Northern Bobwhite Population Characteristics, Productivity, and Hen Survival in West Central Louisiana

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Abstract: We examined aspects of northern bobwhite (*Colinus virginianus*; hereafter quail) population dynamics in longleaf pine (*Pinus palustris*) forests on the Vernon Ranger District, Kisatchie National Forest, located in west central Louisiana. We used sex, age, and weight data from 246 birds captured a total of 404 times during 9 February–20 June 1991–1993 in baited traps to describe population characteristics. We used data from 128 (106 F:22 M) birds trapped, radio tagged, and monitored during 3 field seasons to describe productivity and survival of these birds during March through August. The best-fit linear-logistic model (G2 = 7.42, 5 df, $P = 0.1912$) indicated that proportions of second year (SY) birds captured during spring depended on year; but sex ratios of captured birds were independent of year. Thus, we estimated that the breeding population contained 42.4 ± 3.1% (mean ± 1 SE) females and the proportion of SY birds varied among 62.5 ± 7.1%, 46.2 ± 5.3%, and 66.4 ± 4.6% during 1991, 1992, and 1993 respectively. Adult birds were consistently (no significant interactions with year or day, $P > 0.1$) 4.1% heavier than SY birds (168 ± 1.2 g vs. 161 ± 1.1 g). We observed no difference in the relationship between body mass and sample date among years ($P > 0.1$), but females experienced a curvilinear change in mass compared to males, which decreased at a rate of 0.12 ± 0.03 g/day. Average clutch size for 39 completed nests pooled over years was 13.3 ± 0.4. Pooled estimated nest success was 48 ± 8%. Of 40 nests found, 19 produced hatchlings for an average production rate of 5.9 ± 1.0 hatchlings per clutch, but 12.4 ± 0.4 hatchlings per successful nest. Proportional

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hazards regression models indicated that hen survival was not affected by age ($P = 0.25$), but that hens were 1.8 times as likely to die ($P = 0.05$) during 1992 than during 1991 and 1993. Estimated 150-day (Mar–Jul) survival rates for hens were 16 ± 4% during 1992 and 36 ± 4% during 1991 and 1993, which were lower or similar to several other studies of breeding season mortality.

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Church et al. (1993) documented a national downward trend in quail populations during recent decades. In the southeastern United States, changing agricultural practices have decreased the capability and availability of quail habitat (Klimstra 1982). Pine (*Pinus* spp.) and mixed pine-hardwood forests are the primary quail habitats today (Bell et al. 1985). Several pine-dominated national forests in the southeastern United States provide habitat to endangered red-cockaded woodpeckers (*Picoides borealis*), and land management plans designed to benefit red-cockaded woodpeckers are often perceived to benefit quail (Brennan 1991). If these species are coupled, portrayal of silvicultural prescriptions as beneficial to both a threatened species and a popular small game animal may create more common ground among local stakeholders. To establish this link, wildlife managers need good baseline information on spring/summer quail population dynamics so that effects of habitat prescriptions can be gauged (Brennan 1993).

As part of the Louisiana Cooperative Quail Project, we investigated population characteristics, productivity and spring-summer survival (mid Feb–mid Aug) of quail on the Vernon Ranger District, Kisatchie National Forest (hereafter Vernon District) in west central Louisiana during 1991–1993. We examined these aspects of quail biology in the Vernon District for 3 reasons. First, Kisatchie National Forest, particularly the Vernon District, offers the best quail public hunting opportunities within Louisiana. Second, management guidelines for the Vernon District along with others soon to be implemented are designed to benefit its abundant red-cockaded woodpecker population and other wildlife. Finally, we noticed that wing survey data for west central Louisiana had a lower juvenile quail proportion than southeastern Louisiana (unpubl. data, La. Dep. Wildl. and Fish. [LDWF], Baton Rouge). This study sets a base for further tests of regional differences in quail productivity and survival within Louisiana.

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Methods

Study Area

The Vernon District is located approximately 30–45 km southeast of Leesville, Louisiana (30° 55'–31° 05' lat., 92° 55'–93° 15' long.). Fort Polk Military Reservation is adjacent to the 34,400 ha national forest (U.S. For. Serv. 1988). Gently rolling topography intersected by numerous drainages is characteristic of the area. Longleaf and slash pine (*P. elliottii*) dominate the overstory vegetation. Understory vegetation is mainly bluestem (*Andropogon* spp., *Schizachyrium* spp.) and panicum (*Panicum* spp., *Dichanthelium* spp.) grasses (Pearson et al. 1987). Soils are generally fine sandy loams (U.S. Conserv. Serv. 1989) and of low fertility (St. Amant 1959). Prescribed fire is applied during winter on a 3-year rotation over most of the Vernon District (Pearson et al. 1987).

In 1990, a quail management area, approximately 2,000 to 2,500 ha, was established on the eastern side of the Vernon District. The area is bounded by Six-Mile Creek on the west, Fort Polk Military Reservation on the north, State Road 463 on the east, and Forest Service Road 449 on the south. During early 1991, the management area was the focal point for the study. Due to poor trapping success in March 1991, we expanded the study area in April approximately 6.5 km to the west. During 1992 and 1993, we included the entire Vernon District to increase the likelihood of radio tagging 60 female birds/year.

Trapping and Telemetry Techniques

Quail were located by using a tape-recorded quail "covey" call played at dawn when birds leave the night roost and frequently call to one another (Stoddard 1931). We subsequently established bait sites in areas where quail responded to the tape. In 1991, we captured birds beginning mid-March by using a collapsible trap (Smith et al. 1981). We cleared a 1 × 1 m site of vegetation and baited it using cracked corn and wheat. After quail began using a baited site, a trap was set over the bait. During 1992 and 1993, we used modified lily-pad traps (Backs et al. 1985) and collapsible traps. Modified lily-pad traps were placed in travel corridors or stretched through large thickets.

We checked traps once daily sufficiently near dusk to minimize chances of catching birds after traps had been checked while allowing enough time for trapped birds to find a roost site after release. We marked captured birds with aluminum legbands (size 7, Natl. Band and Tag Co., Newport, Ky.), weighed (±1 g) them and determined their sex and age (adult or second year [SY]) by plumage characteristics (Rosene 1969:44–45). All females and a few males were equipped with 5–6 g 150–152 MHz crop-mount radio transmitters. Transmitter vendors differed among years (Am. Wildl. Enterprises, Tallahassee, Fla., 1991; Wildl. Mat., Carbondale, Ill., 1992 and 1993). We used vehicle-mounted, null-peak antenna system (4-element), 2 handheld, directional antennas (a 3-element and a 2-element), and a portable radio receiver to locate birds.

Population Characteristics

We used linear logistic models to test for relationships among proportions of birds captured according to sex, age, and year (Feinberg 1977). We produced estimates of population characteristics based on "best-fit" models. We grouped birds according to sex, age, and year of capture and compared weight changes through the capture period. We used mixed model procedures (PROC MIXED; Littell et al. 1996) to test for differences among cohorts while accounting for covariance among repeated measurements.

Productivity and Survival

We defined productivity based upon clutch size, nest success, hatching success, and chick survival. After the breeding season began (April–May), we conducted daily searches for radio-tagged hens' nests. We marked nest sites with flagging ribbon (tied such that ribbon did not flutter in the breeze) 20–25 m away from the nest site to avoid attracting predators to nests. To determine clutch size, we inspected clutches every 2 days when hens were absent from nests until clutch size remained constant. Hens on active nests were visited daily and checked with telemetry equipment approximately 25–30 m from the nest during incubation. At all times, nest sites were minimally disturbed so as to avoid interrupting incubating birds and leading predators to nests. A rank sum test was used to detect differences in clutch sizes between years.

We defined nesting success as the ratio of nests producing at least 1 hatchling to total nests and hatching success as the ratio of hatchlings to number of eggs. Brood members were counted when 4 weeks old to assess fledging success (ratio of birds fledging to birds hatching). Attempts to measure weekly survival by counting chicks at their night roost proved futile because dense, brushy roosting cover made it difficult to approach roosting hens and broods without disturbance. Approaching roosts to within 4–5 m caused a distressed, agitated behavior in brooding hens. Because chicks are hidden under hens, inaccurate counts would result without actually flushing the hen. Fisher's Exact test was used to detect differences in nest success and hatching success between years. A rank sum test was used to detect differences in number of hatchlings per clutch among years (Heisey 1987).

From date of capture until late August, we checked radio-tagged quail daily to observe survival. Observing day-to-day location direction changes for each bird was used to indicate if birds were alive. At least once a week, we visually checked birds by homing toward the radio signal (White and Garrott 1990:42). Upon finding a dead bird, we attempted to identify causes of mortality by inspection of the carcass, radio tag (best source of identification), and the immediate area where the transmitter was found. Predators unable to puncture the enamel coating of the radio were identified as avian predators. Terrestrial predators left tooth marks. We used proportional hazards regression (PROC PHREG; Allison 1995) to test for differences between ages, among years, and with varying initial capture weight. We used the counting method approach to account for delayed entry of birds into the risk set and used 1 March as the origin. To arrive at a final model, we used backward stepwise elimination of insignificant ($P > 0.1$) terms. We used Kaplan-Meier procedures (Pollock et al. 1989) to estimate 150-day survival rates and depict survival curves for different groups of birds.

Unless otherwise noted, all estimated values such as means, proportions, and survival rates are reported as estimates ±1 standard error of the estimate.

Results and Discussion

Population Characteristics

During the 3 years of this study, we captured 246 birds a total of 404 times during 9 February–20 June 1991–1993 (Table 1). Lily-pad traps accounted for approximately 64% of all captures during the 1992 field season. The best-fit linear-logistic model ($G2 = 7.42$, 5 df, $P = 0.1912$) indicated that proportions of SY birds captured during spring depended on year, but sex ratios of captured birds were independent of year. Thus, we estimated the population contained 42.4 ± 3.1% females overall and 62.5 ± 7.1%, 46.2 ± 5.3%, and 66.4 ± 4.6% juveniles during 1991, 1992, 1993 respectively. Most age ratios reported for quail populations are based on fall hunting season wing surveys. Such age ratio estimates generally show a high juvenile proportion (usually 70% to 80%) (Rosene 1969). In some studies, no difference has been found in age ratios from fall to spring (Marsden and Basket 1958, Kabat and Thompson 1963). Other studies (Bennitt 1951, Rosene 1969, Simpson 1976) found reductions in juvenile percentages from fall to spring. Most reductions were attributed to the vulnerability of juveniles to shooting. Without data on fall percentages of juveniles, we cannot say if there had been a reduction in either adults or juveniles. The age ratios in 1991 and 1993 were similar to those reported by Olinde and Kimmel (1992, 1993) and Reid and Goodrum (1960) for birds taken by hunting in west central Louisiana. If our spring and summer data for 1992 accurately reflect the 1991 fall age ratio, a poor hatching success or poor chick survival seems likely for 1991 breeding season. However, Olinde and Kimmel (1992) found 80 ± 2% juveniles in the harvest, which suggests that our spring ratios did not reflect the regional production index. Observing more adults than SY birds is inconsistent with present knowledge

Table 1. Sex and ages of northern bobwhite captured (radio tagged) during 9 February–20 June 1991–1993 in west central Louisiana.

	Females		Males[a]		
Year	Adult	SY	Adult	SY	Total
1991	8 (8)	11 (11)	10 (3)	19 (4)	48 (28)[b]
1992	15 (15)	23 (23)	34 (0)	19 (0)	91 (38)
1993	14 (14)	35 (35)	22 (6)	36 (7)	107 (62)
Total	37 (37)	69 (69)	66 (9)	74 (11)	246 (128)[b]

a. Table body excludes 4 males of unknown age used to calculate sex ratio.

b. Radio2tagged total includes 2 males of unknown age.

of quail population dynamics and would require large differences in fall-spring survival of adult and hatch year birds (see Burger et al. 1995). Our observed 1992 age ratio remains an enigma.

In quail populations, sex ratios slightly favor males (Leopold 1945, Bennitt 1951, Kabat and Thompson 1963, Simpson 1976), but with a 50:50 sex ratio at hatching (Rosene 1969). After birds pass their first winter, the sex ratio is skewed toward males (Stoddard 1931). Our results are consistent with these previous observations.

Inspection of the complete mixed model (one assuming separate, quadratic regression lines among all sex, age, and year groupings) indicated that rates of weight change were heterogenous overall, but that weight changes were similar among years and between birds of the same sex. Relying upon the principle of conditional error, we chose the most parsimonious model to explain these weight data. The final model included a significant difference due to age (F = 18.56; df 1, 135; $P < 0.0001$), a linear decrease of male weights with date of capture ($\beta = -0.12 \pm 0.03$; F = 16.4; df 1, 135, $P < 0.0001$) and linear ($\beta = -0.33 \pm 0.09$; F = 12.97; df 1, 135 $P < 0.0004$) plus quadratic ($\beta = -0.0025 \pm 0.00068$ F = 13.4; df 1, 135, $P < 0.0004$) terms relating female weight to date of capture (Fig. 1). Adult birds were consistently (no significant interactions with year or day $P > 0.1$) 4.1% heavier than SY birds (168 ± 1.2 g vs. 161 ± 1.1 g). The heaviest male, caught 12 February 1992, was an adult weighing 200 g. The same bird was recaptured 2 and 5 days later and weighed 195 g and 189 g, respectively. An SY male, caught 12 February 1992, weighed 198 g (the heaviest SY male). Two adult females were captured that weighed > 200 g (Fig. 1).

Quail average monthly weights were slightly higher in our study than those reported by Perkins (1952) for birds in southwest Louisiana. Weight changes were comparable to weight cycles described by Roseberry and Klimstra (1971). The mean weights of males decreased 0.12 g/day, which mimicked the pattern observed by Roseberry and Klimstra (1971) but at an apparently reduced rate (0.12 g/day vs. ~0.2 g/day). Variations in female weights over time were also less dramatic than what these authors observed. Weight losses have been attributed to energy loss during pair formation, territory defense, and brood rearing (Rosene 1969). Mean weights either decrease or remain stable until mid-March and then increased. Size increases in the reproductive organs coincided with weight increases in hens (Rosene 1969). Hamilton (1957) found that males lost weight and females gained weight from early spring and summer. Roseberry and Klimstra (1984) found that weights correspond almost exactly with the breeding season in that females increased weight and males decreased weight during the spring.

Productivity

Average clutch size of 39 completed clutches pooled across years was 13.3 ± 0.4. Of 40 nests found, 19 (48 ± 8%) successfully hatched a total of 236 chicks. This equates to an average production rate of 5.9 ± 1.0 hatchlings per clutch, but 12.4 ± 0.4 hatchlings per successful nest. We observed no evidence that nest success differed among years ($P = 0.32$), but small sample sizes hindered our ability to detect

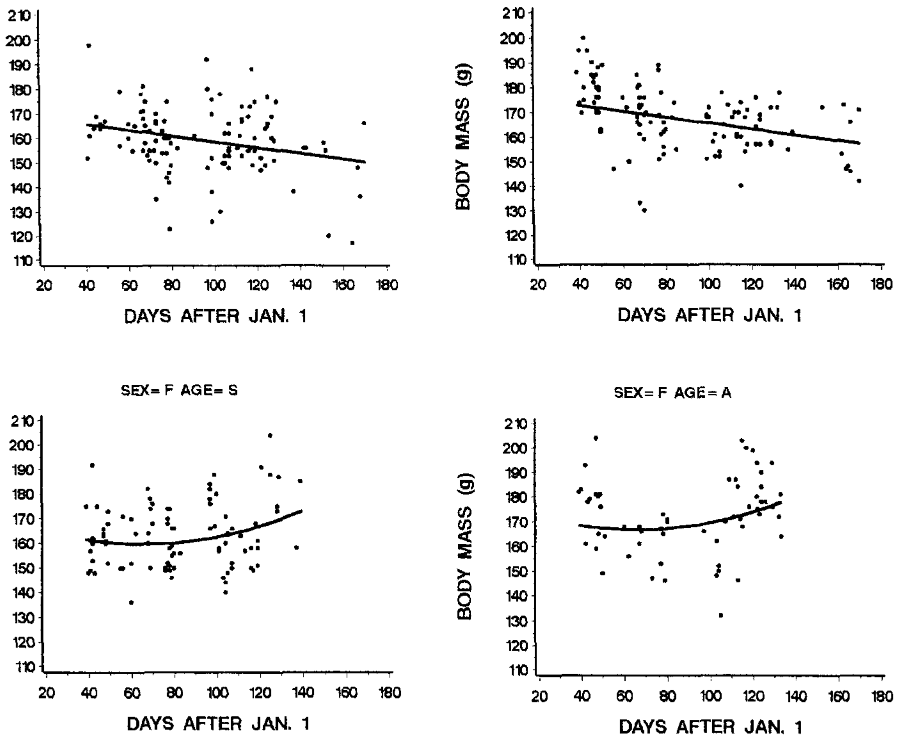

Figure 1. Seasonal weight patterns observed in 246 northern bobwhites captured 404 times during 9 February–20 June 1991–1993 in west central Louisiana.

even modest differences. We also note that during 1992, eggs from 4 nests were in the process of hatching when fire ants attacked and destroyed all eggs and hatchlings. Clutch and hatch sizes were slightly higher than observed by Simpson (1976) in southwest Georgia (12.0 eggs/nest and 10.1 hatchlings/successful nest). Nest success was much higher than 18.1% observed by Simpson (1976) and 23.0% observed by Dimmick (1975) and higher than 33% reported by Roseberry and Klimstra (1984). We observed 2 instances of apparent polyandry resulting in 4 nests incubated principally by males and 5 instances of extended male incubation following mortality of the female. Stoddard (1931) reported that males incubated 25% of nests. Curtis et al. (1993) documented both polyandry and male incubation of nests following the mortality of a hen. Inter-study comparisons of nest success are often difficult because studies that rely on nest searches may fail to account for nests destroyed before they are discovered (i.e., no adjustment similar to Mayfield Method). Hens spent little time at the nest site prior to incubation; therefore, we may have missed nests failing early in laying. Nevertheless, we believe this population enjoyed relatively high nest success during our study.

We were only able to document chick loss through 4 weeks for 7 successfully hatched clutches. Chicks surviving to 4 weeks/number hatched were 8/8, 12/12, 7/14, 8/12, 11/14, 0/12, and 0/12 or 55 ± 5% overall. For another 12 successfully hatched clutches, hens died (5) or were lost (3) prior to 4 weeks after hatching, were hatched by untagged males (2), or hatched $<$ 4 weeks from the termination of field work (2); for these 12 clutches we could not determine chick loss.

The relatively high nesting success rate that we observed may be attributed in part to the region's generally low fertility and low rainfall compared to other areas in the Southeast. Except for a brief period following the harvest of the virgin longleaf forest, west central Louisiana supported relatively low numbers of quail, about 1 bird per 30 acres (St. Amant 1959). The management practices on the Vernon District for red-cockaded woodpeckers have resulted in an extremely open habitat on the uplands. Vegetation characteristics and lower fertility result in few prey, including quail, for meso-predators. As a consequence, meso-mammalian predators such as raccoons, skunks, and opossums are probably at lower densities than in southeast Louisiana or sites such as the Red Clay Hills in Georgia. Additionally, few woody corridors from bayheads and draws existed to distribute predators into uplands. Therefore, the likelihood of a nest predator encountering a quail is lower than that for higher fertility sites.

Survival

Although we radio tagged 106 female quail during our study, we excluded 10 birds from analysis that died or were otherwise censored during the first 7 days after capture. Of these 96 hens, 54 died, and we censored 33 hens due to our inability to detect their radio signal (e.g. radio failure, death and movement of radio tag out of our range, or emigration from the study area) prior to mid-August. We attributed 59%, 13%, and 6% of deaths to avian, mammalian, and reptilian predators, attributed another 13% of losses to predation by an unknown predator, and could not determine the cause of death for 5 (9%) birds.

Proportional hazards regression models indicated no effect due to age ($P = 0.20$) or initial weight ($P = 0.25$), but significantly lower ($P = 0.05$) survival during 1992 than during 1991 and 1993. Estimated 150-day (Mar–Jul) survival rates for hens were 16 ± 4% during 1992 and 36 ± 4% during 1991 and 1993 (Fig. 2). These estimates were lower than spring-fall survival of quail in Georgia (43.8%; Burger et al. 1998), similar to Missouri (33%; Burger et al. 1995), but possibly higher than north Florida (62-day survival of 55%; DeVos and Mueller 1993). If we assumed a constant hazard for the rest of the year (unlikely according to Burger et al. 1995, but see Burger et al. 1998), this equates to annual survival rates of 1.1% and 8.3%. These estimates bracket estimates for 2 populations in Missouri farmlands (5%; Burger et al. 1994, 1995) and 1 in North Carolina (6%; Curtis et al. 1988), but are below an estimated 14.3 ± 1.2% mean annual survival rate observed during a long-term banding study of quail in North Florida (Pollock et al. 1989). Burger et al. (1995) reasoned that quail populations with annual survival $\leq$10% are not likely sustainable. However, indexes of quail abundance for west central Louisiana were stable prior to and during our study (unpubl. data, LDWF, Baton Rouge, La.). Thus, either our estimates of spring-summer survival are biased low or assuming a constant hazard within a year is untenable.

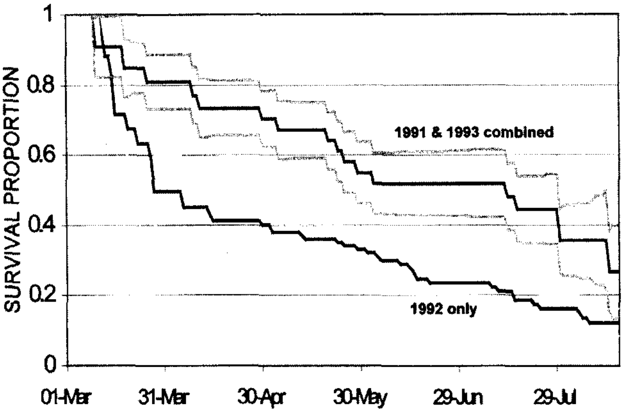

Figure 2. Survival rates of 54 and 32 radio-tagged northern bobwhite hens surviving ≥ 7 days monitored during March through August 1991 + 1993 and 1992, respectively, in west central Louisiana. Depicted are Kaplan-Meier curves and associated standard errors (calculated using staggered entry).

Although we accumulated >6,700 exposure days of data (2,798 adult and 3,953 SY),we were unable to detect differential survival rates for adult and SY hens. It seems likely that by March SY hens have accumulated sufficient experience to survive at similar rates to adults during spring-summer, especially given social behavior of quail during some of this period. We note that a fairly large, 15 year-long banding study (averaging 500 males + female banded/year) failed to detect age-specific differences in annual survival rates of hens (Pollock et al. 1989).

Management Implications

The Vernon District currently supports a relatively stable population of quail at a low density. We found relatively high nest success, but low survival of breeders and potential breeders during spring-summer. To us, this implies that to enhance this population, efforts should be made to increase survival, especially in early spring and summer. We believe that survival could be enhanced in the Vernon District through vegetation manipulation that produces both escape and foraging cover during late winter and early spring. A recently proposed alternative management scheme for longleaf pine ecosystems (U.S. For. Serv. 1997) calls for increased use of controlled burning, but with greatly increased protection of drainages, intermittent or otherwise. Burn plans that protect a different 2- to 5-ha block per 50 ha burn each burning cycle would greatly benefit quail. Protected areas should not be close to riparian areas because such positioning might increase mammalian predator dispersal. Protected areas would provide residual grass and allow development of patchy woody cover close to forage. These actions should provide a substantial addition to winter habitat quality including increased fruit production. Woody development will add diversity to large open expanses of upland.

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