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Effects of predation and hunting on adult sage grouse *Centrocercus urophasianus* in Idaho

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Although sage grouse *Centrocercus urophasianus* have declined throughout their range in North America, little is known about annual mortality patterns of this species. Thus, we summarize a long-term data set on timing and causes of mortality of sage grouse. Predation was the most common cause of death for radio-marked sage grouse. For adult males, 83% of deaths were attributed to predation and 15% to hunting. However, for adult females, 52% of deaths were caused by predation while 42% were attributed to hunting. We rejected the hypothesis that type of mortality (predation vs hunting) was independent of gender of sage grouse. For males, 70% of deaths occurred during spring and summer (March-August) and 28% occurred in September-October. For females, 52% of mortalities occurred during spring and summer and 46% occurred in September-October. We rejected the hypothesis that time of death is independent of the gender of sage grouse. In six of 15 years (40%), harvest rates for adult females may have exceeded 10% while this rate was only exceeded in two of 15 years (13%) for adult males.

Key words: hunting, mortality, predation, radio-telemetry, sage grouse

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Sage grouse *Centrocercus urophasianus* have been a popular and relatively common gamebird in western North America (Patterson 1952, Autenrieth 1981, Braun & Beck 1985). However, little is known about annual mortality of the species, especially with regard to predation and hunting. A long-term decline (-33%) in breeding populations of the species throughout its range (Connelly & Braun 1997) suggests that a better understanding of these mortality factors is necessary for appropriate management decisions.

Although little is known about annual mortality patterns, survival and reproduction by sage grouse have been well documented. Zablan (1993) reported that survival rates for females averaged 55%, whereas survival rates for yearling and adult males averaged 52 and 38%, respectively. In Idaho, annual survival of male sage grouse ranged within 46-54%, and female survival ranged within 68-85% (Connelly, Reese, Wakkinen, Robertson & Fischer 1994). Estimates of sage grouse nest success vary within 12-86% (Trueblood 1954, Gregg 1991, Schroeder, Young & Braun 1999), and average clutch size varies from 6.0 to 9.5 eggs (Sveum 1995, Schroeder 1997). Renesting by sage grouse varies regionally from <20% (Patterson 1952: 105, Eng 1963, Connelly, Fischer, Apa, Reese & Wakkinen 1993) to >80% (Schroeder 1997). Despite some vari-

ation, sage grouse generally have low reproductive rates and high annual survival compared to most gallinaceous species (Zablan 1993, Connelly et al. 1994, Schroeder 1997, Schroeder et al. 1999).

Mortality of sage grouse populations in Idaho has been studied almost continuously from 1977 to the present. This paper synthesizes long-term data on predation and hunting rates on sage grouse in Idaho and compares predation and hunting rates between sexes. We make management recommendations based on the analyses.

Study areas

Fieldwork was conducted on seven different study sites along the Snake River Plain in southern Idaho. The areas were dominated by big sagebrush *Artemisia tridentata*, bluebunch wheatgrass *Agropyron spicatum*, needle and thread grass *Stipa* spp. and a variety of forbs. Complete descriptions of the study areas are given in Connelly (1982), Klott, Smith & Vullo (1993), Fischer (1994) and Apa (1998). Coyotes *Canis latrans*, badgers *Taxidea taxus*, ravens *Corvus corax*, and golden eagles *Aquila chrysaetos* were common predators in all study areas. During 1977-1995, grouse in all study areas were subject to relatively liberal hunting seasons during September and October that were either 14 or 30 days with a two or three bird bag limit and four or six bird possession limit. During 1995-1998, grouse seasons were more restrictive with some areas closed and others having a one or two bird bag limit and two or four bird possession limit, with seasons of seven or 14 days.

Methods

Sage grouse were captured on and near leks using spotlights (Giesen, Schoenberg & Braun 1982, Wakkinen, Reese, Connelly & Fischer 1992). All birds were banded and varying numbers each year were equipped with either solar or battery powered transmitters weighing <20 g. During the 1990s, most transmitters contained mortality indicators.

Birds were monitored 1-3 times weekly during spring, summer and early fall. However, during late fall and winter birds may have only been monitored monthly in some study areas because of access and personnel limitations. Radio-locations were made from the ground with a hand-held, 3- or 4-element yagi antenna. When signals could not be detected from the ground, locations were made from fixed wing aircraft using dual H antennas and a forward-facing 4-element yagi antenna.

We noted the general health and condition of all birds captured and marked. Evidence obtained at the mortality site (e.g. tracks, droppings, bite marks) and previous telemetry data were used to assess cause of death. If cause or time of death could not clearly be identified, we did not include the information in our analysis. During winter and spring, most grouse occurred in relatively isolated habitats where causes of death, other than by predation, were rare.

Information on hunter-killed birds was obtained by returns of bands and radios by sportsmen. These efforts were aided by establishing game check stations during the opening weekend of every season to obtain sex and age data on harvested birds and detailed information on marked birds shot by hunters.

Temporal patterns for mortality and harvest rates of banded and radio-marked birds are only reported for adults because sample sizes for juveniles were too small for meaningful comparisons. A G-test with a William's correction factor (Sokal & Rohlf 1981:737) was used to assess the hypotheses that time and type of mortality were independent of gender. We considered differences significant if $P < 0.10$.

Results

Predation was the most common cause of death for radio-marked sage grouse (Table 1). For adult males, 83% of documented deaths were attributed to predation and 15% to hunting. However, for adult females, 52% of deaths were caused by predation while 42% were attributed to hunting (see Table 1). Other causes of death included vehicles and powerlines, but these accounted for only 6% of total mortality (see Table 1). We rejected the hypothesis that type of mortality (predation vs hunting) was independent of gender of sage grouse ($G = 5.75$, $df = 1$, $P < 0.025$) and concluded that female grouse were more likely to die from hunting than were male grouse.

Table 1. Causes of death of 117 radio-marked adult sage grouse in Idaho during 1978-1998. Numbers in parentheses indicate the percentage of total deaths for each gender attributed to the cause of death.

Sex	Predation	Hunting	Vehicles	Powerlines	Other	Total
Male	33(83)	6(15)	0	1(2)	0	40
Female	40(52)	32(42)	3(4)	0	2 (3)	77
Total	73(62)	38(32)	3	1(9)	2(17)	117

Table 2. Number of deaths of 103 radio-marked sage grouse in bimonthly intervals in Idaho during 1978-1998. Numbers in parentheses indicate the percentage of deaths for each bimonthly interval.

Sex	Jan/Feb	Mar/Apr	May/Jun	Jul/Aug	Sep/Oct	Nov/Dec	Total
Male	1 (2)	3 (7)	14 (35)	11 (28)	11 (28)	0	40
Female	0	10 (16)	17 (27)	6 (10)	29 (46)	1 (2)	63
Total	1 (1)	13 (13)	31 (30)	17 (17)	40 (39)	1 (1)	103

Of all deaths, 39% occurred in September and October, 30% in May and June, and 17% in July and August (Table 2). Of the September-October deaths, 95% were due to hunting. Only one of these birds appeared to be a crippling loss. Only 2% of the recorded deaths occurred during winter (November-February; see Table 2). For males, 70% of deaths occurred during spring and summer (March-August) and 28% occurred in September-October (see Table 2). For females, 52% of mortalities occurred during spring and summer and 46% occurred in September-October (see Table 2). We rejected the hypothesis that time of death is independent of the gender of sage grouse ($G = 10.076$, $df = 5$, $0.10 < P < 0.05$) and concluded that females suffer higher mortality than males during September and October.

During 1978-1998, 2,100 male and 149 female sage grouse were marked with only leg bands. Direct band returns for sage grouse marked during 1978-1998 indicated an overall return rate for males of 3.5% with yearly variation ranging within 0-10%. The overall return rate for females was 6.0% with yearly variation ranging within 0-50%; however, only four females were banded the year that the 50% return rate was recorded. Because all of the studies were dependent on radiotelemetry, we had relatively few years when >20 banded female grouse were available to hunters. Thus annual sample sizes for females were relatively small.

Mortality rates estimated from radio-marked grouse were only slightly higher than those of band returns (Table 3). However, radio-telemetry data suggest that in six of 15 years (40%), return rates for adult females may have exceeded 10% while this rate was only exceeded in two of 13 years (15%) for adult males (see Table 3).

Discussion

Sage grouse generally have high annual survival and low reproductive rates (Zablan 1993, Connelly et al. 1993, Connelly et al. 1994). Although predation was the most common cause of death for adult sage grouse in Idaho, high annual survival (Connelly et al. 1994) and relatively few deaths over winter suggest that predation had little impact on sage grouse populations. Wallestad (1975) also reported relatively few deaths of

Table 3. Harvest rates of 504 radio-marked sage grouse in Idaho during 1978-1998.

	Adult males			Adult females			Overall		
Year	Marked	Shot	% Shot	Marked	Shot	% Shot	Marked	Shot	% Shot
1978	3	0		1	0		4	0	
1979	6	0		11	0		17	0	
1980	4	0		10	2	20	14	2	14.3
1981	0	0		1	0		1	0	
1982	0	0		0	0		0		
1983	0	0		0	0		0		
1984	0	0		0	0		0		
1985	0	0		0	0		0		
1986	11	1	9.1	8	0		19	1	5.3
1987	16	0		21	1	4.8	37	1	2.7
1988	8	0		44	1	2.3	52	1	1.9
1989	14	2	14.3	47	2	4.3	61	4	6.6
1990	7	0		54	8	14.8	61	8	13.1
1991	9	0		79	8	10.1	88	8	9.1
1992	8	0		39	0		47	0	
1993	35	2	5.7	16	1	6.2	51	3	5.9
1994	14	0		8	2	25	22	2	9.1
1995	6	1	16.7	4	2	50	10	3	30
1996	0	0		0	0		0		
1997	0	0		0	0		0		
1998	0	0		20	3	15	20	3	15
Total	141	6	4.3	363	30	8.3	504	36	7.1

adult birds from predation. Generally, sage grouse appear to suffer the highest natural mortality during spring and summer.

Studies of the effects of exploitation on some gamebird species suggest that hunting may be an additive form of mortality (Bergerud 1985, 1988). Hunting has been shown to have negative effects on bobwhite quail *Colinus virginianus* (Roseberry 1979, Robinette & Doer 1993, Dixon, Horner, Anderson, Henriques, Durham & Kendall 1997), ruffed grouse *Bonasa umbellus* (Kubisiak 1984), and sharp-tailed grouse *Tympanuchus phasianellus* (Gregg 1990). However, other investigators have concluded that hunting has little effect on upland game populations (Dorney & Kabat 1960, Palmer & Bennett 1963, Hoffman 1985).

Hunting has been reported to have little influence on sage grouse populations (Braun & Beck 1985, Wallestad 1975), although research has suggested that this species may be vulnerable to overharvesting on a local basis (Autenrieth 1981, Crawford & Lutz 1985, Zunino 1987).

Our analysis suggests that female sage grouse are more susceptible to hunting than males, and that losses of females to hunting may be more than twice as high as losses of males. The vulnerability of females to hunting is likely due to their clumped distribution during the hunting season (i.e. females concentrating with juveniles in or near moist areas) compared to males that tend to be more dispersed.

Little information is available in the literature on harvest rates of sage grouse. In Colorado, return rates for adult males ranged within 5-15% whereas rates for adult females were 8% (Braun & Beck 1985, Zablan 1993). During 1968 in Idaho, harvest rates were 22 and 8% for banded adult male and female sage grouse, respectively (Autenrieth 1981). However, for juveniles, harvest rates were 19% (Autenrieth 1981). Overall harvest rates (for all sexes and ages combined) ranged from < 3% in Oregon (Willis, Keister, Immell, Jones, Powell & Durbin 1993) to 25% in Wyoming (Patterson 1952). Generally, published information indicates that overall harvest rates for sage grouse vary within 0-25% with little apparent difference between sexes. The highest harvest rates were reported from parts of Idaho (Gray 1967, Autenrieth 1981) and Wyoming (Patterson 1952) while the lowest rates were reported from Colorado (Braun 1998) and Oregon (Willis et al. 1993).

In our study, harvest rates from band return and radio-telemetry data were similar, suggesting that a high proportion of bands were reported. Our data indicated that harvest rates varied annually for both sexes, and rates for females were relatively high (>10%) during some years. However, data on males were limited compared to those on females, and return rates for males may be biased by small sample sizes. Crawford & Lutz (1985) also reported variable harvest rates for sage grouse in Oregon.

Modern hunting can reduce breeding stocks of a variety of wildlife species (Peek 1986: 358) and hunting may be additive to over-winter mortality for many grouse species (Bergerud 1988: 702). Johnson & Braun (1999) also suggested that hunting mortality may be additive for sage grouse and suggested decreasing hunting in some areas to further test this idea. Sage grouse have low over-winter mortality with natural mortality largely occurring in spring and summer. Females generally appear more vulnerable to hunting than males. Therefore, we agree with Bergerud (1988) and Johnson & Braun (1999) that hunting losses are likely additive to winter mortality and may result in lower breeding populations. Additive mortality does not necessarily imply that populations cannot withstand some level of exploitation (Peek 1986: 286), especially given the variable and often low annual harvest rates for sage grouse. For most sage grouse populations, caution should be exercised when establishing hunting seasons (Schroeder et al. 1999), hunting should be delayed in fall to allow population mixing, and bag and possession limits should be relatively conservative (Braun 1998).

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