QUAIL REPRODUCTION AND WEATHER IN ALABAMA

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The annual reproduction of Alabama bobwhite quail, *Colinus virginianus* (Linnaeus), as measured by the percentage of juvenile quail in the bag, was studied by the authors for 8 consecutive years starting with the 1952-53 hunting season. A total of 57,080 quail wings was contributed by hunters for this study. Procedures have been described previously (Haugen and Speake, 1958). Ratios of juvenile to adult birds were determined from the wing samples for the state as a whole, and seven soils regions considered separately. Hatching dates were estimated for birds less than 150 days old collected almost entirely before December first. Sample size necessary for reliable estimates of percentage juvenile was determined to be about 800 wings from a region.

Differences in adult-juvenile ratios from year to year usually varied in the same direction when different regions were compared, but some regions had a consistently higher percentage of juveniles than others. Year to year differences, however, seemed to be related to some over-all factor in the environment affecting the success of quail reproduction for the entire state. The most probable such factor is weather during the reproductive season. There is much literature on this subject resulting from studies conducted before and concurrently with this study—in the Southeast and elsewhere.

In addition to state-wide and regional age ratios, our data consists of weather records, population measurements and hunting success measurements from a study area, observations on spring dispersal, local brood counts and a summer cock call index route. Comparisons have been made between many types of weather conditions and reproductive success in an attempt to (1) determine the type or types of reproductive season weather favorable or unfavorable to quail reproduction and (2) find means of predicting reproductive success.

Weather may affect the hatchability of quail eggs or cause nest desertion (Errington, 1935), (Lehmann, 1946), (Kimstra, 1957), or it may affect survival of young or possibly all of these. Drought may indirectly affect the survival of quail by causing severe reduction in food supplies (Haugen, 1955).

Observations made during the past 10 years in central Alabama lead to the conclusion that most coveys undergo spring dispersal by the last week in April, but usually not sooner. Significant numbers of quail nests are present in the field from May through August as shown by study of estimated hatching dates of quail chicks from the wing study representing the 1952 through the 1959 reproductive seasons. Percentages of chicks hatching during periods of the nesting seasons are as follows: Before July 1—48.2, July—23.0, August—19.1, September—8.7, October—0.4.

Most Alabama quail begin first nesting attempts in late April and early May; therefore, most first attempts at nesting are in progress during May. In fact, there are probably more nests in the field during May than in any other month. There are large numbers of nests in the field during June, July and August, and many of these, especially in July and August, are thought to be attempts at renesting. Stoddard (1931, p. 224-225) found that normal mortality in first nesting attempts may be 60 to 80 percent. In southern Illinois, Klimstra (1957) found that hatching success was 39.4 percent for 352 nests examined during a six-year period.

RELATIONSHIP OF STATE-WIDE REPRODUCTIVE SUCCESS TO WEATHER

Weather records from the U. S. Weather Bureau, "Climatological Data Alabama," were examined for the State of Alabama for 8 years (1952-59).

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Climographs were constructed, and weather was compared with reproduction of quail over the entire State. A statistically significant, direct correlation was found between rainfall May through August and percentage of young in the bag ([Table VI, Appendix], Fig. 1). There was a less significant inverse relationship between total temperature deviations May through August and percentage of young in the bag ([Table VI, Appendix], Fig. 1). This data strongly suggests that good quail reproduction is favored by normal or higher than normal rainfall, coupled with lower than normal temperature. The two years with best reproductive success (1955 and 1958) had the highest rainfall combined with the lowest temperatures, and the three years with poorest success (1952, 1953 and 1954) had lower than normal rainfall and higher than normal temperatures.

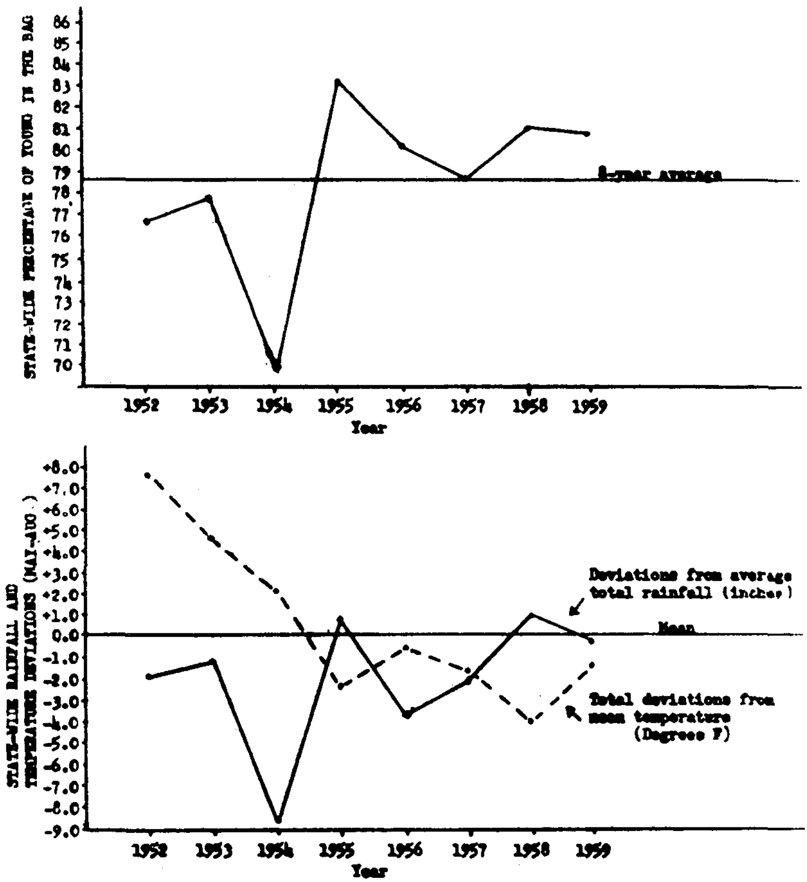

Fig. 1. Percentage of young quail in the bag from Alabama wing samples compared to rainfall and temperature during the reproductive season

Unless otherwise specified in this paper, average total rainfall and average temperature values are deviations from long-term means, either state-wide, regional or local for the period May through August.

RELATIONSHIP OF REGIONAL REPRODUCTIVE SUCCESS TO NESTING AND REARING SEASON WEATHER

Enough wings were received during seven hunting seasons (1953-54 through 1959-60), so that wings from some regions within the State could be analyzed separately. Over the period as a whole, consistent differences in reproductive success between regions were apparent (Table I). These differences were not related to any factor that we have determined, but it is possible that soil fertility may be important.

TABLE I

PERCENT JUVENILE QUAIL IN THE BAG DURING A SEVEN-YEAR PERIOD (1953-54 TO 1959-60) FROM SEVEN SOILS REGIONS OF ALABAMA (55,527 QUAIL WINGS IN THE SAMPLE)

Region	*% Juv. 7-Yr. Period*	*Highest Year*	*% Juv.*	*Lowest Year*	*% Juv.*
Appalachian	81.9	1959	(86.5)	1954	(74.9)
Tennessee Valley	81.0	1959	(86.8)	1957	(75.7)
Black Belt	77.7	1955	(84.9)	1954	(67.7)
Upper Coastal Plain	78.1	1955	(83.4)	1954	(67.5)
Piedmont	77.6	1959	(81.5)	1954	(64.9)
Lower Coastal Plain	77.5	1955	(83.5)	1954	(69.7)
Clay Hills	75.1	1955	(82.4)	1954	(64.4)

Year-to-year trends in reproductive success within regions varied with rainfall and temperature conditions. In some cases, reproduction between regions appeared to vary as weather differences between the regions varied.

The very best seasons of reproduction for all regions were wet-cool seasons or seasons with approximately normal weather. The poorest seasons were very dry or hot-dry seasons (Table II).

TABLE II

RELATIONSHIP OF QUAIL REPRODUCTION TO MAY THROUGH AUGUST WEATHER FOR SEVERAL ALABAMA SOIL REGIONS

		Regional Average		
Region	*Year*	*Total Rainfall Deviations from Normal*	*Total Temp. Deviations from Normal*	*Devia. from Regional Avg. % Juveniles*
Appalachian	1959	−0.38	+0.6	+4.6
Appalachian	1957	−2.12	−1.0	+1.7
Appalachian	1958	+0.62	−2.4	+1.6
Appalachian	1956	−0.82	0.0	+0.9
Appalachian	1955	−0.65	−2.5	+0.6
Appalachian	1954	−5.69	+1.4	−7.0
Tenn. Valley	1959	+1.78	−4.0	+5.8
Tenn. Valley	1955	−0.44	−3.4	+3.5
Tenn. Valley	1956	−1.05	0.0	+2.3
Tenn. Valley	1958	+3.73	−6.6	+0.4
Tenn. Valley	1954	−6.27	+2.2	−4.6
Tenn. Valley	1957	−2.26	−3.1	−5.3
Piedmont	1959	−2.17	−4.5	+3.9
Piedmont	1954	−5.31	−2.3	−12.7
Upper Coastal	1955	+1.56	−9.0	+5.3
Upper Coastal	1958	+1.73	−6.1	+3.4
Upper Coastal	1956	−5.82	−4.7	+2.0
Upper Coastal	1959	−1.48	−3.0	+1.2
Upper Coastal	1957	−2.67	−4.1	−1.7
Upper Coastal	1954	−9.07	−2.5	−10.6

TABLE II—*Continued*

RELATIONSHIP OF QUAIL REPRODUCTION TO MAY THROUGH AUGUST WEATHER FOR SEVERAL ALABAMA SOIL REGIONS

Region	*Year*	*Regional Average Total Rainfall Deviations from Normal*	*Regional Average Total Temp. Deviations from Normal*	*Devia. from Regional Avg. % Juveniles*
Black Belt	1955	+0.32	−2.9	+7.2
Black Belt	1953	−1.89	+4.4	+3.3
Black Belt	1958	+1.13	−4.0	+1.4
Black Belt	1959	−0.68	−0.3	+0.1
Black Belt	1957	−1.47	−1.0	−0.3
Black Belt	1956	−4.10	+0.8	−1.5
Black Belt	1954	−9.56	+4.3	−10.0
Clay Hills	1955	+2.72	−1.4	+7.3
Clay Hills	1958	−0.41	−2.3	+2.9
Clay Hills	1956	−4.99	+0.9	+2.6
Clay Hills	1957	−2.85	−1.6	−0.6
Clay Hills	1959	−2.60	−1.4	−0.9
Clay Hills	1954	−9.83	+4.3	−10.7
Lower Coastal	1955	+2.49	−3.2	+6.0
Lower Coastal	1958	−0.49	−3.1	+4.0
Lower Coastal	1956	−0.79	−1.3	+2.2
Lower Coastal	1957	+4.61	−0.2	+2.0
Lower Coastal	1959	+2.55	−0.5	−0.2
Lower Coastal	1953	−5.07	+2.1	−5.9
Lower Coastal	1954	−9.54	+0.1	−7.8

In this table only regions and years where wing samples were adequate to determine whether or not productivity was above, below or approximately normal for the region were used. That is the reason some years and some regions are not well represented.

Evidence in favor of the theory that weather during the nesting season affects quail reproduction is seen when some comparisons are made between regions in the same year. Year by year comparisons follow.

In 1953 only two regions produced samples that were considered large enough to use, these were the Black Belt and the Lower Coastal Plain. The Black Belt had higher than average quail reproduction that year with a regional average total rainfall for May through August of 1.89 inches below normal and was hot with regional deviations from average temperature for the same period totaling 4.4 degrees above normal. The Lower Coastal Plain, by contrast, was very dry (−5.07 total rainfall deviation) and hot with +2.1 temperature deviation from regional normal. This region had very poor quail reproduction.

In 1954 all seven regions had extremely dry, and most had unusually hot reproductive seasons. All regions had very poor quail reproductive success; however, the two regions that suffered the least (Tennessee Valley and Appalachian) had only about one-half the rainfall deficiency when compared with South Alabama.

All regions except the Piedmont were represented by adequate wing samples in 1955. They all had normal or more than normal rainfall and normal or less than normal temperatures. All regions had above average quail reproductive success.

Again in 1956, an adequate sample of wings was received from all regions except the Piedmont. There was some climatic variation between regions that year, with most regions having dry-cool weather or dry weather with practically normal temperatures. In one region, it was quite dry (Upper Coastal, 5.82 inches below normal), but at the same time quite cool (4.7 degrees below normal). All regions had better than average reproduction, except the Black Belt, which was slightly below normal.

In 1957 adequate wing samples were received from all regions except the Piedmont. There was little variation in average rainfall and temperature deviations for five of the six regions. All regions except the Lower Coastal Plain had rainfall deficits of about 2-3 inches and were all cooler than normal. Quail reproductive success varied from seriously below normal for the Tennessee Valley to significantly higher than normal in the Lower Coastal Plain, the only region having higher than normal rainfall.

Six regions could be compared in 1958. Only the Piedmont had too small a sample to be considered. The six regions had above normal or almost normal rainfall and in all cases the temperatures were much below normal. All six regions had above normal quail reproduction for the first time since 1955, a year wih very similar weather pattern.

All seven soils regions produced enough wings in 1959 to be considered. Rainfall varied from around two and one-half inches below normal to about two and one-half inches above normal. Temperatures were distinctly cooler than normal to normal. Quail reproduction varied from about normal to very good. The best reproductive success was measured from Tennessee Valley wings, and this region was the only one having distinctly wetter *and* cooler weather conditions. In 1959 no region was significantly below normal in reproductive success.

The three years (1954, 1955, 1958), in which all regions had very similar weather patterns, were also the three seasons when quail reproduction was the most similar between regions. If weather affected quail reproduction, this is what one would expect. During these three years of similar weather patterns, the regional samples came closest to being samples drawn from the same population in regard to effects of weather. It is probable also that the years with the most variable weather among regions had the most variable weather within regions, then effects of the weather in one locality might be obscured in the wing samples by effects in another area. This data would be expected to be less reliable than where weather patterns were more uniform.

Regional data indicate that good productivity can occur when rainfall is 2 to 3 inches below normal for the important summer months provided temperature is cool to normal, but excellent quail productivity is most likely to occur when rainfall is above normal and temperatures are below normal.

RELATIONSHIP OF FALL QUAIL POPULATION TO WEATHER DURING NESTING AND REARING SEASON

Quail populations were measured in the fall and late spring at the 1,409-acre Piedmont Agricultural Substation, Camp Hill, Alabama. Censuses were conducted by Wildlife Unit personnel using Unit bird dogs for a ten-year period (1950-1959). This census was part of a long-term study designed to measure the effects of habitat changes and improvements on the quail population, but it seems that reproductive season weather may be more important in any one year than ordinary habitat changes.

Fall quail populations on this area that were above average followed weather during May through August that was wetter and cooler than average. Drier than normal reproductive seasons were followed by fall quail populations that were significantly below average, with one exception—1953 (Fig. 2). There was a statistically significant, direct relationship between total rainfall May through August and fall quail population (Table VI, Appendix). Weather data used in this study came from data collected on or very near the area during a 59-year period. There is evidence indicating that 1953 may not have been a year of such low fall population as was measured by the census. Out of the entire 10-year census period, 1953 was the only season that had a large increase (18.6 percent) from fall to the following spring (Table III). This suggests that there were quail on the study area which were not found during the fall census, or that there was an abundance of birds on adjacent lands and some of them moved onto the study area during the winter.

Fall population size seemed dependent on successful summer reproduction and did not seem related to the previous spring population. The year with the second highest fall population (1955) was preceded by the lowest breeding population measured. There was a *decrease* of 10 quail in the fall following the highest spring population (1956). Habitat changes on the area in some years were insignificant, while in some other years the changes would have been expected to cause effects on the fall populations opposite to what actually occurred (Speake, unpublished).

Table III

Quail Population at the Piedmont Agricultural Substation of Auburn University (1950 to 1959)

Year	*Spring Population*	*Fall Population*	*% Change Spring to Fall*	*% Change by Following Spring*	*Gunhours Per Bird Bagged in Hunt. Season*
1959	90	162	+80	−23.5	2.1
1955	61	160	+162	−25.6	3.4
1950	83	131	+58	−35.1	. .
1957	71	126	+77	−40.5	2.5
1952	71	117	+65	−32.5	. .
1958	75	117	+56	−23.1	8.0*
1956	119	109	− 8	−34.9	4.1
1954	102	103	+ 1	−40.8	7.9
1953	79	86	+ 9	+18.6	3.4
1951	85	74	−13	+ 4.1	. .

* During the late summer, quail food patches were deliberately destroyed. At the same time, a good pine and oak mast crop was produced. These two factors made quail harder to find.

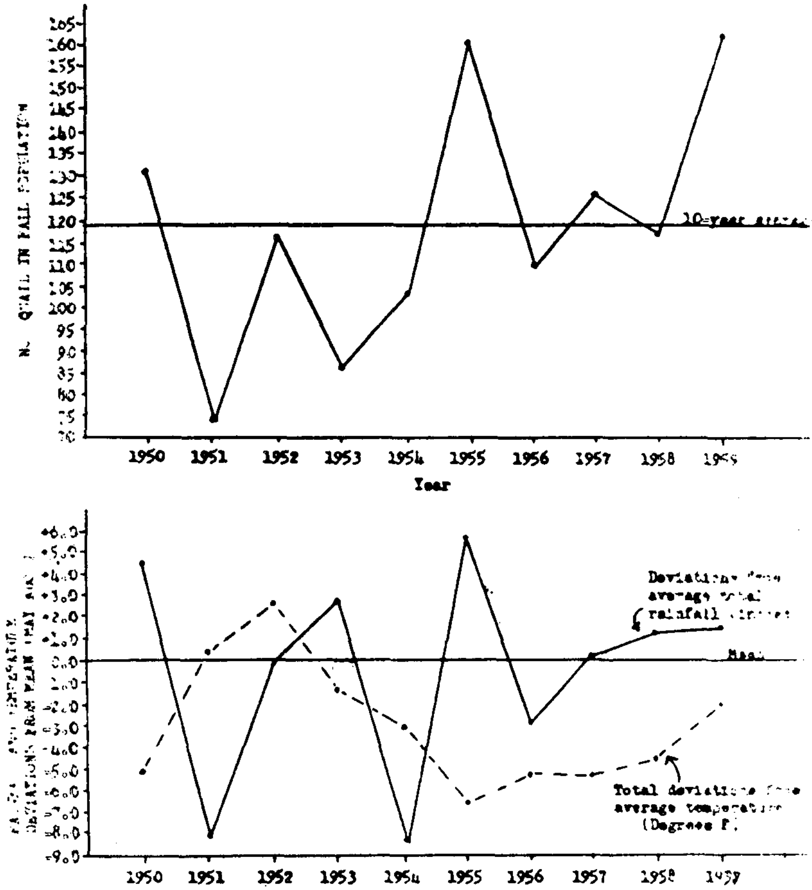

Fig. 2 Comparison of fall quail population at Piedmont Substation, Ca[illegible] Alabama, with Substation weather during the reproductive seas[illegible]

RELATIONSHIP OF CHRONOLOGY OF HATCH TO WEATHER AND REPRODUCTIVE SUCCESS

During the entire eight-year period, 52.8 percent of the aged juveniles hatched after July 1. Extreme years were: 1954, 41.0 percent and 1955, 67.5 percent hatching after July 1.

It was reasoned that reproductive seasons with almost uniform weather, either favorable or unfavorable, would not yield data where chronology of hatch could be compared to weather. However, if wet or normally wet and cool weather was favorable and dry and especially dry and hot weather was unfavorable, then where the following kinds of reproductive seasons occur, the corresponding types of distribution of hatch would also occur. Seasons with wet or normal May and dry June, July and August should have smaller proportions of late-hatched quail (hatched after July 1) than seasons with dry May and wet or normal June, July and August. This is exactly what happened, with only one exception out of eleven cases (Table IV). The exception was the Appalachian region in 1955, and 1955 was an exceptional year indeed. Productivity was so high state-wide, that it is unexplainable, except on the theory that after the disastrous year of 1954, a low breeding population "exploded" in an environment suddenly improved after several years of drought—1954 being the worst year of the drought. Errington (1945) found that, "summer gains tended to be in inverse ratio to spring densities," during a 15-year quail population study in southern Wisconsin.

TABLE IV

COMPARISON OF TWO TYPES OF WEATHER PATTERN AND CORRESPONDING DISTRIBUTION OF HATCH

Type of Weather and Region	*Year*	*Rainfall and (Temperature) Deviations from Normal* May	*Rainfall and (Temperature) Deviations from Normal* June-August	*% Hatch Occur. after July 1. Departure from 8-Yr. State Avg. (52.8)*
Early Wet or Normal and Late Dry Seasons				
Tennessee Valley	1957	−0.26(+0.3)	−2.00(−4.6)	−14.0
Statewide	1952	+1.49(+0.5)	−3.43(+7.1)	−10.5
Appalachian	1957	+1.33(+0.6)	−3.45(−1.6)	− 9.8
Statewide	1957	+1.16(+0.3)	−3.33(−1.7)	− 7.6
Appalachian	1959	+3.34(+1.8)	−3.72(−0.2)	− 6.5
Statewide	1959	+2.47(+1.2)	−2.70(−2.6)	− 2.9
Appalachian	1955	+2.17(+1.9)	−2.82(−4.4)	+11.2
Early Dry and Late Wet or Normal Seasons				
Tennessee Valley	1956	−1.22(+1.9)	+0.17(−0.9)	+ 2.2
Appalachian	1958	−1.40(−0.3)	+2.02(−2.1)	+ 2.4
Lower Coastal	1958	−1.79(−0.5)	+1.30(−2.6)	+ 6.4
Lower Coastal	1956	−1.29(+1.9)	+0.50(−3.2)	+ 8.2

* Adequate wing samples for estimating percent hatch occurring after July 1 were hard to obtain since only juveniles shot during the first and sometimes the second week of the hunting season could be used. No samples were considered with less than about 300 wings for a region, except in the case of 1952, where the statewide total was 208 wings. The 1952 data in this table and Fig. 3 may not be significant.

Correlation coefficients were calculated (Table VI, Appendix) between June through August rainfall deviations in seasons that were hypothesized to be favorable early and unfavorable late, seasons that were hypothesized to be unfavorable early and favorable late and state-wide deviations from average percentage of juveniles hatching after July 1. Correlation coefficients between May rainfall deviations in the same seasons and deviations from average percentage juvenile hatching after July 1 were also figured. There was a direct relation between June through August rainfall and percentage late hatch ($r = .538$) but at a low level of significance (28 percent). There was an inverse relation between May rainfall and percent late hatch ($r = -.310$) but also at a low level of significance (46 percent). It should be noted that the only exception to these relationships was a very large one for the Appalachian region in 1955 (the unusual year described above). If this season had not been used, the correlations would have been much more significant.

Usually in Alabama the more numerically important the late-hatched segment of juveniles—the higher the proportion of juveniles in the hunter's bag, on a state-wide basis (Fig. 3). The correlation between state-wide percentage juvenile quail in the bag and percentage juveniles hatching after July 1 was found to be statistically significant (Table VI, Appendix). The question of whether juvenile quail are more vulnerable to the gun than adults arises here. If this was the case, it would always be expected that in seasons with unusually late hatches, the percentage of juveniles would be higher than normal, whether the population was higher or not. There may indeed be a slight bias in such cases during the extremely early part of the hunting season in very unusual years such as 1955, but it is not believed to be significant. Haugen and Speake (1957) found that in most years (1952-56), seventy-five percent of juvenile Alabama quail were practically indistinguishable from adults in weight and appearance by the first week in November. In 1955 seventy-five percent were practically indistinguishable by November 23, the day before the hunting season. Also in 1955, the percentage juveniles in the bag during weeks of the hunting season fluctuated widely when compared on a week-to-week basis, but when compared on an accumulative basis, there was almost no fluctuation after a sample size of 500 wings was attained. Bennitt (1951), in a 7-year Missouri study, found that percentage young in the bag drops very little from week to week during the hunting season. Reid and Goodrum (1960), in an 8-year study made in southwestern Louisiana, found that percentage young in the bag did not vary significantly from early to late in the hunting season. It is concluded that the actual adult-juvenile ratio in the quail population is practically the same as found in the wing samples.

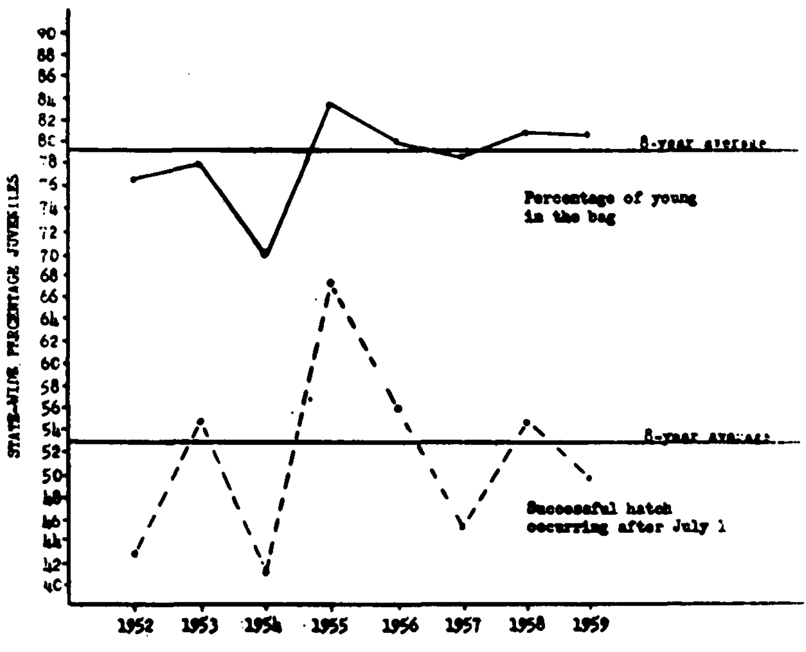

Fig. 3. Percentage of young quail in the bag from Alabama wing samples compared to percentage of successful hatch occurring after July 1.

ESTIMATION OF NESTING ACTIVITY BY USE OF A SUMMER COCK CALL ROUTE

A summer call index route was conducted for 7 years similar to that used in Missouri by Bennitt (1951). This central Alabama route was run approximately weekly from April or May through August and, in some years, through September. Twenty-two stations at 1-mile intervals were used. Listening was begun at station number one 15 minutes before official sunrise and continued for three or no more than five minutes. The number of cocks heard calling at each station was recorded. The total number of cocks calling per station was that day's call index.

The quail call index route was thought to be a possible index to nesting activity, as well as an index to breeding population. If the call index approximately measures nesting activity, there should be at least three ways to check the truth of the matter—at least in years when first nesting attempts are fairly successful: (1) A rough check can be had by establishing covey break-up time and pairing time in the spring, then estimating the approximate time that most early nests should hatch. (2) An excellent check can be made by aging a sample of summer quail broods from the region where the call count is being made. (3) A sample of quail wings collected the following fall will give still another check.

Examination of Table V will reveal some agreement between the summer call index for Lee County, Alabama, and other methods of estimating the distribution of the hatch. For the years 1954, 1957 and 1959, the summer's peak of the Lee County call index route has occurred within 10 days of the estimated peak of the hatch obtained from aging summer broods (Table V). This is a close agreement since the call route was run at only weekly intervals; however, the amount of data was small since only one route was run, and the number of broods observed was rather small. In 1955, 1956 and 1958, just a few broods were aged.

TABLE V

DISTRIBUTION OF THE ALABAMA BOBWHITE HATCH AS ESTIMATED BY SEVERAL MEANS

	Lee and Tallapoosa County Observations					*Statewide*
Year	*Summer Peak of Call Index Curve*	*Estimated Peak of Early Hatch from Covey Break-Up and Pairing Observations*	*Peak of Hatch from Estimated Hatching Dates of Summer Broods*	*Estimated % Hatch Occurring after July 1 from Brood Observations*	*Avg. Call Index for August*	*% Hatch Occurring after July 1 (Wing Study)*
1954	June 8	May 30–June 15	June 1 (17 broods)	6.2	0.56	41.0
1955	July 5	May 29–June 15	....	. .	1.50	67.5
1956	June 5	May 30–June 15	....	. .	1.18	56.0
1957	June 16	May 26–June 11	June 11 (33 broods)	42.4	0.75	45.2
1958	June 12	July 5–Aug. 2	....	. .	0 87	54.4
1959	June 24	May 30–June 15	June 22 (23 broods) July 10	60.8	1.09	49.9

Spring dispersal and pairing observations in Lee and Tallapoosa Counties indicate that the peak of the early hatch should have occurred within a two-week period which included the estimate obtained from summer broods, except in 1959, and which also was within five days of the summer call count peak for 1954, 1956, and 1957.

In 1955 covey break-up and pairing occurred at about the same period as in 1954, 1956, 1957 and 1959, but since brood observations, peak call index, and later on the state-wide quail wing study, all indicated a hatching peak one month later than normal, indications are that many early nests were unsuccessful.

If the call index is a true measure of nesting activity, the relative amount of late nesting from year to year should be indicated by the call count (Table V). From 1954 through 1958, the average Lee County call index for August increased or decreased in the same direction as the state-wide hatch occurring after July 1. Brood observations in significant numbers were available for only 3 years (1954, 1957, and 1959). During the same years, estimated percent of hatch occurring after July 1 from wings greatly increased also (Table V). A correlation coefficient (Table VI, Appendix) was calculated between average Lee County call index for August and state-wide percentage hatch occurring after July 1 (1954-59), and the correlation was statistically significant. It appears that bobwhite whistling intensity varies up or down with nesting activity and that probably sharp drops in the call index correspond to peaks of hatching.

DISCUSSION

Many investigators of quail biology have come to the conclusion that weather plays an important role in reproductive success. Stoddard (1932, p. 345-346) believed that "the birds are prolific enough to hatch off and rear broods in all but extreme weather conditions unless under the additional handicap of an abundance of natural enemies." Errington (1935) believed drought could be detrimental to quail reproduction.

Leopold (1945) in a study of sex and age ratios among bobwhites in southern Missouri came to the conclusion that year-to-year fluctuations in percent young were results of local weather fluctuations affecting nesting success. Stanford (1955) reported that favorable weather helped bring about a great increase in Missouri reproductive success in 1955 after several years of drought.

In Texas, two investigators found that rainfall had an important effect on quail nesting. In southwest Texas, Lehmann (1946) found that rainfall was important in initiating bobwhite nesting. Parmalee (1955) studied quail nesting in east central Texas. He concluded that average to heavy winter or spring rainfall was conducive to a good nesting season. Robinson (1957) reports the effects of April through September weather on quail productivity in Kansas. He found that good productivity occurred when total rainfall for these months exceeded 16 inches. Poor productivity occurred when total rainfall was less than 14 inches. When rainfall was between 14 and 16 inches, productivity seemed to be related to average temperature. Moderate temperatures were correlated with good productivity and high temperatures with poor productivity. He found that autumn populations on a study area in south central Kansas were correlated with local climatic conditions and this was in agreement with the correlation between weather and quail productivity for the whole state of Kansas.

Frye (1948) concluded that excessive summer rainfall was detrimental to quail production in an area that was flat enough so that flooding sometimes occurred. In northwest Florida, Murray (1958) found that quail productivity was highest during summers of high rainfall and low mean temperatures.

In Kentucky (Durell, 1957) found that above normal rainfall in April, May or June seemed to increase the number of quail broods hatched during the succeeding month, and Wunz (1959) concluded that weather was the most important single factor influencing population trends. Low populations were associated with severe summer drought and increasing populations with near normal weather, and in 1958 a decrease was associated with extreme cool and wet weather.

Reid and Goodrum (1960) studying quail populations and reproductive success in southwest Louisiana found that the, "better winter bobwhite populations were significantly related to high reproductive success the preceding nesting season," and, "In general, the best quail crops followed cool moist summers while poorest reproductive success followed hot dry summers." They believed that temperature and precipitation readings may be useful for predicting annual quail production and winter quail populations.

Several classes of unrelated and partly unrelated evidence mutually support the conclusion that annual bobwhite quail reproductive success in Alabama is largely controlled by the weather, and that good reproduction is strongly favored by normal or excess amounts of rainfall and normal or cooler than normal temperatures during the months of May through August. Unusually hot-dry weather during this period is detrimental to high quail productivity. This evidence is reinforced by similar evidence in the literature from other parts of the bobwhite range. Altogether, the evidence is rather conclusive.

Total quail populations have been seen to fluctuate strongly as percentage juveniles in the population fluctuates—this would be expected generally because about three-fourths or more of fall quail populations are birds of the year. It appears that an increase in percentage juveniles from 70.0 to 83.4 as occurred between 1954 and 1955 can be interpreted to mean that there were about twice as many juvenile quail in the population in 1955 as compared to 1954. The Alabama sex ratio figured from 7,218 birds shot in the 1955-56 season was 46.7

percent hens (this includes juveniles as well as adults—the sex ratio of adult birds was probably even more unbalanced in favor of males). This percentage compares closely with that found by Stoddard (1931, p. 90). If it is assumed that hens made up 46.7 percent of the breeding population both in 1954 and 1955, the average number of chicks raised to maturity per adult hen was 5.0 in 1954 and 10.8 in 1955. To the quail hunter, this means that, in seasons of good productivity, it will probably require only one-third to one-half the effort required to bag a quail than in poor seasons (Table III).

It is not intended to suggest that nesting and rearing season success is the only important factor determining year-to-year quail populations. It does appear reasonable to believe that for a given large area in Alabama, barring extensive changes in the land use pattern, the most important factor determining a fall population will be the productivity as affected by weather. It is well known among game bird propagators, that the temperature and humidity have an important effect on quail eggs especially at hatching time. If the air in an incubator is too dry at hatching time, chicks may stick to the inner membrane and the eggs will not hatch even if the chicks are alive (Hart and Mitchell, 1947). Probably, temperature and moisture interacting, exert a great influence on hatching success in Alabama.

There is additional reason to believe that the effects of weather under Alabama conditions are more important on the nests than the chicks. Information from the wing study, covey break-up observations and brood observations show that there is nearly always a large June hatch from first nesting attempts. Most of the hatch that occurs before July 1 comes in June and from May nests. Percentage of quail hatch occurring before July 1 has almost always been associated with rainfall and temperature in May (Table IV).

Assuming that quail produce only one brood per pair per season, the possibilities for successful hatch occurring after about July 1 would depend on what had occurred earlier since most of these late nests would be second or third attempts.

High percent young in the bag has almost always been associated with abnormally large percentages of late hatched birds in this study (Fig. 3). (Important exceptions were some regions of Alabama in 1959.) This probably means that under present conditions in Alabama, nest destruction and/or destruction of young birds by agents other than weather is so important that a season's reproductive success usually depends on the success of second and third nesting attempts. Perhaps this condition could be remedied on areas under intensive management, so that extremely poor hunting seasons could be largely avoided.

It appears that the bobwhite call index can be developed into a useful tool for estimating progress of the nesting season. It can already be used as an index to winter quail populations (Rosene, 1957), and an index to hunting success (Bennitt, 1951). Routes representing a region could be set up and run weekly from May 1 through August or September for a few years, until the average pattern becomes apparent. From then on, comparisons could be made and chronology of the hatch estimated. This information along with weather records for May through August should enable an investigator to estimate the relative success of the coming quail season by the end of August.

SUMMARY

Evidence on the effects of spring and summer weather on bobwhite quail reproductive success in Alabama is presented. Data consist of 57,080 quail wings contributed by hunters during an 8-year period, and representing the hatching seasons 1952 through 1959. Additional data were obtained from a quail population study made concurrently on a 1,409-acre area in the Alabama Piedmont, from local brood observations and a quail cock call route.

Quail reproduction as measured by percentage of juveniles in wing samples was best when total rainfall was higher than normal, or normal and accompanied by average seasonal temperatures no higher than normal during the period from May through August. Extremely dry-hot years were much poorer than average in quail reproduction. This was true for the State as a whole from 1952 through 1959, and in soil regions considered separately from 1953 through 1959.

Fall populations censused intensively on a 1,409-acre study area in central Alabama fluctuated in the same general way as for the State and regions of the State from 1952 through 1959. They were correlated with weather in the same way from 1950-1959. There was a single exception (1953) to both of the above statements, and this may have been more apparent than real.

Chronology of the hatch, also based on wing samples, was associated with reproductive season weather in such a manner that the data support findings relating to the effects of weather on reproduction.

A 21-mile cock call index route was run in central Alabama during the summers of 7 years (1954-59). Covey dispersal observations, brood observations, and state-wide quail wing data when compared with the central Alabama call index, indicate that the call index can be used to estimate the relative amount of nesting activity.

Literature is reviewed and discussion is presented on the possible significance of these findings and the possibility of using weather data and call-index routes to predict relative quail reproduction success from year to year.

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APPENDIX

TABLE VI

STATISTICAL ANALYSIS OF ASSOCIATIVE RELATIONSHIP BETWEEN PAIRS OF SOME ATTRIBUTES

Relationship Between	*Correlation Coefficient* ("r")*	*("t")*	*Relationship is Significant at Percentage Level Below*
State-wide average total rainfall for May through August *and* state-wide % young in the bag (1952-59)	.885	4.653	1%
Piedmont Substation total rainfall for May through August *and* Piedmont Substation fall populations (1950-59)	.812	3.933	1%
Average Lee County call index for August *and* state-wide % hatch occurring after July 1 (1954-59)	.930	....	1%
State-wide % young in bag *and* state-wide % hatch occurring after July 1 (1952-59)	.773	2.985	3%
June through August total average rainfall deviations (some state-wide and some regional, but not overlapping) *and* corresponding % young hatching after July 1. In years having seasons of distinctly early wet or normal and late dry weather and seasons that were dry early and late wet or normal (1952-59)	.5382	1.564	28%
May total average rainfall deviations (some state-wide and some regional, but not overlapping) *and* corresponding % young hatching after July 1. In years having seasons of distinctly early wet or normal and late dry weather, or early dry and late wet or normal weather	–.310	.7988	46%
State-wide total deviations from monthly mean temperatures (May-Aug.) *and* state-wide % young in the bag (1952-59)	–.384	1.019	35%

* Formulas used were $r = \frac{Sx_1x_2}{\sqrt{(Sx_1^2)(Sx_2^2)}}$ and $t = r\sqrt{\frac{(n-2)}{(1-r^2)}}$ from Snedecor (1950) p. 138 and p. 149.