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The Effects of Raven Removal on Sage Grouse Nest Success

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ABSTRACT: We measured the effects of common raven removal on the nest success of greater sage grouse. One cause of sage grouse population decline is thought to be reduced nest success due to egg depredation by ravens. Ravens are nest predators that have substantially increased in abundance in response to current human land-use practices. In many areas, wildlife managers use egg baits treated with DRC-1339 to reduce raven numbers in sage grouse habitat. The effects of raven removal on grouse nest success and identification of any compensatory nest predators are largely unknown. During 2002 and 2003, USDA WS removed ravens from an experimental area in Nevada, within which we deployed miniature, camouflaged video cameras with time-lapsed recorders at sage grouse nests. Using continuous video monitoring throughout the incubation period, we determined the identity and observed the behavior of sage grouse nest predators. Sage grouse nest success during 2002 and 2003 was 74% (n = 19), with no depredations of sage grouse nests or sage grouse nest visitations by ravens. We also observed the behavior of animals that encountered nests, and we identified possible biases with estimating raven "take" from the attrition of egg baits. We found video cameras to be effective devises for identifying predators. These results may be useful in formulating future predator removal activities for sage grouse management.

KEY WORDS: *Centrocercus urophasianus*, nest success, predator control, raven damage management, sage grouse, video nest monitoring

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INTRODUCTION

The common raven (*Corvus corax*) is considered a subsidized predator that has substantially increased in abundance throughout the intermountain west (Knight and Call 1980). The increase is strongly associated to anthropogenic resource subsidies (Boarman 1993), including power lines, roads, and landfills. Ravens are accomplished predators of bird nests and fledglings, and increased raven abundance in areas of human subsidies is thought to have "spillover predation" effects (Boarman 1993). Ravens may diminish many human benefits and disrupt ecosystem function when unnaturally abundant.

Increased raven numbers are thought to have cascading ecological effects, including increased sage grouse nest failure due to egg depredation by ravens (Alstatt 1995, Batterson and Morse 1948). An important constraint on sage grouse population growth is poor nest success (Autenrieth 1981). The USDI Fish and Wildlife Service has been petitioned to list the greater sage grouse (*Centrocercus urophasianus*) under the Endangered Species Act, and recently the Gunnison sage grouse (*C. minimus*) became a candidate species for listing. Wildlife damage management may have an important role to play in future sage grouse conservation plans. It is important that wildlife managers understand sage grouse responses to management actions to design effective wildlife damage management activities.

Animals that encounter sage grouse nests must be unambiguously identified to determine the effects of raven removal. Identification of predators will allow researchers to understand the efficacy of raven removal by measuring raven depredations. Also, identification will provide an understanding of any compensatory predator effects. In other words, researchers can determine if non-target predators are compensating for raven loss by destroying eggs that ravens would have depredated.

Using continuous videography at natural nests in the wild is an effective method to objectively identify predators and behavior (Pietz and Granfors 2000). The conventional method of identifying bird nest predators is the observation of predator sign from nest and egg remains at depredated nests. Using this method, it is difficult to accurately identify predators due to unreliable and misleading sign. Problems include multi-predator visits to nests, change in predators due to egg variations, different patterns of depredation within predator species, and similar patterns of depredation between predator species (Lariviere 1999). Photography with motion-sensor cameras may be useful but also problematic (Thompson et al. 1999). For example, film is rapidly depleted as a result of frequent female movements. Direct researcher observations are infrequent and bias toward diurnal predators (Pettingill 1976). The use of natural nests (Pietz and Granfors 2000) is critical to truly understand the dynamics of nest depredation because the differences between artificial nests (Major and Kendal 1996) and natural nests may influence predator composition at nests (Wilson et al. 1998). We used miniaturized camera and continuous video recorder that allowed unbiased identification of predators at sage grouse nests and also allowed us to observe predator behavior.

METHODS

The study area was located approximately 48 km south of Jackpot, Nevada and 18 km west of Nevada State Route 93 (UTM; 0673931, 4592958). USDA Wildlife Services (USDA WS) carried out systematic raven damage management procedures annually since

2001 and plans to continue until 2005 during the months of March - July. The purpose of raven removal was to increase nest success within a recently established population of Columbian sharp-tailed grouse (*Typanuchus phasianellus columbianus*); it was not carried out to benefit sage grouse reproduction per se.

Raven Removal

USDA WS conducted 5 standard raven surveys along the raven removal route during 2003. Raven surveys were initiated in early March prior to raven damage management activities and terminated in early July following the fate of all sage grouse nests. Each survey entailed counting the number of ravens observed every 800 m along a 27-km raven removal route.

The primary method of raven removal was through the use of chicken egg baits treated with DRC-1339, an avicide used to control avian pests (Spencer 2002). USDA WS placed 2 egg baits every 250 m along the raven removal route every 7 days. All depredated, missing, and undisturbed eggs were recorded within 72 h of placement, and non-depredated eggs were disposed. USDA WS estimated 1 raven "take" for every 4 eggs that were fully destroyed or missing from the placement area, and they used this formula as a conservative analogue to the standard of 1:2. We video-recorded 5 egg baits during the month of July to identify other egg bait predators.

Sage Grouse Nest Success

We captured female sage grouse near known leks during the time period 1 April - 15 May, both in 2002 and in 2003. We used spotlights and multi-frequency noise to capture grouse with nets (Giesen et al. 1982, Wakkinsen et al. 1992). We banded and fit 24 female sage grouse with 20-g necklace-style radio transmitters during 2002 (n = 8) and 2003 (n = 16).

We located each grouse at least 2 times per week until nesting behavior was observed. We radio-marked nests with 6 g-transmitters and used the distance between radioed females and radioed nests to determine the onset of incubation (Coates 2001). A nest was successful if ≥1 egg hatched from the clutch (Rearden 1951). Unsuccessful nests were classified as abandoned (female is >300 m from nest for 3 consecutive relocations) or depredated.

Predator Identity

We used miniaturized cameras with video recording systems to monitor sage grouse nests during 2002 and 2003. Cameras were camouflaged to avoid bias in the encounter frequency of animals that rely on visual cues to locate nests (Herranz et al. 2002). A subset of nests without video systems was used as a control to determine if the presence of the system affected nest success. Cameras were equipped with infrared night illumination (Pietz and Granfors 2000), not detectable by vertebrates, and placed 1 m from the nest. A 20-m cable was buried and connected to a continuous-recording, time-lapsed VCR (Pietz and Granfors 2000). We changed VHS tapes and batteries every 3 days and wore rubber boots and gloves to mask human scent.

RESULTS

Raven Removal

USDA WS placed a total of 6,184 egg baits along the raven removal route during 2002 (n = 2,420) and 2003 (n = 3,764). USDA WS removed an estimated 366 and 318 ravens during March - July of 2002 and 2003, based on egg disappearance and 1:4 ratio. Raven surveys indicated a declining trend in observed raven numbers from March to July during 2003 (Figure 1). During March, raven numbers were at a high of 5/km^2 and declined by July to a low of 0.31/km^2.

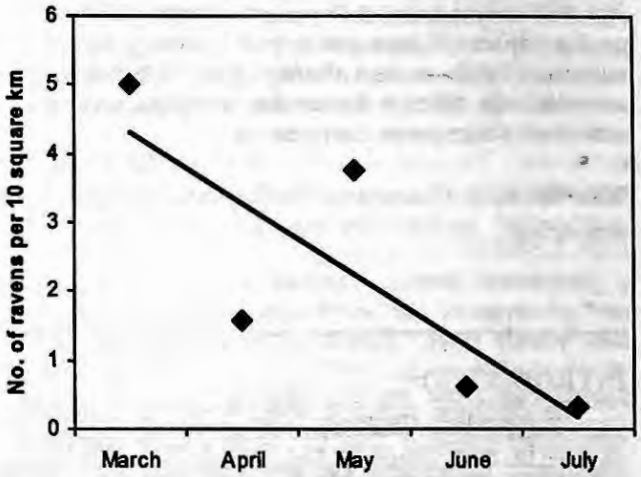

Figure 1. Number of ravens counted per 10 km^2 at a raven damage management area in NE Nevada, March-June 2003.

Sage Grouse Reproduction

Overall nest success was 73.6% (n = 19; Table 1). Of the nests that failed, depredation accounted for 60% (n = 3). We calculated an expected nest success from reported values in the literature to compare to our observed value. The expected nest success was 42.6% based on 14 studies of sage grouse nest success from 1941-1997 reported by Schroeder et al. (1999). Our observed nest success frequency was significantly greater than the expected nest success frequency ($G^2 = 3.961$, $p = 0.047$). There was no difference in nest success between video-recorded nests and control nests ($G^2 = 0.217$, $p = 0.641$).

Table 1. Success, depredation, and abandonment of greater sage grouse nests in an area of raven damage management activities in NE Nevada, 2002-2003.

	Nest Success		Nest Depredation		Nest Abandonment	
	# of Nests	N(%)[a]	# of Nests	N(%)[b]	# of Nests	N(%)[c]
2002	6	5(83)	1	1(100)	1	0(0)
2003	13	9(70)	4	2(50)	4	2(50)
Total	19	14(74)	5	3(60)	5	2(30)

[a] % of nests that produced ≥1 chick

[b] % of failed nests that were depredated

[c] % of failed nests that were abandoned

Predator Identity

A total of 13 nests were monitored using videography (n = 2, 2002; n = 11, 2003). Approximately 4,450 continuous incubation hours were recorded (950 h, 2002; 3500 h, 2003). A badger (*Taxidea taxus*) was the only predator to be identified by videography. We identified 6 different species of animals that encountered nests. We observed a Richardson's ground squirrel (*Spermophilus elegans nevadensis*) bite 3 eggs, but it did not penetrate the eggshells of a nest, while the female was away. A Townsend's ground squirrel (*Spermophilus townsendii*) dug up material around a nest but did not depredate eggs. A Great Basin pocket mouse (*Perognathus parvus*) and a least chipmunk (*Tamius minimus*) ate eggshells and eggshell membranes following a hatch. A Northern pocket gopher (*Thomomyns talpoides*) encountered a nest seemingly without depredating eggs. Of the 5 video-recorded egg baits, a Richardson's ground squirrel was observed eating and carrying off 2 egg baits on 2 occasions. No other animal was observed encountering egg baits.

DISCUSSION

We found that the observed sage grouse nest success near an area of raven removal activities (73.6%) was significantly greater than the expected nest success based on 14 studies (42.6; Schroader et al. 1999). Also, we found that 60% of the nest failures were due to depredation while 40% failed for other reasons. Low nest success in many sage grouse populations is associated with declining numbers of greater sage grouse (Aldridge and Brigham 2001). Previous studies have suggested that ravens are the primary predator of sage grouse nests and one of the greatest constraints to population increases of sage grouse (Autenrieth 1981, Batterson and Morse 1948).

Did the removal of ravens affect nest success of sage grouse? To answer this question it is important to understand nest success without the influence of raven removal in this study area. We have no direct knowledge of sage grouse nest success prior to raven removal because this project was initiated 2 years following the onset of raven removal. However, a translocated population of Columbian sharp-tailed grouse was monitored prior to the onset of substantial efforts to remove ravens during 1999-2000 (Coates 2001). The average nest success of sharp-tailed grouse prior to raven removal was 42% (Coates 2001). During the systematic raven removal activities, nest success of sharp-tailed grouse was 75%. Raven removal possibly increased nest success of sharp-tailed grouse. Therefore, it is possible that nest success was greater than the expected value of greater sage grouse in this study due to raven removal activities; this may be consistent with a study in Oregon that described increase nest success due to predator removal (Batterson and Morse 1948). Furthermore, ravens are considered primary predators (Autenrieth 1981), but we did not identify any raven encounters at video-recorded sage grouse nests. It is possible that raven removal decreased the occurrence of raven depredations.

Further investigation at this site, such as measuring nest success at various distances from the raven removal route, is needed to truly understand the relationship between raven removal and nest success. Our findings are preliminary, and during 2004-2005 we will measure nest success at various distances from the raven removal route to further identify any correlation.

Ground squirrels have been documented as effective sage grouse nest predators (Schroeder and Baydack 2001). However, we observed the Richardson's and Townsend's ground squirrels encounter nests and not depredate any eggs. On one occasion, a Richardson's ground squirrel appeared to bite 3 eggs but did not penetrate the eggshells. Least chipmunk and Northern pocket mouse were observed eating and crushing eggshells following a hatch. Therefore, subsequent scavenges by rodents may result in misidentifying sage grouse nest predators based on egg and nest remains.

Video recording is useful for evaluating the effectiveness of management activities on estimating raven "take." We observed a Richardson's ground squirrel depredate 2 egg baits but not sage grouse eggs. If ground-dwelling animals prove to be substantial egg bait predators, then elevated egg platforms may be important to target only corvids. Further egg bait recordings may provide an identification of these predators and an empirical basis for estimating raven "take."

Videography appears to be an effective tool for identifying sage grouse nest predators. Remains of eggshells and nests alone may not be reliable, due to biases that we observed associated with identifying predators from egg and nest remains (Lariviere 1998), such as subsequent eggshell scavenging and inter-specific predation patterns.

In conclusion, it is probable that direct raven removal increased sage grouse nest success in NE Nevada. This is consistent with experimental research of raven removal impacts on sage grouse nest success in Oregon (Batterson and Morse 1948). The majority of management plans recommend restoring habitat as a means of minimizing the predator-prey interactions. Due to the time lag between the beginning and completion of restoring sagebrush steppe communities and the rapidly declining rate of sage grouse abundance, it may be important to incorporate raven damage management activities for endangered populations until habitat quality is sufficient at concealing nests from predators.

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