Notes

Observations of Territorial Breeding Common Ravens Caching Eggs of Greater Sage-Grouse

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Abstract

Previous investigations using continuous video monitoring of greater sage-grouse *Centrocercus urophasianus* nests have unambiguously identified common ravens *Corvus corax* as an important egg predator within the western United States. The quantity of greater sage-grouse eggs an individual common raven consumes during the nesting period and the extent to which common ravens actively hunt greater sage-grouse nests are largely unknown. However, some evidence suggests that territorial breeding common ravens, rather than nonbreeding transients, are most likely responsible for nest depredations. We describe greater sage-grouse egg depredation observations obtained opportunistically from three common raven nests located in Idaho and Nevada where depredated greater sage-grouse eggs were found at or in the immediate vicinity of the nest site, including the caching of eggs in nearby rock crevices. We opportunistically monitored these nests by counting and removing depredated eggs and shell fragments from the nest sites during each visit to determine the extent to which the common raven pairs preyed on greater sage-grouse eggs. To our knowledge, our observations represent the first evidence that breeding, territorial pairs of common ravens cache greater sage-grouse eggs and are capable of depredating multiple greater sage-grouse nests.

Keywords: cache; *Centrocercus urophasianus*; common raven; *Corvus corax*; eggs; greater sage-grouse

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Introduction

Reproductive failure in most avian species is largely a result of nest predation, accounting for an average of 80% of nest failure across a wide range of species (Martin 1993). Birds nesting in human-altered landscapes often face further increased risk of nest predation attributable to increased abundance of predators (Kurki et al. 1997, 1998; Manzer and Hannon 2005). Often, these predators are subsidized by infrastructure that provide perch sites for avian predators or cover and den sites for terrestrial mammals (Manzer and Hannon 2005; Coates and Delehanty 2010). Numerous avian and terrestrial species are known to depredate nests, and predation of bird eggs by common ravens *Corvus corax* has been well documented (Montevecchi 1979; Marr and Knight 1982; Marquiss and Booth 1986; Ewins 1991; Avery et al. 1995). As common raven numbers increase and their distribution expands as the result of anthropogenic activities (Boarman 1993; Sauer et al. 2011), a concern over the negative impacts of egg predation by common ravens and the resulting adverse effects on species recovery and persistence has grown.

One species of particular concern is the greater sage-grouse *Centrocercus urophasianus*, whose populations

across the western United States and southern Alberta and Saskatchewan, Canada face numerous threats, including habitat loss, fragmentation, and alteration attributed to wildfire and human disruption of sagebrush communities (Schroeder et al. 2004; Knick and Connelly 2011). Continuous video monitoring of greater sage-grouse nests has unambiguously identified common ravens as a primary egg predator responsible for 46.7 to 59.0% of nest predations in some areas of Nevada (Coates et al. 2008; Lockyer et al. 2013). However, information is lacking regarding the quantity of greater sage-grouse eggs an individual common raven consumes during the greater sage-grouse nesting period, and the extent to which common ravens actively hunt greater sage-grouse nests. Bui et al. (2010) posited that territorial breeding common ravens, rather than nonbreeding transients, are most likely responsible for greater sage-grouse nest predations, but data to support this hypothesis are not easily obtained. For example, although videography at greater sage-grouse nest sites can unambiguously identify common ravens as a nest predator, no inferences can be made about the age, breeding status, or frequency at which an individual raven depredates greater sage-grouse nests. Dietary studies based on pellets can be misleading and biased, as only nondigestible material can be quantified (Stiehl and Trautwein 1991). Direct observations of common ravens consuming prey is rare and typically requires painstaking behavioral observations (Boarman and Heinrich 1999). Such investigations are further complicated by the fact that both breeding and nonbreeding ravens scatter-hoard food items (i.e. cache food in multiple locations, up to several kilometers from the source; Heinrich and Pepper 1998; Boarman and Heinrich 1999). Here, we describe greater sage-grouse egg depredation observations obtained opportunistically from three common raven nests located in Idaho and Nevada where depredated greater sage-grouse eggs were found at or in the immediate vicinity of the nest site, including the caching of eggs in nearby rock crevices.

Methods and Results

Observations from three common raven nest sites reported here were collected during the execution of two larger studies: 1) a resource selection study for nesting common ravens conducted during 2007–2009 on Department of Energy lands located in southeastern Idaho (Coates et al. 2014; Howe et al. 2014) and 2) an ongoing greater sage-grouse demography and nest predation study located in the Tuscarora Mountains of north central Nevada (U.S. Geological Survey unpublished data). Both study areas are high-desert sagebrush–steppe landscapes with varying degrees of habitat fragmentation and alteration by industrialization, multiple land-use activities, and wildfires. Upon discovering depredated greater sage-grouse eggs nearby each of the three common raven nests, we opportunistically monitored the nests by removing eggs that were completely or partially consumed, as well as any egg shell fragments, during each subsequent visit to estimate the extent to which the common raven pairs preyed on greater sage-grouse eggs.

During May 2008, we identified two common raven nests on the Idaho study site where depredated greater sage-grouse eggs were found nearby. The first nest was located on a small platform on an inactive communication tower located approximately 50 m from a large basalt crater. On 5 May 2008, we found and collected eight completely or partially consumed greater sage-grouse eggs that were clustered together on the rim of the crater. We returned 1 d later and collected three more broken or fractured eggs whose contents had been consumed. We returned on 13 May 2008 and found four additional depredated greater sage-grouse eggs. We returned to the nest site during the 2009 breeding season, however, the nest was not occupied.

The second common raven nest was located on a rock ledge at the entrance of Middle Butte cave, a basalt lava tube. On 16 May 2008, we found and collected three broken or fractured greater sage-grouse eggs from the rocks along the rim of the lava tube located within 20 m of the nest. We visited again on 6 June 2008 and collected seven greater sage-grouse eggs whose contents had been consumed. We returned to this nest site the following breeding season; and on 21 May 2009, we observed 12 depredated greater sage-grouse eggs.

The third common raven nest was located in Nevada on the Tuscarora study area on a small rock outcrop within a known greater sage-grouse nesting area. In late May 2011, 17 eggs, both whole and broken, were found cached in the rock crevices immediately adjacent to the nest and scattered over the rocky ridge within 50 m of the nest. We revisited the nest site in mid-June 2012. The nest was active, with three young common raven chicks present; however, we were unable to find any additional greater sage-grouse eggs or fragments around the rocky outcrop. This could be attributed to our late-season visit, as common raven predation of greater sage-grouse nests occur most frequently during the early incubation period (Coates and Delehanty 2008; Lockyer et al. 2013).

Discussion

To our knowledge, our observations represent the first evidence that single pairs of breeding, territorial common ravens are capable of depredating and caching eggs from multiple greater sage-grouse nests. Greater sage-grouse typically lay 5.6–8.2 eggs per clutch (Taylor et al. 2012). Based on the average number of greater sage-grouse eggs from all the observed common raven nest sites and caches (n = 13.5), this would equal two to three greater sage-grouse nest depredations per pair of common ravens per nesting season. However, this estimate likely under represents the number of nests depredated by a pair for multiple reasons. First, it is likely that not all depredated eggs were located despite our effort to thoroughly check the areas in the immediate vicinity of the nest sites and cache location. Common ravens cache temporary surpluses of food at multiple locations (Stiehl 1978; Heinrich 1988), and they often

conceal their caches with leaves, earth, grass, or snow (Heinrich 1988; Kilham 1988). For example, common ravens cached thick-billed murre *Uria lomvia* eggs and chicks in moss during the early breeding season in Canada (Gaston et al. 1985, as cited by Boarman and Heinrich 1999). Furthermore, the eggs we located likely represent only those eggs that were not immediately consumed at the depredated nest site. A study of greater sandhill crane *Grus canadensis* nest predation reported that common ravens consumed 67% of the eggs at the nest and cached the remaining 33% (Austin and Mitchell 2010).

Although we were unable to precisely locate the cache sites for the two Idaho nest sites, we believe that it is reasonable to assume that the common raven pairs were caching eggs in crevices of the rock walls near their nests where they also consumed them, as was found at the Tuscarora nest site. It is important to note that our observations were merely opportunistic while conducting ecological studies that were not designed to actually locate common raven cache sites or to conduct behavioral investigations. Although we did not directly observe common ravens caching, retrieving or consuming the eggs, dietary investigations of breeding common ravens are often based on pellets, skeletal remains, and eggshells collected within the vicinity of nest sites (Marquiss and Booth 1986; Stiehl and Trautwein 1991). Investigations into the food storage behavior of the northwestern crow *Corvus caurinus* found that food was always eaten at the cache site, with the exception of clams, which were dropped onto nearby rocks (James and Verbeek 1983). Furthermore, it is unlikely that other common ravens or avian predators consumed the greater sage-grouse eggs within such proximity, as common ravens actively defend their nesting territories and do not allow other ravens to consume foods near their nests.

The number of greater sage-grouse eggs found at or near these common raven nest sites indicates that some breeding ravens depredate multiple greater sage-grouse nests during the nesting season, and cached eggs likely provide an important source of nutrition during the incubation and nestling stage. Eggs are well suited for long-term storage, as they are protected by the eggshell and chemical properties of the albumen prevent microbial activity (Freeman and Vince 1974). Food cached in rock crevices would remain cooler than the ambient temperature and thus preserved for a longer duration of time. Eggs cached in rock crevices would also be well hidden from, and easily defended against, conspecifics.

Results from a common raven survey study (Bui et al. 2010) indicated that territorial common ravens may be more likely responsible for depredation of greater sage-grouse nests than those that were nonbreeding. Our observations support that hypothesis in that these observations verify depredation by territorial common ravens. However, nothing can be extrapolated from our observations regarding nonbreeding common ravens. Although one study found breeding and nonbreeding common raven diets to be similar during the spring (Marquiss and Booth 1986), further research that focuses on differences in predation rates of greater sage-grouse nests and food storage behaviors between breeding and nonbreeding common ravens is warranted. In addition, our study did not quantify the proportion of the population that exhibit behaviors of greater sage-grouse nest predation and caching eggs. Thus, it is also possible that not all common ravens cache eggs and depredate greater sage-grouse nests.

Nest predation is a natural ecological process in avian systems (Martin 1988); and at low densities in habitat of sufficient quality and quantity, common raven's effect on the nesting productivity in other bird species is likely minimal. This study did not quantify the relative importance of nest predation by common ravens on greater sage-grouse populations. However, ultimate factors related to habitat loss and fragmentation often associated with cropland conversion, urban expansion, wildfire, and invasion of nonnative vegetation (Schroeder et al. 1999, 2004; Crawford et al. 2004; Knick and Connelly 2011) are more likely to regulate greater sage-grouse populations at large spatial scales. Nevertheless, land-use practices that artificially enhance common raven nesting opportunities, such as power line development (Knight and Kawashima 1993; Steenhof et al. 1993; Howe et al. 2014) across contiguous or fragmented sagebrush ecosystems, could result in reduced demographic performance for sensitive species such as greater sage-grouse through means such as increased risk and hyperpredation (Courchamp et al. 2000) of nests and chicks. Coupled with other low population vital rates (Schroeder 1997; Schroeder et al. 1999), this effect may limit population recruitment and maintenance of greater sage-grouse populations.

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