SCABIES AND ELK MORTALITIES ON THE NATIONAL ELK REFUGE, WYOMING

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Abstract: During winter 1982-83, mortalities from the Jackson Hole elk herd, wintering on the National Elk Refuge, were located and biological data regarding age, sex and condition were recorded. A total of 170 mortalities occurred: 101 (59.4%) adult bulls, six (3.5%) spike bulls, 29 (17.1%) cows, 29 (17.1%) calves and five (2.9%) antlerless (either cows or calves). The percent of adult bulls among the mortalities was significantly ($P<0.001$) greater than their percent composition (19%) of the winter herd. The mean age of male mortalities (excluding calves) was 7.35 years (N=89). The mean age of female mortalities (excluding calves) was 11.86 years (N=22). At least 63 of the adult bull mortalities during winter 1982-83 showed clinical signs of scabies or psorotic mange. The presence or absence of scabies could not be confirmed in another 32 carcasses because little or no hide remained. Two old ($\bar{x}=16.0$ years) adult cow mortalities had scabies but scabies was not evident on calf or spike mortalities. The incidence of scabies, evidenced by alopecia, during winter 1983-84 was 27.8% of adult bulls, 9.6% of spikes, 33.3% of cows, and 1.0% of calves. The percent of bulls among total winter mortalities is significantly correlated ($P<0.05$) with the percent of bulls in the winter herd over the past 15 years. A herd reduction program, initiated in 1977, increased the overall bull:cow ratio of the Refuge herd. Field observations indicate that the high bull:cow ratio is unique to the herd segment that summers in Grant Teton National Park. The rising bull:cow ratio may have predisposed more bulls to scabies as a result of debilitation during the rut.

INTRODUCTION

The purpose of this study was to determine age and sex of winter elk mortalities on the National Elk Refuge (NER), Wyoming, and the incidence of scabies, psorotic mange, among mortalities. Winter losses are an expected occurrence among ungulates of northern latitudes in the United States and Canada, and in fact, were instrumental in the creation of the NER (Wilbrecht and Robbins 1978). Although winter losses can escalate in severe winters, their contribution to annual losses among hunted populations of elk existing on sufficient habitat, is usually far less than the hunter harvest.

In situations where available winter range has been reduced due to usurpation by man, as is the case of the Jackson Hole elk herd, winter feeding of elk has dampened the effects of adverse winter conditions on natural mortality rate (Murie 1951, Anderson 1958). Winter mortality on the NER during the past 45 years has averaged about 2% of the wintering herd, although an effort was not generally made prior to 1968 to locate and record all mortalities.

Data collected during the winter of 1982-83 from winter elk mortalities are discussed in relation to the complexity of the management of the Jackson Hole elk herd.

I thank the staff of the National Elk Refuge and G. Roby of the Wyoming Game and Fish Department for assistance with locating mortalities and collection of teeth. I also thank T. Moore and other personnel at the Wyoming Game and Fish Laboratory in Laramie for their efforts to age the teeth.

HISTORICAL PERSPECTIVE

Jackson Hole, Wyoming, was historically a wintering area for elk. Cole (1969) wrote that "The 1887 to 1911 estimates of 15,000 to 25,000 elk in the Jackson Hole herd, with highest numbers reported during severe winters, should establish the fact that the area was a historical wintering (ground)." In 1884, the first settlers arrived in Jackson Hole and homesteaded lands where elk had wintered. By 1909, homesteaders and ranchers had settled large areas of the elk's winter range. Conversion of the land for livestock use, "tusk" hunting, and several severe winters, resulted in heavy elk losses during the winters of 1889, 1890, 1891, 1909, 1910 and 1911. These losses, and depredation by elk on ranchers' haystacks, resulted in appeals from residents of Jackson Hole that brought national attention to the elk situation. During the winter of 1910, the Wyoming State Legislature appropriated $5,000 to purchase hay to feed the elk. But the amount was inadequate, and hundreds of elk died that winter (Wilbrecht and Robbins 1978). During the severe winter of 1911, elk losses were conservatively estimated at 2,500 and 75% of the calves died before spring arrived (Brown 1947). That same year, the U.S. Congress appropriated $20,000 for the purchase of hay and conducting of studies to determine what should be done to alleviate the situation (Anderson 1958).

As a result of the studies, Congress appropriated $50,000 in 1912 and 1913 to purchase land for the production of feed for elk. From its initial size of 1,760 acres in 1912, the Refuge has increased - through federal acquisition of homesteads and a 1,760 acre donation by the Izaak Walton League - to its present 24,300 acres.

Supplemental feeding of elk has been necessary 63 out of the 72 years of the Refuge's existence. Although the Refuge produces about 13,000 tons of herbaceious forage (Anon. 1984), deep, crusted snow generally limits the availability of forage by February and necessitates supplemental feeding. Since 1912, the average duration of supplemental feeding has been 75 days. The 5,000 to 9,000 elk which winter on the Refuge are split up and fed on three to five separate feedgrounds on the Refuge. Hay was fed to the elk, either in loose (up to 1938) or baled form (1938-1974). In 1975, a change was made to pelleted alfalfa hay. Feeding trial studies, conducted from 1971 through 1973, showed that the elk readily accepted the pelleted feed and weight changes were similar to those in control groups of elk fed stem hay. Additional studies were conducted from 1972-74, to observe the acceptance and behavior of free-ranging elk fed alfalfa pellets on one or more of the Refuge feedgrounds, before the conversion to alfalfa pellets was made.

Winter losses of elk and other North American ungulates are often difficult to assess. On the National Elk Refuge, where elk are concentrated on about 12,000 acres from December through April most years, mortalities can readily be located and tallied.

Murie's (1951) studies of the National Elk Refuge elk during the 1920's and 1930's outlined several causes of winter mortality, of which necrotic stomatitis was the most prevalent. This disease still exists in the NER herd but to a much lesser degree than in the past. Murie (1951) found that the parasitic condition known as scabies, or psoroptic mange, was a factor of somewhat lesser importance among mortalities. Scabies continues to afflict a percentage of the Refuge herd.

Since Murie's studies, investigation of mortalities on the Refuge has been limited. Several important management changes, occurring during the past 35 years, have affected the summer distribution of elk wintering on the NER and hunting pressure experienced by the various herd segments. The most important of these may be the addition of the valley (eastern portion) of Grand Teton National Park (GTNP) to the existing mountainous portion of the Park in 1950 (Fig. 1). Following the expansion of the Park, a summering herd segment developed in the expanded area of GTNP. The GTNP elk are harvestable only east of the Snake River in the Park (as detailed in Public Law 787) and on the NER. As a result, elk which summer in GTNP, experience less hunting pressure than elk on the National Forest summer ranges in the Teton Wilderness (TW) and Gros Ventre (GV) drainage and elk that summer in southern Yellowstone National Park (SYNP) which must migrate through National Forest lands each fall.

METHODS

During winter 1982-83, an attempt was made to locate every elk mortality on the NER. Searches from the feedtrucks, Thiokol (over-snow vehicle), horseback and on foot were conducted from late October 1982 through June 1983 to locate carcasses. Once located, each carcass was classified as adult bull (branch-antlered), spike bull, cow, or calf; sex was determined on calves; calves and yearlings were aged based upon tooth eruption and replacement techniques (Taber 1969:391); both incisors 1 were pulled to age animals older than yearling; and a gross examination was made of the carcass for external maladies or injuries. In particular, I tried to determine if the animal was afflicted with scabies. The incisors were sent to the Wyoming Game and Fish Department Laboratory in Laramie for decalcification, sectioning and cementum annuli reading.

RESULTS

Age and Sex of Mortalities

Results of the annual mid-winter classification count on February 23, 1983, showed that 5,878 elk were on the NER. Between the time when the earliest fall migrants arrived in late October 1982 and the last of the herd migrated north in May 1983, 170 elk mortalities occurred on the

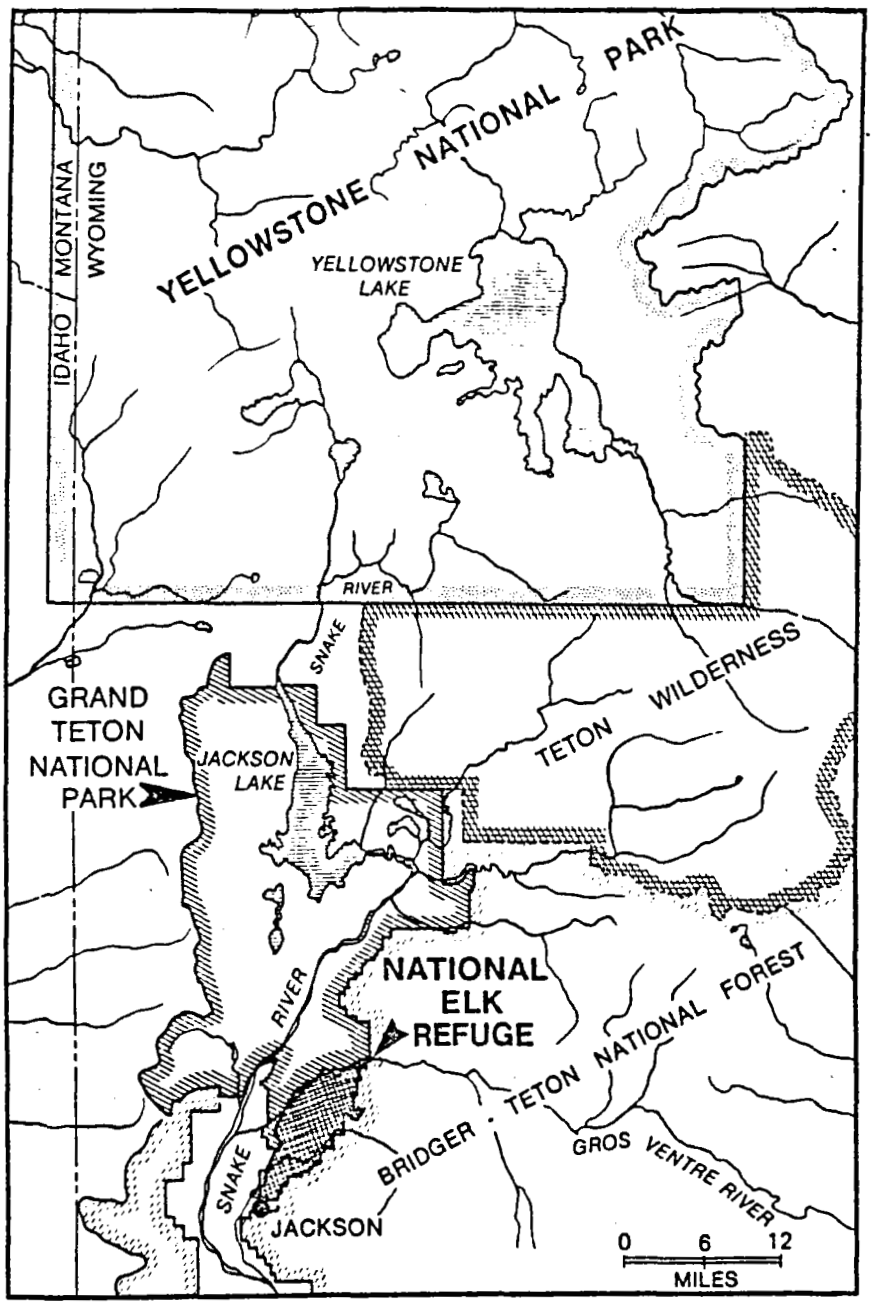

Fig. 1. Area used by the Jackson Hole elk herd (from Robbins et al. 1982:481).

Refuge. Of those, 165 were examined and classified (101 adult bulls, six spike bulls, 29 cows and 29 calves). Five antlerless animals (cow or calf) were not examined. The percent composition of each class among total mortalities compared to the percent composition of each class in the winter herd, is shown in Table 1. There was a significant difference (X^2=121,df=3,P<0.001) between the observed mortality rates by class compared to the expected mortality rates (based upon composition of each class in the winter herd). Sixty-one percent of 165 classified mortalities were adult bulls, although only 19% of the winter herd was adult bulls.

One hundred forty of the carcasses were aged (Table 2). Excluding calves, the mean age of male mortalities was 7.35 years and that of females was 11.86 years. Five of 22 cows were 18 1/2 to 27 1/2 years of age. One bull mortality was 18 1/2.

Sex was recorded for all adult mortalities examined but for only four of 29 calves (one male, three females) because of scavenging by coyotes, ravens, magpies, bald and golden eagles. Scavengers quickly find and begin feeding on the carcasses of elk mortalities in winter. The flesh and entrails are sometimes completely consumed within 48 hours, particularly in the case of calves.

Mortalities with Scabies

Scavenging precludes the possibility of determining cause of death of most mortalities on the NER. However, a gross examination was made of 165 carcass remains during winter 1982-83 to detect any superficial maladies, particularly scabies. Scabies, or psoroptic mange, in elk is caused by the mite Psoroptes equi var cervinus (Thorne et al. 1982). The mite lives out its life cycle on its host but is readily transmitted by direct contact from one host animal to another. With the exception of bighorn sheep (Ovis canadensis), P. equi var. cervinus is host specific to elk

Table 1. Percent composition of the winter herd and percent composition of total winter mortalities of each age/sex class of elk, winter 1982-83.

	Bulls	Spikes	Cows	Calves
Percent of Herd	19	8	56	16
Percent of Mortalities	61	4	18	18

Table 2. Age/sex composition of 140 elk mortalities aged by tooth eruption/replacement and cementum annuli examination techniques on the National Elk Refuge during winter 1982-83.

Age	Male	Female	Sex Undetermined	Total
Calf	1	3	25	29
1 1/2	6	2		8
2 1/2	1			1
3 1/2	3	1		4
4 1/2	4	1		5
5 1/2	16	1		17
6 1/2	14	1		15
7 1/2	10	2		12
8 1/2	14	1		15
9 1/2	7	2		9
10 1/2	5	1		6
11 1/2	3	1		4
12 1/2	2			2
13 1/2	1			1
14 1/2	1	1		2
15 1/2		2		2
16 1/2	1	1		2
17 1/2				
18 1/2	1	1		2
19 1/2		1		1
22 1/2		1		1
23 1/2		1		1
27 1/2		1		1
Adult - Not Aged	18	7		25
Antlerless - Not Aged			5	5
TOTAL	108	32	30	170

(Thorne et al. 1982). Because of the large number of animals wintering on NER (an average of 6,980 elk in 1912 to present), it is likely that most if not all the elk wintering on the NER are hosts of the scabies mite. Murie (1951:166-168) reported that scabies was prevalent in the NER elk in the 1920's and 1930's and that it was reported among the elk as far back as records go. He wrote that severe cases of hair loss were chiefly associated with mature bulls although "quite a few adult cows are at times afflicted." Scabies was rare in younger animals and calves. Murie speculated that rutting activity and scanty feeding by adult bulls during the rut tended to lower their vitality, increasing susceptibility to

scabies. In this weakened condition of lowered resistance, a mite population may increase on an elk and the clinical signs of "scabbing" and alopecia become manifest. The adverse weather conditions of late fall and winter may aggravate the condition of scabied elk and create a negative energy balance.

Figures 2 and 3 show the distribution of cow and bull elk mortalities by month. The most striking difference is the earlier onset of mortalities in bulls and the number which had died prior to the start of supplemental feeding on February 3. More bull mortalities occurred in January, the coldest month of the year, than any other month.

Of the 101 adult bulls which died on the Refuge, at least 62% (63) showed clinical signs of scabies. Another 32 may have had scabies, but there was insufficient hide among the remains to make a determination. Only two of 29 cow elk mortalities (7%) had scabies, and no spike bull or calf mortalities were scabied.

Among males (yearling and older), age of mortalities with scabies was similar to mortalities that either did not have scabies or in which presence or absence of scabies could not be determined (Fig. 4). However, the mean age of scabied male mortalities (7.9) was greater than in non-scabied mortalities because no yearling and two-year-old males were scabied. The two cow mortalities with scabies averaged 16 years old.

Incidence of Alopecia in the Herd

During winter 1983-84, a census of alopecia among elk on the Refuge's feedgrounds was conducted. Standard criteria were used by observers to classify the severity of hair loss on each elk. Alopecia generally begins at the base of the neck and then spreads along the back and shoulders. For elk, having alopecia extending no further than 1/4 the distance along the length of the back or having only a limited patchy loss of hair, alopecia was recorded as "light". For elk in which alopecia extended more than 1/4 the distance along the back from the base of the neck, or elk in which alopecia extended less than 1/4 the distance along the back but hair loss was also evident on the neck and/or face, the condition was recorded as "severe". Table 3 shows that alopecia is most prevalent on adult bulls (27.8%) followed by spike bulls (9.6%).

Relationship of Mortalities to Herd Composition

Although quantitative information regarding the past incidence of scabies in the NER elk herd is not available, the percent composition of bulls among total winter mortalities was recorded in previous years. Figure 5 shows a significant positive correlation ($P<0.05$) between the percent of bulls in the winter herd and the percent bulls among total winter mortalities over the past 15 years. Figure 6 shows the degree of correlation increases when spikes are added to the percent of bulls in the winter herd. Logic might dictate that, as a class of animal becomes proportionately more abundant in the herd, likewise it would become proportionately more abundant among mortalities. However, the body size

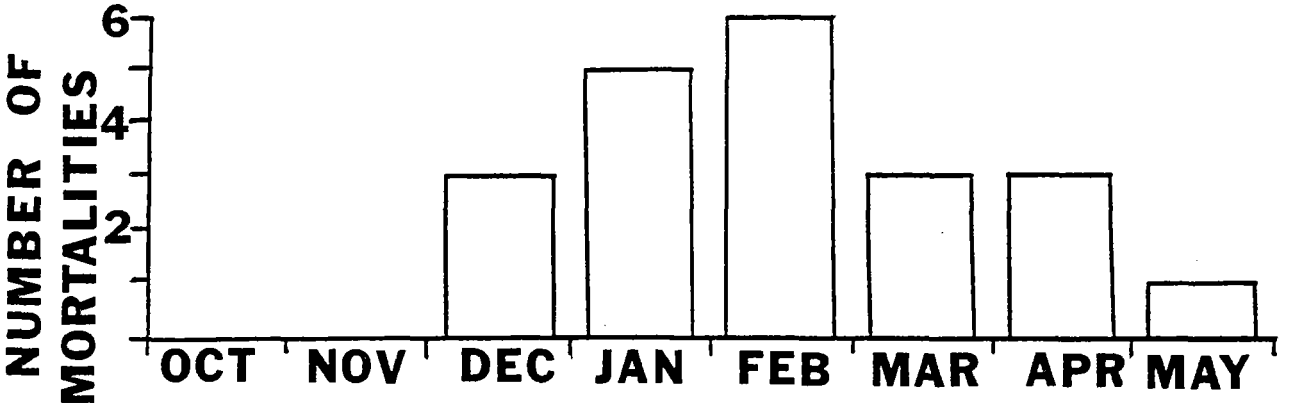

Fig. 2. Distribution of cow elk mortalities by month, winter 1982-83.

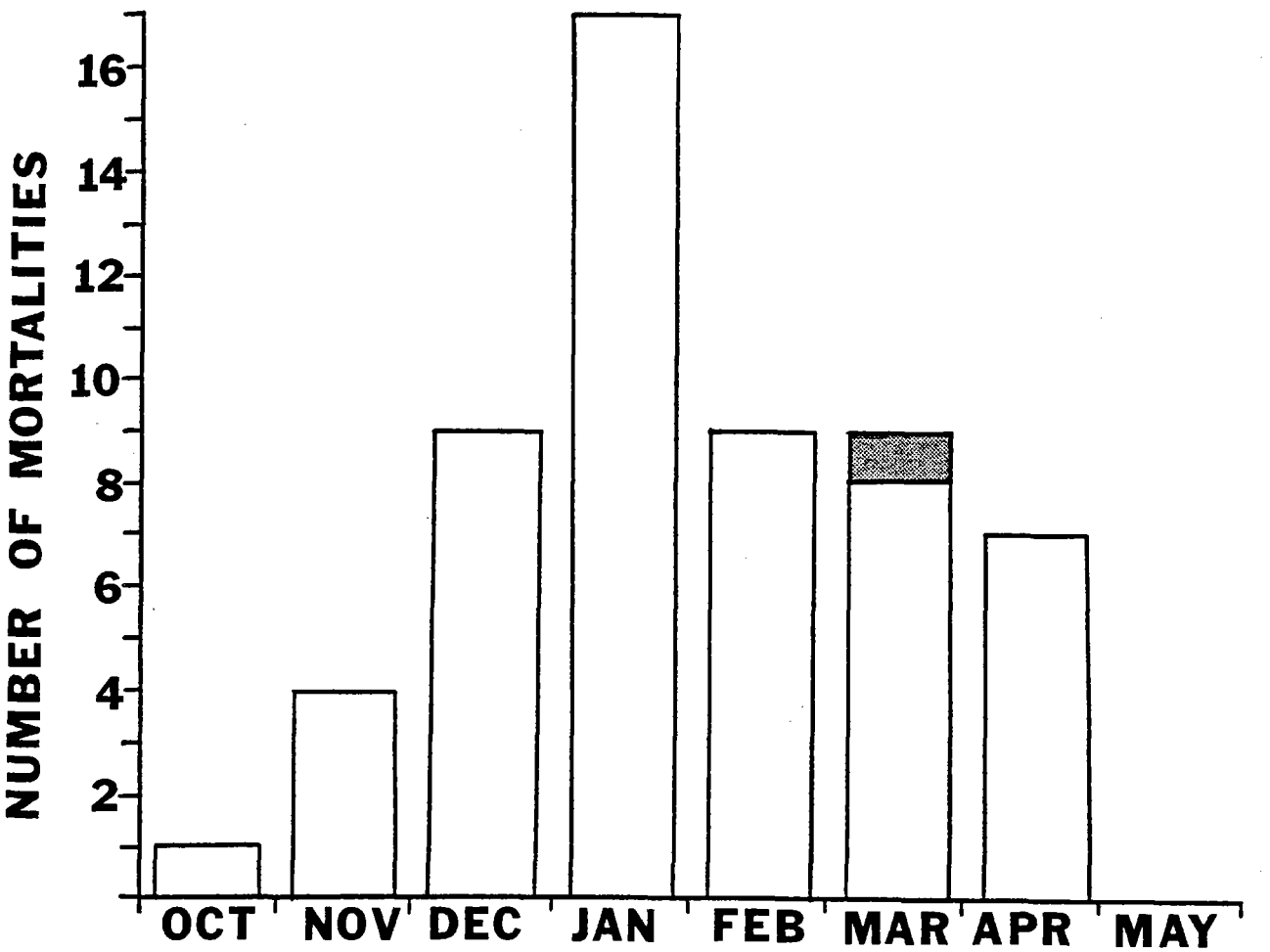

Fig. 3. Distribution of adult bull and spike bull (shaded) elk mortalities by month, winter 1982-83.

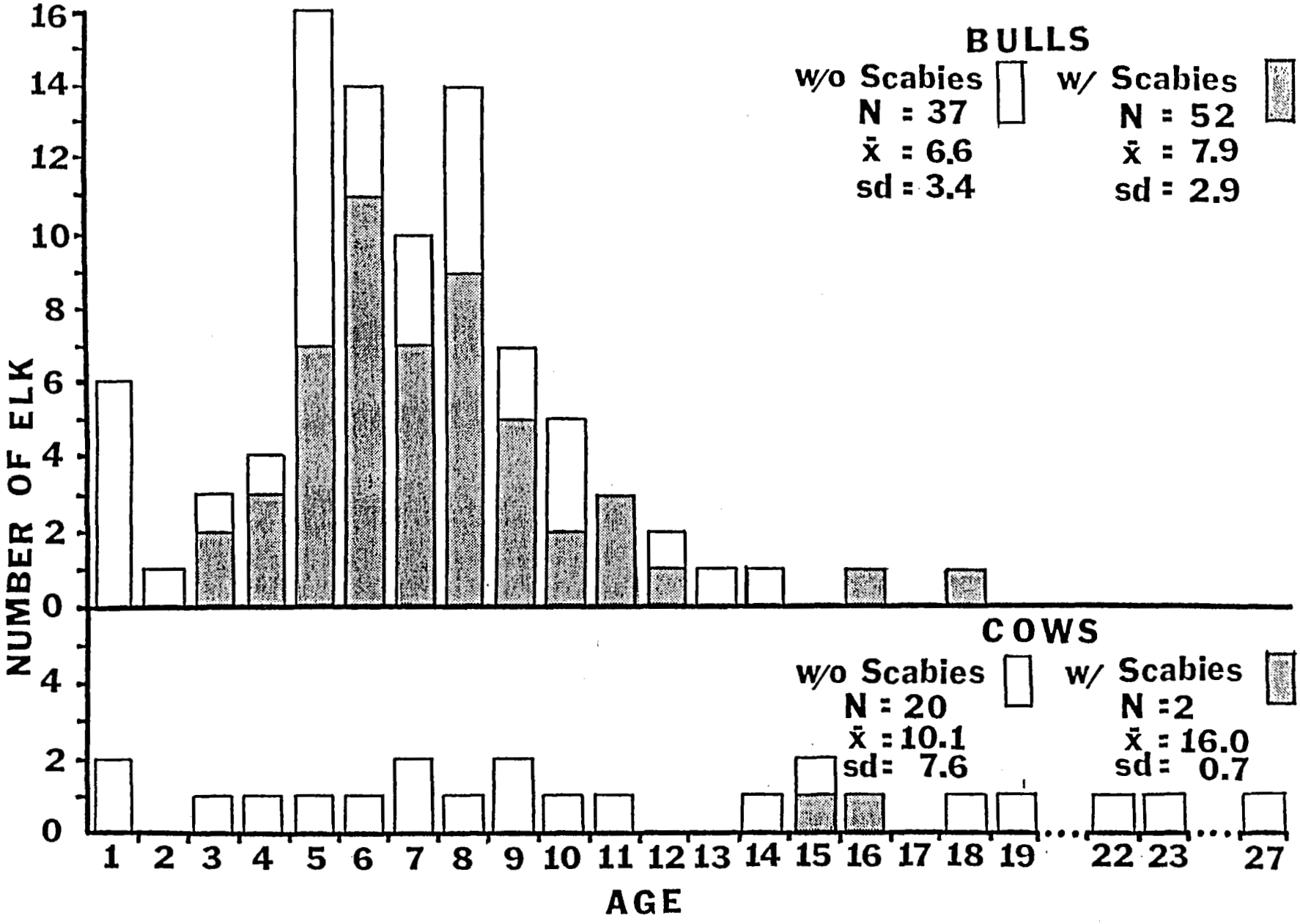

Fig. 4. Age of elk mortalities with scabies and without scabies (includes 25 bulls in which insufficient hide remained to make a determination) on the National Elk Refuge winter 1982-83.

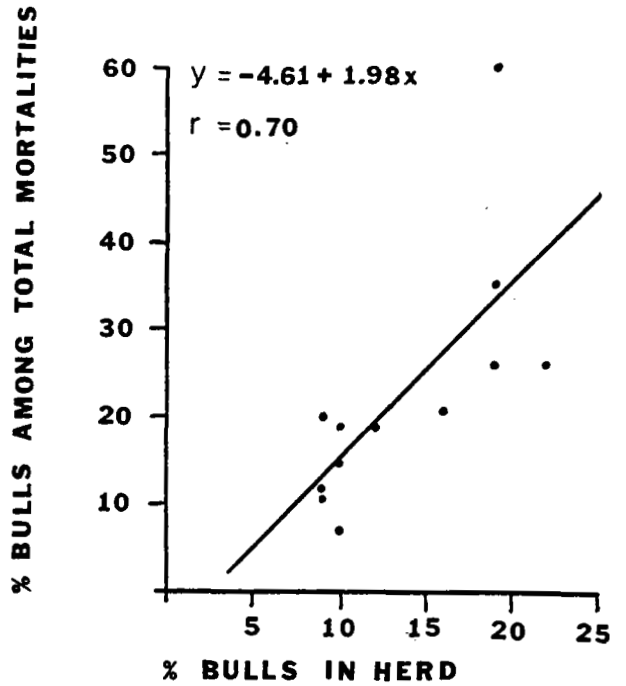

Fig.5. Relationship between percent composition of bulls in wintering herd and percent bulls among total winter mortalities 1969-83 (n=12).

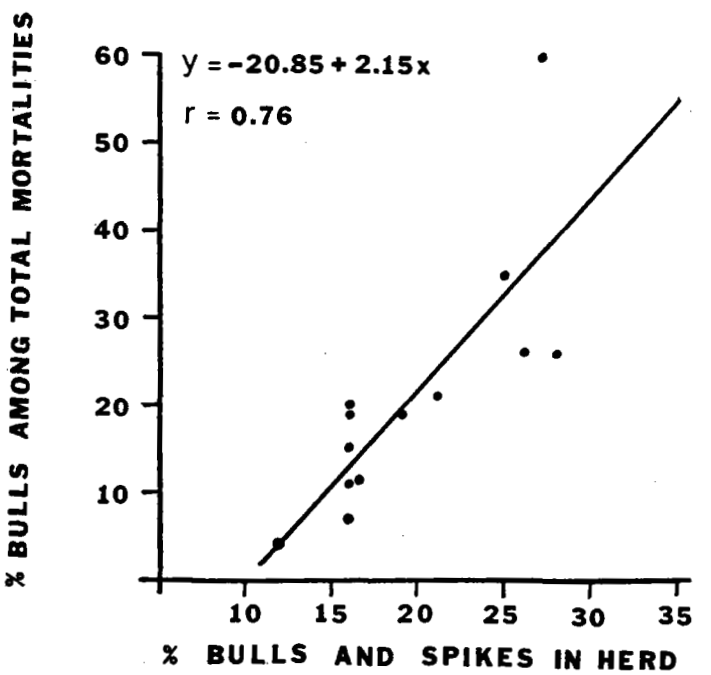

Fig.6. Relationship between percent composition of bulls and spikes in wintering herd and percent bulls among total mortalities 1969-83 (n=12).

and antlers of adult bulls enhance their competitive status on the Refuge winter range and supplemental feed lines. Thus, competition for food should not affect the survival of bulls during winter. There were not significant correlations between percent of bulls among total mortalities (1975-83) and 1) the number of days in the supplemental feeding period (n=7, r=0.364), or 2) the average number of pounds of supplemental feed/elk/day fed (n=7, r=-0.303). More likely, adult bulls arrive on the winter range in poorer condition than the other classes due to a decline in body condition associated with rutting behavior. Bulls that are lean and have alopecia are among the earliest arrivals to the Refuge in the fall. Hunters on the Refuge and in GTNP kill scabied bulls each year in November and Wyoming Game and Fish Department personnel are aware of only two elk killed in recent years on National Forest lands north of Jackson that had scabies (T. Toman, pers. comm.). Ground and aerial monitoring of the fall migration and radio-telemetry locations of elk (unpubl. data, NER files) reveal that in most years, many elk from GTNP summer ranges migrate to NER in advance of elk from the Gros Centre, Teton Wilderness and southern Yellowstone National Park herd segments (Fig. 1). Refuge classification counts have shown that among the early migrants, there is a high percent of bulls. For example, on November 19, 1982, 1,350 elk had migrated to the south end of NER. Of those, 650 (48%) were males (388 branch-antlered and 162 spikes). At that time, scabies was evident on quite a number of bulls, although the number was not determined. On November 22, 1982, there were 1,700 elk on the south end of the Refuge and 971 (57%) were males (775 branch-antlered and 196 spikes). Only 43% were cows and calves. Only in GTNP could such a high proportion of males occur in the population due to limited hunting pressure exerted on those elk, and regulations aimed at reducing the antlerless segment in recent years.

Table 3. Incidence of alopecia observed in the National Elk Refuge wintering elk herd, winter 1983-1984.

Class	Number	Number (%) Lightly Alopecia	Number (%) with Severely Alopecia	Total Number (%) with Alopecia
Calf[a]	706	7 (1.0)	0	7 (1.0)
Cow[a]	2,886	92 (3.2)	2 (0.1)	94 (3.3)
Spike[a]	345	33 (9.6)	0	33 (9.6)
Bull[b]	1,050	240 (22.9)	52 (5.0)	292 (27.8)
TOTAL	4,987	372 (7.5)	54 (1.1)	426 (8.5)

[a]From February 6 count

[b]From January 31 count

Chronology of Bull Mortalities

Scabied bull carcasses were discovered as early as October 26, 1982 on the Refuge and at least 15 had died by December 31. Another 13 had died prior to the initiation of feeding on February 3, 1983. Another 17 scabied bull carcasses, found north of the Jackson National Fish Hatchery in April, died prior to February judging by the weathering of hide and skeletal remains. Thus, 45 of the 63 scabied bull mortalities occurred before supplemental feeding was necessary.

DISCUSSION

The Wyoming Game and Fish Department and U.S. Fish and Wildlife Service work under a cooperative agreement to manage for an average of 7,500 elk on the NER in winter. During winter 1975-76, there were 7,858 elk on the Refuge. The following fall and winter were mild and snow-free and the lightest elk harvest in recent years was obtained on the Jackson Hole herd. A total of 1,176 elk were harvested in 1976 compared to about 3,000 in most years (G. Roby, pers. comm.). Liberal seasons were implemented in the fall of 1977 and hunting regulations in GTNP and NER shifted harvest pressure to females with antlerless-only permits issued for much of the season. A harvest of 3,756 animals was obtained. The NER classification count for winter 1977-78 totalled 8,491 elk. Regulations to reduce elk numbers, particularly females in GTNP, continued through fall of 1983. The harvest averaged 3,413 elk from fall 1977 through 1983 (Table 4). The NER classification count for winter 1983-84 totalled 5,010 elk. During the reduction period, the adult bull segment was reduced 23% but the number of cows in the population was reduced 44%.

Table 4. Annual elk harvest from the Jackson Hole elk herd 1976-1983.

	1976	1977	1978	1979	1980	1981	1982	1983
Total Elk Harvested	1,176	3,756	2,880	3,321	3,740	4,290	3,548	2,355

Note: Data are for the Jackson Herd which includes elk wintering on the National Elk Refuge, the Gros Ventre State feedgrounds, and on native winter range north of Jackson. Data obtained from G. Roby, Wyoming Game and Fish Deparment.

Harvest statistics from GTNP show that the percent of bulls harvested from 1974-79 that were 4+ years of age was 9% compared to 19% 4+ years of age from 1980-83. Cows in the 4+ category remained at 42% of those harvested (R. Wood, GTNP unpub. data). Thus, the herd reduction resulted in a larger percent of the NER wintering herd being comprised of adult bulls (12% prior to 1977, 21% in 1984), and the age structure of the bulls being shifted toward older animals. As the percent of bulls in the winter herd increased, so did their percent composition of total winter mortalities on NER. This relationship suggests that despite what extrinsic factors exist, bull mortalities (relative to total mortalities) are a function of competition or stress between bulls - probably during the rut. Haigh (1984) stated that for captive breeding purposes, bulls with the largest volume and highest percent motility of sperm are those with the largest scrotal circumferences. These tended to be seven year-old bulls. Thus, the mean age of 7.35 years for bull mortalities appears to coincide with the age of greatest reproductive potential and possibly sexual activity.

As discussed earlier, the high bull:cow ratio appeared to be associated with the GTNP summer herd segment where the sex ratio during fall 1982 may well have approached 1:1. Competition for females under such circumstances, and associated inter-male rivalry and sparring, would serve to increase the contamination of other animals with psoroptic mites and drain energy reserves of males. Thus, alopecia, leanness, and occasionally emaciation were already evident in November.

For many of the bulls that died, the days prior to death were often spent in areas conducive to thermoregulation. This was true even during the period of supplemental feeding when wandering 1 km or more from the Refuge's four feedground locations to lee hillsides or areas of dense sagebrush and chokeberry stands often meant missing out on the daily feeding of alfalfa. Carcasses were often found in places with maximum solar and minimum wind exposure. In their last days, some scabied animals showed little or no responsiveness to the supplemental feeding operations, apparently favoring to conserve energy and remain in those areas less exposed to the wind than the feedground locations. Malnutrition/starvation or hypothermia may ultimately bring on death although such weakened animals may be predisposed to opportunistic diseases or parasites as well (Murie 1951:168). Worley (1979) noted that elk with heavy tick and mite infestations also tended to have heavy internal parasite loads. Bergstrom and Robbins (1979) found that elk in the valley portion of GTNP had a 30 to 40% incidence of lungworm (Dictyocaulus viviparus) during summer/early fall compared to a 13-16% incidence among elk along Wolverine Creek and Big Game Ridge of southern Yellowstone Park and the northern Teton Wilderness. Both summer herd segments winter on NER.

Regarding the years 1968-1980, Robbins et al. (1982:505) stated that "about 10-20 scabby elk die on the Refuge each winter; most are mature bulls but mature cows are sometimes lost." Thorne et al. (1982:247) related the appearance of clinical scabies to the nutritional intake and physical condition of elk. Murie (1951:169) believed the best precaution for reducing scabies was the avoidance of overstocking to maintain good, productive elk range.

Stress-related nutritional deficiencies precipitated by a rising bull:cow ratio in GTNP may have increased the incidence of scabies in bulls and mortality of bulls recently. Unfortunately, quantitative data on the incidence of scabies on the NER or in other elk herds have not been recorded in the past. Colwell and Dunlap (1975) reported scabies in a single bull elk in northern Idaho and Houston (1982:192-193) reported its occurrence in the Northern Yellowstone elk herd. Houston (pers. comm.) felt the incidence of alopecia among elk in that herd might approach the percentages I described from the NER.

Although it apparently predisposes a number of elk to die each winter on the NER, scabies is not a density dependent population control because it does not cause significant losses of females or young. However, it is possible that the conditions under which scabies manifests itself may lead to poorer overall health of the elk herd. If in this manner reproductive success or survival of offspring are affected, there may be a mechanism at work dampening the rate of increase of the herd.

There are many unanswered questions concerning scabies in the Jackson Hole elk herd. Winter nutrition has been suggested as one cause of scabies. In that case, one would expect all of the summer herd segments that winter on the Refuge to be afflicted with scabies. It is noteworthy that most of the bull mortalities with scabies have large heavy antlers. The elk generally do not leave the Refuge winter range until May. Antler growth recommences in April prior to migration. How then do those bulls grow such massive antlers if prior to and during early antler growth they are undernourished? Arrival of scabied bulls on the Refuge in October and November suggests that malnourishment or physiological stress is encountered prior to the fall migration (probably between completion of antler development in August and migration). Another possibility is that clinical scabies is cyclic in individual elk.

Research is needed to answer these and other questions regarding scabies. Dusting or dipping elk with a topical insecticide could theoretically control psoroptic mites. However, effective treatment of 7,000 elk twice in a 10-14 day period (the incubation period of eggs which would not be killed by an initial treatment) appears neither practical nor logistically possible. Systemic insecticides have been used to control parasites in livestock and may hold promise for treating scabies in elk. Experimental testing of the pharmacological effects of such insecticides on elk should precede field administration.

Investigation of the cause-effect relationship of scabies in the Jackson Hole elk herd is also needed. Identification of the conditions which lead to the initial debilitation of elk, allowing mite colonies to multiply, may disclose management options for a long-term solution to the problem.

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