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RELEASING CAPTIVE-REARED MASKED BOBWHITES FOR POPULATION RECOVERY: A REVIEW

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ABSTRACT

Efforts to reestablish the endangered masked bobwhite (*Colinus virginianus ridgwayi*) to its former historic range have been a primary focus on the Buenos Aires National Wildlife Refuge (BANWR) since it was established in 1986. Prerelease conditioning techniques developed prior to refuge establishment continued to be utilized in an effort to improve postrelease survival of captive-reared masked bobwhite chicks. Foremost among these techniques was the use of wild Texas bobwhite (*C. v. texanus*) males as foster parents. Texas foster parents were released with broods from 1985–1996. The efficacy of this technique was evaluated in 1994 using radio telemetry. Results suggested that postrelease survival of chicks was poor. Using an adaptive approach, prerelease protocols were modified over several years in an effort to improve postrelease survival among chicks. Since 1995, released chicks were monitored via radio telemetry and results of the modified releases indicated survival had improved. Though these results are preliminary and this study is ongoing, it appears that our modifications to prerelease conditioning may improve survival rates of captive-reared masked bobwhite chicks. The results of this research project may have implications for captive-reared quail release projects elsewhere.

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INTRODUCTION

Historically, quail have been one of the most popular upland gamebirds throughout the United States (U.S.), and are of national importance to outdoor enthusiasts today. Recreational hunting opportunities have declined in recent years, largely due to a near ubiquitous decline in northern bobwhite (*Colinus virginianus)* populations nationwide (Brennan 1991). This unfortunate event has become a source of concern among both biologists and hunters. Habitat loss is the primary factor thought to be responsible for the northern bobwhite population decline (Brennan 1991). Therefore, many recent management programs have focused on improving habitat conditions. In many situations, aggressive habitat management is needed and such management actions often result in improved quail population levels, if a viable population is present before such habitat management actions are applied. Unfortunately, many areas throughout the U.S., that historically supported viable quail populations, no longer do so. Efforts to restore quail populations in areas where local extinctions have occurred often requires a reintroduction program.

Reintroducing quail into various parts of the country has been a controversial issue for decades. Stoddard (1931) discussed releasing both pen-reared birds as well as wild stock in the Southeast and believed quail reintroductions and translocations were worthwhile endeavors, especially if habitat conditions were suitable. However, Kabat and Thompson (1963) stated that releasing captive-reared birds in Wisconsin could not be justified due to chronic lack of success and the high expenses involved. In contrast, Kozicky (1993) believed reintroducing captive-reared birds to repopulate formerly occupied habitats, or to supplement wild populations at low densities, represented a major opportunity to enhance quail populations. He suggested the technique not be dismissed prematurely, and challenged scientists to develop a safe and efficient means of accomplishing successful captive-bred releases. Hurst et al. (1993) emphasized that additional research on methods of producing and releasing wild, disease-free quail must be developed before they could fully endorse the technique.

Unfortunately, the U.S. Department of the Interior, Fish and Wildlife Service (USDI, FWS) often does not have the luxury of debating the deficiencies and merits of reestablishing endangered species to historic habitats. The USDI, FWS has a legal mandate to restore an endangered species to habitats the species formerly occupied within the U.S. as part of the recovery process. In many cases, releasing captive-reared birds and

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mammals may be the only viable alternative. Such is the case with the endangered masked bobwhite, which was extirpated from the U.S. about 1900 (Brown 1900, 1904).

The masked bobwhite occupies a limited geographic range and is presently thought to be restricted to the Buenos Aires National Wildlife Refuge (BANWR) in southeastern Arizona and two privately owned ranches in northwestern Sonora, Mexico. Masked bobwhite life history is documented by Tomlinson (1972) and Brown (1989), and recovery history is documented in the Recovery Plan (U.S. Fish and Wildlife Service 1995) as well as by Kuvlesky et al. (*this volume*). The USDI, FWS launched a propagation and release research program using captive-reared masked bobwhite chicks during the 1970's. The agency attempted to reestablish a self-sustaining population in the Altar Valley of Arizona for almost 15 years (Kuvlesky et al. *this volume*). Though a self-sustaining population never materialized, several important release techniques were developed during this period (Ellis and Tomlinson 1974, Ellis et al. 1978, Ellis and Carpenter 1981) that were eventually adopted by BANWR when it was established in 1986 (Kuvlesky et al. *this volume*). In our paper, these techniques will henceforth be referred to as the "*established*" propagation and release techniques. USFWS biologists believed the continued use of established techniques would have eventually resulted in success had sufficient habitat been protected from livestock grazing. Since livestock were not permitted on BANWR, it was assumed that application of the established techniques would inevitably yield a self-sustaining masked bobwhite population on BANWR.

Established propagation and release techniques were used for 10 years and succeeded in establishing a breeding population of masked bobwhites. However, doubt remained as to whether a self-sustaining population had been established. Postrelease survival of chicks seemed poor, and this prompted questions regarding the efficacy of the established protocols. The effectiveness of using Texas bobwhites, for example, was seriously questioned because chick telemetry studies and field observations indicated broods and foster parents were not staying together following release. It was possible that foster parents were abandoning their "adopted" broods for receptive masked bobwhite hens, because releases occurred during the masked bobwhite breeding season. It was also possible that chicks did not stay with foster parents because imprinting had not occurred. Because of these concerns, the 1995 Recovery Committee recommended significant changes to the established propagation and release protocols. They believed such changes would yield improved postrelease chick survival (U.S. Fish and Wildlife Service 1996). The Recovery Committee's recommendations were implemented during summer 1995 and have continued, with modifications, to date. The purpose of our paper is to: (1) describe the prerelease conditioning techniques used from 1994 to 1998, and; (2) to compare the survival of chicks released under established protocols in 1994 with those released under the new protocols from 1995 to 1998. In addition, we briefly discuss the implications that prerelease conditioning has on masked bobwhite recovery as well as for the reestablishment of other quail populations throughout the country.

STUDY AREA AND METHODS

The evaluation of prerelease conditioning techniques on BANWR began during June 1994 and continued each year through 1998. BANWR is located in southeastern Arizona approximately 97 km south of Tucson. The Refuge consists of over 48,000 ha of semidesert grassland, which is described in detail by McLaughlin (1992) and Burgess (1995), with elevations in the grassland ranging between 975–1159 m above sea level. Soils and vegetation were similar on all sites used in this study. Annual precipitation averages 48 cm and is bimodally distributed in the form of intense late summer thunderstorms (July to September) and more uniform winter precipitation (November to February). Average annual temperatures are between 13–16 ° C (McClaran 1995) with 60–90 days of frost during winter and more than 60 days of hot weather (≥27° C) during May, June, and July.

Prerelease Conditioning Techniques: 1994

Masked bobwhite chicks utilized during 1994 were obtained from a captive population maintained by the Patuxent Environmental Research Center (PERC) in Laurel, Maryland. Established propagation and release protocols were utilized in 1994. Prerelease conditioning involved pairing a brood of 12–15 2-week old chicks with a sterilized Texas male foster parent (Ellis and Carpenter 1981) in a standard Petersime poultry brooder unit. If the prospective foster parent displayed aggressive, protective behavior of a brood the adoption was considered successful. The foster parent was partitioned on the brooder shelf by a wire mesh wall that allowed the chicks to move in and out of the area confining the adult. This ensured the safety of the chicks if, for some reason, the adult did not adopt them. For all successful adoptions, foster parents and their respective broods were marked with individually numbered aluminum leg bands or wing-mounted patagial tags. Family groups were maintained in brooder units for 1 week, then transferred to elevated outdoor caged runs (20cm × 0.5m × 3m) where they were given water and commercial gamebird starter feed. The runs consisted of a wood frame with wire mesh floor and sides and an aviary netting top. Fiberglass roof panels (0.3 × 0.3m) on each end of the run provided shade and cover. Half of the groups remained in these runs for 2 weeks and then were released to the wild. The other half were placed on the ground in flight pens (4 × 5 × 10m) after spending 1 week in the runs and were held for an additional week before they were released. Flight pens were constructed of metal post frames, covered with aviary netting which were secured to the metal frame, and then planted to native grass and watered regularly to encourage lush

herbaceous growth and insect abundance. Family groups had the opportunity to forage for native food although supplemental food and water were also provided. Family groups were gathered during the morning of the designated release day, a transmitter was attached to a chick and the adult, and the group was transported via a wooden release box (15cm × 0.5m × 0.7m) to a site. They were then released under a shrub with a dense herbaceous understory. At release, chicks were about 4.5-weeks old. Releases were conducted from early August to late September. During this period, 213 chicks were released as 15 family groups (average brood size = 14.2). Within these groups, 15 Texas bobwhite adults and 10 masked bobwhite chicks were fitted with transmitters.

Preconditioning Release Techniques: 1995

In an effort to improve postrelease chick survival, modifications were made to the established prerelease protocol in 1995. In addition to 2-week-old chicks, PERC also shipped 1-day-old chicks to the BANWR because biologists believed that day-old chicks would imprint more readily on the adult foster parents than 2-week-old birds. Both Texas bobwhite males and adult masked bobwhite males and females were used as foster parents. Twenty chicks were placed on each brooder unit shelf with their prospective foster parent. Heat and light levels in brooder units were slowly manipulated to ensure that chicks would be better adapted to natural conditions when they were moved outdoors. Heat in brooder units was maintained at approximately 32° C for 2 weeks and then was reduced a few degrees each day until a minimum temperature of 23.8° C was reached. Heaters were then turned off 2–3 days before family groups were moved outdoors. Fluorescent lights were initially utilized on a 24-hr basis to facilitate feeding and watering activities. However, continuous exposure to light seemed to stimulate cannibalism among chicks; therefore, exposure to artificial and natural light was minimized for several days. Chicks were then gradually exposed to natural light each day by adjusting miniblinds in brooder rooms. Full exposure to natural light was achieved 2 days prior to transporting each family group to the outdoors. While in brooders and runs, chicks were fed both commercially obtained and naturally occurring invertebrates, as well as the gamebird starter. Family groups were placed in flight pens 4.5 weeks after chicks were introduced to brooder units, and once in the flight pens they remained on the ground until they were released to the wild. Releases occurred during the early (September to October) and late (March) covey season to ensure that family groups remained intact as a covey unit. Each chick released was ≥ 8-weeks old. Temporary release pens (1.2 × 7.3 × 7.3m) were erected at selected release sites and were constructed of PVC pipe, 6.35mm wire mesh hardware cloth and aviary netting. Groups of 30–50 masked bobwhites (2–3 family groups) were placed in each release pen for 1 week. Within each release group, 2–4 chicks were fitted with transmitters prior to being placed into each pen. Commercial scratch grain was dispensed twice daily in release pens via automatic Moultrie feeders. Quail were released after a 7-day acclimation period and were permitted to leave pens undisturbed. Food was provided for an additional week to permit masked bobwhites more time to acclimate to the release site. Ten groups (average group size = 41.1) totaling 411 masked bobwhite were released during 1995–1996, and a total of 35 birds were fitted with radio transmitters.

Prerelease Conditioning Techniques: 1996

During 1995, cannibalism was responsible for higher rates of chick mortality in the brooders than had been observed in previous years. Numerous dead chicks had wounds on their feet, beaks and eyes. Additional potential sources of mortality included bacterial infections, light level and/or temperature. The poor survival rates observed in 1995 prompted prerelease protocol modifications in 1996 in an effort to increase the numbers of chicks released. Refuge biologists also hoped that the construction of a new propagation facility, and the relocation of the captive masked bobwhite population from the PERC to BANWR, would result in greater numbers of chicks being released on the refuge. Moreover, because the BANWR assumed complete responsibility for masked bobwhite propagation, refuge officials controlled every aspect of the propagation and release program. This provided biologists with the flexibility necessary to modify protocols in a manner that would improve the quality of masked bobwhite chicks released on the refuge.

For example, in 1996, biologists were finally able to transport every masked bobwhite chick hatched at the facility to brooder units at refuge headquarters within hours proceeding a hatch to maximize the probability that chicks imprinted on foster parents. Approximately 20 1-day-old chicks were placed in a brooder unit with individual Texas and masked bobwhite foster parents. Another protocol modification implemented in 1996 involved placing red light covers over the fluorescent lights in each brooder unit to reduce cannibalism. Also, curtains were hung around brooder heating units to minimize the cooling effects of drafts and to concentrate heat in one area of the brooder shelves. Biologists hoped that this would eliminate the temperature extremes that may have contributed to the excessive chick mortality that occurred in brooder units in 1995. The remaining prerelease conditioning techniques were consistent with those utilized in 1995. We hoped that the relocation of the captive flock to the BANWR, and the new modifications to the propagation and release protocols implemented in 1996, would result in the release of more chicks to the wild than was the case in 1995. However, the transition associated with constructing the new facility and moving the captive flock delayed the onset of breeding among captive birds. Consequently, the number of hatches was reduced which resulted in the release of fewer masked bobwhite chicks in 1996 than in previous years. Three groups (average group size = 32.3)

totaling 97 chicks were released and 7 birds were fitted with transmitters.

Prerelease Conditioning Techniques: 1997 and 1998

The Texas bobwhite foster parent program was terminated during spring 1997 as a result of recommendations made by the Recovery Committee during a meeting convened during December 1996. Henceforth, only captive-reared masked bobwhite adults were used as foster parents. All other prerelease conditioning techniques remained consistent with those used in 1996. Twelve groups (average size = 29.8) totaling 358 quail were released in 1997. Fourteen chicks and 7 adults were fitted with radio transmitters. In 1998, 8 groups (average size = 32.6) totaling 261 birds were released. Three adults and 7 chicks were fitted with transmitters.

During the 5-year study period, radio telemetry was used to monitor postrelease chick survival and was measured in days. Average daily survival was calculated for each year; however, statistical analysis of the data set was not attempted due to small sample sizes and the many different variables introduced each year. Poncho-type transmitters (Kuvlesky 1990) were placed around the necks of selected adults and chicks prior to release. Radio monitoring commenced 1-day postrelease and any mortality that occurred 24-hours postrelease was classified as a zero because it was unlikely the bird survived 1 full day. Thereafter, monitoring occurred every other day until a mortality occurred or a signal was lost. We assumed that signal loss was a mortality and survival was calculated through the last day of detection.

RESULTS AND DISCUSSION

The radio-marked chicks propagated and reared under the altered protocols in 1995 (n = 34), 1996 (n = 5), and 1997 (n = 22) survived for a longer period of time (x = 12.03, 22.8, 7.86 days, respectively) than did those released under established protocols in 1994 (x = 3.26 days). Survival declined in 1998 (x = 2.75 days); however, the sample size was small (n = 4) due to limited radio availability. Although 1–3 weeks postrelease survival was poor, it was an improvement over survival of 3 days. Nevertheless, it is generally accepted among professional quail managers that survival of captive-reared quail is poor after release and Guthery (1986) noted that captive-reared birds die at a high rate once they are released to the wild. It is also possible that radio-marked captive-reared chicks suffered higher mortality than those released without radios. We suspect this did occur among radio-marked masked bobwhites on the BANWR. Despite reports by others (Boag et al. 1973, Lance and Watson 1977) that transmitter packages did not cause wild galliformes to suffer higher mortality than would be expected, contrasting evidence does exist. For instance, Urban and Klimstra (1972) evaluated the effects of several transmitter designs on northern bobwhites in Illinois and reported that a period of adjustment was necessary after a radio was attached as more than half of all mortalities occurred within the first 5 days of instrumentation. Similarly Lance and Watson (1977) suspected that radio-marking red grouse (*Dendragapus obscurus*) chicks could have a detrimental effect on chick survival even though they observed no such effect on adults. Therefore, we acknowledge that attaching radios to captive-reared masked bobwhite chicks likely elevates mortality probabilities; however, this elevated mortality should have been similar for all years. Results indicate radio-marked chicks released under the modified propagation and release protocols of 1995 to 1997 survived longer than did those released under the established protocols in 1994.

It is not possible to prove statistically that the new protocols adopted between 1995 and 1998 resulted in greater survival among all of the chicks released during this period. However, circumstantial evidence suggests that BANWR masked bobwhite population did increase from 1995 to 1998. Masked bobwhite sightings reported by BANWR personnel and visitors were among the highest recorded since the Refuge was established in 1986 and incidental sightings have continued to increase each year. Moreover, biologists were able to locate masked bobwhites on 1995 to 1998 release sites more easily than in previous years and were also able to monitor these coveys for longer periods of time. Covey sizes that were monitored were also larger (10–20 individuals) than had been observed previously. Annual call-counts are conducted on standard routes throughout the Refuge and the number of birds heard each year since protocols were modified has steadily increased. Nine birds were heard in 1995, 17 in 1996, 36 in 1997, and 51 in 1998.

The circumstantial observations obtained between 1995 and 1998 do not prove the masked bobwhite population increased as a result of the propagation and release modifications that were implemented in 1995. We recognize that we have no conclusive quantitative evidence of a masked bobwhite population increase. Nevertheless, the telemetry and call count data, as well as the circumstantial observations, were all obtained during varying weather patterns and habitat conditions. Northern bobwhites generally are less abundant during dry years and this is true of bobwhite populations whether they exist in Illinois (Roseberry 1989) or south Texas (Kiel 1976, Lehmann 1984). Masked bobwhites respond to drought in a similar manner. Significant population declines recorded during a 28-year call-count survey in Sonora, Mexico were associated with dry weather (Camou et al. 1998, Kuvlesky et al. *this volume*). One would therefore assume the dry conditions that occurred on BANWR during the fall, winter and late spring 1995–1996 would have depressed masked bobwhite survival and this might have indeed happened. Yet higher survival was apparent among radio-marked chicks during this period than occurred among radio-marked chicks during the same period in 1994–1995 which was a warm winter with at least average precipitation. We suspect the improved survival observed each year for radio-marked birds was representative of what occurred among all chicks re-

leased. We also hypothesize that the 1995 to 1998 protocol modifications enhanced postrelease survival of masked bobwhite chicks.

Quantifying the individual impacts of each protocol modification on postrelease survival was, of course, desirable. Unfortunately, designing an experiment to accomplish this was not possible due to personnel, financial and facility constraints. Moreover, during spring 1995, the Recovery Committee recommended immediate actions be taken to improve postrelease survival of captive-reared masked bobwhite chicks before a catastrophic event decimated the existing BANWR population. Furthermore, immediate measures were deemed necessary in 1995 in an effort to mitigate recent political pressures applied by adversaries of the recovery program (Kuvlesky et al. *this volume*). Consequently, we can only speculate as to the contributions individual protocol modifications may have had on the increased postrelease survival of masked bobwhite chicks that was observed in 1995 to 1998.

Exposing young chicks to insects prior to release not only allows the chicks to develop the skills necessary to capture and eat insects, but also provided an important nutritional source necessary for chicks. Brennan et al. (1996) stated insects were critical for feather growth and development and the more insects available to chicks, the quicker they grow, thermoregulate, fly and evade predators. The insects given to masked bobwhite chicks while in captivity could provide crucial nutritional requirements needed to meet the physiological demands of rapidly growing hatchlings. Insect supplementation may yield a stronger, more adaptable bird when it is eventually released to the wild. The benefits insects have on postrelease survival of masked bobwhite chicks are unknown, but based on knowledge about the nutritional needs of bobwhite chicks, continuing the use of insects as part of the prerelease protocol modifications seems practical.

Allowing chicks to spend a prerelease period in flight pens and temporary release pens enables the chicks to experience and adapt to the environmental factors that will confront them when they are released to the wild. Furthermore, providing chicks with the prerelease opportunity to gradually adapt to temperature extremes, learn to forage for natural foods, and select appropriate thermal and escape cover probably also improves postrelease survival probabilities.

Releasing chicks during the covey season instead of during July and August may also increase postrelease survival. Like other bobwhite subspecies, masked bobwhites form and remain in coveys during fall and winter (Tomlinson 1972, Brown 1989). Therefore, releasing masked bobwhite chicks in large groups during fall and winter increases the probability that these groups will remain together, and this likely results in higher survival rates among chicks at least through winter. Moreover, fall releases ensure that adult foster parents remain with chicks, whereas adults released during the bobwhite breeding season may have abandoned broods to search for a prospective mate. Finally, conducting later releases with older chicks, which were larger and stronger, may have been another factor that increased postrelease survival.

The 1995 modifications to the established prerelease conditioning protocol appear to have contributed to an increase in the postrelease survival of captive-reared masked bobwhite chicks. Masked bobwhite prerelease conditioning will continue under the current protocols though we will continue to refine them in an effort to improve postrelease survival every year. We therefore anticipate that the BANWR masked bobwhite population will slowly increase as recruitment among the established population increases and postrelease survival of captive-reared chicks improves each year.

MANAGEMENT IMPLICATIONS

The implementation of improved propagation and release protocols for captive-reared masked bobwhite chicks was deemed necessary and, although the results of applying these modifications are preliminary, it appears recovery efforts on the BANWR were enhanced. It will be necessary to continue to evaluate the modified protocols and we will make a serious effort to subject these modifications to more rigorous scientific scrutiny. Nevertheless, we are optimistic that the continued application of these protocols will improve masked bobwhite numbers on BANWR, and also will prove useful in reestablishing new populations in Sonora, Mexico and other areas in the U.S. (if suitable sites in the historic range are located). Additionally, we suspect that application of the modified propagation and release protocols will improve the survival probabilities of wild masked bobwhites when they are eventually translocated from Sonora, Mexico to the BANWR.

The results of this study also may have implications for quail managers throughout North America. The improved propagation and release protocols may prove useful to biologists or private landowners that wish to reestablish quail populations on areas that provide suitable habitat but are devoid of quail. Additionally, these protocols could be implemented when the intent is to simply supplement a wild population. We do, however, advise individuals that are considering these management options to adhere to the recommendations of Hurst et al. (1993). We also request that scientists interested in our preliminary results implement similar studies. Replicating studies is an important part of the validation process and we welcome any dialogue that will improve our abilities to successfully propagate and release captive-reared masked bobwhites.

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LITERATURE CITED

Boag, D.A., A. Watson, and R. Parr. 1973. Radio-marking versus back-tabbing red grouse. Journal of Wildlife Management 37:410–412.

Brennan, L.A. 1991. How can we reverse the northern bobwhite population decline? Wildlife Society Bulletin 19:544–555.

Brennan, L.A., J.M. Lee, R.S. Fuller, S.W. Manley, L.W. Burger, and G.A. Hurst. 1996. Of bugs and birds: the importance of insect foods for bobwhite. Quail Unlimited Magazine 15: (4)12–13, 15–17.

Brown, H. 1900. Conditions governing bird life in Arizona. Auk 17:31–34.

Brown, H. 1904. Masked bobwhite (*Colinus ridgwayi*). Auk 21: 209–213.

Brown, D.E. 1989. Arizona gamebirds. University of Arizona Press, Tucson.

Burgess, T.L. 1995. Desert grassland, mixed shrub savanna, shrub steppe, or semi desert scrub? The dilemma of coexisting growth forms. Pages 31–67 *in* M.P. McClaran and T.R. Van Devender (eds.). The desert grassland. University Arizona Press, Tucson.

Camou, G., W.P. Kuvlesky, Jr., and F.S. Guthery. 1998. The effect of rainfall on endangered masked bobwhite breeding activity in northcentral Sonora, Mexico. Pages 253–260 *in* Proceedings of the 8th Annual Border States Conference. Tucson, AZ.

Ellis, D.H., and R. Tomlinson. 1974. Development of release techniques for masked bobwhites. Annual Res. Progress Report, Patuxent Wildlife Research Center, Patuxent, MD.

Ellis, D.H., S.J. Dobrott, and J.G. Goodwin, Jr. 1978. Reintroduction techniques for masked bobwhite. Pages 345–354 *in* S. Temple (ed.). Endangered birds: management techniques for preserving threatened species. University of Wisconsin Press, Madison.

Ellis, D.H, and J.W. Carpenter. 1981. A technique for vasectomizing birds. Journal of Field Ornithology 52:69–71.

Guthery, F.S. 1986. Beef, brush and bobwhites: quail management in cattle country. Golden Banner Press. Corpus Christi, TX.

Hurst, G.A., W.R. Davison, T. DeVos, E.L. Kozicky, and A.D. Peoples. 1993. Releases of pen-raised quail. National Quail Symposium Proceedings 3:180–182.

Kabat, C., and D.R. Thompson. 1963. Wisconsin quail, 1834–1962, population dynamics and habitat management. Wisconsin Conservation Department, Technical Bulletin Number 30, Madison.

Kiel, W.H., Jr. 1976. Bobwhite quail habitat characteristics and management implications in south Texas. Transactions of the North American Wildlife and Natural Resources Conference 41:401–420.

Kozicky, E.L. 1993. The history of quail management with comments on pen-rearing. National Quail Symposium Proceedings 3:1–7.

Kuvlesky, W.P., Jr. 1990. The influence of habitat component interspersion on habitat selection of northern bobwhite of the Rio Grande Plains of Texas. Dissertation. Texas A and M University, College Station.

Lance, A.N., and A. Watson. 1977. Further tests of radio-marking on red grouse. Journal of Wildlife Management 41:579–582.

Lehman, V.W. 1984. Bobwhites in the Rio Grande plain of Texas. Texas A and M University Press, College Station.

McClaran, M.P. 1995. Desert grasslands and grasses. Pages 1–30 *in* M.P. McClaran and T.R. Van Devender (eds.). The desert grassland. University of Arizona Press, Tucson.

McLaughlin, S.P. 1992. Vascular flora of Buenos Aires National Wildlife Refuge (including Arivaca Cienega), Pima County, Arizona. Phytologia 73:353–377.

Roseberry, J.L. 1989. Effects of the 1988 drought on bobwhites in southern Illinois. Transactions of the Illinois Academy of Science 82:169–176.

Stoddard, H.L. 1931. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons, NY.

Tomlinson, R.E. 1972. Review of literature on the endangered masked bobwhite. U.S. Fish and Wildlife Service. Research Publication 108:1–28.

Urban, D., and W.D. Klimstra. 1972. An evaluation of some marking techniques used on bobwhite quail. National Bobwhite Quail Symposium Proceedings 1:289–294.

U.S. Fish and Wildlife Service. 1995. Masked bobwhite recovery plan. (2nd Revision). Albuquerque, NM.

U.S. Fish and Wildlife Service. 1996. Masked bobwhite (*Colinus virginianus ridgwayi*) population and habitat viability assessment workshop. Albuquerque, NM.