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POPULATIONS AND REPRODUCTIVE EFFORT AMONG BOBWHITES IN WESTERN TENNESSEE

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ABSTRACT

Relationships between pre-breeding (March) and post-breeding (December) populations, and certain characteristics of reproductive effort are described for a population of bobwhites (*Colinus virginianus*) in western Tennessee. Numbers of quail on the 2100-acre study area ranged from 681 to 1269 in March, and from 1007 to 1587 in December during the period December, 1966 to March, 1974. A total of 1571 nests were studied to determine such items as hatching rate of nests with eggs (23.0%) and clutch size (x=11.9 eggs). Of all variables examined, total number of nests found on the nesting area showed the strongest positive correlation with post-breeding population size (r=0.81) and summer gain (r=0.72). The predictive value of "total nests" for post-breeding populations was high (R^2=0.65). Environmental events which influence the physiological condition and numbers in the breeding population are believed to be most important in determining summer gains and post-breeding (December) population density.

INTRODUCTION

The nesting ecology of bobwhites has been investigated in several portions of the species' broad range. An early but extensive investigation by Stoddard (1932) presented a thorough description of several facets of bobwhite nesting ecology in the coastal plain of Georgia and Florida. Errington (1933) described the nesting of bobwhites in Wisconsin, near the northern extremity of its range in the mid-western region of North America. Since those early studies, other investigators in Illinois (Klimstra and Scott 1957), Texas (Parmalee 1955; Lehman 1946), Georgia (Simpson 1972) and Tennessee (Dimmick 1968, 1971) have expanded our knowledge of such aspects as regional preferences for nesting habitat, predominant causes of nest destruction, chronology of nesting and clutch size. Perhaps a major contribution which these studies have made to our understanding of quail population dynamics is the composite picture they present of a species having a high biotic potential, capable of producing large broods, and of withstanding heavy nest losses through its strong renesting potential and lengthy breeding season. It is, however, these same features which so confuse our efforts to relate nesting "success" or "failure" to annual productivity.

Most efforts to "predict" productivity (autumn populations) have centered on either various weather parameters which influence nesting success (notably Edwards 1972 and Stanford 1972), or bobwhite male whistling activity as independent variables (Rosene and Rosene 1972; Ellis, Thomas and Moore 1972). Several of these studies have suggested mechanisms and pathways through which these environmental and/or behavioral characteristics may function as predictors. It remained, however, for Roseberry and Klimstra (1972) to define such a mechanism through their careful analysis of bobwhite population fluctuations, nesting statistics, land use and weather patterns during an 18-year period in southern Illinois. The present study, conducted on a 2100-acre study area in Tennessee, provides additional information delineating significant relationships between reproductive efforts and autumn density of bobwhite populations.

This report is a contribution from the University of Tennessee McIntire-Stennis Project 3. I am grateful to Mr. James M. Bryan, Mr. James Warmbrod, and Mr. D. W. Smith, all of the Ames Plantation, for their help in several phases of this study. Dr. Boyd Dearden, the University of Tennessee - Knoxville, aided materially in the statistical interpretation of data. Numerous graduate and undergraduate students contributed to the field studies on quail nesting and population density.

METHODS AND MATERIALS

The study was conducted on Ames Plantation, an 18,600-acre Agricultural Experiment Farm in Hardeman and Fayette counties, Tennessee. The topography of the area is flat. Soils are mostly deep, fertile silt loams. Important crops include soybeans *(Glycine max)*, corn (*Zea mays*), and cotton (*Gossypium hirsutum*). Beef cattle and forestry are other important enterprises. Idle areas are predominantly covered with broomsedge (*Andropogon virginicus*), but frequent controlled burning has encouraged species diversity, including good to excellent production of wild legumes. A modest amount of hunting for quail occurred on the study area, with about 10 percent or less of the population shot each year. A more complete description of the study area was presented by Dimmick (1971).

The bobwhite population occupying a 2100-acre study area was censused twice annually, in March and December, by a team of 5 to 7 persons walking abreast at intervals of approximately 20 to 25 yards. These censuses were initiated in December, 1966 and are continuing to the present time. Nesting habitat comprised about 800 acres of the study area; each nesting season since 1967 about 200 acres of this habitat was searched for nests by 3 to 5 persons walking adjacent to each other parting the vegetation with staffs. Nests were revisited periodically to determine such items as clutch size, nest initiation date, success or failure of the nest, and hatching date.

Correlation and regression techniques were utilized for statistical interpretation of results.

RESULTS

Population number was determined twice annually, in December and March, except for 1966 and, of course, 1974. The nesting data were complete for 1967-73. Statistical analyses considering both sets of data were possible thus only for the period 1967-73, though other data were utilized for interpretation of results.

Population

The post-breeding population of bobwhites on the study area (determined by flush-census in December) reached greatest numbers of 1505 birds in 1968 (1 bird/1.4 acres) and 1587 birds in 1972 (1 bird/1.3 acres) (Figure 1). Lowest post-breeding populations followed these two peak years, resulting from declines of approximately 33 percent and 28 percent, respectively.

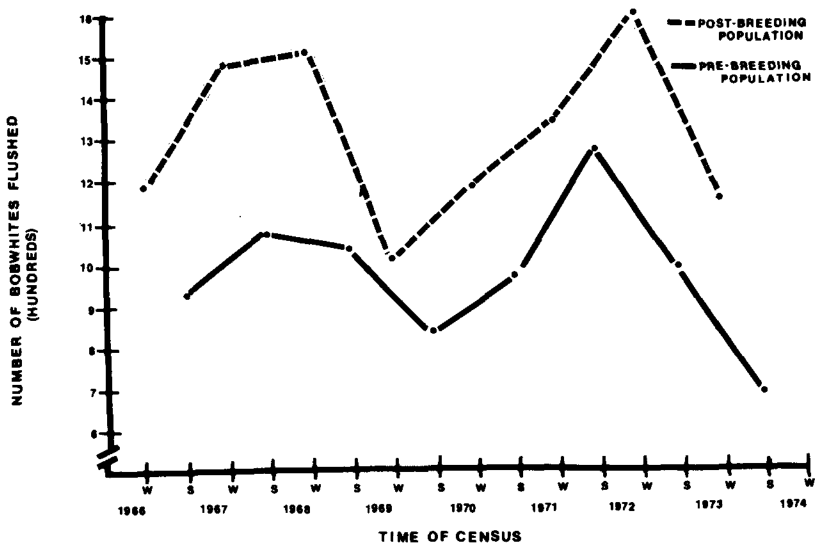

Figure 1. Pre-breeding (S) and post-breeding (W) populations of bobwhites on the study area, Ames Plantation, Tennessee, 1966-74.

Peaks in the pre-breeding and post-breeding populations occurred in the same years (Figure 1). However, lowest pre-breeding populations followed, rather than preceded, troughs in the post-breeding population. The correlation between pre-breeding and post-breeding populations was positive, but weak (r=0.50).

Post-breeding population size and summer gains (production) were positively correlated (r=0.61). In two years characterized by high post-breeding populations, summer gains were also high (approximately 40 to 60 percent above pre-breeding populations). However, the greatest post-breeding population (1972) accompanied a summer gain of only 25 percent (Table 1). The lowest post-breeding population, occurring in 1969, represented a decrease of 2.5 percent from the pre-breeding population, while other low post-breeding populations reflected summer increases of 16 to 41 percent.

"Over-winter losses" varied moderately between years (17.4 to 40.5 percent), with one exception (Table 1). The greatest pre-breeding population occurred following a winter of unusually low mortality (4.8 percent decline). The lowest followed a winter of high mortality (40.5 percent). This decline was particularly dramatic. It occurred during a year when the post-breeding population was at a low point, and reduced the pre-breeding population to the lowest level observed during the study. Positive and negative changes in the population primarily reflected changes in the number of coveys occurring on the study area rather than changes in the size of coveys. Mean covey size was relatively constant between years, ranging from 12.0 to 14.6 during December, showing weak correlation with population size (r=0.47). The number of coveys, however, ranged from 73 to 111 and was strongly correlated with population size (r=0.88). This same pattern prevailed for the March population.

Table 1. Population and reproductive characteristics for bobwhites on Ames Plantation, Tennessee, 1966-1974.

	Pre-nesting Population(March)				Post-nesting Population(December)			
Year	Coveys	Birds	Winter loss(%)	Covey size(x)	Coveys	Birds	Summer gain(%)	Covey size(x)
1966	-	-	-	-	90	1184	-	13.1
1967	76	925	-21.8	12.2	101	1478	+59.7	14.6
1968	81	1073	-27.4	13.2	108	1505	+40.2	13.9
1969	82	1033	-31.3	12.6	73	1007	-2.5	13.8
1970	66	832	-17.4	12.6	89	1179	+41.7	13.2
1971	77	964	-18.2	12.5	111	1334	+38.3	12.0
1972	95	1269	-4.8	13.0	111	1587	+25.1	14.3
1973	85	983	-38.0	11.8	93	1145	+16.4	12.3
1974	62	681	-40.5	11.0	-	-	-	-
All Years								

Nests			Hatching rate				Clutch Size	
			Nests w/eggs		Active Nests			
Total	Nests w/eggs	Active	%	No.	%	No.	x	No.
308	123	24	17.1	21	33.3	8	11.4	26
238	147	44	25.2	37	45.4	20	11.5	53
177	93	48	36.6	34	41.7	20	12.6	44
177	83	29	25.3	21	31.0	9	13.4	26
244	110	22	18.2	20	40.9	9	12.6	20
248	102	31	19.6	20	22.6	7	11.2	27
179	108	34	25.0	27	50.0	17	11.3	37
1571	766	232	23.0	180	39.0	90	11.9	233

The December population was negatively correlated with the proportionate loss suffered by the population during the previous winter (r=-0.63). Thus, "unfavorable" winters negatively affected populations the ensuing autumn. As this negative correlation is somewhat stronger than the positive correlation between pre-breeding and post-breeding populations, one may speculate that "condition" of the breeding birds may be more significant to production than numbers of breeders present, though both are important.

Reproduction

The parameters examined to measure the reproductive effort of bobwhites included the following items: (1) total number of nest constructed; (2) the number and fate of nests which contained eggs or egg fragments when first observed; (3) the number and fate of nests which were accumulating eggs or being incubated when first observed; (4) size of clutch for those nests believed to contain complete clutches.

Total nests constructed. During the 7 nesting seasons, a total of 1571 bobwhite nests were found on the study area (Table 1). The number varied per season from a low of

177 nests in the 1969 and 1970 seasons to a high of 308 in 1967. Slightly more than 50 percent of these nests gave no evidence of having ever contained eggs; the ultimate fate of these nests thus was undetermined. The proportion of nests lacking evidence of eggs varied between years from 39.2 percent to 61.1 percent, but appeared to be unrelated to other variables such as hatching success or post-breeding populations. Of particular significance, however, was the strong positive correlation (r=0.81) between the total number of nests constructed and the post-breeding population. Of all variables tested, total number of nests provided the strongest correlation with December bobwhite density on the study area.

Nests with eggs or egg fragments. A total of 766 nests observed during the study period contained evidence of use by quail in the form of whole or partial eggs in the nest structure. The number ranged from 83 to 147 per breeding season, and was positively correlated (r=0.60) with autumn bobwhite density. These nests were examined to determine hatching success or failure, for the appearance of egg shells remaining in the structure after the nest became inactive offered some clues to its ultimate fate. The proportion of nests in this sub-set of the total sample of nests which were believed to have hatched ranged from 17.1 to 36.6 percent; over the study period, 23 percent of the 766 nests were estimated to have hatched. Careful examination of these data revealed a major weakness in using "percent successful nests" in this sub-set as an estimate of productivity of the nesting population. Correlations between this variable and the number of quail in the post-breeding population, the number of coveys in the post-breeding population, and the percent increase over the spring breeding population were all strongly negative.

It is probable that the failure of "percent successful nests" to correlate positively with those population characteristics partially reflects the difficulty of correctly assessing the true fate of nests which were found after they became inactive. Nests were often visited by secondary destructive agents such as cotton rats (*Sigmodon hispidus*), ants (*Formicidae*), and other animals which altered the appearance of the egg shells sufficiently to prevent accurate determination of the outcome of the nesting effort. Evidence left at the nest site was highly variable in quantity and quality, and apparently, decisions of the observers were occasionally incorrect with respect to whether the nest was destroyed, abandoned, or hatched. It is also possible that differential survival of chicks between years was a more important variable then "nest success" in influencing production; this variable was not measured. But of greatest significance, I believe, is the fact that "hatching rate" alone gives no estimate of the extent of renesting, and thus does not reflect the success rate of hens in producing broods.

Nests active when first observed. Those nests which were accumulating eggs or were being incubated when found offered the best opportunity to interpret individual nest histories. The number of active nests found each year ranged from 22 to 48, totaling 232 for the study period (Table 1). Of this sample of nests, 38.8 percent were known to have hatched at least one chick. This proportion of "successful nests" was markedly higher than the estimate of "successful nests" based on all nests containing eggs or egg fragments (23.0 percent). Despite the increased accuracy for determining the fates of this sub-set of nests, data derived from it were no more helpful in relating "nest success" to productivity or autumn population. The correlations between "success" and post-breeding populations was weakly negative (r=-0.47). Inspection of the data revealed that while the second highest "nest success" was followed by the second highest autumn population, the third highest "success" preceded the lowest autumn population. The highest autumn population followed a breeding season when the success of active nests was lowest for the 7-year study period.

Clutch size. Mean clutch size for 233 completed clutches was 11.9 eggs, varying from 11.2 to 13.4 over the 7 nesting seasons (Table 1). Mean clutch size was negatively correlated with pre-breeding population size (r=-0.61), suggesting a possible inverse relationship between density and this aspect of production. The relationship between clutch size and post-breeding populations was similarly negative (r=-0.59), however, indicating that variations in clutch size alone would not be likely to serve as a densitydependent regulator of post-breeding population size for bobwhites on my study area.

Predicting Winter Population.

Several statistics were examined to determine their usefulness for predicting post-breeding population levels on the study area. One variable, the total number of nests found on the nesting study area during summer, showed strong positive correlation with post-breeding populations (r=0.81). Its correlation with "summer gains" was also positive (r=0.72). The variable "total nests found" thus was assumed to be the best indicator of reproductive effort of the several statistics examined. The square of the multiple correlation coefficient (R^2) between reproductive effort and post-breeding populations was 0.65. Thus, 65 percent of the variation in post-breeding populations was explained on the basis of variations in the total number of nests constructed on the study area (Figure 2). Considering the multiplicity of events and factors that have some potential for influencing reproduction and productivity of a population, this degree of relationship for a single factor is remarkable indeed.

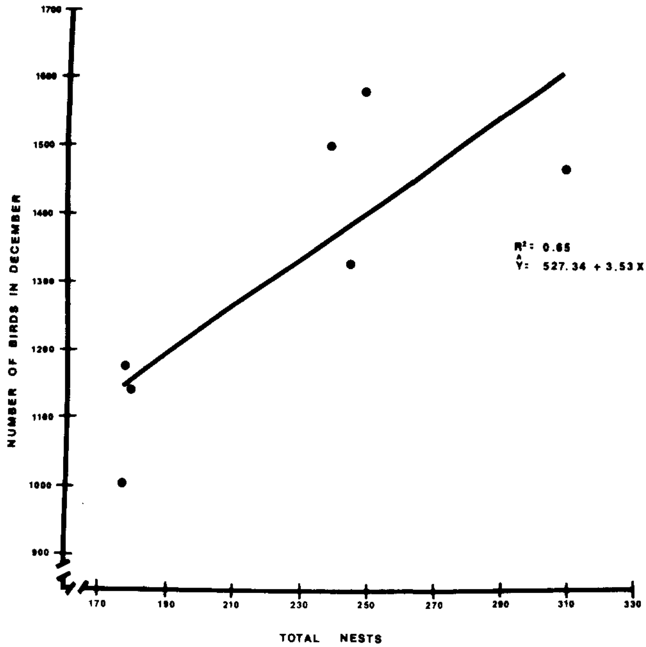

Figure 2. Relationship of total number of nests on the nesting area to number of birds in the population in December on Ames Plantation, Tennessee, 1967-73.

DISCUSSION AND CONCLUSIONS

The moderate year-to-year fluctuations in both winter and spring populations probably reflect the relatively stable, diversified, high-quality habitat comprising the study area, and the moderate climatic conditions which prevailed during the period of study. The rather complex ecosystem occupied by bobwhites in western Tennessee provides many checks and balances against single-factor catastrophic occurrences such as might occur in more rigorous environments at arid or frigid extremities of its range. While annual variations occurred in such weather factors as spring rains, summer dry spells, winter snows and cold periods, the extremes encountered during the period 1966 to 1974 did not appear sufficient to produce dramatic changes in populations. Irruptions in populations such as reported by Jackson (1962) in Texas, and severe prolonged declines as apparently occurred in Wisconsin (Kabat and Thompson 1963) are unlikely to occur near the ecological center of the bobwhite's range.

The most marked decline due to over-winter losses occurred between December, 1973 and March, 1974, a winter generally characterized as one of the mildest on record in western Tennessee. One extensive ice storm occurred in January, but was accompanied by temperatures which stabilized just below freezing for a period of about three days. Field observations indicated that no sharp decline in bobwhite numbers immediately accompanied that storm, though it may have contributed to losses which occurred later. A more significant factor appeared to be the prevailing mild, summy weather which caused mid-winter sprouting and eventual deterioration of the waste soybeans which Eubanks (1972) demonstrated to be the prime winter food source for bobwhites on Ames Plantation. And though the impact of this apparent loss of their prime food source was detected through our flush census in March, the losses were subtle rather than dramatic. No instances of "Masses of huddled, starving quail and uncoordinated coveys...", as reported by Stanford (1972) during "Snow-Cold" winters in Missouri, were encountered on Ames Plantation. Instead, quail changed their feeding areas, moving from soybean field edges deeper into woods where their attention seemed to be attracted by seeds of sweet gum (*Liquidambar styraciflua*). The reduction in abundance of soybeans also was reflected in significantly greater reductions in body fat reserves of quail collected on the study area during March, 1974 than of those shot in 1973 (Dabney 1974). Robel (1972) described the importance of adequate fat reserves for providing "starvation protection" to quail and influencing their survival during late winter. The reduced fat reserves of quail on Ames Plantation likely resulted from the loss of their staple food, and caused the sharp decline in numbers.

Variations between years in "summer gains" were striking, and quite difficult to understand. Particularly intriguing was the situation during 1969 when a nesting population of intermediate density combined with an apparent high nesting success ratio to produce a December population which was lower (-2.5 percent) than the March population. However, the decline from winter, 1968 to spring, 1969 was greater than average, and the total number of nests found on the study area in 1969 was lowest of the study period (with 1970), both factors suggesting that nesting effort per bird may have been minimal due to poor condition of breeding birds.

The difficulty in relating "nest success" to summer gains lies largely in the inability to determine the extent of renesting which is accomplished by the nesting population. The proportion of nests which hatch is not necessarily related to the number of hens which successfully produce a brood of young, and is not a good indicator of the population's reproductive success for any given season.

Of the several nesting parameters examined, the total number of nests found provided the strongest correlation with summer gains (r=0.72) and December population size (r=0.81). It appears likely that this variable better than any other reflects renesting effort.

Particularly pertinent is the observation by Roseberry and Klimstra (1972) that "...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." These authors also noted that total and relative productivity were not influenced by annual differences in mean clutch size or hatchability rates of eggs. Thus it would appear that events occurring during the breeding season which affect nest success directly are much less influential in determining productivity for that year than are events which occur prior to the breeding season and act upon the density and physical condition of the breeding population. Roseberry and Klimstra (1972) found breeding density, snow cover during the previous two winters, and spring rainfall all to account individually for significant variation in summer production. Stanford (1972) also observed the negative effects of severe winter weather upon quail production in Missouri.

No instances occurred during the nesting seasons of 1967 to 1973 which implicated summer weather as a dominant influence on production of quail as has been reported elsewhere (Stanford 1972). Temperatures in summer are typically hot in west Tennessee, and each year several consecutive days of +100°F may be expected. Summer droughts severe enough to reduce growth and production of crops also occur sporadically. During the study period, however, no combination of heat and drought appeared severe enough to produce the effects of "...hens dying on their nest", or chicks baking in the shells as Stanford (1972) reported for Missouri. These events may well occur, and in portions of the bobwhite's range, may be a common and significant factor in the species' life history. They did not occur on Ames Plantation during the period of study.

In general, environmental events which reduce the quality of winter habitat (primarily food), or stress the birds directly, may reduce the total nesting effort by decreasing the extent of renesting. Roseberry and Klimstra (1972) noted that renesting by bobwhites in southern Illinois was reduced during breeding seasons preceded by unusually heavy winter snowfall. Presumably, the quail entered the breeding period with lowered vigor associated with inadequate or unavailable winter food. In the more favorable climatic regime occurring in western Tennessee, environmental variables may act more subtly upon the quantity and quality of the bobwhite's winter food. Winter snow, for example, while not uncommon, rarely remains long enough to be seriously detrimental. It appears reasonable to assume, nevertheless, that it is the availability of winter food which determines the physiological condition of the birds entering the breeding season, and which ultimately determines the extent of renesting and hence, the population's productivity.

The implication for management seems clear. Producing adequate winter foods for bobwhites is highest priority. A healthy, vigorous population of breeders is capable of persistent renesting, so that even in the face of heavy nest predation, most hens will produce broods of chicks. Management efforts directed toward reduction of nest predation likely will be unrewarding in terms of enhanced production of bobwhites.

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MOVEMENT OF WILD TURKEY HENS IN RELATION TO THEIR NESTS[1]

by
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ABSTRACT

Wild turkeys (**Meleagris gallopavo osceola**) on a study area in Florida nested 1.4 miles from winter release sites and 1.2 miles from their late winter range. Net distance and direction of movement of 12 hens from winter range to nesting sites was only about 0.2 miles west. The hens usually roosted within one mile of their nests during the laying period (mean distance 0.8). Renesting was within one mile (mean 0.8) of the first nest. Two hens radio-tracked during the laying period used 100 to 200 acres daily and usually roosted less than one mile from their nests. Laying was in late morning through early afternoon. Hens tended to visit their nests for about one hour during the first half of the laying period, but remained progressively longer with each egg laid after the sixth or seventh. During the period of incubating behavior, hens left their nests about every two days (mean 1.86) for about two hours (mean 1.95) but were extremely variable in this. They were six times more frequently absent from their nests in mid-morning or late afternoon than at noon. One hen continued incubating behavior on a clutch of infertile eggs for 64 days. Some management implications are discussed.

[1]This is a contribution of the Federal Aid to Wildlife Restoration Program, Florida Pittman-Robertson Project W-41.