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A 10-YEAR STUDY OF BOBWHITE QUAIL MOVEMENT PATTERNS[1]

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Abstract: The movement patterns of 676 bobwhite quail (Colinus virginianus) on two study areas on Tall Timbers Research Station in northern Florida were studied during a 10-year period. Eighty-six percent of the quail moved no more than 400 m from their first documented location in a one- to five-year period. Ninety-eight percent moved less than 800 m. Movements greater than 1,000 m occurred but were rare. There were no substantial differences in the annual movements of males and females or immatures and adults; however, the few birds which made longer movements (>800 m) tended to be immature males. The average distance an individual quail moved during a two-week shooting period was greater than the distance moved during the preceding two-week trapping period, but the average difference was only 82 m and therefore insignificant from a practical viewpoint. Movements during shooting averaged 150 m and were not extensive enough to force quail off the study area. Egress and ingress were minimal and approximately balanced. The population was much less mobile than bobwhite populations in other portions of the species' range.

Movements of animals can influence a population as drastically as natality and mortality. Therefore, knowledge of the movement patterns of a wildlife population is essential to the understanding of population dynamics and has practical implications for management. Management studies of bobwhite quail (Colinus virginianus) have been underway at Tall Timbers Research Station (TTRS) in Leon County, Florida, since 1970. The purpose of the present study was to investigate the movement patterns of the TTRS bobwhite populations. Specifically, the objectives were to determine (1) year-to-year movements, (2) movements during trapping and shooting periods, and (3) egress and ingress.

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STUDY AREAS

Tall Timbers Research Station consists of approximately 1,300 ha in northern Leon county, Florida, approximately halfway between Tallahassee, Florida, and Thomasville, Georgia. Tall Timbers lies within the Tallahassee Red Hills subregion of the Coastal Plain, characterized by a mature topography of rolling hills with gentle to moderate slope and hilltop elevations of 60 to 90 m above sea level (Hendry and Sproul 1966). Soils are generally well-drained sandy or sandy loam topsoils overlying loamy subsoils. The climate is temperate with mean annual temperature of 20 C and annual rainfall between 79 and 264 cm [mean ($\bar{x}$) = 155 cm]. Winter and summer are typically

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wet seasons, but periods of several weeks without rain are common.

Approximately 85 percent of TTRS is in woodland, primarily open stands of mature loblolly (Pinus taeda) and shortleaf pine (P. echinata) interspersed with live oak (Quercus virginiana). The woodlands are burned in February or March each year, and a herbaceous cover rich in legumes such as partridge pea (Cassia spp.), native lespedezas (Lespedeza spp.), and beggarweeds (Desmodium spp.) develops in the spring. Fields and fire ecology plots are protected from burning by an extensive network of fire lanes plowed each year (Kellogg and Doster 1971, Kellogg et al. 1970, 1972). Tall Timbers Research Station has not been intentionally managed for quail since 1964, but land management practices have been relatively favorable to quail. The bobwhite population is protected from all hunting except that associated with the management study.

After a preliminary census of the bobwhite population at TTRS in 1969, two study areas were selected for comparison of management techniques: a North site of 204 ha and a South site of 212 ha (Figure 1). The sizes of the areas were dictated by the manpower available to conduct the study. The sites are separated by a two-lane highway and at the nearest point are approximately 75 m apart. Based on the 1969 population estimates, the study sites had approximately equal densities of quail.

In the springs of 1969, 1970, and 1971, fields on the North site were planted in corn, but no planting was done on the South site. In 1972, 1973, and 1974, corn was planted on the South site, but not the North. Thereafter, for the duration of the study, fields on both sites were planted. Corn was harvested with mechanical pickers in the fall of each year. No herbicides or pesticides were used. Further descriptions of the area are available (Beadel 1962, Kellogg and Doster 1971, Kellogg et al. 1970, 1972, Smith 1980).

METHODS

Beginning in 1970 and continuing through 1979, bobwhite quail at TTRS were censused annually. Quail were trapped and banded in late January or early February of each year. The trapping period lasted from 6 to 14 days. Funnel-type quail traps similar to those described by Stoddard (1931) were placed in sites considered to be frequently used by quail. Approximately one trap per 2-2.5 ha was used. Traps were weighted with bricks and covered with dead vegetation to protect captured birds from raptors and other predators. Cracked corn was used as bait. There was no prebaiting of trap sites.

Although many trap sites were used repeatedly throughout the study, trap sites and total number of traps varied somewhat from year to year. When trap sites were relocated, traps were moved a maximum of 60 to 75 m. In 1971, 1975, and 1976, additional traps were placed outside the boundaries of the study areas to ascertain the extent of movement off the study sites. The areas in which extra trapping was conducted are indicated on the map in Figure 1. Extra trapping was concurrent with trapping on the study sites.

When captured for the first time in a given year, quail were sexed, aged, and banded with a number-coded size 7 aluminum leg band. The identification numbers of any bands from previous years were recorded. Adults had completed at least one post-nuptial molt and were at least 1.5 years old. Juveniles were six to eight months old at the time of capture.

Immediately after banding, all birds were released at the site of capture except during an additional trapping period in 1975 when, after censusing was completed, birds were trapped and removed from the South study site to intentionally reduce the population to one bird per 4 ha. Trapping was terminated when the percentage of recaptured quail was 70-90 percent for several days.

Collection by shooting began within a week after trapping ended and lasted from four days to two weeks. Collection parties of two or three hunters using two or three dogs were assigned a portion of the study area to cover each day. Both study sites were hunted until approximately 20 percent of the population had been collected.

Hunters recorded the sex and age of all collected birds and the identification number of any bands. Precise locations at which birds were shot were mapped by hunters in 1977, 1978, and 1979. In several years, parties hunted in areas outside the study site (at least 45 m away from the boundaries) to monitor movement of banded quail off the study areas. In 1973, 1975, and 1976, extra shooting was conducted on the areas where extra trapping was done outside the boundaries.

Year-to-Year Movements

Movement records were compiled from the trapping and banding data for all quail captured at least two years during the study. A compsite map of all traps enumerated in the movement records was constructed using individual maps of trap locations from each of the 10 years of the study. An electronic digitizer was used to assign Cartesian coordinates to each trap site on the composite map.

The straight-line distance between two traps at which a bird was captured represented the minimum distance moved (MDM) during the period between winter captures. Actual distance moved by a bird could have been much greater. The MDM was calculated for all possible combinations of trap sites in an individual record. Thus, the movement record of a quail captured four consecutive winters yielded three 1-year MDM, two 2-year MDM, and one 3-year MDM (Figure 2).

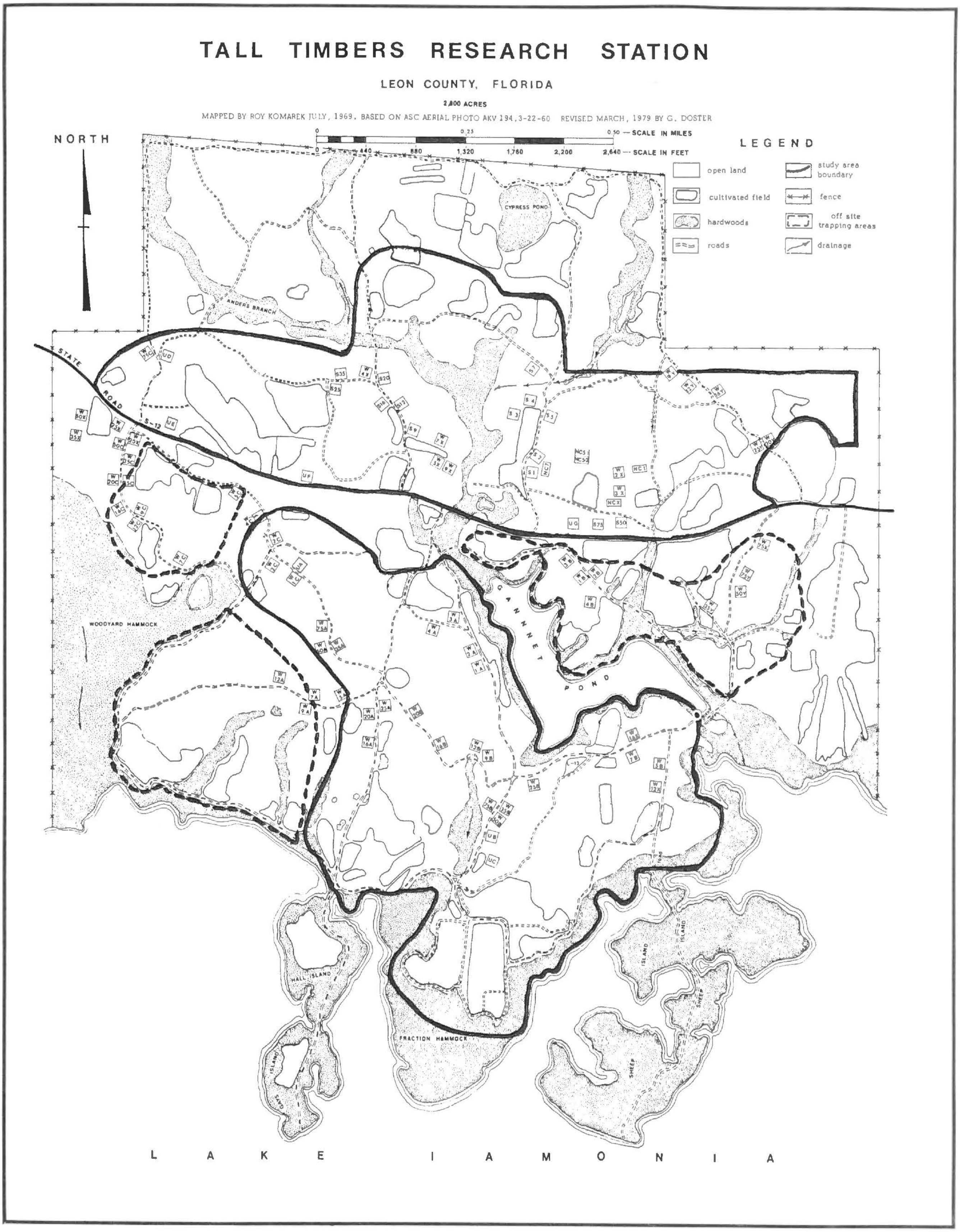

Fig. 1. Map of Tall Timbers Research Station showing North Study Site, South Study Site, and off-site trapping areas.

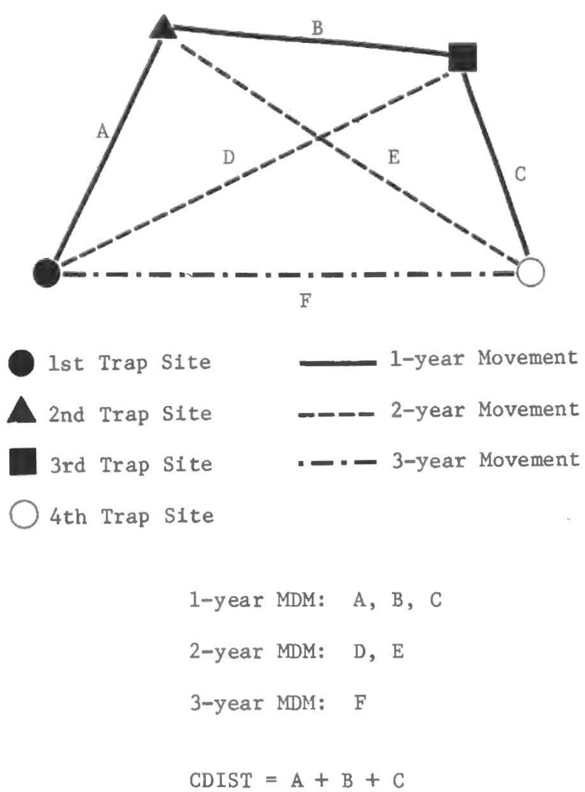

Fig. 2. Diagram and description of the various distances calculated for a quail captured four consecutive winters.

For birds captured three or four consecutive winters, straight-line distances between annual captures were summed. This cumulative distance (CDIST) represented the best estimate available of the actual distance moved by a quail from first to last capture (Figure 2).

Two approaches were used to analyze MDM data. In the first approach, all year-to-year movements by an individual bird were included when calculating descriptive statistics [$\bar{x}$, Standard Deviation (SD)]. In the second, only one movement for each bird, MDM from first to last trap site, was used in calculations.

A paired t-test (Ostle and Mensing 1975) was used to determine the significance ($P \leq 0.05$) of the difference between two consecutive one-year movements of an individual quail. One-year movements were subjected to an analysis of variance (ANOVA) to determine whether significant differences ($P \leq 0.05$) were attributable to year, age, sex, or study site. The design was unbalanced, with an unequal and disproportionate number of observations in subclasses; therefore, a linear least square analysis was used to perform the ANOVA (Ostle and Mensing 1975). Duncan's (1955) multiple range test was used to compare means of significant main effects and a selected interaction term.

Movement during Trapping and Shooting Periods

Records of movements within the trapping period were compiled for all quail trapped at least twice during the trapping periods in 1977, 1978, and 1979. An individual retrap record consisted of the sequence of trap sites at which a bird was captured within a trapping season. The distance from first to last trap site in a retrap record was assumed to represent the distance moved by a bird during the trapping period (TDIST).

Distances moved during shooting (SDIST) were calculated for all banded birds shot during 1977, 1978, and 1979. The straight-line distance between the site at which a bird was shot and the trap site at which it was last captured in the preceding trapping period was assumed to represent SDIST. A paired t-test was used to determine the significance ($P \leq 0.05$) of the difference between SDIST and TDIST for birds retrapped and shot within the same census period.

Additional Movement Records

In addition to the movement records obtained from trapping and shooting, other records were collected that, while not providing conclusive information, provided insight into the egress and ingress patterns of the population. Movements were analyzed for those banded birds that changed from one study site to the other between winters or were shot or trapped outside the boundaries. Approximate locations at which banded quail were recovered on adjacent properties were plotted on a Grady County, Georgia, or Leon County, Florida, map, and distances moved since last capture were measured.

Population Estimates

Chapman's (1951) modified Lincoln Index was used to estimate the quail population on each study site at the beginning of winter trapping each year. Population sizes after censusing were calculated by subtracting all known losses during the census from the population estimates derived from the banding returns. Pre- and post-census densities of quail on each study site each year were calculated. Correlation analyses were used to determine the significance ($P \leq 0.05$) of the relationships between mean annual movement and quail densities.

RESULTS AND DISCUSSION

Distances Moved from Year to Year

During the 10 years of censusing, 6,033 quail were banded one or more times, and of these, 574 were banded for two or more years. The trapping records of these 574 TTRS quail yielded 710 MDM ranging in duration from one to five years. Sample means and frequency distribution of MDM obtained by using only one movement per bird were similar to those obtained when all possible year-to-year movements by a bird (Table 1) were included in the analysis (Smith 1980). Further discussion of distances moved by TTRS quail is based on the total number of MDM recorded, irrespective of duplication of movements by individuals.

Five hundred eighty-four 1-year MDM were obtained from the trapping records of 529 quail (Table 1). Approximately 88 percent of the one-year MDM were less than 400 m. Ninety-eight percent of the birds moved no more than 800 m from their initial trap site in a year's time.

Data from this study and Simpson's (1976) were obtained in the same general region and on study areas of approximately the same size. The frequency distributions of one-year MDM were very similar, with more than 96 percent of both populations moving no more then 800 m in a one-year period. A greater percentage of TTRS quail remained within 400 m of the initial trap site, which suggested that the TTRS population was even more sedentary than Simpson's.

Differences in winter-to-winter movements of TTRS and Wisconsin quail (Kabat and Thompson 1963) were substantial. A much greater percentage of the Wisconsin quail moved more than 800 m, and though no statistical test could be made, the mean distances moved were obviously different. None of the TTRS annual movements recorded in trapping exceeded 1,600 m, although 33.6 percent of the Wisconsin movements did. Most birds moving distances greater than 1,600 m at TTRS probably would have moved off the study site. Movements between 800 and 1,600 m were easily possible on the combined study areas, yet only 1.7 percent of the movements were within that category. If so few annual movements at TTRS were between 800 and 1,600 m, then probably even fewer were longer than 1,600 m. Approximately the same percentage of Texas (Lehmann 1946) and TTRS quail moved no more than 800 m, but one-year movements in the TTRS population were more concentrated in the "less than 400 m" category. Therefore, one-year MDM of TTRS quail were more limited than those of quail in Wisconsin and Texas.

Several investigators have obtained year-to-year quail movements incidental to studies of seasonal movements. Such studies have been generally short-term, and the number of annual movements recorded were few. Murphy (1951) reported eight annual movements for Missouri quail ranging from 400 to 2,640 m, five of which were less than 800 m. In another study on the same area, seven of nine quail moved less than 800 m in one year (Lewis 1952). Extremely long one-year movements ($\bar{x}$ = 8,184 m) were recorded for two quail in a low density Indiana population (Hoekstra and Kirkpatrick 1972). Most of the Wisconsin quail trapped 10 to 16 months after banding moved less than 800 m (Errington 1933). Stoddard's (1931) movement analysis of south Georgia-north Florida quail included movements of various durations. His results were generally similar to those of this study in that the movements he reported were less than those of quail in other regions.

Two-year movements further substantiated the sedentary nature of TTRS quail. Eighty percent

Table 1. Summary of 710 winter-to-winter movements of bobwhite quail at Tall Timbers Research Station, 1970-1979.

Distance moved (m)	1 - Year Number(%)	2 - Year Number(%)	3 - Year Number(%)	4 - Year Number(%)	5 - Year Number(%)	Total Number(%)
0 - 200	335 (57.4)	45 (42.9)	2 (11.1)	1 (50.0)		383 (53.9)
201 - 400	178 (30.5)	39 (37.1)	9 (50.0)		1 (100.0)	227 (32.0)
401 - 600	50 (8.6)	14 (13.3)	4 (22.2)			68 (9.6)
601 - 800	11 (1.9)	6 (5.7)	1 (5.6)			18 (2.5)
801 - 1,000	3 (0.5)					3 (0.4)
1,001 - 1,200	3 (0.5)	1 (1.0)	1 (5.6)	1 (50.0)		6 (0.8)
1,201 - 1,400	3 (0.5)		1 (5.6)			4 (0.6)
1,401 - 1,600	1 (0.2)					1 (0.1)
TOTAL	584 (100.1)	105 (100.0)	18 (100.1)	2 (100.0)	1 (100.0)	710 (99.9)
Average MDM	214	267	425	630	249	228
Standard Deviation	196	185	290	693		203
Range	0 - 1,478	0 - 1,069	71 - 1,250	140 - 1,120		0 - 1,478

of the 2-year movements were less than 400 m, and 99 percent were less than 800 m (Table 1).

The mean of three-year MDM was greater than the means of the one-and two-year MDM (Table 1), and 39 percent of three-year movements were greater than 400 m. However, the number of three-year movements was probably too small to conclude that three-year movements were actually greater. Four-and five-year movements were even fewer. Two males, first captured as immatures, were recaptured four years after initial banding. One moved only 140 m from the original trap site; the other moved 1,120 m. A third male, banded as a immature, was recovered five years after the first capture only 249 m from the original trap site. Movements of long duration are interesting but probably contribute little to the movement patterns of the population as a whole since so few birds survive to make such movements.

Differences in Movement among Yearly Intervals

Although there was no clear pattern in the mean differences, there was a general tendency for longer movements in the later years of the study (Table 2). Comparison of sample means raised a fundamental question: What magnitude of mean difference was biologically or practically significant? Average MDM for the first interval, 1970-1971, was statistically different from all other means, yet the difference between means of the first two intervals was only 52 m. Such a slight difference in the average distance moved by quail during those two years was not practically different. Maximum mean difference between years was 227 m. A difference of this magnitude probably was indicative of a meaningful difference in the movement of quail during the two intervals, 1970-1971 and 1977-1978.

Changes in habitat over time might have affected movement, but the only major change in land use at TTRS during the years of census was the pattern of corn planting. Corn fields are apparently beneficial to quail (Nevels 1952, Kellogg et al. 1972), but we detected no relationship between the presence of corn fields and movement on a study site. In the years when corn was planted on one study area and not the other, there was no significant difference between mean annual MDM of the two sites. Quail did not move long distances toward the corn fields.

Fluctuations in population size could influence yearly movements. Several investigators have suggested that bobwhite quail in more densely populated areas are less mobile than birds in less densely populated areas (Errington 1941, Errington and Hammerstrom 1936, Urban 1972). Others believed population density and movement were directly related; population pressure forced birds to move (Murphy 1951, Loveless 1958). Present data were sufficient to consider only the relationship between annual movement and winter density.

Yearly estimates of the population size and density on each study site at the time of trapping and after censusing are presented in Table 3. Winter densities on the two study sites differed significantly ($t = 2.98$, $P < 0.02$). Therefore, analyses were performed separately for the North and South study sites. Since only one population estimate per year was obtained for each study site, the effects of year and density

Table 2. Average one-year movements (m) of bobwhite quail at Tall Timbers Research Station for nine yearly intervals.

Interval	Number	Average MDM	Standard Deviation	Range
1970-71	131	142	101	0 - 529
1971-72	134	194	172	0 - 972
1972-73	120	221	230	0 - 1,478
1973-74	46	244	180	0 - 718
1974-75	53	211	160	0 - 519
1975-76	23	334	309	0 - 1,203
1976-77	37	292	248	0 - 1,028
1977-78	14	369	315	65 - 1,391
1978-79	26	295	155	0 - 600
TOTAL	584			

Table 3. Population and density estimates (birds/ha) of bobwhite quail on the North and South study sites at Tall Timbers Research Station, 1970-1979.

Year	Study site[a]	Number at start of trapping period	Standard Error (95% CI)	Density at start of trapping period	Number at end of shooting collection[b]	Density at end of shooting collection
1970	N	1,158	58 (1,044-1,272)	5.6	918	4.5
	S	723	70 (586-860)	3.4	592	2.8
1971	N	1,411	84 (1,246-1,576)	6.9	1,159	5.7
	S	829	59 (713-945)	3.9	684	3.2
1972	N	1,555	73 (1,412-1,698)	7.6	1,220	6.0
	S	608	39 (532-684)	2.9	459	2.2
1973	N	713	33 (648-778)	3.5	526	2.6
	S	742	41 (662-822)	3.5	543	2.5
1974	N	563	39 (487-639)	2.7	410	2.0
	S	426	34 (359-493)	2.0	306	1.4
1975	N	410	28 (355-465)	2.0	304	1.5
	S	355	15 (326-384)	1.7	136	0.6
1976	N	463	35 (394-532)	2.3	367	1.8
	S	228	27 (175-281)	1.1	177	0.8
1977	N	343	29 (286-400)	1.7	261	1.3
	S	138	12 (114-162)	0.6	97	0.5
1978	N	378	35 (309-447)	1.8	295	1.4
	S	213	26 (162-264)	1.0	165	0.8
1979	N	501	37 (428-574)	2.4	385	1.9
	S	504	37 (431-577)	2.4	385	1.8

[a]N = North; S = South.

[b]Number at end of shooting collection = Number at start of trapping period - known losses during census.

could not be separated in the analysis. Any conclusions drawn from the results of those analyses are subject to this qualification.

The relationship between annual movement and population density was investigated by correlating the bobwhite density during a given winter with mean annual MDM from that winter to the next. Density at the time of trapping and mean one-year MDM were negatively correlated. Correlation of the two measures was highly significant on the South study site ($r = -0.73$, $P < 0.02$) and not significant on the North ($r = -0.58$, $P < 0.10$). The correlations between density after censusing and mean annual MDM were similar (South, $r = -0.75$, $P < 0.02$; North, $r = -0.56$, $P < 0.12$). The relationship between winter population density and movement during the preceding year was also evaluated, but the correlation was not significant.

Differences in Movements between Sexes and Age Classes

Some have suggested that male bobwhites tend to move farther than females (Hood 1955, Loveless 1958, Kabat and Thompson 1963), but others found no sex differential in movement (Stoddard 1931, Errington 1933, Murphy 1951, Simpson 1976). Loveless (1958) reported that there was no difference in the spring and summer movements of adult and immature quail, and Simpson (1976) concluded the same about fall movements. Results of this study disclosed slight sex and age differentials in quail movement. Mean one-year MDM was significantly greater for males and immatures (Table 4). Comparisons of mean annual MDM for sexes and age classes revealed that although a statistically significant difference existed, a biological or practical difference did not. The data did suggest, however, that those few birds making extensive movements will most likely be immatures, and probably males.

Patterns and Directions of Movement

The cumulative distance (CDIST) moved between traps for 55 quail captured three consecutive years ranged from 43 to 1,219 m and averaged 415 m (SD = 269 m). A single female captured four consecutive years had a CDIST of 465 m. There was no consistent pattern of movement for bobwhites with consecutive yearly captures. Some tended to move in a straight line away from the initial trap site; however, consecutive movements of other birds formed a more acute angle, resulting in final locations nearer to the initial capture site. Forty-one of the 574 birds giving movement records were trapped the first and last time at the same trap location. Similarly, there were no significant differences in directional (N, S, E, W) movements.

Movement during Trapping and Shooting Periods

Normal movements of TTRS quail might have been reduced during trapping because of the intensive use of baited trap sites. On the other hand, hunting possibly stimulated movement. Rosene (1969) contended that coveys flushed too frequently would move from an area. Errington and Hammerstrom (1936) thought that shooting or other continuous disturbances could cause a covey to relocate within its range but would seldom drive it out of its range altogether.

Distance moved during trapping and shooting periods could be compared for 130 TTRS quail which had been retrapped and later shot during the same census period (1977-1979). Quail were shot 5 to 14 days after being trapped for the last time. For these 130 quail, mean distance moved during trapping (TDIST) was 73 m (SD = 84 m), and mean distance moved during shooting was 155 m (SD = 105 m). For an individual quail, SDIST was significantly greater than TDIST ($t = 7.56$, $P < 0.001$). However, mean difference between SDIST and TDIST was only 82 m, which is insignificant from a practical standpoint.

Additional shooting movement records were available for 102 banded quail shot but not retrapped during the same census period. Thus, SDIST was known for a total of 232 banded quail. Shooting movements ranged from 0 to 544 m, and mean SDIST was 150 m (SD = 104 m). Movements of this magnitude would have caused few birds to leave the study sites. therefore, movement during shooting was concluded to be of little practical importance.

Recoveries of banded birds by parties hunting outside the boundaries also were indicative of the extent to which quail moved off the areas after trapping and during shooting on study areas. Parties hunting in areas more than 45 m away from the study site boundaries recovered no banded birds. However, in 1973, 1975, and 1976, when hunting outside the study sites was more intensive and conducted along the boundaries, banded birds were collected. Shooting in the buffer zone between the study sites in 1973 yielded 39 quail, of which 17 had been banded that year. In 1975, 18 of 43 birds shot outside the study sites were banded, but only 1 of 17 birds shot in 1976 was banded.

Exact shooting locations for the birds were not recorded, so distances moved from last trap to shooting site were not known. However, the majority of banded birds shot off the areas were last captured at trap sites located on the periphery of the study sites. Movements of less than 90 m would have placed all birds except two outside the boundary. One bird moved a minimum of 230 m off the study area, and another, 650 m. The distances moved by these birds probably were not different from those of birds shot on the area. Most likely the covey ranges of these birds overlapped the boundaries, and these quail were shot within their normal ranges.

Table 4. Average one-year movements (m) of bobwhite quail at Tall Timbers Research Station for sexes and age classes.

Variable	Number	Average MDM	Standard Deviation	Range
Age				
Adult	186	177	141	0 - 972
Immature	398	231	215	0 - 1,478
Sex				
Male	339	230	213	0 - 1,478
Female	245	191	168	0 - 1,203

Egress and Ingress

Information on egress and ingress was provided by (1) band returns from birds shot on adjacent properties, (2) shooting outside the boundaries, (3) trapping outside the boundaries, and (4) movements between study sites. During the 10 years of study, only six banded birds were recovered on surrounding properties. The hunting on surrounding properties was intensive enough that if large numbers of TTRS quail moved long distances, then more banded quail would have been collected. Shooting parties intensively hunted TTRS areas outside the study site boundaries several years. Their collections should have detected the presence of banded survivors from the previous year that had moved and remained outside the study sites, but no such birds were collected. Results from trapping outside the boundaries disclosed that very few banded birds were trapped outside the study areas in succeeding years. Similarly, only 9 of 156 birds originally trapped outside the study areas were recaptured the following year on the study sites. The above data indicate that egress and ingress were minimal and generally equivalent. An approximately equal number of birds moved from one study site to the other, which further supported the conclusion of balanced egress and ingress. These conclusions are similar to those of Simpson (1976), who found a very small number of birds moving onto adjacent properties.

Several studies have attempted to assess egress and/or ingress from recapture data. In a Wisconsin population, 42 percent of the birds emigrated from the study area during spring (Buss et al. 1947); in another, 79 percent emigrated (Kabat and Thompson 1963). Extensive spring dispersal occurred in a Missouri population; half the adult birds in a spring population had moved onto the study area since winter (Murphy and Baskett 1952). Another study on the same area found considerable ingress during the spring (Lewis 1954).

Failure to retrap a reasonably high percentage of banded birds has been interpreted as indicating movement of large numbers from the population (Lehmann 1946, Loveless 1958). As Lewis (1952) noted, such a conclusion is questionable since it fails to take into account the high turnover rate in quail. In the present study, 86 percent of the 5,521 banded birds that survived the shooting period at TTRS were never recaptured. It is obvious that the majority of these banded birds did not move off the study sites.

Considered as a whole, the results of this study depict a quail population in which very little movement occurred. The great majority of the population was extremely sedentary. Some birds moved long distances, but the number of birds making such movements was very small. Even when disturbed by shooting activities, quail moved very little. Movement in and out of the study sites occurred but was minimal and generally confined to areas along the periphery of the study sites. Most likely this was normal movement by birds whose ranges overlapped the artificial boundaries. The conclusion consistent with these results is that the banded birds not recaptured disappeared not because they moved, but because they died. Movement of TTRS quail is so limited that movement can be disregarded as a major factor in population dynamics.

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