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ABSTRACT

We examined reproduction by relocated and resident northern bobwhites (*Colinus virginianus)* on an intensively managed 563-ha study area in Trinity County, eastern Texas. During the late winters of 1990–1992, 155 South Texas (84 hens, 71 cocks) and 136 East Texas (64 hens, 72 cocks) bobwhites were captured, radio-tagged, and relocated to the study area; 139 resident birds (73 hens, 66 cocks) were also captured, radio-tagged, and released at the point of capture. For the 3 years combined, the 33 South Texas, 33 East Texas, and 39 resident hens alive at the beginning of the breeding season produced 6, 13, and 22 documented nests ($P = 0.004$) and 0, 3, and 4 fledged broods. Pooled, the number of nests by East Texas and resident hens was higher than that of South Texas hens ($P = 0.003$); numbers of nests of East Texas and resident hens were similar ($P = 0.150$). Our results do not support relocation of South Texas bobwhites into the East Texas Pineywoods.

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INTRODUCTION

At one time, the northern bobwhite was considered the most important game bird of the southeastern United States (Mahan 1984). Historically, quail populations increased and decreased as man altered the environment. Land use practices associated with pioneer settlements were typified by patchy farming patterns which provided ideal quail habitat, resulting in population increases until about 1900. From the early 1900's to the mid-1940's, quail densities remained relatively high. However, since the mid-1940's, quail numbers have declined over much of the South (Mahan 1984, Brennan 1991).

As early as the late 1930's, state agencies began attempting to restore bobwhite populations (Lay 1965). Predator control, reduction in bag limits, and restocking of pen-raised and wild-trapped birds were attempted, usually with little success (Lay 1965, Coggins 1986). In eastern Texas, for example, up to 20,000 bobwhites wild-trapped in Mexico were released per year for several years prior to 1940. That effort was discontinued in 1940 because resident bobwhites were at carrying capacity (Lay 1965).

Almost without exception, declining northern bobwhite populations were due to habitat degradation; research demonstrated that the best way to restore bobwhite populations was to recreate suitable habitat conditions (Klimstra 1972). Within a given habitat, quail density is largely dependent on annual productivity and low nest success rates may be a major factor limiting reproduction (Stoddard 1931).

During 1989, Temple-Inland Forest Products Corporation initiated a project to restore the northern bobwhite population on a 563-ha portion of the South Boggy Slough Hunting Club in Trinity County, which is in the Pineywoods Ecological Region of eastern Texas (Gould 1975). The project involved creation of optimum bobwhite habitat and relocation of wild-trapped birds from South Texas and East Texas to the study area, which had a small remnant population (<

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25 birds) of native, resident bobwhites. Although a pilot study in Florida suggested that local bobwhites can be successfully relocated to suitable habitat (DeVos and Mueller 1989), no known study investigated nesting success of relocated birds. The objective of this study was to evaluate and compare nesting success of relocated and resident northern bobwhites.

METHODS

The study area, approximately 17 km southwest of Lufkin, Texas, was comprised of upland pine and mixed pine-hardwood forests. When habitat modifications were initiated, overstory trees were 50–60 years old and 27–34 m tall. Diameter at breast height averaged 35–45 cm and basal area ranged 20–27 m^2/ha. Habitat modifications included reduction of basal area to 9–13 m^2/ha by harvesting suppressed, intermediate, and some codominant trees. Patches of escape cover and food plots were established throughout the study area. When the young pine plantations are included, escape cover comprised approximately 30% of the study area. Food plots, described in detail by Parsons et al. (*this volume*), comprised approximately 20% of the study area.

Four hundred and thirty bobwhites were captured, radio-tagged, and released on the study area during January–March of 1990, 1991, and 1992. One hundred and fifty-five (84 hens, 71 cocks) South Texas bobwhites (*C. v. texanus*) (Johnsgard 1973) were captured on the King Ranch in Kleberg and Kenedy Counties Texas. Most East Texas birds (64 hens, 72 cocks) to be relocated were captured in forested areas on North Boggy Slough Hunting Club, approximately 15 km north of the study area. Both East Texas relocated and South Boggy resident birds (73 hens, 66 cocks), which were captured on the study area, are classified as *C. v. mexicanus* (Johnsgard 1973). Each captured bird was aged, weighed, checked for injuries, banded, and fitted with a frequency-specific chest-mounted transmitter. The transmitters, provided by American Wildlife Enterprises, were based on the design by Shields et al. (1982). Relocated birds were released in ≥ 4-bird coveys at predetermined sites throughout the study area; resident bobwhites were released at the point of capture. After release, birds were radio-located approximately 5 days per week throughout the breeding season and early fall; during the fall deer hunting season, radio-tracking was reduced to 2 to 3 days per week.

During the nesting season, which for the purpose of this study extended from 1 May–24 September, if a bird was radio-located in the same place for several days, the site was searched to determine if the bird was incubating eggs. If a nest was located, it was flagged and marked on a habitat map. When radio telemetry indicated that the bird had permanently left the nest, it was checked to determine clutch size and fate of the eggs. If possible, numbers of eggs laid and hatched were determined. Fate of the nest was classified as apparently successful if ≥ 1 egg hatched or apparently unsuccessful if not; if unsuccessful, it was classified as abandoned or destroyed by predators. Snake depredation was assumed when eggs in the nest disappeared and the dome of the nest cup remained intact. If integrity of the cup was damaged or destroyed, mammalian predation was assumed. If an incubating bird moved away from the nest area before the eggs hatched, the nest was classified as abandoned.

Bobwhites which produced chicks were intensively radio-tracked for at least 4 weeks after the eggs hatched (Parsons 1994, Parsons et al. *this volume*). Clutch size, numbers of eggs hatched per clutch, and numbers of broods fledged (i.e., capable of sustained flight) were examined using descriptive statistics. The numbers of nests recorded were compared among the 3 groups of bobwhite using Chi-square tests of homogeneity. Numbers of hens alive at the beginning of the nesting season, numbers of nests recorded, and numbers of hens for which no nest was found were used for these tests. The Chi-square tests computed the expected values using joint marginal probabilities for each cell and calculated Chi-square values using observed and calculated expected values. The null hypothesis was that there was no difference among the 3 sources of quail being compared. All statistical tests were performed at an alpha level of 0.05.

RESULTS

For the 3 years combined, there were 105 radio-tagged female bobwhites at the beginning of the nesting season (Table 1). Eighteen radio-tagged hens were alive at the end of the nesting season; 4, 6, and 8 hens were from South Texas, East Texas, and South Boggy, respectively. Forty-eight hens were known to be dead, and the signal was lost on 39, primarily due to transmitter failure, transmitter harness failure, or hens (either alive or dead) that simply could not be radio-located. Except for 1992, all hens actively radio-tracked throughout the nesting season definitely attempted to nest. In 1992, 1 East Texas and 3 South Boggy hens that lived through the breeding season were not observed nesting. However, nesting may have been disrupted before the nest could be located.

Forty-one nests were documented for 105 radio-tagged hens alive at the beginning of the 3 combined nesting seasons. Eggs in 13 of these nests hatched and 7 of the broods are known to have fledged. Numbers of nests varied among the reintroduction sources, with East Texas relocated and South Boggy resident hens producing at least 2 and 3 times, respectively, as many nests as South Texas relocated hens (X^2 = 12.865, 2df, P = 0.004) (Table 1). When nests produced by hens from eastern Texas (*C. v. mexicanus*) were pooled and compared to those by birds from southern Texas (*C. v. texanus*) the difference was also significant (X^2 = 12.840, 1df, P = 0.003). Conversely, numbers of nests produced by the 2 sources from eastern Texas were similar (X^2 = 0.025, 1df, P = 0.150) (Table 1).

Of the 13 broods produced by radio-tagged hens, 7 were known to have fledged. Two broods were lost to predation before fledging and fate of the remaining

Table 1. Numbers of relocated (South Texas and East Texas) and resident radio-tagged hens alive at the beginning of the nesting season (May 1) and numbers of documented nests, successful nests (≥1 egg hatched), and fledged (i.e., flying) broods produced by these hens in East Texas, 1990–1992.

Reintroduction source	Year	Hens	Nests		Fledged broods
			Recorded	Successful	
South Texas					
	1990	12	2	0	0
	1991	7	2	0	0
	1992	14	2	0	0
	Pooled	33	6	0	0
East Texas[a]					
	1990	9	3	2	2
	1991	3	3	1	0
	1992	21	7	1	1
	Pooled	33	13	4	3
Resident[a]					
	1990	5	2	2	1
	1991	16	12	4	1
	1992	18	8	3	2
	Pooled	39	22	9	4

[a] An East Texas hen and a resident hen each made 2 nesting attempts.

4 is unknown because contact with the radio-tagged parent was lost before the chicks fledged. East Texas cocks were recorded incubating 5 nests for which the hens could not be definitely identified; the 2 such 1990 nests were probably produced by East Texas hens. Two of these 5 were successful; 1 brood was definitely lost to predation and the cock that incubated the other disappeared before the chicks fledged. Two other east Texas cocks assumed incubation shortly after the hens (1 South Boggy, 1 East Texas) completed the clutches; the East Texas hen definitely nested again. One nest was successful and the brood fledged; the other nest was unsuccessful. Also, a South Boggy cock and an East Texas cock assumed incubation duties after the East Texas hens with which they appeared to be paired died; both nests were successful, but both cocks lost their transmitters before the chicks fledged. No South Texas cock was observed incubating eggs. Finally, 3 flightless broods and 7 fledged broods from unknown nests were also recorded; the 3 flightless broods all fledged. Most flightless and fledged broods for which no nests were found were the result of South Boggy or East Texas radio-tagged cocks paired with unknown hens.

Estimated clutch initiation dates were determined for the 46 nests and for the 10 flightless and fledged broods recorded during the study. Forty-six, 23, 21, 8, and 2% of the clutches were initiated during May, June, July, August, and September, respectively. Estimated hatching dates were determined for 25 clutches. Eggs in the majority of the nests hatched during June (32%) and July (36%); eggs in a few nests hatched in August (12%), September (16%), and October (4%). For 36 nests with complete clutches, mean number of eggs per nest was 12.4 (S.D. = 3.2). One clutch, with 8 eggs, was known to be a second nesting attempt by an East Texas hen which had lost an unknown number of eggs in her first attempt. Two South Boggy hens made second nesting attempts after their first nests, both with unknown numbers of eggs, were lost to predation; 1 nest was destroyed, and the other abandoned, before the clutches were complete. Average clutch sizes for 17 South Boggy, 11 East Texas, 4 South Texas, and 4 unknown-hen nests were 11.7, 12.2, 15.3, and 11.5 respectively. The number of eggs that hatched was known for 14 nests; for these, the mean was 12.1 (S.D. = 3.6). For the 17 fledged broods recorded, mean number of chicks was 8.3 (S.D. = 4.4).

DISCUSSION

Although numbers of hens alive at the beginning of the nesting season were similar among groups (Table 1), South Texas bobwhites produced fewer nests and fledged broods than did hens from the other groups. As a result, bobwhites relocated from South Texas probably contributed little to the observed population recovery on the study area. An associated genetic study supports this conclusion (Nedbal et al. 1997).

Survival during the nesting season is a major reason for the lower number of nests produced by South Texas hens. In a concurrent study, Liu et al. (*this volume*) found that South Texas bobwhites had lower survival through the breeding season than did East Texas and resident birds. During that period, South Texas bobwhites suffered higher predation rates than did other groups. The authors attributed this to differences in microhabitat selection on the study area.

South Texas hens that nested had little success fledging chicks. Only 5 nests with eggs were recorded; 4 were depredated by snakes, and an avian predator took the hen associated with the fifth nest before the eggs hatched. However, 2 broods assumed to have been produced by South Texas birds were recorded. In 1 case, a South Texas hen paired with a South Texas cock was known to be nesting, but the eggs hatched before the nest was located. However, a week after the chicks fledged, behavior of the adult bobwhites suggested that they had lost the chicks (Parsons 1994). The other South Texas hen was checked in late August

of 1990 and did not appear to be nesting. In early October, she was flushed with 10 flying chicks that may have been hers.

There were no obvious differences in nesting characteristics of the bobwhites in our study area and those elsewhere. Ninety percent of all nests were initiated during May, June, and July. In Illinois, Klimstra and Roseberry (1975) reported that 80% of clutches were initiated during the same 3 months. In our study, 80% of estimated hatching dates were in June, July, and August; 75% of clutches hatched during the same time period in Illinois (Klimstra and Roseberry 1975). For the 3 groups, mean clutch size in this study (12.4 eggs) was equal to that reported by Sloan (1987) in South Texas, and compares favorably to 12.9 and 13.6 observed by Parmalee (1955) in central Texas and Simpson (1972) in Georgia, respectively. The 4 known-size South Texas clutches averaged 15.3 eggs; all 4 were initiated in May, and thus were most likely first nests. Average clutch sizes for 5 East Texas and 7 resident nests produced in May were 13.6 and 12.1, respectively. In Missouri, Burger et al. (1995) reported an average clutch size of 15.2 eggs for first nests incubated by hens. Thirty-three percent of the documented nests were successful. If failed nests of the 5 South Texas birds are excluded, hatching rate increased to 37%. Both rates are similar to the 34% reported by Klimstra and Roseberry (1975), somewhat higher than the 27 and 28% reported by Sloan (1987) and Klimstra (1950), and lower than the 44 and 45% reported by Burger et al. (1995) and Lehmann (1984), respectively.

Twenty-four (52%) nests were lost to predation. Lehmann (1984) and Sloan (1987) reported losses of 46 and 53%, respectively, in South Texas. In other areas, predator-related nest losses of 37, 50, 37, and 38% were noted by Stoddard (1931), Klimstra (1950), Klimstra and Roseberry (1975), and Burger et al. (1995), respectively. Snakes depredated 22 (48%) of all known nests. Snake predation in this study was lower than the 50% reported by Sloan (1987) but much higher than the 25, 12, 12, and 17% reported by Jackson (1947), Klimstra and Roseberry (1975), Lehmann (1984), and Burger et al. (1995), respectively. At the time of our study, raccoons, coyotes, and wild hogs were hunted and trapped on the South Boggy Slough Hunting Club. The higher percentage of snake predation in this study may be the direct result of lowering these predator populations, thus reducing their depredation of bobwhite nests. In an effort to determine what species of snakes were preying on the eggs, remote cameras were placed at several nest sites. Although no pictures were taken of any nest predators, during the spring of 1992, 3 bobwhites were radio-located inside Texas rat snakes (*Elaphe obsoleta*); 2 of these birds were hens. Neither hen was known to be nesting but both had enlarged ovaries. This suggests that snakes depredated numerous nests before incubation began.

Five (11%) of the 46 nests were abandoned. This value is similar to the 11% reported by Jackson (1947) and Klimstra and Roseberry (1975), lower than the 20% recorded by Sloan (1987), and higher than the 5 and 2% observed by Lehmann (1984) and Burger et al. (1995). In our study, 2 of the 5 nests were abandoned soon after a remote camera was placed at the nest site. Also, a nest was abandoned after the hen was captured off the nest to replace the failed radio-transmitter. If the 3 nests knowingly disturbed are eliminated, nest abandonment in this study would be only 4%. Regardless, both values are relatively low when compared to most other studies. Perhaps in expanding populations, hens demonstrate stronger nest fidelity than in populations at carrying capacity.

Only 1 nest (2%) was depredated by mammals. This value was much lower than those recorded in other studies. Sloan (1987) and Burger et al. (1995) reported that 27 and 12% of all nests were depredated by mammals. Finally, although Parsons (1994) recorded an average of 1.9 fire ant (*Solenopsis invicta*) mounds within an 11-m radius of the nests, only 1 nest was apparently depredated by ants. At random points in the habitat, he recorded 2.1 mounds in the same size circle.

MANAGEMENT IMPLICATIONS

Before initiation of habitat modification, the land manager at the Boggy Slough area knew of only a small covey of bobwhites on the study area. By February 1992, there were an estimated 225 resident bobwhites on the study area (Liu et al. *this volume*). The design of our study did not allow us to compare the relative contributions of the 3 groups of bobwhites to the population increase. However, this study did demonstrate that bobwhites relocated from the South Texas Plains to the East Texas Pineywoods were inefficient in their ability to successfully nest, hatch eggs, and fledge chicks into the population. Conversely, there were no obvious differences in reproductive efficacy of resident bobwhites and those relocated to the study area from disjunct areas in the Pineywoods, especially when the contributions of East Texas cocks are included. If managers elect to modify forested areas and recreate suitable bobwhite habitat, it may be possible to enhance population recovery by stocking with wild-trapped birds from nearby areas. Conversely, although bobwhites in South Texas are often abundant and easy to capture, our data do not support using such birds to restore bobwhite populations in East Texas and the southeastern United States.

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