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ABSTRACT

We trapped mountain quail (*Oreortyx pictus*) from relatively abundant populations in southwestern Oregon for re-introduction or augmentation in areas of central and eastern Oregon where they were rare or extirpated. We captured 2,596 mountain quail during 2001–2010 using treadle-style traps, of which 1,430 were released in Oregon; the remaining birds were transferred to Idaho, Nevada, and Washington. Yearlings (hatch-year) comprised 69.6% of the total ($n = 2{,}596$). Analysis of nuclear DNA from 850 captured quail revealed 50.5% were male. We radiomarked 800 (55.9%) of the quail released in Oregon and monitored them to estimate reproductive success. We located 150 nests in Oregon; at least 1 egg hatched in 110 (73.3%) nests. Average ($\pm$ SE) clutch size was 10.2 $\pm$ 0.2 eggs and average number of chicks hatched from successful nests was 8.3 $\pm$ 0.3. Sixty-eight nests (45.3%) were incubated exclusively by males, 78 (52.0%) exclusively by females, and 4 (2.7%) by birds of unknown gender. Males incubated slightly larger clutches (11.0 $\pm$ 0.3) and hatched more eggs than females (5.5 $\pm$ 0.5). Males also regularly contributed to brood-rearing. The reproductive effort and nest success of translocated mountain quail was comparable to native populations in Oregon. Translocations may be an effective means of restoring mountain quail populations that have been extirpated or augmenting populations that have substantially declined.

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Key words: clutch size, mountain quail, nest success, Oregon, *Oreortyx pictus,* translocation

INTRODUCTION

Mountain quail have the most northerly distribution of New World quail with a geographic range that extends from northwestern Mexico to Vancouver Island, British Columbia. They occupy some of the highest elevations and diverse habitats known for quail in North America (Gutiérrez 1980, Brennan et al. 1987, Gutiérrez and Delehanty 1999). Mountain quail populations have declined in the western Great Basin, particularly in western Idaho, southeastern Washington, and south-central and southeastern Oregon (Brennan 1989, Crawford 2000). Concern over the decline of mountain quail in eastern Oregon and apparent habitat recovery due to increased riparian protections prompted the Oregon Department of Fish and Wildlife (ODFW), Oregon State University, and the U.S. Forest Service in 2001 to plan for restoration of mountain quail populations in historic ranges in eastern Oregon by translocating wild quail captured from viable populations in southwestern Oregon. Mountain quail are an excellent candidate for translocations because of abundant source populations in western Oregon, relative ease of capture and handling, and potentially high reproductive capacity.

North American quail evolved reproductive strategies that allow rapid increase in populations during favorable conditions. Most North American quail are monogamous breeders, but they often exhibit flexibility in breeding strategies. Northern bobwhites (*Colinus virginianus*), for example, may use polygyny, whereby a female mates with $>$ 1 male, and the female and $\geq$ 1 male incubate independent nests; this strategy explained successful triple-brooding in this species and was confirmed after decades of doubt (Guthery and Kuvlesky 1998). Mountain quail in contrast appear to be strongly monogamous. A female may lay 2 clutches simultaneously in separate nests with the male and the female each actively incubating a clutch (Delehanty 1995, 1997; Pope and Crawford 2001; Beck et al. 2005). Male mountain quail also brood chicks hatched from their nests, often separately from the brood of the female (Delehanty 1995, Pope and Crawford 2001). The combined nests of associated individuals with simultaneous double-clutching may produce up to 26 mountain quail chicks per adult pair during one breeding season (Pope and Crawford 2001).

Translocations have been used as a conservation technique to re-introduce species or augment populations in areas where their abundance has decreased or where they have been extirpated (Scott and Carpenter 1987). Availability of source populations, high productivity, and ability to withstand repeated handling and transport make mountain quail a good candidate for translocation projects (Pope and Crawford 2004, Stephenson et al. 2011). Monitoring reproductive efforts of translocated species is a crucial step to assess the efficacy of translocation and to inform future management decisions. Monitoring is

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especially important for little known species such as mountain quail (Vogel and Reese 1995, Gutiérrez and Delehanty 1999). Our objectives are to describe sex and age ratios of captured mountain quail, and to describe sex- and age-specific nest success and nesting characteristics (e.g., clutch size) of translocated quail in Oregon. We used long-term (2001–2010) data collected at 6 sites in central and eastern Oregon.

METHODS

Study Area

We conducted our study in central and eastern Oregon in Crook, Grant, Harney, Jefferson, and Malheur counties during 2001–2010. Habitat for mountain quail in the study area primarily included western juniper (*Juniperus occidentalis*) and mountain mahogany (*Cercocparpus ledifolius*) woodlands, ponderosa pine (*Pinus ponderosa*) and eastside white oak (*Quercus garryana*) forest and woodlands, and Ceanothus (*Ceanothus* spp.)-Manzanita (*Arctostaphylos* spp.) shrublands (Johnson and O'Neil 2001). Long-term (1981–2010) climate of the study area included similar mean minimum and maximum temperatures for Grant (John Day = 1.6 and 17.6 °C, respectively), Jefferson (Madras = 2.4 and 16.8 °C), and Harney (Fields = 3.0 and 17.1 °C) counties; mean total annual precipitation was 33.5 cm at John Day (Grant County), 30.8 cm at Madras (Jefferson County), and 23.0 cm at Fields (Harney County) (Western Regional Climate Center 2011).

Capture and Handling

Mountain quail were captured during November–February 2001–2010 in southwestern Oregon using custom-made treadle-style traps baited with grain. Age classification was based on the coloration of greater primary coverts (Leopold 1939). Individuals with coverts of uniform color were classified as adults; those with buffy-colored covert tips were classified as juveniles. We reclassified juveniles as yearlings for analysis of reproduction following the spring translocation.

Gender of mountain quail may be difficult to assign and we used DNA analysis from blood taken from a tarsal vein. Analysis was done either by Wildlife Genetics International, Nelson, BC, Canada or DDC Veterinary, Fairfield, OH, USA. Gender testing by these labs was assumed to be accurate. We did not submit blind test samples, but reference samples were analyzed with samples submitted to DDC Veterinary (Randall Smith, personal communication). Captured mountain quail were held in a facility specifically constructed for this species at the ODFW Southwest Regional Office in Roseburg, Oregon. Quail were typically released in March each year and an attempt was made to release pen-mates in the same area in an effort to preserve any pair bonds that may have formed during captivity. All birds were leg-banded prior to release and a subset was radiomarked with ≤6-g necklace-style transmitters (Model PD-2C, Holohil, Carp, ON, Canada; Model AWE-Q, American Wildlife Enterprises, Monticello, FL, USA).

Monitoring

Nest sites were located during April–July each year by homing on radio-marked birds and visually identifying mountain quail incubating clutches. Nesting quail were flushed to locate nests and to record clutch size. Nests and egg remains were examined to record nest success or failure after the end of incubation. Nests with ≥1 hatched egg were considered successful. Nests were not monitored sufficiently often to reliably examine probabilities for nest survival, as average time between visits was 15.3 ± 1.5 days.

Data Analyses

We used 2-tailed *t* tests to examine differences in clutch size and number of eggs hatched by gender and age class (yearling, adult) of incubating individuals. We assessed nest success by comparing proportions of successful nests based on gender-age class. We constructed 95% confidence limits (CLs) for all analyses, and assumed a difference existed if CLs did not overlap between any 2 groups.

RESULTS

During 2001–2010, 2,596 mountain quail were captured for translocation. Most (69.6%) were juveniles (hatch-year) and on average (± SE) represented 71.2 ± 1.8% of the captured quail in each year (range = 64–78%) (Table 1). We collected blood samples for DNA analysis from 850 mountain quail of all age classes. DNA analysis indicated that 421 (49.5%) were female and 429 (50.5%) were male (Table 2). Females comprised 320 (51.6%) of the juveniles while 300 (48.4%) were male. Adults comprised 27.1% of the sample, of which 101 (43.9%) were female and 129 (56.1%) were male.

Clutch Size

Males incubated 68 (46.6%) and females 78 (53.4%) of 146 nests where the incubating bird was of known gender. Mean (± SE) clutch size for all age and gender classes was 10.2 ± 0.2 ($n = 142$). Males incubated larger clutches ($n = 67$, mean = 11.0 ± 0.3, 95% CL = 10.4–11.7) than females ($n = 75$, mean = 9.5 ± 0.3, 95% CL = 9.0–10.1) when the data were pooled. Clutch size did not differ among adult females ($n = 20$; 95% CL = 8.0–10.8), yearling females ($n = 55$; 95% CL = 9.1–10.1), and yearling males ($n = 52$; 95% CL = 10.0–11.5), but was slightly higher for adult males ($n = 15$; 95% CL = 11.1–13.1) than either age class of females. No difference was found between yearlings ($n = 107$; 95% CL = 9.7–10.6) and adults ($n = 35$; 95% CL = 9.6–11.5) when data were pooled by age class.

Nest Success

Gender of incubating birds and nest fate were known for 142 nests, of which 67 were incubated by males and 75 by females. Apparent nest success was 82% (95% CL = 72–91%) for all males and 69% (95% CL = 59–80%)

for females, but was not different. There was no difference in nest success between yearlings (77%, 95% CL = 68–85%) and adults (71%, 95% CL = 55–86%). There was a difference when comparing the number of eggs hatched by adult females (95% CL = 3.8–8.1), adult males (3.9–9.8), yearling females (4.1–6.2), and yearling males (6.5–8.9); yearling males hatched on average 7.7 eggs (Fig. 1A), whereas yearling females hatched on average 5.3 eggs (Fig. 1B). A slight difference was observed when data were pooled by gender (95% CL = 6.4–8.6 for males, 95% CL = 4.5–6.4 for females), but not by age (95% CL = 5.6–7.3 for yearlings, 95% CL = 4.7–8.0 for adults).

Table 1. Age characteristics of mountain quail (n = 2,596) captured in southwestern Oregon, 2001–2010.

Year	Adult (≥1 yr of age)	Juvenile (<1 yr of age)	Juvenile (%)
2001	15	54	78.3
2002	27	66	71.0
2003	89	182	67.2
2004	26	89	77.4
2005	124	249	66.8
2006	136	238	63.6
2007[a]	134	238	64.0
2008	69	239	77.6
2009	81	238	74.6
2010	88	214	70.9
Totals	789	1,807	69.6

[a]Excludes one unknown individual.

DISCUSSION

Age Ratios

There is some evidence of trapping bias based on age class for California quail (*Callipepla californica*) (Crawford and Oates 1986). We could not ascertain if the much greater proportion of juveniles in our capture sample was an artifact of trapping vulnerability based on age category (juvenile vs. adult). However, our results suggested the proportion of juveniles was relatively constant (range = 64–78%) across the 10-year study period. This represented a relatively consistent age ratio compared to other portions of the species' range, especially arid regions, where water can be a limiting factor. The proportion of juveniles in the Mojave Desert ranged from <1% in a dry year to 93% in a 'moist' year (Delehanty 1997). Disparate age ratios among years with varying precipitation were also reported for mountain quail near Joshua Tree, San Bernardino County, California (Miller 1950).

Sex Ratios

Little is known about sex ratios of mountain quail, but a study of wild-captured quail in southwestern Oregon suggested sex ratios may be slightly female-biased (Pope and Crawford 2001). A sample of mountain quail captured in west-central Idaho was also biased toward females (Beck et al. 2005). Miller (1950), in contrast, suggested a nearly 50:50 sex ratio with some evidence toward more males. Most North American quail have male-biased populations; however, the least sexually dimorphic species (such as mountain quail) appear to have the least skewed sex ratios (Brown and Gutiérrez 1980). We assumed no measurable capture bias associated with gender. Our data suggested the sex ratio pooled across all age classes was close to 50:50. However, our capture sample indicated the adult population was biased toward males, while the juvenile population was slightly biased toward females. A shift toward a male-biased population among older age-classes has long been recognized for other quail species, (e.g., California quail [Emlen 1940] and northern bobwhites [Leopold 1945]).

Other published studies of quail included hypotheses that the energetic cost of egg production and incubation, as well as the vulnerability of females while nesting may contribute to lower survival during spring, thus favoring males in the adult segment of the population. A large proportion of male mountain quail incubate clutches and raise broods, which suggests the energetic cost of egg production, and resulting need to spend more time feeding, may also be an important factor in reducing female survival. Male and female mountain quail are known to have similar nest attentiveness patterns (Pope

Table 2. Gender and age (yearlings = < 1 yr of age, adults = ≥ 1 yr of age) and percent males by age of mountain quail released in central and southeastern Oregon, 2001–2010.

	Yearlings			Adults			All ages		
Year	Males	Females	Males (%)	Males	Females	Males (%)	Males	Females	Males (%)
2001	27	27	50.0	10	5	66.7	37	32	53.6
2002	30	22	57.7	10	10	50.0	40	32	55.6
2003	43	58	42.6	24	15	61.5	67	73	47.9
2004	34	36	48.6	10	8	55.6	44	44	50.0
2005	66	62	51.6	29	24	54.7	95	86	52.5
2006	24	28	46.2	16	13	55.2	40	41	49.4
2007	15	27	35.7	9	10	47.4	24	37	39.3
2008	21	18	53.8	9	5	64.3	30	23	56.6
2009	20	27	42.6	6	3	66.7	26	30	46.4
2010	20	15	57.1	6	8	42.9	26	23	53.1
Total	300	320	48.4	129	101	56.1	429	421	50.5

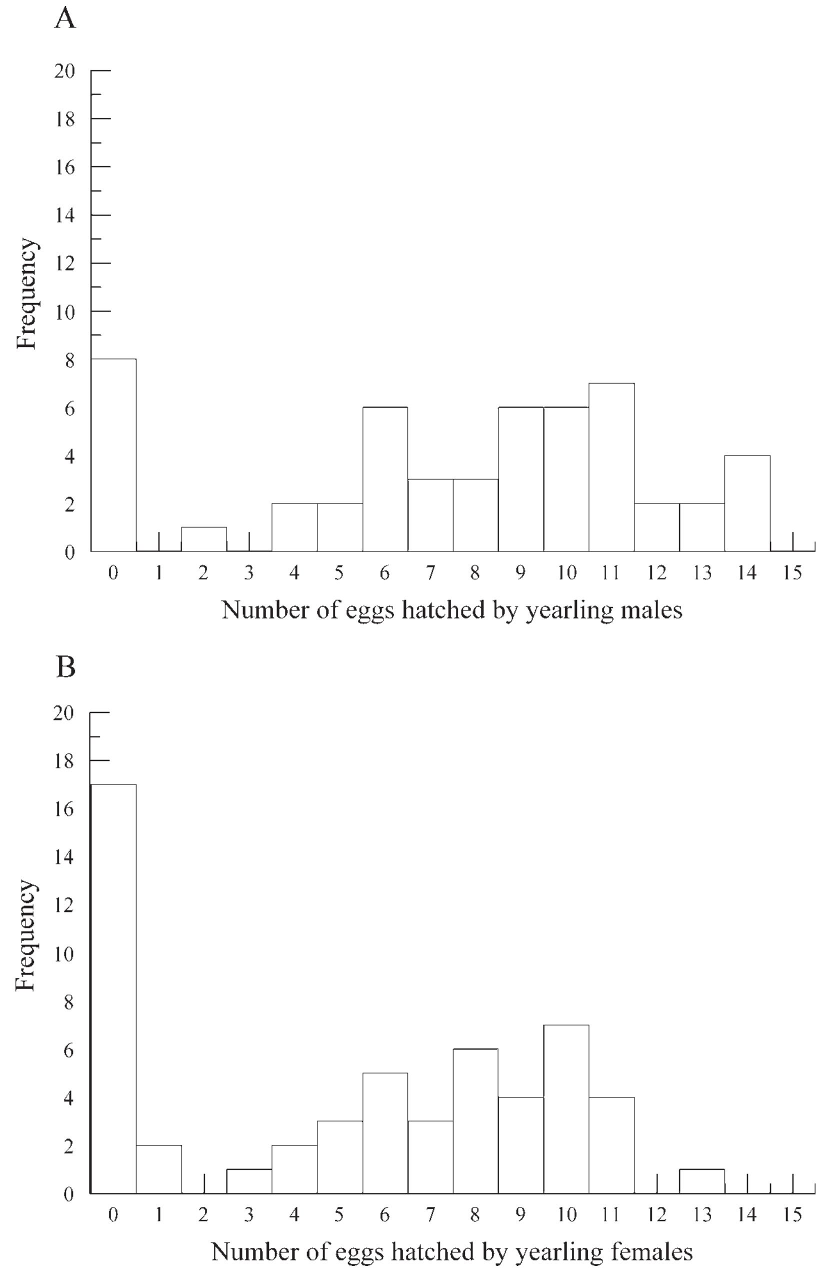

Fig. 1. (A) Frequency of number of eggs hatched by translocated yearling male ($n=52$) and (B) yearling female ($n=55$) mountain quail in central and southeastern Oregon during 2001–2010.

2002) and, in one study, female mountain quail had higher survival during the breeding season (Nelson 2007). No gender differences in survival for any season were found for mountain quail in west-central Idaho, and translocated quail in western Idaho and southeastern Washington (Stephenson et al. 2011).

Brown and Gutiérrez (1980) suggested quail with similar sex ratios would have less sexual selection, less intra-male competition, and would be less sexually dimorphic, such as scaled (*C. squamata*) and mountain quail. They lacked data for mountain quail, but cited several papers that reported sex ratios for scaled quail. Data from mountain quail in Oregon show a tendency to be biased toward males, but these ratios more closely approximate ratios reported for scaled quail than highly sexually dimorphic species like Montezuma (*Cyrtonyx montezumae*), Gambel's (*Callipepla gambelii*), and California quail (Brown and Gutiérrez 1980).

Clutch Size

Our finding that males incubated larger clutches than females is consistent with findings from 48 native (not translocated) mountain quail nests in Idaho, where males incubated significantly larger clutches (12.6 ± 0.3) than females (11.4 ± 0.4) (Beck et al. 2005). Clutches incubated by males averaged 11.9 ± 0.4 while those by females averaged 10.9 ± 0.4 in a previous study of 55 nests in Oregon, incubated by both native and translocated birds, but the difference was not statistically significant (Pope and Crawford 2001). Our data and those from other studies indicate the mean clutch size for nests incubated by males was larger than females. Both members of the pair begin incubation within a few days of each other (Pope and Crawford 2001, Beck et al. 2005), suggesting eggs are being contributed to both clutches during the laying period. However, males usually start incubation first (Pope and Crawford 2001, Beck et al. 2005), suggesting the clutch of the male-incubated nest may be completed first. Clutches completed first during the annual reproductive cycle for quail are usually the largest (Johnsgard 1973, Rolland et al. 2011).

The relatively short breeding season, apparent monogamy of paired quail (Pope 2002, Beck et al. 2005), and rarity of renesting attempts (Pope and Crawford 2001, Beck et al. 2005, Abel 2008) limit the possibility of mountain quail using other reproductive strategies with sequential nests (Beck et al. 2005) such as those reported for northern bobwhites (Burger et al. 1995). The selective advantage of the reproductive strategy used by mountain quail would be strengthened if male-incubated nests are more successful and hatch more eggs.

Nest Success

The secretive nature of mountain quail, monomorphism, and remote areas they inhabit make observations of their distinctive breeding behaviors difficult. Consequently, it was relatively recent that male mountain quail were observed to independently incubate clutches and brood chicks with no assistance from females (Gutiérrez 1977, Heekin 1993, Delehanty 1995, Pope and Crawford 2001).

We defined a successful nest as one with ≥ 1 egg hatching; thus, a successful male-incubated nest would not necessarily result in increased fitness if a smaller proportion of the clutch hatches due to inferior incubation behavior, or other reasons. However, adult males not only incubated larger clutches than other age and sex classes, but males hatched slightly more eggs on average than females of pooled age classes. The successful nesting characteristics associated with males on our study sites supports the continuance of male participation in simultaneous double clutches as a reproductive strategy.

Most nests were discovered after several eggs had been laid or after initiation of incubation, and it is difficult to estimate the total time spent on nesting activity (egg-laying and incubation). Beck et al. (2005) used an average of 1.2 days per egg laid, and estimated the period of nesting activity averaged 59 days (range = 54–64 days). A single egg was found by chance in Oregon in a nest cup on 23 April and later hatched by the male of a marked pair as part of a 14-egg clutch on 29 June ($\geq$68 days of nesting activity) (Abel 2008). Individual eggs of mountain quail are exposed to the environment for a longer period of time than observed for other quail species given the long period of nesting activity required for simultaneous double clutches.

MANAGEMENT IMPLICATIONS

Mountain quail may be good candidates for translocations because of their ability to withstand capture and handling, ability to persist in diverse vegetation types, and abundant source populations in parts of their range. Translocated mountain quail in our study exhibited similar reproductive traits to native quail, which indicated the birds were able to reproduce successfully after translocation. Translocation of mountain quail may be an effective method for restoring this species to suitable habitat within their historic range.

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