Survival Rates of Bobwhite Quail Based on Band Recovery Analyses
Author(s): Kenneth H. Pollock, Clinton T. Moore, William R. Davidson, Forest E. Kellogg, Gary L. Doster
Source: *The Journal of Wildlife Management*, Vol. 53, No. 1, (Jan., 1989), pp. 1-6
Published by: Allen Press
Stable URL: http://www.jstor.org/stable/3801295
Accessed: 05/08/2008 09:26

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at http://www.jstor.org/page/info/about/policies/terms.jsp. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at http://www.jstor.org/action/showPublisher?publisherCode=acg.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is a not-for-profit organization founded in 1995 to build trusted digital archives for scholarship. We work with the scholarly community to preserve their work and the materials they rely upon, and to build a common research platform that promotes the discovery and use of these resources. For more information about JSTOR, please contact support@jstor.org.

http://www.jstor.org

SURVIVAL RATES OF BOBWHITE QUAIL BASED ON BAND RECOVERY ANALYSES

KENNETH H. POLLOCK, Southeastern Cooperative Wildlife and Fisheries Statistics Project, Institute of Statistics, North Carolina State University, Box 8203, Raleigh, NC 27695-8203
CLINTON T. MOORE,[1] Southeastern Cooperative Wildlife and Fisheries Statistics Project, Institute of Statistics, North Carolina State University, Box 8203, Raleigh, NC 27695-8203
WILLIAM R. DAVIDSON, Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, GA 30602
FOREST E. KELLOGG, Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, GA 30602
GARY L. DOSTER, Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, GA 30602

Abstract: We present the results of a long-term (1970–85) band recovery study of northern bobwhite quail (*Colinus virginianus*) at Tall Timbers Research Station, Leon County, Florida. The mean annual survival rate of male quail (18.7 ± 1.2 [SE] %) was significantly ($P = 0.01$) greater than that of females (14.3 ± 1.2%). The difference between survival of young (6–9 months old) and adults (>1 yr old) was 3 ± 2.2% and not significant. Survival rates varied significantly among years. The mean harvest was 23.3 ± 0.53%/year. Young male quail were harvested at a significantly higher rate than adult males (2% difference). There was no significant difference between harvest rates of young and adult females. Juvenile male and female harvest rates were not significantly different. However, adult females were harvested at a significantly higher rate than adult males (5% difference). Harvest varied among years. The mean annual kill (harvest rate + crippling loss) was approximately 30% for both sexes. Male and female natural mortality were approximately 52 and 56%, respectively. There was evidence of additivity of hunting and natural mortality for this population harvested in late winter. Our long-term study provides information on the survival processes for northern bobwhite quail that can be used to enhance management of the species.

J. WILDL. MANAGE. 53(1):1–6

Although research on northern bobwhite quail began in the 1920's (Stoddard 1931, Errington 1933), studies of quail survival have been limited. Sound management requires good estimates of mortality rates. Mortality for hunted species can be estimated from band recovery data using models prepared by Brownie et al. (1985). These models also provide band recovery rate estimates. Harvest rate is easily obtained if the reporting rate of bands is known. Total kill estimates follow from harvest estimates if an estimate of crippling loss is available. With these data managers can partition hunting and natural (nonhunting) mortality.

A recent series of papers questions whether hunting and natural mortality are additive (Anderson and Burnham 1976, Anderson et al. 1982, Nichols and Hines 1983, Burnham and Anderson 1984, Burnham et al. 1984, Nichols et al. 1984). Most of this work applies to waterfowl, particularly mallards (*Anas platyrhynchos*), for which the most band recovery data are available.

We report the results of a long-term band-recovery study of bobwhite quail at Tall Timbers Research Station, Leon County, Florida. We obtained survival estimates and test the additive and compensatory mortality hypotheses (Anderson et al. 1982).

W. L. Cornelius assisted with computing and J. D. Nichols reviewed an earlier draft of the manuscript. We thank present and past coworkers and many biologists and volunteers, especially wildlife technician students at Abraham Baldwin Agricultural College, for their help. This study was supported in part by Tall Timbers Research Station, Tallahassee, Florida and by an appropriation from the Congress of the United States. Funds were administered and research coordinated under the Federal Aid in Wildlife Restoration Act and through the U.S. Fish and Wildlife Service.

METHODS

Quail populations were studied on 2 tracts (204 and 212 ha) at Tall Timbers Research Station, Leon County, Florida (Smith 1980). Open

[1] Present address: Florida Game and Fresh Water Fish Commission, Wildlife Research Laboratory, 4005 S. Main Street, Gainesville, FL 32601.

Table 1. Annual survival rate (SR) estimates and standard errors (Brownie et al. 1985) for northern bobwhite quail age and sex classes banded at Tall Timbers, Florida, 1970–85.

	Male				Female			
	Young		Adults		Young		Adults	
Year	SR	SE	SR	SE	SR	SE	SR	SE
1970	0.2233	0.0720	0.3210	0.1027	0.2394	0.0729	0.2183	0.0910
1971	0.1976	0.0473	0.2536	0.0754	0.3212	0.1168	0.3158	0.1386
1972	0.2636	0.0640	0.2265	0.0704	0.1239	0.0439	0.0808	0.0419
1973	0.0641	0.0253	0.1074	0.0402	0.0791	0.0325	0.0586	0.0369
1974	0.0972	0.0385	0.2798	0.0994	0.0927	0.0410	0.2981	0.1413
1975	0.2449	0.1244	0.2663	0.1490	0.0568	0.0449	0.1928	0.1320
1976	0.2675	0.1555	0.1251	0.0947	0.0801	0.0394	0.0143	0.0232
1977	0.0629	0.0412	0.1330	0.0946	0.0452	0.0485	0.0549	0.0912
1978	0.1148	0.0570	0.1559	0.1151	0.2186	0.1116	0.2520	0.2429
1979	0.1524	0.0536	0.2974	0.1433	0.1255	0.0570	0.0755	0.0713
1980	0.1346	0.0600	0.3041	0.1393	0.1762	0.0729	0.1109	0.0820
1981	0.2676	0.1789	0.0871	0.0819	0.0419	0.0200	0.0458	0.0340
1982	0.1948	0.0992	0.0518	0.0481	0.0794	0.0507	0.2108	0.1355
1983	0.2701	0.1108	0.3529	0.2056	0.1108	0.0514	0.1364	0.1269
$\bar{x}$	0.1825	0.0246	0.2116	0.0247	0.1279	0.0168	0.1475	0.0272

annually burned stands of loblolly (*Pinus taeda*) and shortleaf pine (*P. echinata*) characterized the study sites. Herbaceous plants dominated the open understory. We captured quail in corn-baited live traps, banded them with aluminum bands, and released them (Dimmick et al. 1982). We placed traps at a mean density of approximately 1 trap/2 ha. From 1970 to 1985 we trapped in January–February for 15–20 days.

We initiated a systematic shooting harvest 2–3 days after trapping ended to collect a second sample of birds using a different sampling method. The harvest continued until the harvested sample equaled approximately one-half of the banded sample. This required coverage of the study sites 3–5 times in approximately 10 days (Dimmick et al. 1982, Kellogg et al. 1982). Details on the quail banding (Smith 1980, Dimmick et al. 1982, Kellogg et al. 1982) and crippling loss calculations (Doster et al. 1982) are not described here. The quail band reporting rate was 100%.

The band recovery data used in our analyses is available from KHP. We banded a mean of 560 birds/year. The mean ratio of juvenile to adult bandings was approximately 4:1 with males and females banded in approximately equal numbers. We did not recover any quail >3 years beyond its banding year, thus the band recovery matrices were sparse.

We used programs ESTIMATE and BROWNIE (Brownie et al. 1985) to compute survival and recovery rate estimates for young and adult banded quail of both sexes. These models provided options for testing age, sex, and year-dependency of survival and recovery rates. We judged the fit of each model using general goodness-of-fit tests and special tests for comparing models. We tested null hypotheses of equality of survival means with 1- or 2-tailed normal Z-tests. Where we could not reject a null hypotheses, we collapsed banding tables over the dimension tested and refit a simpler model. For some of the BROWNIE runs we added a small number (i.e., 0.1) to some of the zero counts to obtain estimates. We also used program SURVIV (White 1983) to calculate survival and recovery rates under the ultrastructural model described by Anderson et al. (1982). This model tests additive versus compensatory mortality hypotheses. We placed the relationship $S_i = S_0(1 - \beta K_i)$ directly in the SURVIV model statements where: S_i = the annual survival probability in year i, S_0 = the annual survival probability in the absence of hunting, β = the slope of the linear relationship between annual survival rate and annual kill rate, and K_i = the annual kill probability in year i.

In practice we need to estimate the relationship between the annual recovery rate (f_i) and K_i. As the mean crippling loss rate was 22% (Doster et al. 1982) and the reporting rate of bands was 100%, this relationship is: $K_i = f_i/(1 - 0.22) = 1.28\, f_i$. Thus $S_i = S_0\,(1 - 1.28\, \beta f_i)$

Table 2. Annual survival rate (SR) estimates and standard errors (Brownie et al. 1985) for northern bobwhite quail sex classes, pooled over ages, banded at Tall Timbers, Florida, 1970–85.

	Male		Female		Combined	
Year	SR	SE	SR	SE	SR	SE
1970	0.2317	0.0462	0.2532	0.0539	0.2410	0.0351
1971	0.2503	0.0411	0.2084	0.0410	0.2307	0.0291
1972	0.2317	0.0370	0.1117	0.0272	0.1787	0.0236
1973	0.0991	0.0244	0.1055	0.0312	0.1021	0.0193
1974	0.1591	0.0389	0.1443	0.0431	0.1533	0.0290
1975	0.1561	0.0478	0.0860	0.0395	0.1255	0.0320
1976	0.2356	0.0687	0.1249	0.0500	0.1857	0.0434
1977	0.1193	0.0452	0.0754	0.0520	0.1113	0.0369
1978	0.1796	0.0651	0.2392	0.0820	0.2045	0.0511
1979	0.2273	0.0602	0.1176	0.0431	0.1747	0.0374
1980	0.1531	0.0406	0.1633	0.0473	0.1587	0.0310
1981	0.1254	0.0341	0.0631	0.0238	0.0976	0.0213
1982	0.1470	0.0573	0.1626	0.0673	0.1520	0.0433
1983	0.2969	0.0845	0.1519	0.0559	0.2244	0.0502
$\bar{x}$	0.1866	0.0122	0.1434	0.0120	0.1672	0.0085

was the relationship built into the model. If mortality is completely compensatory, then $\beta = 0$. It if is completely additive, then $\beta = 1$.

RESULTS

We used Model H_1 of program BROWNIE (Brownie et al. 1985:59) to estimate age and year-specific survival rates for male bobwhite quail (Table 1). The 3% difference between mean young and adult survival rates was not significant ($P = 0.20$) in a normal test of equal survival rates versus the 1-tailed alternative of higher adult survival rate (Brownie et al. 1985:181). We could also not reject the null hypothesis ($P = 0.11$) of no age dependence versus age-dependent survival and/or recovery rates in a composite test (Brownie et al. 1985:88). Therefore we calculated year-dependent survival estimates for the combined young and adult male data using Model 1 of program ESTIMATE (Brownie et al. 1985:15) (Table 2). A goodness-of-fit test suggested the model is adequate ($P = 0.13$). Survival rates varied markedly among years with a high of 30% in 1983 and a low of 10% in 1973. Mean estimated annual survival was 18.7 ± 1.2%.

We estimated female survival rates using the same models as described for males (Tables 1 and 2). We found the 2% difference between mean young and adult survival rates not significant ($P = 0.27$) by the 1-tailed normal test. In the composite test of age-dependent survival and/or recovery rates, we could not reject the null hypothesis of no age dependence ($P = 0.78$). We therefore calculated year-specific survival estimates for the combined female data using Model 1 of program ESTIMATE in Table 2. The goodness-of-fit was marginal ($P = 0.07$). Again the survival rate estimates varied substantially among years with a high of 25% in 1970 and a low of 6% in 1981. Mean estimated annual survival was 14.3 ± 1.2%.

From Table 2 we can compare male and female annual survival estimates. There is good agreement within most years with the male estimates being slightly higher. We tested the null hypothesis of equal mean male and female survival rates with a 2-tailed normal test. The 4 ± 1.46% difference between the male rate and the smaller female rate was significant ($P = 0.01$). For completeness, the year-specific banding estimates from Model 1 of program ESTIMATE for the combined sex data are presented in Table 2.

We considered the question of age dependence further by combining male and female data and running Model H_1 of program BROWNIE again. The 3% difference (SE = 2.2%) between mean young and adult survival rates was nearly significant ($P = 0.08$) when we used the 1-tailed normal test described earlier.

We estimated harvest rates by sex and age class using Model H_1 of BROWNIE (Table 3), the model used to estimate the survival rates of Table 1. Using a 2-tailed normal test, we found a significant difference of 3% between young

Table 3. Annual harvest rate (HR) estimates and standard errors (Brownie et al. 1985) for northern bobwhite quail age and sex classes banded at Tall Timbers, Florida, 1970–85.

	Male				Female			
	Young		Adults		Young		Adults	
Year	HR	SE	HR	SE	HR	SE	HR	SE
1970	0.1869	0.0229	0.1393	0.0244	0.2083	0.0230	0.2000	0.0344
1971	0.1911	0.0196	0.1299	0.0285	0.1620	0.0187	0.1786	0.0388
1972	0.1972	0.0193	0.2413	0.0368	0.2354	0.0218	0.1337	0.0378
1973	0.2866	0.0258	0.2416	0.0442	0.2669	0.0264	0.2397	0.0564
1974	0.2947	0.0331	0.2859	0.0597	0.2562	0.0345	0.3005	0.0907
1975	0.3500	0.0356	0.3343	0.0520	0.3533	0.0370	0.3482	0.0693
1976	0.2151	0.0301	0.1118	0.0411	0.2027	0.0330	0.1853	0.0739
1977	0.2149	0.0373	0.1413	0.0747	0.2472	0.0457	0.4619	0.1362
1978	0.2683	0.0400	0.3036	0.1042	0.1705	0.0331	0.1589	0.0922
1979	0.2110	0.0265	0.2456	0.0668	0.2170	0.0283	0.2016	0.0733
1980	0.1866	0.0238	0.2256	0.0481	0.1956	0.0264	0.2187	0.0597
1981	0.2074	0.0234	0.1909	0.0549	0.2367	0.0253	0.2117	0.0601
1982	0.3214	0.0510	0.1308	0.0821	0.2727	0.0475	0.3829	0.1081
1983	0.2654	0.0304	0.2176	0.0651	0.2439	0.0300	0.3640	0.1189
1984	0.1869	0.0277	0.1430	0.0434	0.1962	0.0275	0.2553	0.0752
$\bar{x}$	0.2389	0.0080	0.2055	0.0152	0.2310	0.0081	0.2561	0.0207

and adult mean annual harvest rates for males ($P = 0.05$). The young had the higher harvest rate. For females the young had a 3% lower harvest rate than the adults, but the difference was not significant ($P = 0.26$) using the same test. Mean harvest rates of young male and female quail were not significantly different ($P = 0.69$). However, adult females had a higher ($P = 0.05$) mean harvest than adult males by 5%.

In analogy to Table 2 for survival rates, Table 4 presents harvest rates for males, females, and combined sexes using Model 1 of program ESTIMATE. The male and female mean estimates are almost identical. Combined sex mean annual harvest rates varied substantially with a low of 17% in 1971 and a high of 35% in 1975. The combined sex mean annual harvest rate was 23.3 ± 0.53%. A 22% crippling loss rate (Doster et al. 1982) implies a mean annual kill of 29.8%.

We fitted the ultrastructural model of Anderson et al. (1982) to the male and female data separately and to the combined sex data. Because age differences were not significant in previous analyses, we ignored age to increase precision of the estimates. In all 3 cases, we were unable to reject the null hypothesis of complete additivity (H_0: $\beta = 1$, H_1: $\beta < 1$). For the male and combined sex data we rejected the null hypothesis of complete compensation (H_0: $\beta = 0$, H_1: $\beta > 0$). These tests provided strong evidence in favor of additivity of hunting and natural mortality for this bobwhite quail population.

DISCUSSION

Adult quail had slightly higher survival rates than juveniles. The young birds were almost 1 year old when banded and were probably physiologically and behaviorally equivalent to adults. We found a significantly higher rate of mean annual survival for male quail (18.7%) than for females (14.3%). We anticipated this finding because adult bobwhite sex ratios are characteristically biased in favor of males although the ratio of hatching is 1:1 (Stoddard 1931, Rosene 1969). The substantial variation in survival rates among years probably resulted form variation in natural mortality and hunting mortality from year to year. These survival rates were lower than those reported by Curtis et al. (1988) for the same research station using radio telemetry. However, in the area they studied, no hunting was allowed, which makes a comparison difficult.

Our survival estimates could be biased low if there was any banding induced mortality (Brownie et al. 1985). We do not believe this is a serious problem. Many quail were caught repeatedly in the traps and searches of the areas around the traps never revealed dead quail. Another possible source of negative bias on our survival estimates is band loss (Brownie et al. 1985). This was not a problem in our study. Many quail were double banded and when recaptured all quail retained both bands.

Table 4. Annual harvest rate (HR) estimates and standard errors (Brownie et al. 1985) for northern bobwhite quail sex classes, pooled over ages, banded at Tall Timbers, Florida, 1970–85.

	Male		Female		Combined	
Year	HR	SE	HR	SE	HR	SE
1970	0.1687	0.0169	0.2071	0.0191	0.1862	0.0127
1971	0.1734	0.0163	0.1654	0.0166	0.1700	0.0116
1972	0.2093	0.0168	0.2185	0.0191	0.2135	0.0126
1973	0.2729	0.0221	0.2641	0.0237	0.2685	0.0162
1974	0.2843	0.0286	0.2517	0.0316	0.2689	0.0212
1975	0.3457	0.0293	0.3492	0.0326	0.3464	0.0218
1976	0.1937	0.0251	0.2027	0.0300	0.1974	0.0193
1977	0.1947	0.0326	0.2680	0.0435	0.2239	0.0263
1978	0.2729	0.0371	0.1642	0.0307	0.2166	0.0240
1979	0.2146	0.0245	0.2169	0.0263	0.2146	0.0179
1980	0.1909	0.0210	0.2007	0.0238	0.1944	0.0157
1981	0.2097	0.0215	0.2341	0.0233	0.2196	0.0157
1982	0.2972	0.0444	0.2843	0.0430	0.2877	0.0306
1983	0.2561	0.0275	0.2517	0.0290	0.2536	0.0199
1984	0.1695	0.0232	0.2023	0.0258	0.1838	0.0172
$\bar{x}$	0.2346	0.0073	0.2342	0.0078	0.2330	0.0053

The female adult harvest was higher than that of adult males by 5%, while for juveniles the mean harvest appeared to be equal for both sexes. Young males are more vulnerable to harvest by 3% compared to adult males. Young females also had a 3% lower harvest estimate than adult females but the difference was not significant. Results were consistent with our expectations except for the higher vulnerability of adult females compared to adult males. We have no biological explanation for this phenomenon and we know of no references in the literature supporting it.

The mean annual harvest estimates varied substantially in the early part of the study from a low of 17% in 1971 to a high of 35% in 1975. After 1975 researchers made a concerted effort to keep the harvest consistent from year to year and this is revealed by the estimates. However, it was not possible to standardize completely and harvest rates fluctuated from 18 to 28% in later years.

We partitioned our mortality estimates into hunting and natural mortality. Mean annual mortality rates were 81.3 and 85.7% for males and females, respectively. We applied the 29.8% kill rate calculated earlier and obtained crude natural mortality estimates of 51.5 and 55.9% for males and females, respectively. If hunting mortality is viewed as additive, this population was under substantial hunting pressure.

Our data strongly suggests that under this harvest system, the mortality processes were additive. This result by itself makes our study of particular value. We emphasize, however, that the harvest in this study was not synchronous with typical bobwhite hunting reasons. We harvested for approximately 10 days from about 7 February to 21 February each year. This is 2 months later than a typical hunting season. Roseberry (1979) pointed out that late season harvests tended to be additive. Roseberry and Klimstra (1972) and Roseberry (1979) noted a degree of compensation in bobwhite populations harvested under typical hunting chronologies. Anderson and Burnham (1981) criticized Roseberry (1979) for the methodology used; Roseberry (1981) responded. Curtis et al. (1988) documented high natural mortality during January–March on bobwhite at Tall Timbers in an unhunted population. With the harvest occurring at the time of high natural mortality it is hard to come up with a compensation mechanism. However, if the harvest were over before the high natural mortality, a reduction in natural mortality due to reduced density would provide a density dependent mechanism. We believe a banding study similar to ours with harvest at the time of typical hunting seasons could provide a valuable test of additive versus compensatory mortality hypotheses.

LITERATURE CITED

ANDERSON, D. R., AND K. P. BURNHAM. 1976. Population ecology of the mallard: VI. The effects

of exploitation on survival. U.S. Fish and Wildl. Serv. Resour. Publ. 128. 66pp.

———, AND ———. 1981. Bobwhite population responses to exploitation: two problems. J. Wildl. Manage. 45:1052–1054.

———, ———, AND G. C. WHITE. 1982. The effect of exploitation on annual survival rate in mallard ducks: an ultrastructural model. Pages 33–39 *in* Proc. Eleventh Int. Biom. Conf. Biom. Soc., Washington, D.C.

BROWNIE, C., D. R. ANDERSON, K. P. BURNHAM, AND D. S. ROBSON. 1985. Statistical inference from band recovery data—a handbook. Second ed. U.S. Fish and Wildl. Serv. Resour. Publ. 156. 305pp.

Burnham, K. P., and D. R. Anderson. 1984. Tests of compensatory vs. additive hypotheses of mortality in mallards. Ecology 65:105–112.

———, G. C. WHITE, AND D. R. ANDERSON. 1984. Estimating the effect of hunting on annual survival rates of adult mallards. J. Wildl. Manage. 48:350–361.

CURTIS, P. D., B. S. MUELLER, P. D. DOERR, AND C. F. ROBINETTE. 1988. Seasonal survival of radio-marked northern bobwhite quail from hunted and non hunted populations. Int. Radio-telemetry Symp. In Press.

DIMMICK, R. W., F. E. KELLOGG, AND G. L. DOSTER. 1982. Estimating bobwhite population size by direct counts and the Lincoln Index. Proc. Natl. Bobwhite Quail Symp. 2:13–18.

DOSTER, G. L., F. E. KELLOGG, W. R. DAVIDSON, AND W. M. MARTIN. 1982. Hunter success and crippling losses for bobwhite quail. Proc. Natl. Bobwhite Quail Symp. 2:45–47.

ERRINGTON, P. L. 1933. Mobility of northern bobwhite as indicated by banding returns. Bird-Banding 4:1–8.

KELLOGG, F. E., G. L. DOSTER, W. R. DAVIDSON, AND W. M. MARTIN. 1982. Efficiency of dogs in locating bobwhites. Proc. Natl. Bobwhite Quail Symp. 2:31–34.

NICHOLS, J. D., M. J. CONROY, D. R. ANDERSON, AND K. P. BURNHAM. 1984. Compensatory mortality in waterfowl populations. A review of the evidence and implications for research and management. Trans. North Am. Wildl. Nat. Resour. Conf. 49:535–554.

———, AND J. E. HINES. 1983. The relationship between harvest and survival rates of mallards: a straightforward approach with partitioned data sets. J. Wildl. Manage. 47:334–348.

ROSEBERRY, J. L. 1979. Bobwhite population responses to exploitation: real and simulated. J. Wildl. Manage. 43:285–305.

———. 1981. Bobwhite population responses: a reply. J. Wildl. Manage. 45:1054–1056.

———, AND W. D. KLIMSTRA. 1972. Some aspects of the dynamics of a hunted bobwhite population. Proc. Natl. Bobwhite Quail Symp. 1:268–282.

ROSENE, W., JR. 1969. The bobwhite quail; its life and management. Rutgers Univ. Press, New Brunswick, N.J. 418pp.

SMITH, G. F. 1980. A ten-year study of bobwhite quail movement patterns. M.S. Thesis, Univ. Georgia, Athens. 56pp.

STODDARD, H. L. 1931. The bobwhite quail—its habits, preservation and increase. Charles Scribner's Sons, New York, N.Y. 559pp.

WHITE, G. C. 1983. Numerical estimation of survival rates from band-recovery and biotelemetry data. J. Wildl. Manage. 47:716–728.

Received 9 March 1988.
Accepted 30 August 1988.