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Effect of capture date on nest-attempt rate of translocated sharp-tailed grouse *Tympanuchus phasianellus*

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Attempts to establish functioning populations of prairie grouse by translocation often are unsuccessful due to low reproduction following release. We examined the relationship between capture date and nest attempts of Columbian sharp-tailed grouse *Tympanuchus phasianellus columbianus* during an effort to restore them by translocation to their historic range in northeastern Nevada, USA, during 1999-2000. After observing that females captured relatively early in the trapping period did not attempt to nest, we hypothesized that the likelihood of female insemination is positively correlated to capture date. If females captured at source leks later in the breeding season are more likely to be inseminated, then they may be more likely to nest following release than females that are not inseminated prior to capture. We found that female grouse that were captured from source leks at later dates during the lek-visitation period were more likely to nest following translocation than were females captured during the initial days of female visitation to leks (LogXact Test: $P = 0.001$). Of 40 radio-marked female grouse, 19 (48%) were observed nesting and nest success was 44%. During 2001, we tested the effect of capture date on the presence of spermatozoa in live female grouse captured from leks. Females trapped later in the lek-visitation period were more likely inseminated than females captured early in the lek-visitation period (LogXact Test: $P = 0.036$). We recommend that wildlife managers consider capturing females from source leks several days following the onset of the lek-visitation period to increase the frequency of female nest attempts and increase the probability of establishing a new population during reintroductions.

Key words: Columbian sharp-tailed grouse, nest success, reintroduction, restoration, *Tympanuchus phasianellus columbianus*, translocation

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In the late 19th century, Columbian sharp-tailed grouse *Tympanuchus phasianellus columbianus* were commonly found in Elko County, Nevada, USA (Linsdale 1951), and it was described as the most abundant game bird

throughout the northern Intermountain West (Bendire 1892). During the 20th century, Columbian sharp-tailed grouse experienced substantial declines in abundance (Miller & Graul 1980). Prior to this study, the most recent observation of naturally occurring sharp-tailed grouse in Nevada, USA, was during 1952 (Wick 1955). Our objectives were twofold. We performed the first reintroduction of Columbian sharp-tailed grouse into their native range of Nevada, USA. Simultaneously, we examined the effects of translocation methodologies on nesting behaviour.

Prairie grouse are difficult gallinaceous species to re-establish by translocation (Reese & Connelly 1997). The proportion of successful efforts to restore prairie grouse populations using translocation is low (32%), and failure results from low rates of reproduction following release (Snyder et al. 1999). This may be because male and female reproduction is linked to traditional lek sites, and leks are absent in areas of extirpation. Overcoming the absence of leks, and inducing females to nest upon translocation are major challenges in restoring prairie grouse populations (Toepfer et al. 1990, Musil et al. 1993).

Knowledge of nest attempts, nest success and frequency of females with successful nests among translocated Columbian sharp-tailed grouse is essential to understanding the success or failure of restoration attempts and modifying future translocation procedures. Although nest success rates of translocated grouse (Cope 1992, Gardner 1997) are similar to that of grouse that are not translocated (McDonald 1998), > 50% of translocated females may fail to nest following translocation (Cope 1992, Gardner 1997), compared to 0-28% of resident females (Bergerud 1988, Apa 1998, McDonald 1998).

To better understand the post-release reproductive behaviour of Columbian sharp-tailed grouse populations we examined the relationship between female capture date and subsequent nesting attempts following release. We also estimated nest attempts, nest success and frequency of females with successful nests. Finally, we examined the relationship between female capture date and presence of spermatozoa detected within the cloacae of live female grouse. We hypothesized that females captured at source leks at later dates in the female lek-visitation period are more likely to be inseminated and to nest following their release than females that are captured at early dates.

Study areas

We captured sharp-tailed grouse from 11 leks in the Pocatello and Curlew valleys in southeastern Idaho, USA,

during the springs of 1999 and 2000. Most grouse were captured from leks within Conservation Reserve Program (CRP) grasslands dominated by crested wheatgrass *Agropyron cristatum* and alfalfa *Medicago sativa* and adjacent to native shrub communities. Shrub-steppe and mountain shrub were the dominant native habitat types in this area (Ulliman 1995). Shrub-steppe primarily consisted of big sagebrush *Artemisia tridentata* and bluebunch wheatgrass *Agropyron spicatum*. Mountain shrub was characterized by bluebunch wheatgrass, antelope bitterbrush *Purshia tridentata*, sagebrush and Saskatoon serviceberry *Amelanchier alnifolia*.

Sharp-tailed grouse were released into the Snake Mountains in northeastern Nevada, USA (N 0670859, E 4599749, zone 11). The Nevada Division of Wildlife (NDOW), in cooperation with Idaho Department of Fish and Game (IDFG), chose this area for sharp-tailed grouse restoration within its historic range because of the area's physiographic and vegetation similarities to the capture area. The dominant plant communities were shrub-steppe at lower elevations and mountain shrub at higher elevations. Big sagebrush and crested wheatgrass were prominent components of the shrub-steppe cover types at the release site. Antelope bitterbrush, big sagebrush and Saskatoon serviceberry, with bluebunch wheatgrass as the dominant understory, were the major components of the mountain shrub cover types. Although most habitat types were similar between the capture and release areas, there were no CRP grasslands within the release area.

No sharp-tailed grouse were known to exist at the release site prior to translocation, although a breeding population of greater sage-grouse *Centrocercus urophasianus* was present. A variety of predators including coyote *Canis latrans*, striped skunk *Mephitis mephitis*, American badger *Taxidea taxus*, ground squirrels *Spermophilus* spp., common raven *Corvus corax*, American magpie *Pica hudsonia*, and American crow *Corvus brachyrhynchos* also occurred in the release area. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service and Wildlife Services engaged in raven and coyote removal activities in the area during this study to improve survival and reproduction of grouse (J. Spenser, unpubl. data).

Material and methods

Personnel from IDFG, NDOW, University of Nevada Reno and Idaho State University captured grouse using modified walk-in funnel traps (Schroeder & Braun 1991) in a 'W' wing trap system (Cope 1992) during 3-17 April 1999 and 2000. We began to capture Columbian sharp-

tailed grouse at approximately the onset of female lek visitation as determined by IDFG employees monitoring lek sites for female attendance. We ended trapping when the quota of female grouse to be translocated was met (1999: $N = 15$; 2000: $N = 25$) as set by IDFG. Additionally, 75 male sharp-tailed grouse (1999: $N = 34$; 2000: $N = 41$) were translocated with female grouse. Thus, a total of 49 and 66 sharp-tailed grouse were translocated in 1999 and 2000, respectively. All translocation of sharp-tailed grouse took place during spring to increase the probability of restoration success (Snyder et al. 1999).

We marked all females ($N = 40$) with necklace style, battery-powered transmitters (Advanced Telemetry Systems, Isanti, Minnesota). Radio collars weighed < 17 g, corresponding to $< 3\%$ of total body mass, based on published values of average mass of sharp-tailed grouse in Idaho, USA (596–771 g; Meints 1991, Schneider 1994), to reduce transmitter-caused mortality (Carroll 1990). Antennae were bent near their base, and rested along the back of the females, limiting interference with flight (Marks & Marks 1987). All grouse were classified to age based on plumage (Ammann 1944).

We transported 38 of 40 female grouse to the release site on the day of capture and released them within 24 hours of capture to minimize weight loss (Toepfer 1988, Gardner 1997) and potential stress associated with captivity. Two female grouse were released within 24–48 hours of capture. Also, 42 male grouse were released with females. Grouse were held separately in individual holding boxes overnight and placed in separate compartments of a release box at the release site two hours prior to release. All releases were at sunrise using a soft release method (Rodgers 1992). The soft release method was shown to increase the success of restorations (Snyder et al. 1999) by minimizing immediate dispersal of grouse and promoting display in males (Rodgers 1992).

To monitor females, we used the 'loudest signal method' (Springer 1979), circled each grouse at a distance of approximately 30 m to reduce location error (Hupp & Ratti 1983, Garrott et al. 1986), and recorded the Universal Transverse Mercator coordinates of each location. We initiated telemetry monitoring on all grouse immediately following release. We spent the same amount of time monitoring grouse released early in the translocation period as grouse released later because actual releases took place early in the morning leaving sufficient time to track grouse each day. We avoided flushing radio-marked grouse. We located each marked grouse by air or ground 1–3 times per week for 200 days following the release in 1999 and for 160 days in 2000. Individual grouse were not monitored through successive years.

We attempted to locate nests at the beginning of the incubation period. Females found in the same area as their previous location were then relocated within 24 hours to determine nesting status. After three consecutive relocations, we approached females slowly to confirm nesting. Nests were monitored every 1–2 days to document nest fate. Although we used the same methodology each year to find nests, we modified our nest-monitoring methods between years. During 1999, nests were monitored visually. However, in 2000, we placed a concealed radio-transmitter 5–10 m north of each nest. Signals from the concealed transmitter were used in relation to the transmitter attached to the female to determine if the female was located on or near her nest. If the female was not present for ≥ 3 days, we visited the nest and recorded nest status (abandoned, depredated or hatched) based on egg remains. This method was used to minimize disturbance of nesting females. If a female remained > 100 m from the nest for at least three days and eggs were intact and in the nest, then we considered the nest to be abandoned.

During 2001, we performed cloacal lavage (Quay 1984, Coates 2001) on female grouse captured from the same source leks, and we used the same methods of capture as grouse translocated in 1999 and 2000. The lavage consisted of washing the inner lining of the cloacal urodeum with a buffered solution and collecting the solution for microscopic analysis. We avoided washing the oviduct. We performed microscopy in the field immediately following the cloacal lavage to detect the presence of spermatozoa. If we found one or more spermatozoa, we scored the female as having been inseminated. During 2001, we translocated the grouse to the Snake Mountains in Elko County, Nevada, USA, but released them at a different site than the release site of 1999 and 2000.

Statistical analyses

We performed an exact logistic regression using LogXact (Cytel Software Corporation, Cambridge, MA, USA) to determine if capture date influenced nest attempts ($N = 26$). Exact logistic regression uses an efficient algorithm for analyzing the significance of small samples (Hirji et al. 1987). However, a y-intercept and slope parameter cannot be calculated from the logistic exact test output. Because these parameters are useful in interpreting findings for field application, we also performed a standard logistic regression. We used the estimated slope and y-intercept parameters of the standard logistic regression to fit a response curve and determine a point of inflection. The capture date at the point of inflection represents a 0.5 probability of an attempt to nest for females

captured on that date. Grouse that were unaccounted for or died during the nest initiation period without observed nests were excluded from the analysis of female capture date. We used a criterion of 39 days elapsed from release date as the nest initiation period. This interval represented mean days elapsed from release to nest initiation among females that were observed to nest + 1 SD. All females that were successfully monitored and survived for 39 days following release were included in the analysis. We did not measure the relationship between clutch sizes and capture dates due to inadequate sample sizes.

We pooled data across years and used a simple logistic regression and calculated a correlation coefficient (r^2) to test if ages of female grouse were a function of date of capture ($N = 40$). We used a Fisher's exact test (ϕ) to test for differences in nest attempt rate between grouse of different ages.

We calculated nest success as the percent of nests that produced ≥ 1 chick. We did not adjust nest success to account for exposure days (Mayfield 1975) because we assumed that nests were located in the initial stage of incubation due to our close monitoring of radio-marked females. We calculated the frequency of females that were observed to nest successfully among all released female grouse. We also estimated the percentage of females that nested successfully from those that survived and were successfully monitored throughout the nesting period.

We performed an exact logistic regression using LogXact (Cytel Statistical Software, Cambridge, MA, USA) to examine the relationship between capture date and the detection of spermatozoa within the cloacae of live female grouse during 2001 (Coates 2001).

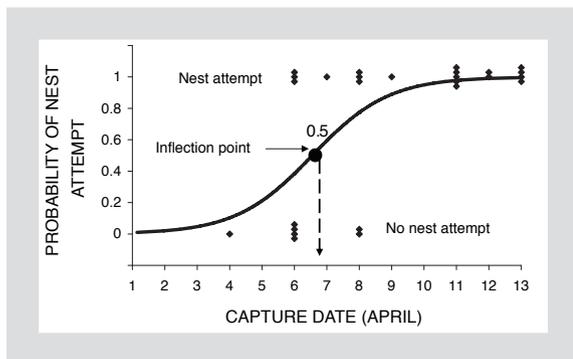


Figure 1. Logistic response curve predicting the probability of nesting attempt in relation to capture date of translocated female Columbian sharp-tailed grouse released in northeastern Nevada, USA, during 1999-2000. Diamonds represent observations of individual females. The point of inflection at approximately 7 April represents a 50% probability of nesting following translocation and occurs several days after the start of female visitation to source leks.

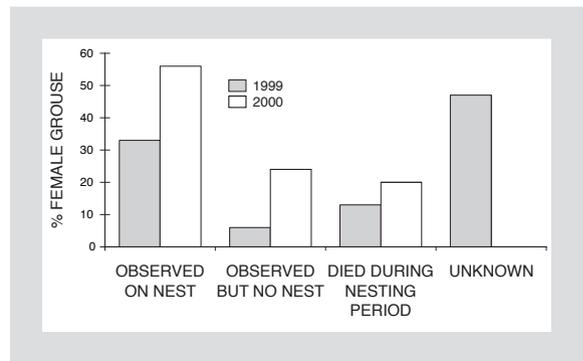


Figure 2. Percentage of translocated female Columbian sharp-tailed grouse ($N = 40$) that were observed on nests (1999: $N = 5$; 2000: $N = 14$), apparently did not nest (1999: $N = 1$; 2000: $N = 6$), died (1999: $N = 2$; 2000: $N = 5$), or were unaccounted for during the nest initiation period (1999: $N = 7$; 2000: $N = 0$), i.e. 1-39 days post-release, in northeastern Nevada, USA.

Results

We observed a strong effect of capture date on nest attempts of female grouse following release (LogXact Test: $P = 0.001$). Females captured later during the lek-visitation period were more likely to attempt to nest than females captured early (Fig. 1). Seven females died during the nesting period and seven were not relocated. We successfully monitored the remaining 26 (1999: $N = 6$; 2000: $N = 20$) of 40 translocated female grouse through the duration of the nesting period. Among these, the date of capture significantly influenced female nesting rates. The calculated point of inflection, predicting a 50% probability of nest attempt, was approximately 7 April (see Fig. 1). Four of nine females (44%) captured on or before 7 April attempted to nest, and 15 of 17 females (88%) captured after 7 April attempted to nest.

Capture date and nest attempts were not correlated to

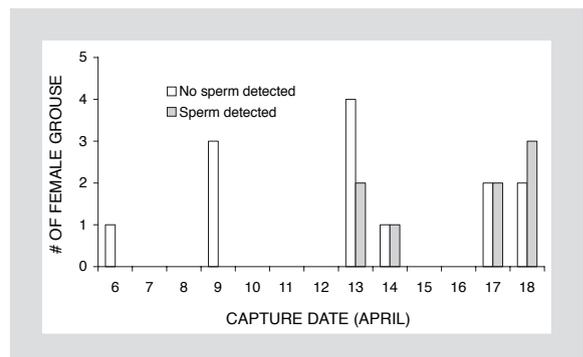


Figure 3. Detection of spermatozoa from samples of cloacal lavage throughout the capture period (i.e. April) of female Columbian sharp-tailed grouse translocated to northeastern Nevada, USA, during 2001.

Table 1. Nest attempts, nest success and female success of Columbian sharp-tailed grouse translocated from southeastern Idaho to north-eastern Nevada, USA, during 1999-2000.

Year	Monitored-female nest attempt frequency		Nest success		Monitored-female success frequency	
	N	% ^a	N	% ^b	N	% ^c
1999	5	83	3	60	3	50
2000	14	70	5	36	5	25
Total	19	73	8	42	8	31

^a Percent of females that attempted to nest from monitored females (1999: N = 6; 2000: N = 20).

^b Percent of nests that produced ≥ 1 chick from all nests (1999: N = 5; 2000: N = 14).

^c Percent of females that hatched ≥ 1 eggs from monitored females (1999: N = 6; 2000: N = 20).

female age ($r^2 = 0.004$, $P = 0.650$ and $\varphi = 0.233$, $P = 0.369$, respectively). Moreover, we did not find a significant year effect on nest attempts ($\varphi = 0.217$, $P = 0.603$). During 1999, six of 15 released females (40%) were monitored throughout the nesting period (Fig. 2). Five females nested (33%) and nest success rate was 83% (Table 1). In 2000, 20 of 25 females (80%) were monitored (see Fig. 2). Fourteen females nested (56%) and nest success rate was 70% (see Table 1). During 1999 and 2000, five of 18 nests (28%) were depredated, and five of 18 nests (28%) were abandoned. During 1999, the fate of one nest was unknown because the nest was not marked and could not be relocated after the female left the area. In 1999 and 2000, eight of 26 female grouse (31%), monitored throughout the nesting period, were successful at hatching ≥ 1 egg (see Table 1). We did not detect any renests in either year.

During 2001, we detected spermatozoa in eight of 21 female grouse (38%) which were captured during 6-18 April. We found the detection of spermatozoa in live female grouse to be a function of capture date (LogXact Test: $P = 0.036$). Females captured at later dates during lek visitation were more likely to have sperm detected within their cloacae than females captured early (Fig. 3).

Discussion

Female grouse captured early during the period when females attend leks were significantly less likely to nest following translocation than females captured later. We were unable to detect differences in nest attempts associated with female age or year of capture. During the translocation of grouse, we employed published techniques designed to promote successful restorations, such as translocation during the spring season, using a soft-release, and translocating > 100 grouse to one release site (Snyder et al. 1999). Despite these precautions, we observed a significant capture-date effect that influences the reproductive behaviour of female grouse following

reintroduction. Understanding the relationship between capture date and nest attempts will allow wildlife managers to develop a more efficient translocation strategy than simply translocating female grouse throughout the female lek-visitation period. Females removed early from the source population may make little contribution to restoration in a new area relative to females captured later even if they survive throughout the nesting period.

Why might female grouse captured early be less likely to nest following release? We hypothesized that females captured early in the lek-visitation period had not been inseminated prior to capture. Female grouse are known to visit leks and males for several days before copulation (Landel 1989) and may copulate multiple times in a breeding season (Landel 1989, Gratson et al. 1991). But females captured early during the lek-visitation period likely have not entered the copulation phase of the reproductive cycle. Indeed, in our study females captured early in the lek-visitation period of 2001 were less likely to have sperm detected within their cloacae than females captured later during the breeding cycle. This pattern of sperm detection mimicked the pattern of nest attempts observed in 1999 and 2000, except that it was shifted to chronologically later dates. Perhaps, this was due to annual variation in weather, with spring arriving relatively late during 2001. Despite the chronological shift, as the breeding season proceeded, spermatozoa were found more frequently in cloacae of captured female grouse, supporting our hypothesis that translocated females inseminated prior to capture at source leks may be more likely to nest following release than females that are not inseminated prior to capture. Sperm storage (Birkhead & Møller 1992) would allow these inseminated females to remain fertile at the release site for some period of time despite the absence of a functioning lek.

Alternatively, perhaps an increase in the number of translocated males at the release site as the breeding season proceeded promoted nesting among late females.

Although, we did not observe any copulations or lek establishment at the release site, during 2000 we observed male grouse displaying intermittently at the release site and a greater proportion of the total female grouse were observed nesting. In three instances, we observed a male traveling with a female following their release. There may have been unobserved copulations away from the release site. Off-lek copulations (Sexton 1979, Gibson & Bradbury 1987) were suspected in another sharp-tailed grouse translocation study in south-central Idaho, USA (Gardner 1997).

Regardless of the mechanism, the capture and translocation of females later in the lek-visitation period likely will increase the probability of post-release reproduction. The logistic response curve showed an inflection point at approximately four days following the approximate onset of female visitation of leks. Allowing several days to elapse between the start of female visits and the removal of females may result in a greater probability of nest attempts following translocation. In our study, females captured while visiting leks after 10 April (approximately eight days after the start of female capture efforts) had > 0.9 probability of nesting following the translocation. The precise time period will vary among capture areas and among years, but the principle remains the same.

The effect of capture date on nest attempt found here may not be as apparent in translocation efforts to augment existing populations of sharp-tailed grouse. Because we reintroduced grouse to an area of extirpation, there were no established leks in the release area. Releasing females near an existing lek with available males may increase the likelihood of copulation and insemination at the release site. Using similar techniques as in our study, four of 36 females (11%) were observed nesting following a reintroduction of Columbian sharp-tailed grouse to south-central Idaho, USA (Gardner 1997). Following the augmentation of an existing population, all translocated female grouse (N = 15) attempted to nest in north-central Washington, USA, during 8-13 April of 1998-2000 (M. Schroeder, pers. comm.). Grouse were captured from the same source population as grouse in our study, and essentially these data are consistent with our results in that all females in our study attempted to nest after 8 April. Nest attempts of grouse captured from established leks and monitored in their home-ranges have been shown to vary from 72 to 100% (Apa 1998, McDonald 1998).

Moreover, the lack of available males at an established lek following nest failure may explain why we did not detect any re-nests despite our careful monitoring, even though re-nesting is common among sharp-tailed grouse

in their home-ranges (83%, Svedarsky 1988; 86%, Bergerud 1988; 86%, Meints 1991), and re-nesting was observed following a translocation to augment a population (M. Schroeder, pers. comm.). It appears important, particularly in areas of reintroduction, to consider capturing female grouse at later dates of the female lek-visitation period during spring season translocations to increase reproduction.

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