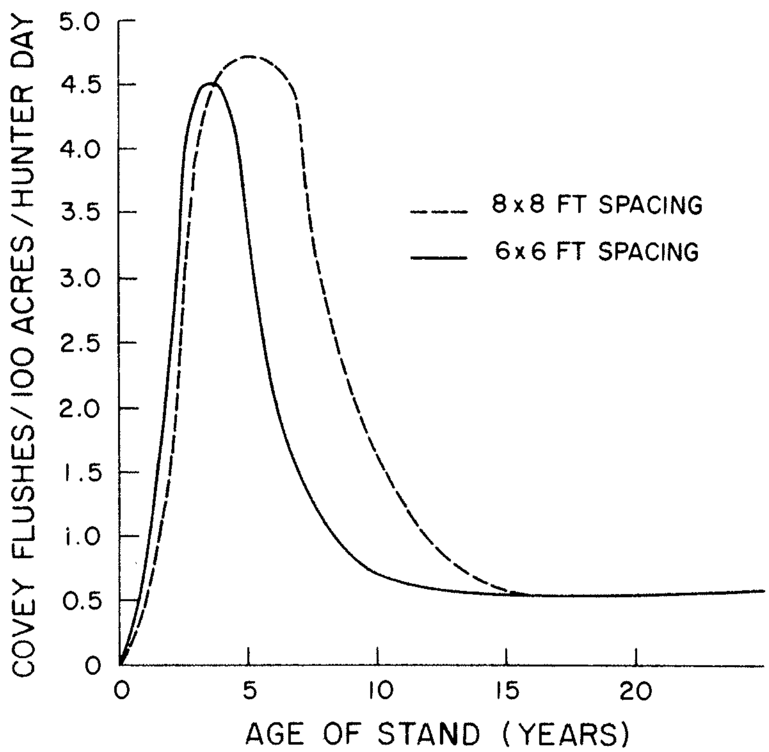

Fig. 1. Generalized effect of plant succession and tree spacing on bobwhite ouail covey-flushes within an area.

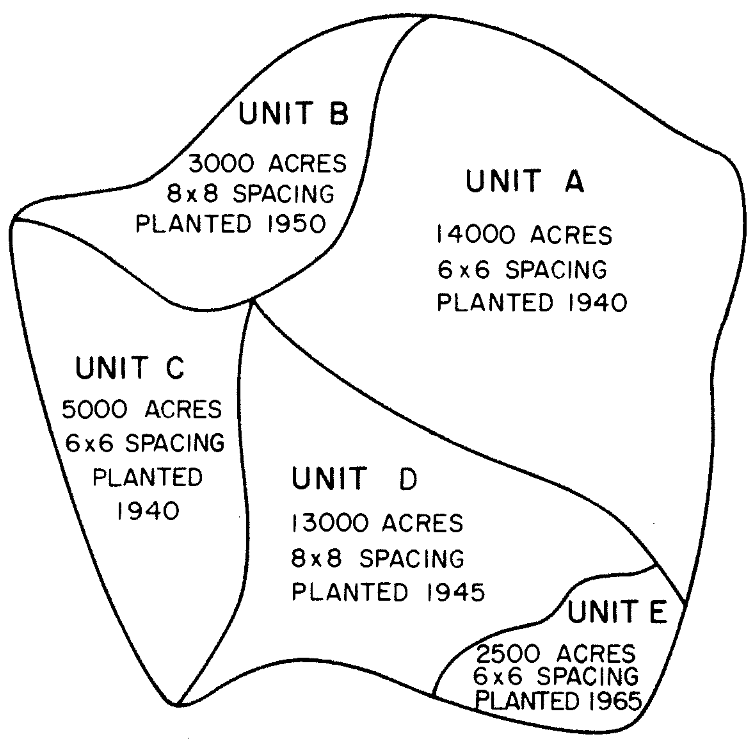

Fig. 2. An area of management, with four units, each with different characteristics, several having different dates of stand origin.

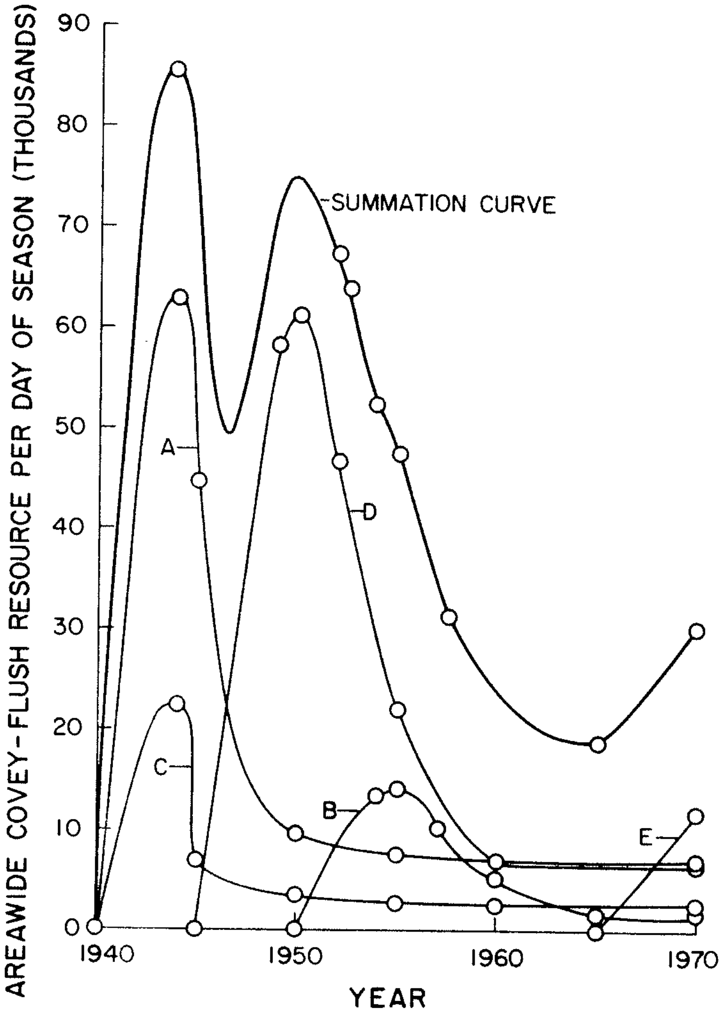

Fig. 3. Covey flush curves for the units shown in Fig. 2, with the summation curve representing the area-wide covey-flush potential per day of the hunting season for the area.

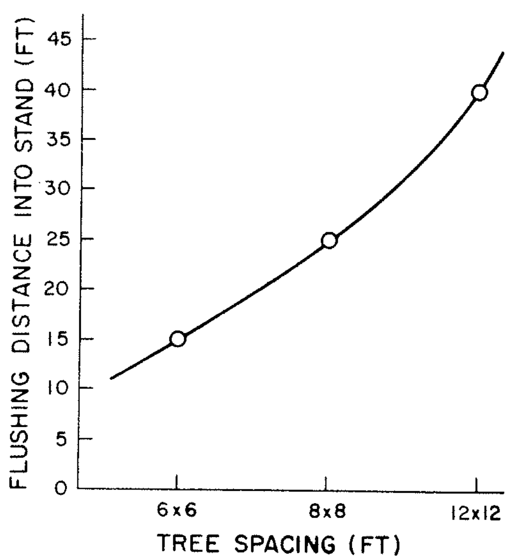

Fig. 4. Hypothetical covey flush counts within pine stands.

SEASONAL CHANGES AND HABITAT INFLUENCING HELMINTHIASIS IN BOBWHITE QUAIL

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Abstract:

Two hundred forty-four bobwhite quail (*Colinus virginianus*) were collected in Kansas and examined for helminths during 1963-1966. Total incidence of helminthic infection was 23%; 24% in juveniles and 22% in adults. Total incidence of nematode infection was 13%, cestodes, 10% and no trematodes were recovered. Six species of nematodes, 1 species of cestode, and 1 species of acanthocephalan were found in the quail examined. Peak incidence of infection occurred from September to November during the 3-yr study.. Incidence of infection was greater during February-April 1965, than during similar periods of 1964 and 1966. Bobwhites collected within 0.5 mile of farms with poultry had a helminthic incidence of 38%, whereas, those collected 1.5 miles or more removed from farms with poultry had an incidence of only 8%, suggesting that poultry may be serving as a reservoir of helminthic infection for wild bobwhites.

Generally it has been found that game birds in the wild are not overtly affected by heminthiasis. However, among birds raised in captivity under certain management conditions, some helminths may be prevalent and cause extensive mortalities (1,3,4,6,9,15). The incidence and degree of infection reported for quail in the wild has been low with the exception of those studies encountering *Aulonocephalus linquisti* (9.15). In high-density areas, quail usually have greater individual burdens and a wider variety of parasites than quail in low density areas (7).

The study reported here (influence of seasons and habitats on the incidence and species of helminth in quail) was in conjunction with a study (R.J.R.) of quail food habitats, energetics, and population dynamics in Kansas. This paper is contribution No. 1150, Division of Biology, Agricultural Experiment Station, Kansas State University, Manhattan, Kansas 66502.

The authors thank W. P. Tidball, Jr. for assistance in necropsy of bobwhite quail and analyses of his data for 1965 as a National Science Foundation Undergraduate Research Participant, and Dr. Ahmet Kalkan for assistance in necropsies in 1964. Financial assistance was provided by the Wildlife Management Institute; Kansas Forestry, Fish and Game Commission; U. S. Department of the Army; and the Kansas Agricultural Experimental Station.

Materials and Methods

All quail were collected on the Fort Riley Military Reservation, Riley County, Kansas, during September 1963 to February 1966 (Fig. 1).

Topography and vegetation of the study area as well as method of collection are described by Robel (13). The birds were eviscerated (esophagus, trachea, crop, proventriculus, gizzard, intestines, and ceca) and the viscera were refrigerated until examined for helminths within several days. Standard parasitological procedures were used for recovering, fixing, and staining helminths.

Results and Discussion

Of 244 bobwhite quail examined for helminths during this study, 194 (79.5%) were juveniles and 50(20.5%) were adults. Tip coloration of the greater upper primary feathers (10) and appearance of the 7th greater primary coverts (5) were used as age criteria. Juveniles exhibited a 23.7% incidence of infection while adults showed a 22.0% incidence, the incidence of infection in the 2 age classes was not significantly different ($p>0.05$). The overall helminthic incidence was 23.3%. The incidences of infection by classes of helminths were: cestodes (10%), reaching peaks in March and April, nematodes (13%), reaching peaks in November and February, and acanthocephala (1%). No trematodes were recovered.

Peak incidence of infection of quail during the 3 yr was in November, 1964, but highest incidence was in other months in 1965 and 1966 (Fig. 1). Temperatures were comparable during October-November of 1964 and 1965, but rainfall was much greater in this period of 1964 compared with 1965 (Fig. 2). The reduced rainfall in October-November of 1965 may have provided less favorable conditions for survival and/or development of helminthic life stages and/or intermediate hosts, thus reducing the helminthic incidence during this period. However, we can offer no explanation for the relatively high helminthic incidence in birds collected during February-April, 1965, compared with the absence of infection in birds collected February-March, 1964, and February, 1966.

Rhabdometra odiosa was the only cestode recovered and it occurred only in juvenile quail. Six species of nematodes were recovered: *Heterakis gallinarum*, *H. bonasae* (rare), *Physaloptera sp.* (rare), *Subulara brumpti*, *Dispharynx spiralis* and *Seurocyrnea colini*. Number of nematodes in the birds ranged from 1 to 21 with a median of 3. The acanthocephalan was a *Mediorynchus sp*. This acanthocephalan has been previously reported from quail (12,14).

Bobwhites collected within 0.5 mile of farms with poultry had a helminthic incidence of 38.0%, whereas those collected 1.5 miles or more from farms with poultry had an incidence of only 8.1% (Fig. 3). That suggests that poultry may be serving as a reservoir of infection (principally, cecal worms) for bobwhite quail. No difference in quail population densities were detected near farm buildings versus areas 1.5 miles or more removed from farm habitation. During the period of this study, poultry husbandry on the farms associated with our study area (Fig. 3) consisted of chickens roosting in coops at night, but being free to roam habitat adjacent to the farm during daytime. Therefore, it was possible for quail to ingest eggs of *Heterakis gallinarum* while feeding in habitat contaminated by unconfined chickens.

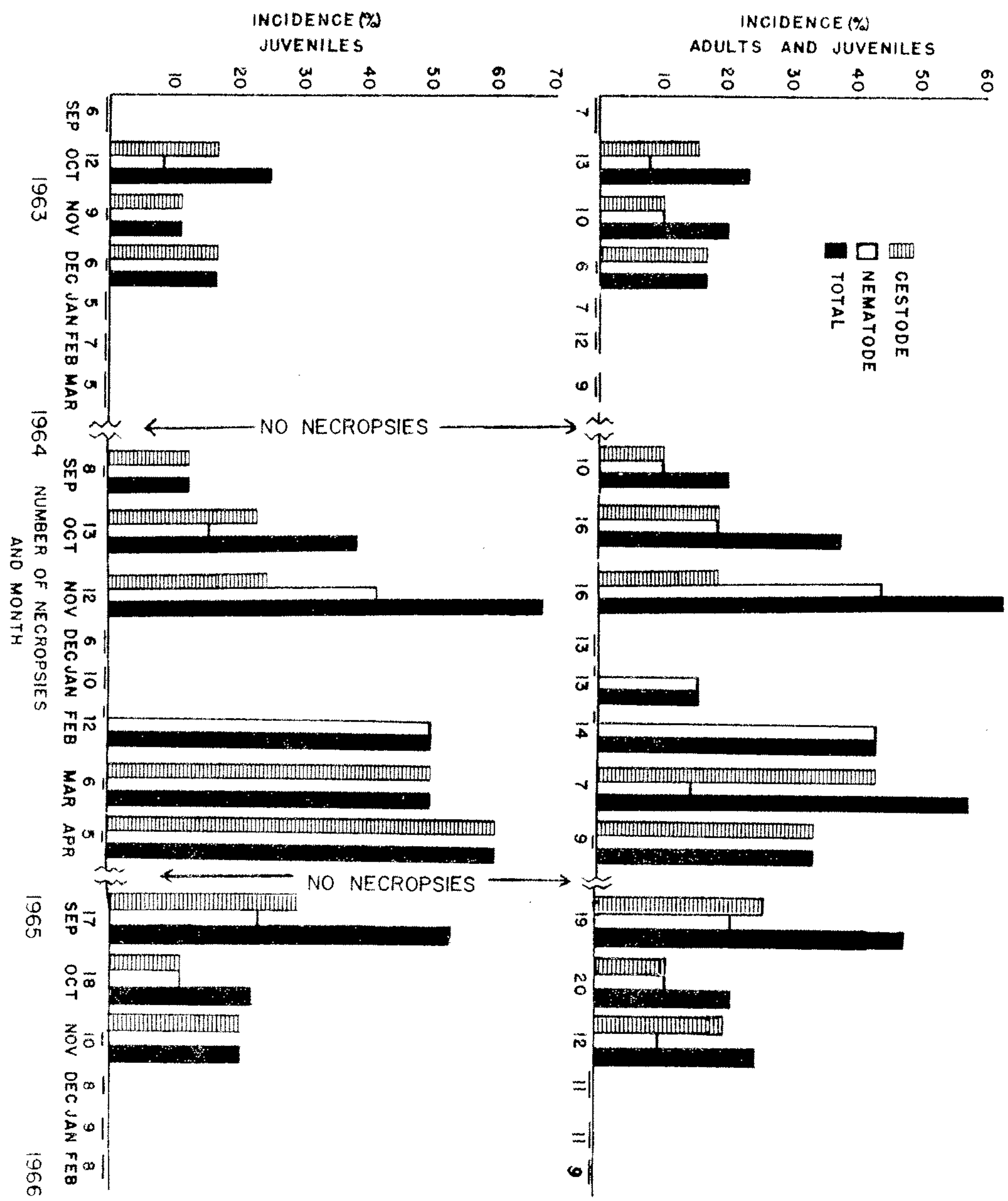

Figure 1. Incidence of infection with cestodes and nematodes in bobwhite quail according to age. Dash lines under the abscissa indicate no helminths recovered.

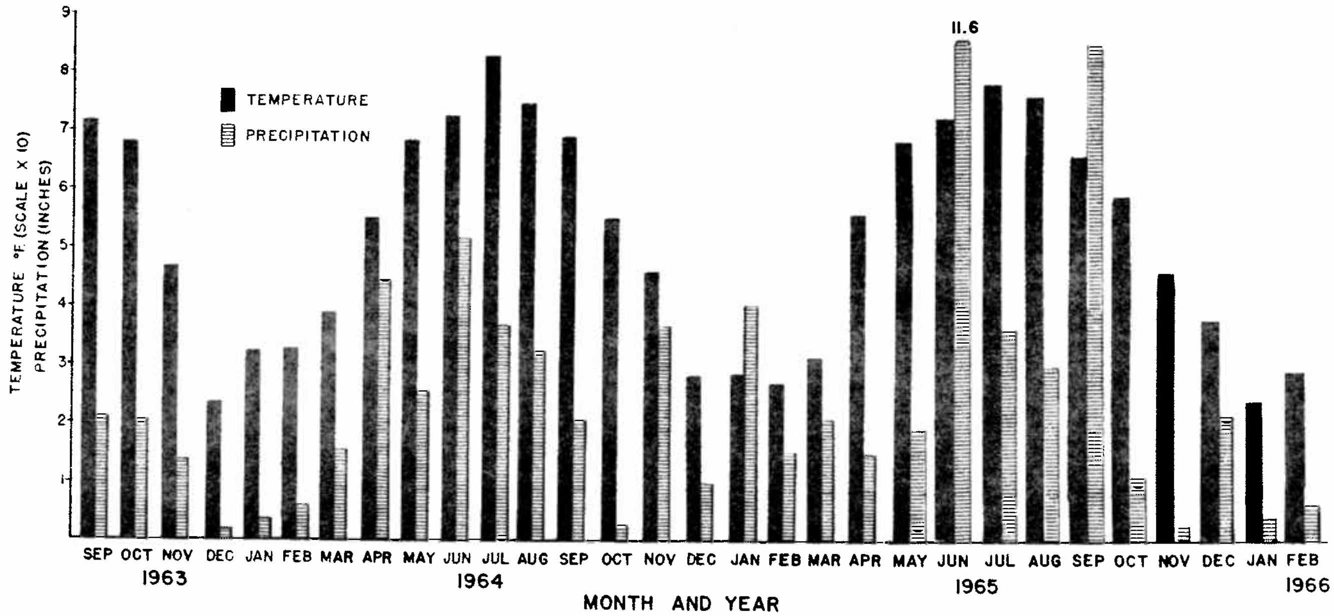

Figure 2. Temperature and precipitation corresponding with collection of bobwhite quail.

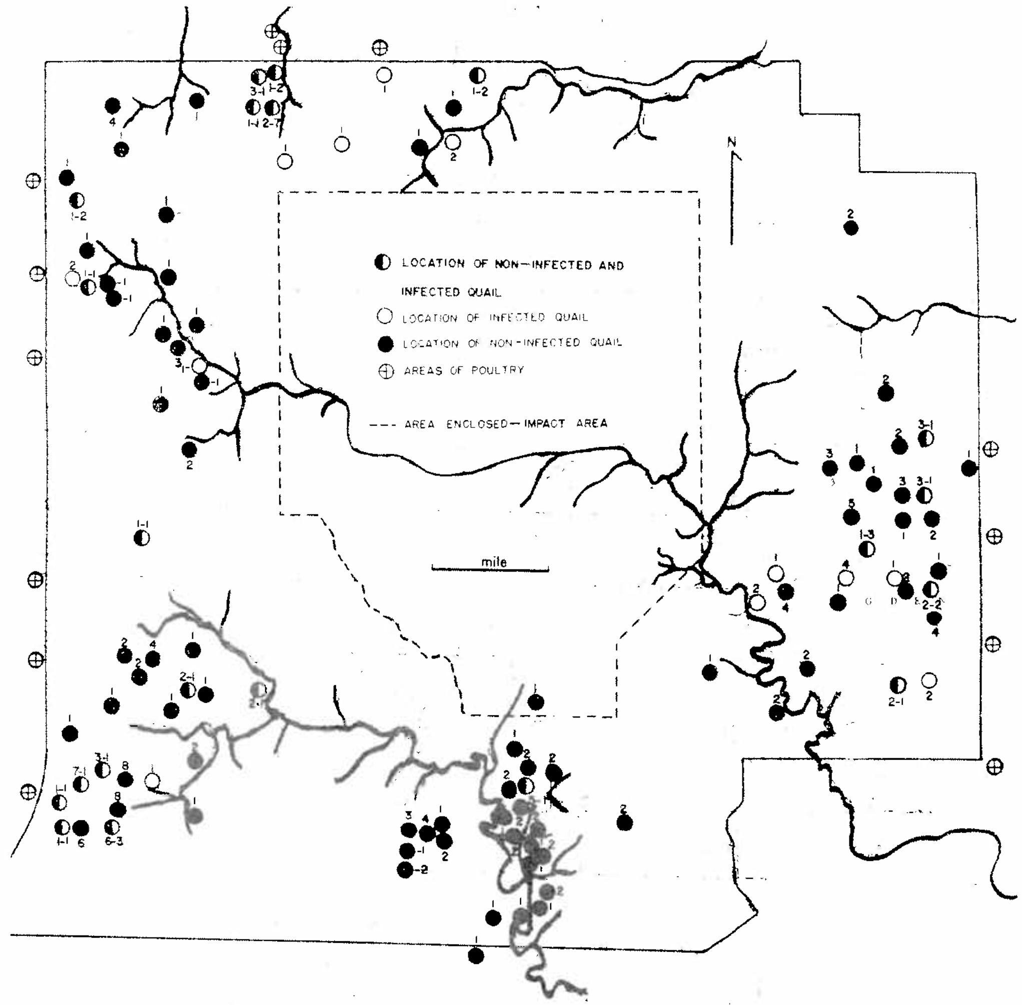

Figure 3. Distribution of non-infected and infected bobwhite quail in the Fort Riley Reservation study area. Numbers by each type of circle designate number of quail in the designated category.

The highest percentage incidence of helminthiasis was associated with the cecal worm, Heterakis gallinarum. Because this species of nematode can infect chickens, turkeys, and pheasants (11), it is not surprising that it was frequently found among quail collected near farms with poultry. This nematode is known to carry the protozoan Histomonas meleagridis, the organism causing blackhead disease of turkeys and pheasants. Research has demonstrated that the bobwhite is refractory to histomoniasis when given virulent strains of the organism cultured in vitro, but is susceptible to histomoniasis when fed embryonated heterakid eggs of worms from chickens (2,8). Laboratory experiments have demonstrated that bobwhites harbor the histomonad up to 6 months after initial infection (2). Bobwhites could be important in spreading the disease to pheasant populations via contamination of the habitat with eggs of Heterakis gallinarum which carry the protozoan.

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POPULATION DYNAMICS OF BOBWHITES ON AN INTENSIVELY MANAGED AREA IN SOUTHERN ILLINOIS

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Introduction

An intensive bobwhite quail management program was placed in operation on about 2,000 acres of The United Electric Coal Companies, Inc. properties near DuQuoin, Illinois in 1954 and was continued through 1959. Included were approximately 800 acres of strictly idle land, 600 acres of mixed idle and agriculture land, and 800 acres of intensive agricultural land. On idle lands, controlled burning, food strip plantings, fallow strips, and release cutting of trees in fencerows and field edges were carried out. Field size was reduced, fencerows widened, and food strips were established in the agricultural areas. In various years pen-reared quail were released, some in spring, some in summer, and some in fall in both areas. This paper describes the bobwhite population dynamics on these properties during 6 yr of management.

Methods

Population levels were determined by 3 censuses: 2 weeks before the hunting season (prehunting), immediately following the termination of hunting (posthunting, late December), and the third week in March (prenesting). Because of summer and early fall releases in 1954 and 1955, liberated quail were recorded as part of the fall population in those 2 yr. On the basis of percent return from harvesting it was estimated that these released birds represented 5 and 10% of the fall-censused populations for 1954 and 1955, respectively. Because of the apparent rate of mortality of liberated birds, it is estimated that they represented no more than 2 to 3% in any of the posthunting censuses and less than 1% in the prenesting censuses. Although some quail from 2 of the fall releases and 1 of the spring releases survived until hunting seasons the following years, such releases were not considered as part of subsequent prehunting-censused populations. Admittedly, not all aspects of the effects of the various releases can be completely evaluated. However, their contribution to population levels on this study area are believed insignificant.

Results and Discussion

Three yr after the installation of management practices the quail population on these properties in the fall showed an increment of about 500% (Table 1); total numbers of quail increased from 136 to 667 birds and 13 to 52 coveys. The actual peak in population during the 6 yr occurred 1 yr later, in 1957, with 747 birds and 52 coveys. Following this peak there was a decline to 498 birds and 44 coveys in 1958 and to 486 birds and 38 coveys in 1959.

Prior to the management program, the quail populations on this area had shown a continuous decline over the previous 8-10 yr, reaching a level of 136 birds and 13 coveys in fall of 1953. This decline was related to the gradual deterioration of the quail habitat due to normal plant succession in the idle lands and increased intensity of intertilled cropping in the agricultural areas. According to reports, the highest populations for these areas occurred 8 to 10 yr previously. However, employees of the Company, who had been in charge of hunting for several years, stated that maximal fall population levels never approached more than 50% of that realized in 1957, following the intensive program of management.

It is acknowledged that quail populations in southern Illinois generally were increasing during the 1953-to-1956 period. An unmanaged area, under study since 1950 near Carbondale, 18 miles southeast of the managed area, was used as a reference. It showed a population increment of about 70% (237 to 392 birds) during this same period. It may be feasible to assume that a major portion of the 500% increase on the managed area at DuQuoin reflected the results of management efforts.

Because of the relationship of the idle and agricultural lands it was possible to establish, somewhat arbitrarily, 3 types of areas based upon use: strictly idle land, intermingled idle and agricultural, and strictly agricultural. The intermediate between the 2 extremes of land use revealed slightly denser quail populations in 5 of 6 years as based on number of acres per bird (Table 2); however, as reported, it likewise held the higher populations before management was installed. At peak population levels (1957) increase associated with land-use types was highest in the idle lands (605%), second highest in agricultural lands (474%), and third highest in the combination area (396%). This suggests that the greatest returns from management were realized for the 2 extremes in land use.

Hunter success per man-hour and total harvest were highest from the combination type of land use in contrast to the other 2. This was believed related to the behavior of the quail as the combination area seemed to hold quail better, and to the fact that they were easier to hunt because of the distribution of cover. Idle areas had extensive heavy cover which afforded protection to quail when pursued by hunters; also, the heavy cover discouraged the novice hunter and made shooting more difficult. In agricultural areas, quail were more widely distributed, being less restricted by cover distribution; furthermore, in sparser cover they flushed more readily and worked less well for the dogs. There was some tendency to hunt the combination area more intensively because quail were easier to find and could be handled better by the dogs. Hence, there may have been a small disproportional hunter pressure in the 3 types of areas.

Of special interest was the hunting pressure experienced by this managed quail population. In 1954, when hunting was restricted, 22 parties averaged 1.8 days of hunting per week during a 30-day season. During the years 1955-59 the area was hunted an average of 4.5 days per week, totaling 90 hunting parties for the season. Such pressure is considered excessive and most undesirable by managers of quail plantations in southeastern United States (2) and results in poor hunting returns either in birds harvested or in covey finds. Because hunting activites were being conducted during morning and afternoon, and because the size of the area did not permit much change in places to hunt, the 90 hunting parties really meant as many as 180 individual hunting trips or an equivalent of 6 per day for the 30-day season. This then greatly magnifies the extent of the hunting pressure.

The effects of the heavy hunting pressure were believed evidenced by the covey finds per hunting party per 0.5 hunter-day. The first week of the season covey finds averaged 3.0 per 0.5 hunter-day; this declined to 0.4, a reduction of 2.6, by the last week of the season. The second and third week showed average covey finds of 2.0 and 0.9, respectively. Hunter success generally declined as the season progressed, and this relates directly to the decline in covey finds.

The progressive decline in covey finds seemed a direct reflection of hunting pressure, which remained relatively constant during the 30-day season. Seemingly, then, there was a progressive decline in the quail population as the season progressed. This was probably true only in part as it was clearly evident that coveys became increasingly hard to find as harrassment from hunters increased. However, field observations indicated that coveys not only changed their habits and utilized heavier cover but some actually moved off the study area.

Posthunting censuses reflected a significant population decline from the prehunting censuses. During the years of heavy hunting pressure (1955-1959), population losses ranged from 57 to 83% (Table 1). In contrast, the Carbondale Research Area, where hunting is more intense than the normal level on private lands, annual quail mortality due to hunting during 1955-1959 ranged from 42 to 67%. These are unusually high compared to an estimated annual harvest of 25% (1) for wild populations on a statewide basis.

Of special interest was the prenesting population on the United

Electric study area following the years of high hunter mortality. In the springs following the hunting seasons of 1955 and 1956, the prenesting populations showed increments of about 32 and 60%, respectively (Table 1). Prenesting populations in 1958 and 1959 revealed virtually no change from the posthunting numbers of the previous 2 years. In contrast, the 1955 prenesting population was about 27% less than the posthunting population of the previous year when hunting was limited. This represents a more normal pattern of decline for wild populations and is similar to that established for the Carbondale Research Area over a 15-year period.

An analysis of the population decline during the hunting seasons and of the quail harvested by hunters showed that actual harvest accounted for only 42 to 51% of the total losses recorded during years of heavy hunting pressure. This indicated that hunter mortality was not solely responsible for the decline in the quail population. Field observations indicated that a possible consequence of the heavy hunter pressure was movement of coveys of quail into surrounding lands not included in the study area. In 1956 a check of about 600 acres of spoilbanks adjacent to the study area on the south and west revealed 12 coveys in an environment considered appropriate for possibly 2 or 3 coveys. A similar situation was apparent for woodland and pasture areas along the south and east borders.

This was limited but good evidence that quail believed dislocated by heavy hunter pressure returned to the managed area within 2 weeks after the hunting season was terminated. This may account in part for the gain in populations or at least the little or no loss recorded during the winters of 1956-59 as evidenced by the prenesting censuses. Probably some additional birds, native to the surrounding areas, also moved on the managed acreage because of its superior habitat during winter. The extent of such movements was not known but 3 to 5 coveys may have been involved in any given year. This was possibly evidenced by the absence of population losses after the 1957 and 1958 hunting seasons when one might have expected at least small declines following hunter-caused mortalities of 62 and 57%, respectively (Table 1).

On the basis of prehunting populations, the peak of population increment occurred in 1956; however, highest fall populations occurred in 1957, 1 year later. This delayed peak reflects a possible carryover from the previous year. Although the percent summer gain clearly reflects inversity when prenesting and prehunting populations are compared (Table 1), such inversities are most strikingly demonstrated in 1958 and 1959 when overall populations were declining and when breeding populations were the highest.

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Table 1. Population Dynamics of Bobwhites on The United Electric Coal Companies, Inc., Duquoin, Illinois, 1954-1959.

Year	Prenesting coveys	of birds	Percent change from post hunting	Prehunting coveys	of birds	Percent change from prenesting	Post hunting coveys	of birds	Percent change from prehunting
1953				13	136				
1954	8	74		22	301	+306.7	18	169	-43.9
1955	17	123	-27.2	34	504	+309.8	10	108	-78.6
1956	16	143	+32.2	52	667	+366.4	12	114	-82.9
1957	20	182	+59.6	52	747	+310.4	30	284	-62.0
1958	24	269	-05.3	44	498	+ 85.1	23	214	-57.0
1959	25	215	+00.4	38	486	+126.0	23	205	-57.8

Table 2. Acres per bobwhite on different land use types, The United Electric Coal Companies, Inc., DuQuoin, Illinois.

Type of land use	Acres per bird					
	1954	1955	1956	1957	1958	1959
Idle area (800 ac.)	6.5	3.8	3.0	2.5	3.0	3.7
Idle and agriculture area (600 ac.)	6.2	3.4	2.0	1.9	4.0	3.5
Agriculture area (600 ac.)	8.4	7.5	4.4	4.2	6.0	6.0
Totals	6.6	4.0	3.0	2.7	4.0	4.1

A MODEL FOR DETERMINING LEAST-COST QUAIL STOCKING PROGRAMS

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Abstract:

A model is presented to allow the calculation of the minimum cost of providing an acceptable level of quail hunter success expressed as kill per day. The model is based on a Poisson distribution for hunter kill per day, the number of hunters, their success rates, quail survival rates, various costs of quail production and release, stocking levels, and frequency of stocking. An example is given.

Game farm quail (Colinus virginianus) have been used primarily to provide hunting opportunity in areas having low populations of game birds and a high level of hunting pressure. Secondarily, these birds have been used to replenish areas where wild birds vanished due to temporary habitat losses or other factors.

In some highly populated urban areas, it may be desirable to stock birds to provide hunting opportunity for the urban hunter on a stock-shoot basis. Although superficially expensive, it can be demonstrated, in areas of high hunter demand and limited habitat, that (A) it is impossible to satisfy hunter demands from natural stocks, and (B) the cost per bird harvested or the mean cost per unit of hunter satisfaction is less under the stock-shoot program than under a natural habitat production program. All evidence indicates that to get the most out of a stock-shoot program, large numbers of birds should be released on limited areas that are heavily hunted. This procedure ensures that a high proportion of the birds will be harvested before the birds die of other causes or before they disperse from hunting areas. Game managers recognize that stocking will not insure increased game populations or even increased harvest levels if the birds are stocked too many months prior to the hunting season. Yet such stocking programs continue.

It is not the purpose of this paper to discuss the biological shortcomings of the use of pen-reared birds to achieve the second objective. Numerous accounts in the literature point out these deficiencies (1,2,3,4).

It is recognized that the percent of the released birds eventually killed by a hunter is inversely proportional to the length of time between the stocking date and the opening date of the hunting season.

Under such a system of intensive management it is important to minimize costs and increase efficiency. A model has been developed to achieve such efficiency. It is based on the previous concept and utilizes the knowledge of game managers about the size and temporal distribution of the kill, cost of raising quail or other game birds, the extent of natural mortality on released birds, the temporal and spatial distribution of the hunting pressure, and the effect of success on the total hunting effort. The model allows a priori assessment of the cost of stocking programs with various rates and replenishment schedules and, thus, the least cost solution for providing satisfactory stock-shoot quail hunting. It is the purpose of this paper to develop such a model and to present its theoretical basis. It is demonstrated that a computer is not required, but the problem could be formulated for computer solution.

Hopefully, this paper will stimulate further use of mathematical models in analyzing biological processes to increase the efficiency of wildlife management.

The support of the Division of Federal Aid, Bureau of Sport Fisheries and Wildlife, Washington, D. C., is gratefully acknowledged.

Development

Through use of mail surveys and other means, the size of the kill, number of days hunted, and the temporal distribution of the kill is known by most state agencies. Marking released birds with leg bands had provided estimates of the natural mortality of these birds as well as the percentage of the birds released that are killed by hunters. Field studies have provided information on behavioral habits of wild birds, such as average covey size at the start of the hunting season. These parameters, with some qualifying assumptions, provide sufficient information to analyze stock-shoot programs. From such analysis a model can be developed. The objective of the model is to minimize the cost of providing an acceptable level of hunter success expressed in terms of the kill-per-day.

Assume that the probability of x kills per day by a hunter follows a Poisson distribution having a mean m, where

$$m = N/C \qquad (1)$$

and

N = the size of the stocked population

C = the number of birds that must be stocked per harvested bird.

Thus, the probability that a hunter bags x birds in 1 day is

$$\frac{m^x e^{-m}}{x!} \; ; \; x = 0,1,2,... \qquad (2)$$

which is the mass function for the Poisson distribution.

The goal of the manager is to provide a sufficient population of stocked birds such that a predetermined percentage of hunters, S, harvests at least x birds per day. The probability that the kill per hunter is equal to or greater than x is

$$p(X \geq x) = P(x,m) = \sum_{\chi=x}^{\infty} \frac{m^x e^{-m}}{x!}$$

The complementary cumulative distribution function, P(x,m), for the Poisson distribution is tabulated in many statistics and mathematics handbooks. To use these tables to determine the number of birds that must be present to ensure with probability S that a single hunter bags at least x birds, one simply searches the table in the rth row or column until he finds a value greater than or equal to S in the column or row corresponding to a particular m. Then from (1),

$$N = m \cdot C. \tag{4}$$

With most stocking programs, birds released to the wild have poor survival. Assume the number of birds dying from causes other than hunting in a given period is proportional to the size of the population. The simplest functional relationship is

$$M = K \cdot N \tag{5}$$

where

M = the number of birds dying of causes other than hunting, and

K = a constant mortality rate per week.

Let P_t represent the number of hunters hunting in a given time period t. P_t is a function of the number of hunters in the population and the success of the previous hunt. This relationship is formulated as

$$P_t = H \cdot S^t; \quad t = 0,1,2,... \tag{6}$$

where

H = the number of hunters that hunt the area on opening weekend, and

S = the percent of hunters bagging at least x birds per day.

The number of hunters is assumed to decrease at a rate proportional to declining success rate, S, between replenishment stockings during the season. It is further assumed that a hunter ceases to hunt in any year as soon as he fails to bag at least x birds in a single hunt.

Due to the leisure patterns of the average citizen, most hunting takes place on the weekends. It is assumed that the amount of hunting during the week (except on opening days) is insignificant. That is, from a total quail population management point of view, the effect of this hunting mortality is completely substitutable with natural losses and is, therefore, included in the constant K in (5).

Each time birds are released, the cost of the effort can be represented by equation 7.

$$TC = F + V \cdot N \qquad (7)$$

where

F = the fixed costs independent of the number of birds released (N)

V = the cost per bird.

In most instances, the size of the stocking programs is sufficiently large so that the fixed costs are negligible and can be ignored. Thus the problem of minimizing cost reduces to one of maximizing the utilization of the released birds. To do so, it is assumed that birds will be released immediately prior to the weekend when most hunting activity takes place.

Define r_t as the stocking level prior to each weekend t, $t = 1,2,\ldots,w$ where w is the length of the hunting season in weeks. The number of birds released prior to the opening weekend is

$$r_1 = P_o N \qquad (8)$$

If Q_t, $t = 1,2,\ldots,w$ is the residual population at the end of the tth week, the replenishment stocking level (r_t) becomes

$$r_t = \begin{cases} 0 \text{ if } Q_t > P_t N \\ P_t N - Q_t \text{ otherwise} \end{cases} \qquad (9)$$

where

$$Q_t = \begin{cases} P_o(N-m)\ (1-K) \text{ if } t = 1 \\ \sum_{i=o}^{t-1} (r_i - P_i m)(1-K) \text{ if } t > 1 \end{cases}$$

The total number of birds released throughout the season is $R = \sum_{t=o}^{w} r_t$.

Example

Assume it desirable to stock enough birds so that 95% of the hunters bag at least 1 bird per day ($S = 0.95$). From cumulative Poisson tables we read across the row corresponding to $x' = 1$ until we find a value greater than or equal to 0.95. This value is found in the column corresponding to $m = 3.0$, the mean kill per day per hunter.

Assume that 1.5 birds must be released per quail harvested ($C = 1.5$). Thus the number of birds to be stocked so that a single hunter will have a 95% chance of bagging at least 1 bird is

$N = mC = 3.0(1.5) = 4.5$

If 20% of the population dies each week from nonweekend hunting causes (K = 0.20), if the hunting season is 4 weeks long and starts on a weekend, and if the expected hunting pressure on the first weekend (P_o) is 1000, then the size of the initial stocking, r_1, will be 4,500 birds.

Using (6); t = 0,1,2,...,4, then the hunting pressure on subsequent weekends is

$$P_0 = 1000$$
$$P_1 = 950$$
$$P_2 = 900$$
$$P_3 = 855$$
$$P_4 = 812$$

The total hunting pressure, P, is 4,517 hunter days. The residual population ($Q_o = 0$) is

$$Q_1 = P_o(N-m)(1-k) = 1000(4.5 - 3.0)(1-0.2) = 1200$$

The replenishment stocking level for the end of the first week is

$$r_1 = P_1 N - Q_1$$
$$950(4.5) - 1200 = 3075$$

The residual population and the replenishment stocking level after the second week is

$$Q_1 = P_1 (N-m)(1-K) = 950(4.5 - 3.0)(.8) = 1140$$

$$r_2 = P_2 N - Q_2 = 900(4.5) - 1140 = 2910$$

In a similar manner, we obtain

$$Q_3 = 900(1.5)(.8) = 1080$$

$$r_3 = 2768$$

and

$$Q_4 = 855(1.5)(.8) = 1026$$

$$r_4 = 2628$$
$$R = \sum_{t=o}^{4} r_t = 15,881$$

The total cost of this effort is

TC = 5(F) + 15,881 (V)

if F = $100.00 and V = 1.00, then

TC = 500.00 + 15,881 = $16,381

The total weekend kill (P·m) is (4517·3.0) = 13,551 quail.

This example demonstrates the use of the model, resulting in a calculation of 4,517 hunter days of quail-based recreation being produced for a minimum total cost of $16,381, or about $3.60 per hunter day.

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FORMULATION OF AN OPTIMUM WINTER FOOD-PATCH MIX FOR BOBWHITE QUAIL

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Abstract:

Many state game agencies are seeking to improve winter quail food and habitat by means of artificial food-patch plantings. The objective of such plantings is to increase the limited supplies of nutrients available to quail in late winter. Desirable qualities of food species included in the seeding mixture are: low seeding cost, high nutrient and energy content, persistent seeds, and cultivation ease.

Presently used mixtures have been formulated in the absence of detailed nutritional analysis and cost-minimization techniques. This paper seeks to demonstrate the utility of modern operations-research technology in such decisions by outlining the procedures for determining the composition of an optimum food-patch mix. This mix will meet nutrient and cultivation requirements at a least-possible cost per acre of food planting. Although a solution is presented, the emphasis of the paper is on the method for obtaining such a solution.

In many states, the establishment of artificial food-patch plantings is a major activity in bobwhite quail management programs. The purpose of these plantings is to increase the quantities of vegetable foods available to quail during the winter when adequate food supplies are critical to survival. Much study has been devoted to the formulation of seed mixtures to be used for constructing these food plantings. The literature abounds with quail food-preference studies for various regions of the country (2,5,10). A number of authors make recommendations for seed mixtures suitable for bobwhite food patches under a variety of conditions (8,9,13).

Artificial food patches, however, are expensive to establish and maintain. Seed procurement and planting costs may be high, especially for nonagricultural plant species. Nutrient content also varies between different quail foods. The mixtures that have previously been proposed were formulated largely on the basis of food-preference data. Little explicit thought was given to the balance of nutrients in the diet or to minimizing the cost of food plantings. Nutritional data concerning both quail requirements and the chemical composition of seeds were minimal. Techniques for cost minimization were, as yet, undeveloped.

In recent years these gaps in knowledge have been narrowed. Minimum dietary requirements have been determined for poultry and some quail species. Biochemical analysis has established the occurrence of nutrients in many grains. Workers in the field of operations research have developed a number of powerful mathematical techniques which, when combined with modern computer capabilities, allow administrators to quickly determine least cost and maximum benefit management alternatives (11,12).

The availability of nutritional data and optimization methods offers an opportunity to rethink and improve the formulation of quail food-patch mixes. This paper seeks to demonstrate the use of linear programming in developing an optimum planting mixture. The food species considered in the following example were selected for use under the climatic conditions of Virginia. In other states, some species would be deleted from consideration while others might be added. The methodology however, is identical for any region, no matter what food plants are included in the analysis.

The authors gratefully acknowledge Dr. Robert H. Giles, Jr., Associate Professor of Wildlife Management, and Mr. Glenn R. Dudderar, Wildlife Extension Specialist, for their aid in compiling data and reviewing the manuscript.

Example Problem

It is desired to establish a series of artificial food patches for bobwhite quail throughout Virginia. The principal objective of the program is to increase the limited supplies of energy and nutrients available to quail in late winter (February), when food appears to be a limiting factor. The manager wishes to determine the seed mix that will provide the maximum metabolizable energy per planting dollar expended. At the same time he would like to provide a balanced diet of protein, calcium, phosphorus, lysine, and sulfur amino acid.

The species selected by the manager for possible inclusion in a planting mixture for Virginia are listed in Table 1. The criteria for the selection of any species are threefold. First, the species must be able to germinate and reach maturity under the climatic and soil conditions of Virginia. Secondly, it must require little or no intensive cultivation. Seedbed preparation may be undertaken, but no other care should be required. Thirdly, the seeds must be persistent and available to quail in February and later months. All 3 are qualitative judgements which must be made by the manager on the basis of his past experience and the advice of agricultural experts.

Table 2 summarizes the nutrient requirements of quail. These are the minimum values which the manager must seek to meet in his food plantings.

Methods

The seed mixture problem may be formulated as a linear programming problem in the following manner.

For each species (i) a coefficient (C_i) representing energy production per dollar expenditure may be determined. Column 1 (energy production) and Column 2 (yield) from Table 1 are multiplied together and the product is divided by the entry in Column 3 (cost). For example, the coefficient for corn is:

$$3400 \times 1900 / 45 = 143555.50$$

If this coefficent is multiplied by a value, x_i, representing the proportion of the seed mixture allocated to species i, the product may be thought of as the proportional contribution of that species to the overall energy/cost ratio of the mixture. The manager's objective is to find the mixture of seed that will make this overall ratio as large as possible, while satisfying other minimum nutrient requirements. These nutrient requirements may be included in the problem as constraints. For each nutrient (j) and plant species (i) a percentage (a_{ij}) may be read from the appropriate column in Table 1. The protein content of corn is, for example, 8.70%. If M_j (as recorded in Table 2) is used to designate the minimum quail requirement for nutrient j, the amount by which seed production by plant species i surpasses this nutrient requirement is given by the expression:

$$P_i (a_{ij} - M_j) x_i$$

where P_i = the potential yield of species i (Column 2, Table 1).

The result may be negative for species with low nutrient contents.

The problem may be summarized for n food species in mathematical notation. The manager's goal is to maximize the overall energy production to cost ratio:

$$\text{Max } X_o = \sum_{i=1}^{n} C_i x_i \qquad (A)$$

However this maximization is subject to a number of constraints:

$$\sum_{i=1}^{n} P_i (a_{ij} - M_j) x_i \geq 0; \text{ for all } j \qquad (B)$$

One such constraint must be applied for each nutrient of interest.

The maximization procedure is subject to only 2 other types of constraints. The sum of the proportions in the final mixture must equal 1:

$$\sum_{i=1}^{n} x_i = 1.00 \qquad (C)$$

Also each individual x_i must be greater than or equal to zero:

$$x_i \geq 0; \text{ for all } i \qquad (D)$$

Obviously no species can compose a negative proportion of the mixture.

Once the problem has been reduced to the form of equations (A) through (D) it may be solved by any 1 of a number of linear programming algorithms adapted to digital computers. The problem presented here was solved with the IBM-supplied mathematical programming system, MPS/360. Initial coefficient calculating and card punching was performed in a FORTRAN IV program written by the senior author.

Results and Discussion

The linear programming solution to the sample problem indicated that 2 species should be included in the planting mixture. Their relative proportions, by weight, should be: sunflower (0.77) and kafir sorghum (0.23). The proportion of all other species in the mix should be 0.00. Multiplying each proportion by the standard seeding rate for that species (Table 1, Column 4), and summing the 2 products indicated that this mixture should be applied at a rate of 24 pounds per acre.

This, then, is the seed mixture which best achieves the manager's stated objectives. It attains the greatest possible energy-production-to-cost ratio while satisfying the constraints set by equations (B) through (D).

However the manager must still exercise some judgement before adopting such a mixture. Energy and nutrient requirements are satisfied, but a number of other considerations are important. The manager must make sure that the selected plant species are relatively familiar to quail. Stoddard (10:125) stated that quail may require 2 or 3 seasons before they will accept a new food. This type of consideration should be applied when initially establishing the list of species suitable for food plantings. In addition the manager must remember that not

Table 1. Nutritional and agronomic characteristics of selected quail food plants.*

Species name	Metab. energy (Kcal/Kg.)	Yield (Kg/acre)	Planting cost ($/acre)	Seeding rate (lbs/acre)	Crude protein (%)	Calcium (%)	Phosphorus (%)	Lysine (%)	Sulfur amino acid (%)
Corn	3400.00	1900.00	45	16.0	8.70	0.04	0.31	0.27	0.34
Serecia Lespedeza	2200.00	91.00	12	15.0	34.70	0.15	0.40	0.15	0.30
Common Lespedeza	2200.00	91.00	12	15.0	40.60	0.15	0.40	0.15	0.30
Lupine	2200.00	91.00	40	28.0	39.20	0.05	0.40	0.10	0.30
Foxtail Millet	2200.00	91.00	20	40.0	12.10	0.05	0.28	0.30	0.13
Japanese Millet	1500.00	91.00	20	40.0	12.00	0.05	0.28	0.30	0.13
Wild Oats	2600.00	400.00	30	64.0	11.70	0.11	0.35	0.36	0.36
Cow Pea	3328.00	220.00	35	90.0	23.40	0.17	0.50	0.15	0.30
Winter Pea	2601.00	136.00	35	60.00	22.50	0.17	0.50	0.15	0.30
Canadian Pea	2600.00	136.00	35	90.00	22.50	0.17	0.50	0.15	0.30
Partridge Pea	2000.00	140.00	35	60.0	36.30	0.17	0.50	0.15	0.30
Broom Sorghum	3400.00	1800.00	25	5.6	9.70	0.03	0.35	0.18	0.09
Grain Sorghum	3500.00	1800.00	25	5.6	11.10	0.04	0.31	0.27	0.45
Hegar Sorghum	3500.00	1800.00	25	5.6	10.00	0.04	0.33	0.18	0.20
Kafir Sorghum	3500.00	1800.00	25	5.6	11.80	0.04	0.33	0.27	0.20
Milo Sorghum	3250.00	1800.00	25	5.6	11.00	0.04	0.29	0.27	0.34
Sorgo Sorghum	3000.00	1800.00	25	5.6	9.60	0.04	0.30	0.25	0.25
Soybean	2500.00	410.00	35	30.0	37.90	0.25	0.59	2.40	1.05
Sunflower	2500.00	1000.00	20	30.0	41.00	0.43	1.04	2.00	1.60

*From Anonymous (1966), Crampton and Harris (1969), and Hubbell (1971).

all of the additional nutrients will be available to quail. Other wildlife species in competition for the same food supply may significantly reduce the effectiveness of any planting program.

After determining an optimum mixture, the manager must make certain that the species to be planted are not potential competitors. Linear programming provides no means of allowing for detrimental interactions; these must be recognized by the manager. One solution to potential competition problems would be strip planting of the individual species, instead of completely random seed dispersal. The manager must also be certain that his mixture is sufficiently diverse to insure success over the range of site conditions on which he must plant (8,13). If it is not, then he should compile separate species lists and redo the analysis for each set of environmental characteristics which he is likely to encounter. Without such analyses the failure of food plants to become established on adverse sites may completely outweigh the value of the entire cost minimization-energy maximization procedure.

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Table 2. Minimum nutritional requirements of quail.*

Nutrient	Percent of diet
Crude protein	24.00
Calcium	0.44**
Phosphorus	0.65
Lysine	1.40
Sulfur amino acids	0.80

* From National Academy of Sciences (1971). Values are for coturnix quail.

**From Miller (1967). A value of 0.20 was used in the actual analysis since it was apparent that no combination of species could meet the requirement of 0.44 percent.

SUMMATION OF THE NATIONAL BOBWHITE SYMPOSIUM

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Your chairman, Dr. Morrison, has given me a difficult task indeed. That is to present to you a summation of this National Bobwhite symposium which in truth is within itself a summation of a large amount of investigative effort and study. No one person could absorb all of this information in a few days, and it would be presumptuous for me to try to do so. Perhaps I may be permitted to bring to you, then, what might be called the "sense of the meeting." Certainly this Symposium reflects the state of the science and art of bobwhite quail research and management including the many ramifications so necessary due to variations in the bird's habitat requirements throughout its wide range.

As was most fitting, the meeting had a prologue in a bird dog demonstration and workshop: without the use of bird dogs the hunting of the bobwhite would lose its attraction to many of its devotees. The use of dogs in bobwhite hunting brings in many extra problems, as the environment must be so managed not only to produce the quail, but to produce conditions in which bird dogs can operate well and be observed properly. In my opinion, altogether too many research people in game management overlook this factor. Production of the game is only half of the job, and in many cases consists of the lesser half.

That the excellent barbeque was not only utilized for nourishment but for many discussions was self-evident and most appropriate; for, after-all, bobwhite hunting is an outdoor sport. One cannot help but wonder how an outdoor symposium would affect the conferees. I have long learned that many differences of opinion are solved quickly and amicably, even in connection with real controversy, when they are discussed right on the ground.

The first panel session: "Trends in Principal Management Themes" was most important, and fittingly was the first of the formal sessions, for the land on which quail are produced and are hunted must be owned by someone. The speakers, along with the discussions, showed the broad conditions under which quail hunting is and must be conducted; ranging from the intensive kind of hunting found on "Private Shooting Preserves" to that found on "Southern Plantations", "State Owned Public Hunting Grounds", and on "Small Farms and Timberlands." That good quail hunting can be obtained under such varying conditions highlights the versatility of both quail production and quail hunting.

The second panel session: "Heretical Ideas About Bobwhite Ecology and Management" discussed pertinent information directly related to management and the potential carrying capacity of quail lands. The subjects from the "One Quail Per Acre Myth", "Two Broods per Year - Fact or Fantasy?", "The Covey Unit - Organized or Disorganized" are in need of further exploration and study. The last paper in this session brought up a problem that has besieged quail management from its very earliest beginnings. "Releasing Pen-raised Quail in Kansas - Its Effect on Hunter Success and Population Levels" was not only of interest but brought on a considerable amount of discussion. It would appear from the discussion that bobwhite quail managers have not been effective in disseminating the results of studies on pen-raised birds, telling where and when they can and cannot be effectively used. Some of this discussion was very similar to those heated arguments of over 30 years ago, as if no progress had been made in understanding this management measure during the interim.

The third panel session: "Landholder-Sportsmen Relations: Solutions for a Problem" is as vital today as it was in the early days of quail management and research. The basis of the conflict between the hunter and the land-holder is found in the basic philosophy anchored in our pioneer heritage: that all of the game belongs to all the people. In quail hunting, this idea clashes directly with the proven management contentions that whatever the land owner does on his land can, and does, affect the quail population and hunting conditions. In other words, by the management of his land for farming, forestry, or other economic practices, he determines whether or not there will be quail to hunt. Stoddard pointed out over 40 years ago that management of the habitat of quail is the determining factor in quail production and abundance. This has been proven and reproven by nearly every scientist ever involved in quail research and has recently been brought up to date by Rosene.

Quail is a crop of the land, just as much as any other economic crop. Once this is realized, it should be evident that the land-owner cannot and will not spend his money to make a more favorable habitat for quail unless he is reimbursed. It is important that we place a monetary value on the quail crop to induce the farmer or land-owner to go into the business of producing more quail hunting. The papers presented at this session: "Pennsylvania's Program to Improve Landholder-Sportsmen Relations", "The Landholders Views on the Problem and The Open Acres Program as a Solution", and the "Sportsmen's Hopes for the Future of Hunting on Private Land" all discussed and stressed important aspects of this fundamental problem in bobwhite hunting for the average hunter. It would appear from these papers and the ensuing discussions that some solutions to this problem are developing in some regions.

I have purposely left until last the Technical Sessions I and II: "Trends in Principal Management Themes" and "Current Research on Bobwhite Life History," respectively. It would certainly be presumptuous for me to even attempt to summarize the 22 excellent papers in these 2 technical sessions. I will, however, take the opportunity at this time to make some comments in lieu thereof. It is gratifying that such a large number of these technical papers were related to quail management and can be properly called management-research papers. I recall some discussions elsewhere that such management research papers could not be brought together and published. The chairman, Dr. Morrison, and his colleagues certainly deserve a great deal of credit for doing something that some people insisted could not be done. These papers show that research on bobwhite ecology is on a sound management basis; and this symposium will, I am sure, stimulate even greater interest in management. The papers also show a great deal of care in using ordinary English so that not only can other researchers understand them, but so can the sportsman. After all, the ultimate purpose of bobwhite research is to primarily furnish hunting of this magnificent game bird.

It may be of interest to you to interject here some comments from Dr. E. W. Nelson, Chief, Bureau of Biological Survey (now Fish and Wildlife Service) to H. L. Stoddard upon Stoddard's entering on duty at Thomasville, Ga. for the Cooperative Quail Investigation in 1924, for it shows the importance placed upon the sportsman and the necessity of applied research.

> "It is scarcely necessary for me to say that the success or failure of the investigation will rest in your hands, and the initiative will rest largely with you as to how the work is carried on and the results obtained. It will naturally be necessary for you to maintain friendly relations with the people with whom you come in contact, both among the contributors to the fund and the residents of the section in which you are working, since such relations will go far toward bringing about a successful conclusion of the work.

It is hoped that you will be able to definitely determine methods whereby the quail can be increased and maintained in numbers far beyond those there present. The subscribers to the fund hold their lands in that region mainly for the quail shooting they get and naturally desire a practical outcome to the investigation."

Today in some circles, we seem to have lost the premise that the purpose of game research, particularly where it is financed by the sportsman's dollar, is that these people who furnish the funds "naturally desire a practical outcome to the investigation." Thus it is heartening to me that in spite of the discussions now going on in those circles as to the relative merits of "pure" (?) game research versus management research, that at least in quail management there is no such hiatus. Certainly this symposium shows that the state of both the art and of the science of bobwhite management research meets Dr. Nelson's earlier admonition as to the value of practical outcome of game research.

It is also most gratifying to me that the use of fire has finally become a recognized tool in the management of the bobwhite. Fully, a third of the papers have made reference to fire. Here again, it may be of interest to quote from the past, and this time from the Dean of both quail research as well as quail management in regard to what we now term "fire ecology", words that were not brought together until only recently (1962).

Stoddard wrote (1931) that fire and the effects of burning:

". . .present a complex problem, one that would require years of careful research on the part of a well-equipped experiment station to work out. Such research is greatly needed, and should be carried on, <u>for fire may well be the most important single factor in determining what animal and vegetable life will thrive in many areas</u>."

The "sense of the meeting" shows up in this regard here with the awarding to George Hurst of the Wendell Bever Award for his most excellent study "Bobwhite Quail Chick Food Habits and Brood Habitat Management" in which he brought out the value of fire management in regard to insect food for quail chicks. I would like to point out that probably the greatest need in bobwhite research is more information of the relationship of insects and their habitat requirements to that of the needs of the bobwhite, particularly for the laying hen and for the baby chick in the first few weeks of its life. Stoddard was the first to point out the dependence of the baby chick on insect food during this period, and every study from which I have information on this situation has verified this fact.

I would like to impress on all of you that all gallinaceous birds require a high protein and high calcium diet at egg-laying time and that young chicks also have this requirement in the first few weeks of life. Where in nature can these birds find such a diet high in both of these factors? Certainly the insect groups can furnish both high protein and calcium requirements. At Tall Timbers Research Station we have recognized that fire and its effects on insect populations are very complex. Let me leave with you the idea that certain insects that live on quail food plants may be of much more value, particularly during the chick-rearing and egg-laying periods, than the plants themselves directly as food.

Another phase of research that appears to be needed in more depth is the relationship of food and other requirements to cold weather around the northern edges of the bobwhite range. These regions are characterized by fluctuations of quail numbers directly related to severe winters. Certainly management research should be able to find ways and means to overcome these wide swings in quail numbers. The goal of research should not be production only in good years. Good game management insists upon tempering such natural extremes even by what might be termed unnatural methods. That food, and its availability is at least a major factor during severe winters has been brought out at these meetings. The question, then, is how can we supplement nature under these conditions? Certainly with today's tools and techniques this problem could be studied in greater depth, and some real benefits would occur to the quail-hunting sportsman by stabilizing the production of quail.

Another allied area for further investigation would be to study the great variations in bobwhite populations that apparently occur at the western edge of its range where moisture is a limiting factor.

I have mentioned these three areas: insect foods, extreme winters, and problems in arid climate, because so much of our game research seems to me, at least, to be a constant repeating of past studies, as if there were no major principles that underlie quail abundance and quail hunting. That past ideas should be questioned and restudied is of course of paramount importance to proper understanding. However, to make continual food studies or to census repeatedly seems to me to be a waste of the sportsmen's and taxpayer's moneys. From a critical viewpoint, it would appear that more imagination, more creativity, and new approaches should be the "order of business" in the future.

In concluding this "summation" it is apparent to me that this National Bobwhite Symposium has shown that the state of both the research and the art of bobwhite management is of high quality. The research and other papers presented here certainly show a high regard for practical application; and the papers themselves can be easily read and understood by both sportsmen and researchers. The group of people that originated, designed and conducted the Symposium have shown a real understanding of quail research and management, as well as the many ramifications of the sportsman-landholder relationship. It is my hope that the same group can hold another such bobwhite symposium when they deem sufficient new information is available.

A PARTIAL BIBLIOGRAPHY OF THE BOBWHITE QUAIL

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This bibliography lists contributions to literature dealing with bobwhite quail. The literature sources surveyed include Wildlife Review, Nos. 1-145; the bibliographies in The Bobwhite Quail: Its Life and Management by Walter Rosene; and The Bobwhite Quail: Its Habits, Preservation and Increase by H. L. Stoddard; Forestry Quarterly, Volumes: 3, 4, 5, 7, 9-14; Journal of Forestry, Volumes 15-64; and Forest Science, Volumes 1-10. Other sources included the literature cited sections of many theses, bulletins, and proceedings of symposia.

Entries have been categorized according to major subjects. Literature available for a particular category usually will be found by searching that category. Additional material may be found by searching other closely related categories.

The regional breakdown of some categories includes the following states (1) southeastern: Kentucky, Virginia, Tennessee, North Carolina, South Carolina, Florida, Georgia, Alabama, and Mississippi; (2) southwestern: Missouri, Arkansas, Louisiana, Kansas, Oklahoma, and Texas; (3) northern: those states to the north of Kansas, Missouri, Kentucky, and Virginia.

Numerous references on diseases and parasites are cited in the article by Kellogg and Doster, on pages 233-68 , in addition to the titles listed here.

The authors acknowledge Mr. Leroy Anderson for his assistance in searching for citations and Mrs. Gay Williams, Miss Jeanne Ray, and the secretaries of the Oklahoma State University Research Foundation for their assistance in typing the manuscript.

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