Cause-specific Mortality of Rocky Mountain Elk Calves in Westcentral Montana

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Introduction

Managers are faced with the daunting task of successfully monitoring populations and of assuring the persistence of elk (*Cervus elaphus*) and of other ungulate species. Elk provide both economic and aesthetic value despite being abundant and widespread. In 2002, elk hunting expenditures from nonresidents and residents in Montana generated more than $67.7 million for the state (Hamlin 2004). Currently, statewide elk population estimates are 130,000 to 160,000, compared to the estimated 55,000 in 1978 (Hamlin 2004).

Often, agencies conduct aerial surveys to monitor ungulate populations and to document changes in population size or recruitment rates (Rabe et al. 2002). Recruitment is the addition of calves into the adult age classes and is generally indexed by the ratio of calves per 100 cows or the proportion of cows with calves at the heel (Houston 1982). Recruitment rates in Rocky Mountain elk (*C. e. nelsoni*) appear to be declining in Montana and in neighboring states. In Montana's Hunting District (HD) 292, the ratio of calves per 100 cows apparently declined from 41 in 1988 to 20 in 2001 (Hamlin 2004, Figure 1). Declining calf to cow ratios in elk have also been documented in the Glacier National Park area (Kunkel and Pletscher 1999), Gravelly Mountains in Montana (Hamlin and Ross 2002), Lochsa and South Fork Clearwater areas of Idaho (Zager 2001), and statewide in Colorado (White et al. 2001). This decline in

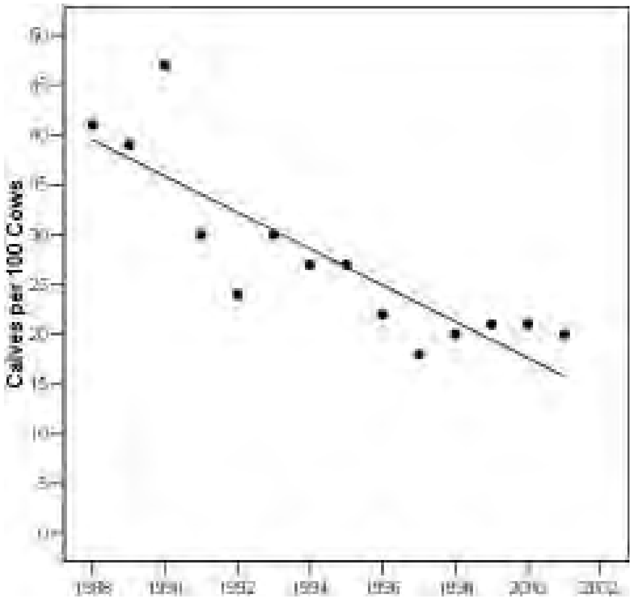

Figure 1. Calf to cow ratios in Rocky Mountain elk obtained from 1988 to 2001 annual spring green-up aerial surveys in westcentral Montana study area (Hamlin 2004).

recruitment is of great concern to wildlife managers because recruitment replaces the loss of adults from predators, harvest and other factors (Gratson and Zager 1999, 2000) and may lead to decreases in population size.

Managers and some segments of the public are concerned that predators are limiting the recruitment of young in many ungulate populations. Substantial predation rates upon neonate ungulates have been documented in some areas for elk (Smith and Anderson 1996, Singer et al. 1997), mule deer (*Odocoileus hemionus*, Bishop et al. 2005), white-tailed deer (*O. virginianus*, Whittaker and Lindzey 1999), caribou (*Rangifer tarandus*, Valkenburg et al. 2004) and moose (*Alces alces*, Keech et al. 2000). Our objectives were to estimate survival and to document the causes of mortality in elk calves in Montana's HD 292 in westcentral Montana. We chose this study area because of the declining trends in the ratio of calves per 100 cows observed during aerial surveys. In addition, Montana Department of Fish, Wildlife and Parks (MTFWP) biologists were simultaneously monitoring and estimating densities of the top predator in this study area, the mountain lion (*Puma concolor*). Other large predators in our study area include grizzly bears (*Ursus arctos horribilis*), black bears (*U. americanus*) and coyotes (*Canis latrans*).

Methods

We captured and equipped elk calves with radio collars or ear transmitters shortly after birth during late May to early June to estimate survival and cause-specific mortality rates. We monitored calves one to three times daily after instrumentation until September 1, from 2002 to 2006, to estimate summer survival. We also obtained an annual survival estimate in 2005 by monitoring calves through their first year. We estimated survival from the marked samples as the number of individuals that died divided by the total number of uncensored individuals. We censored calves when transmitters failed or could not be found, and when tracking devices dropped off calves prematurely.

We located transmitters usually within 12 hours of detecting mortality signals, and we examined the site for remains to determine cause of death. We concluded malnutrition as the cause of death when we observed empty or nearly empty stomachs, red and gelatinous femur marrow, absent kidney fat, low weight gain or weight loss, and no abnormalities (e.g. lesions) associated with disease were present. We concluded predation as the cause of death when hemorrhaging was present and calves did not exhibit signs of malnutrition or disease. Identification of predator species followed O'Gara (1978) using consumption patterns, canine punctures, tracks, scat and hair. We also sent complete carcasses with no sign of hemorrhaging to the MTFWP Research Lab (Bozeman, Montana) to search for signs of malnutrition and disease. We calculated chi-squared statistics and used Fisher's exact test to test for differences in the sources of mortality across years.

Results and Discussion

Survival Estimates

We captured 221 elk calves from May 25 to June 8 between 2002 and 2006 (Table 1). Summer survival estimates ranged from 0.29 to 0.89, with an average rate of 0.74 (standard error = 0.11) across the study period. The annual survival estimate was 0.61 for 2005, compared to the summer survival estimate of 0.79 for marked calves. We censored an additional 11 calves and documented 4 additional mortalities after the 2005 summer period.

Table 1. Fate of calf elk radio marked as neonates during summer (May 25 to August 31) by year on the Garnet Mountains study area, westcentral Montana, 2002 to 2006. Proportions of total mortality for that year are presented in parentheses.

Fate	2002	2003	2004	2005	2006	Total
Mortality	15	3	7	10	6	41
Predation	10 (0.67)	3 (1.00)	4 (0.57)	5 (0.50)	5 (0.83)	27 (0.66)
Bear	6	2	2	1	0	11
Cougar	2	0	1	3	1	7
Coyote	1	0	0	0	1	2
Unknown	1	1	1	1	3	7
Malnutrition	2 (0.13)	0	2 (0.29)	2 (0.20)	1 (0.17)	7 (0.17)
Abandonment	2 (0.13)	0	0	0	0	2 (0.05)
Disease	1 (0.07)	0	1(0.14)	0	0	2 (0.05)
Other[a]	0	0	0	2 (0.20)	0	2 (0.05)
Unknown	0	0	0	1 (0.10)	0	1 (0.02)
Survived	6	25	42	37	41	151
Censored	6	14	3	2	4	29
Total sample	27	42	52	49	51	221

[a] Other mortalities included one drowning and one fence entanglement

Cause-Specific Mortality Rates

Forty-one of the 192 calves (21 percent) retaining their radio transmitters died during their first 13 weeks (Table 1). Predation was the greatest source of mortality, accounting for 27 (66 percent) of all known mortalities. Bear predation was the only source of mortality that differed across years (÷2 = 24.80, df = 4, P < 0.001,), occurring more often in 2002 than in all other years. In addition, bear predation (27 percent of all mortalities) was the greatest single source of mortality in elk calves across years. Mortality varied temporally throughout the summer with 76 percent of all mortalities occurring during the neonatal period from capture to 6 weeks postcapture (Figure 2). Most bear predation (91 percent) and malnutrition (86 percent) mortalities occurred early in the summer during the neonatal period, while the first lion mortality occurred 5 weeks after capture.

Marked calves also died from malnutrition (17 percent), abandonment (5 percent) and disease (5 percent) in addition to predation. Calves died from malnutrition (n = 7, where n represents the sample size) in every year of the study except in 2003. The only cases of capture-related abandonment occurred in 2002, when 2 intact calves were recovered 4 and 5 days postcapture and had lost 3.9 and 7.9 pounds (1.8 and 3.6 kg), respectively. Two marked calves also died from disease (pneumonia) during our study. One calf died from *Escherichia coli* and

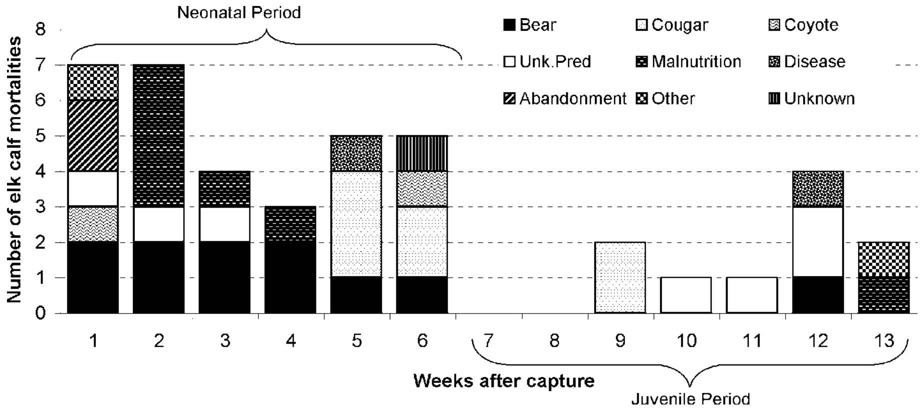

Figure 2. Temporal component of cause-specific mortality (n = 41) of calf elk radio marked as neonates within 13 weeks of capture on the Garnet Mountains study area, westcentral Montana, 2002 to 2006.

Streptococcus (spp.) that infected the lung tissue 5 weeks postcapture in 2002. Similarly, *Streptococcus* (spp.) and *Arcanobacterium pyogenes* infected the lung tissue of the other calf that died 12 weeks postcapture in 2004.

Comparison to Other Cause-specific Mortality Studies on Neonatal Ungulates

The percentage of summer mortality attributed to predation (66 percent) in our study was remarkably similar to rates reported in other elk calf mortality studies (68 percent, Smith and Anderson 1996; 72 percent, Singer et al. 1997; 95 percent, Barber-Meyer et al. 2008). However, the overall summer predation rates (calves killed per total uncensored calves) across elk calf mortality studies were lower in our study (14 percent) than in studies conducted in Yellowstone National Park (YNP) prior to wolf (*Canis lupus*) reintroduction (22 percent, Singer et al. 1997), a more recent YNP postwolf reintroduction study (67 percent, Barber-Meyer et al. 2008) and in Idaho (29 percent, Zager et al. 2002). Bear predation was the primary source of mortality in elk calves across all studies but was much lower (27 percent of all mortalities) in our study, compared to rates reported by Smith and Anderson (50 percent, 1996), Singer et al. (52 percent, 1997) and Barber-Meyer et al. (63 percent). In contrast, summer mortalities attributed to mountain lion predation was higher in our study (17 percent of all mortalities) than in Wyoming (0 percent, Smith and Anderson 1996), YNP prewolf (0 percent, Singer et al. 1997), and YNP postwolf (3 percent, Barber-Meyer et al. 2008).

The level of summer malnutrition (17 percent of all mortalities) in our study was higher than previous mortality studies on neonatal ungulates. Summer malnutrition rates in elk calves ranged from 0-9 percent (Smith and Anderson 1996, Singer et al. 1997, Barber-Meyer et al. 2008). However, Pojar and Bowden (2004) assessed the nutritional condition of mule deer fawns based on thymus gland condition and on weight. They reported that 38 percent of known mortalities died from sickness or starvation from capture to mid-December. We believe cause-specific mortality studies often underestimate neonatal loss due to malnutrition because it is difficult to assess, is generally not assessed when a predator sign is present, is generally assessed only with intact carcasses or is evaluated only during winter months. For example, winter malnutrition was primarily identified by intact carcasses and evaluated from femur marrow fat measurements in mule deer fawns (Bishop et al. 2005). Underestimation of malnutrition may lead to overestimation of mortality caused by predators. We relied on degree of weight loss, absence of milk curds or vegetation in stomach, color and texture of femur marrow, and kidney fat to assess malnutrition. We assessed the nutritional condition of carcasses even when predator signs were present (whenever possible), which resulted in the nutritional condition assessed in 60 percent of the calves killed by predators. For example, one carcass in 2005 had obvious cougar-predation signs (heart and liver partially consumed, spherical entrance wound, tufts of hairs removed, and broken ribs), but the femur marrow was dark red and gelatinous and the rumen was filled with dirt. Therefore, we concluded that malnutrition was the ultimate cause of death.

Conclusions

Many studies have emphasized the high contribution of predators to mortality in neonatal ungulates. In such cases, managers could manipulate the densities and assemblages of predators to change survival of young. Though predation was the primary source of mortality in calves, we believe that predators are not limiting recruitment in the elk population in our study because summer survival estimates were consistently high. However, relating predation to ungulate recruitment and population growth depends on how much of this mortality is additive versus compensatory. We documented relatively high summer malnutrition rates (at least 17 percent of all mortalities) in our study and suggest that some predation is compensatory. In cause-specific mortality studies, it is necessary to investigate mortalities promptly and to assess the nutritional condition of individuals killed. Despite its difficulty with partially consumed carcasses, it is essential to determine whether poor nutrition predisposed young to predation. Otherwise, predation rates reported may be biased high and factors affecting habitat quality and forage availability may be overlooked.

The elk population in our study area is probably more representative of areas across the western United States than to studies conducted on refuges and national parks where hunting is limited or when elk are fed. We also chose a study area that represents conditions where there are currently no wolf packs. However, the presence of wolf-predation signs has continued to increase throughout the study area. We have received several reports of wolf sightings and we have documented a spike elk killed by a wolf (or by wolves) in the study area in 2006. Therefore, our study will serve as a reference to assess the impact of wolves on elk calf survival and recruitment, should they recolonize and establish viable packs.

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