SURVIVAL RATES OF SHIRAS MOOSE (*ALCES ALCES SHIRASI*) IN COLORADO

Roland C. Kufeld[1] and David C. Bowden[2]

[1]Colorado Division of Wildlife, 317 W. Prospect, Fort Collins, CO 80526, USA; [2]Department of Statistics, Colorado State University, Fort Collins, CO 80523, USA

ABSTRACT: Survival rates of 72 radio-collared moose (*Alces alces shirasi*) (42 females and 30 males), >6 months of age when captured in northcentral Colorado, were measured from 1992 through 1995. Individual animals were monitored for up to 4 yrs. Forty-seven radio-collared moose, including 28 females and 19 males, died during the study. Mortality causes and proportion of deaths included legal harvest (76%), illegal kill (15%), auto collisions (2%), and other causes (7%). Annual survival estimates [proportion alive at yr's end excluding fate unknown (unexplained signal loss), legal, and illegal harvest] for all age and sex categories combined were, 0.95, 1.00, 0.94 and 1.00 for 1992 - 1995, respectively . A 95% confidence interval for the non-hunting related, pooled survival rate was 0.967± 0.031. High non-hunting related survival rates suggest that managed sport hunting is the most viable method for maintaining the Colorado moose population in balance with available habitat.

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In 1978 and 1979, 24 moose were transplanted to North Park, Jackson County, Colorado (Duvall and Schoonveld 1988) where moose had been historically rare (Warren 1942, Bailey 1944, Lechleitner 1969). This herd had grown to approximately 382 to 505 animals by 1992 (Bowden and Kufeld 1995). Kufeld and Bowden (1996) described movements and habitat selection of moose in North Park from 1992 through 1995 after a viable population of moose had become established. The purpose of this study was to determine mortality factors and survival rates of animals in that dynamic moose population.

STUDY AREA

The study area, North Park, Jackson County, in northcentral Colorado, has been described in detail by Kufeld and Bowden (1996).

METHODS

Moose were captured and radio-collared throughout the eastern, southern, and central portions of North Park during Dec. 1991, Jan., Mar., Oct., and Dec. 1992, and Jan. 1994. They were located at approximately 2-week intervals from Dec. 1991 through Nov. 1995, mostly by aerial telemetry. Capture and monitoring procedures were described in detail by Kufeld and Bowden (1996).

Estimates of non-hunting related survival rates were made annually (according to calendar yrs) for each age category (calf, subadult, adult) and for each sex. Subadults were 1 - 2 yrs of age. Tests for significant differences in survival were made using Fisher's exact test (Agresti 1990). Such tests are consistent with modelling survival as occurring independently within and among yrs for all individuals. Given this assumption, survival rate estimation follows formulas appropriate for a binomial distribution. Thus, a survival rate estimate is given as $\hat{S} = a/n$ with estimated variance $\hat{V}(\hat{S}) = \hat{S}(1-\hat{S})/(n-1)$ where n is the number of monitored moose beginning each yr (excluding moose that, during the yr, were legally or illegally harvested or whose fate became unknown [unexplained signal loss]), and "a" is the number of the "n" moose that were still alive at the end of the yr.

The Kaplan-Meier procedure (Pollock *et al.* 1989) for making survival estimates was also applied to adjust for censored observations occurring during a yr associated with legal and illegal kills and unexplained signal loss within yrs.

RESULTS

Seventy-two moose, (age when captured: calves = 19 males and 21 females, subadults = 1 male and 3 females, adults = 10 males and 18 females) were monitored for survival. Individuals were monitored for up to 4 yrs. When calves became subadults they were included in the subadult category and subsequently, included in the adult category when they became adults. Thus, the number and sex and age composition of moose available for comparisons is: calves = 19 males and 21 females, subadults = 16 males and 19 females, adults = 17 males and 28 females.

Forty-seven radio-collared moose including 28 females and 19 males were known to have died during the study. Mortality causes and proportion of deaths included legal harvest (76%), illegal kill (15)%, auto collisions (2)%, and other causes (7)%.

Data in Table 1 were used for tests of differences in annual survival rates by sex and age class for 4 yrs extending from 1992 thru 1995. The only mortalities identified in Table 1 are for female calves (3) and adult

Table 1. Radio-collared moose (n) that began the yr, excluding moose that, during the yr, were legally or illegally harvested or whose fate became unknown (unexplained signal loss), and the number (a) of the n that were still alive at the end of the yr in northcentral Colorado, 1992-95[a]

	Age					
	Calf		Subadult[c]		Adult	
Yr[b]	n	a	n	a	n	a
			Female			
1992	9	8	2	2	11	11
1993	2	2	8	8	10	10
1994	8	6	2	2	14	14
1995	0	0	0	0	11	11
Total	19	16	12	12	46	46
			Male			
1992	9	9	1	1	7	6
1993	3	3	4	4	5	5
1994	3	3	3	3	5	5
1995	0	0	1	1	5	5
Total	15	15	9	9	22	21

[a] Forty-two females and 30 males were radio-collared, 3 females and 5 males had unknown fates (monitoring terminated due to unexplained signal loss), 22 females and 14 males were legally harvested, and 3 females and 4 males were illegally harvested.

[b] 1 Jan. - 31 Dec. of each yr.

[c] 1 -2 years of age.

males (1). Annual survival rates within sex by age categories did not differ significantly ($P \geq 0.70$). Fisher's exact test comparing survival rates among 6 age by sex categories (yrs combined) is significant ($P < 0.05$). Pairwise comparisons among the 6 sex by age categories produced a single significant difference when comparing adult female with female calf survival rates ($P = 0.02$); all other comparisons were not significant ($P \geq 0.24$). Since deaths of 2 of the 3 female calves that died were not from age/sex related causes (1 died in an auto collision and 1 died after being harassed by snowmobiles), we discounted age/sex related survival rate differences. Thus, annual survival estimates [proportion alive at yr's end excluding fate unknown, legal, and illegal harvest (a/n)] for all age and sex categories combined (Table 1) were, 0.95, 1.00, 0.94 and 1.00 for 1992 - 1995, respectively. Kaplan-Meier estimates by yr were 0.96, 1.00, 0.95, and 1.00, respectively. Kaplan-Meier estimates include the censored observations identified in the footnote of Table 1, which were excluded from Table 1. Given the nearly identical results of the 2 methods for making survival estimates, we pooled observations (Table 2) and used the simple proportions (a/n) as survival estimates. Thus, the annual, non-hunting related survival estimate for all moose combined was 0.967, with an estimated standard error of 0.016.

Table 2. Pooled estimates of survival of a yr period ($\hat{S}$) and estimated standard error of ($\hat{S}E$) by sex and combined sexes of moose in northcentral Colorado, 1992-95.

Sex	$\hat{S}$	$\hat{S}E$	n[a]
Female	.961	.022	77
Male	.978	.022	46
Combined[b]	.967	.016	123

[a] The number of radio-collared moose that began each year, excluding moose that, during the year were legally or illegally harvested or whose fate became unknown (unexplained signal loss).

[b] A 95% confidence interval for the overall (pooled) survival rate is given as .967 ± .031.

DISCUSSION

Legal harvest was the greatest mortality factor on moose 6 months of age and older in North Park, with illegal harvest ranking second. Illegal harvest occurred primarily during big game hunting seasons and represented a substantial loss of moose in addition to those taken legally by hunters. The number of licenses for moose in Colorado is limited, and licenses for individual sexes are issued through special drawings. Thus, the level of legal harvest by sex can be controlled. However, illegal harvest is difficult to control and may be a function of hunting for elk. Elk and moose seasons run concurrently in Colorado and elk hunters vastly outnumber moose hunters. Because moose were recently reintroduced into the state, many elk hunters are not familiar with moose and their habitat preferences. When hunting in heavy forest cover for elk, some hunters may tend to shoot before fully identifying their target. Most illegally shot radio-collared moose were abandoned where killed, which suggests they may have been the subjects of hunter misidentification. However, circumstances associated with other incidents suggest that some radio-collared moose were identified as moose and deliberately shot and abandoned.

Non-hunting related survival rates of moose 6 months of age and older were quite high in North Park compared to those reported elsewhere (Van Ballenberghe 1987, Osborne *et al.* 1991, Yevtikof 1991) where predation by wolves and bears can be a significant factor. Wolves are absent but black bears occur in North Park. According to Franzmann *et al.* (1980), black bear predation appears to occur when moose calves are

small and may nearly cease by the time the calves are 1-2 months old. Calves in our study were radio-collared at approximately 6 months of age and we observed no incidences of bear predation on radio-collared calves, subadult, or adult animals.

MANAGEMENT IMPLICATIONS

High non-hunting related survival rates of moose in Colorado suggest that managed sport hunting is the most viable method for maintaining the moose population in balance with available habitat. High illegal harvest rates, however, can result in overharvest of moose. We recommend that this problem be addressed through programs to educate hunters about moose habitat preferences, and to encourage them to be sure of their target. The annual Colorado state big game hunting season brochure has included a brief warning to hunters that moose and elk can be found in the same areas, and a reminder that targets must be properly identified. However, much more educational effort is needed. Additionally, maximum fines and penalties for illegally killing a moose should be consistently levied.

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REFERENCES

AGRESTI. A. 1990. Categorical data analysis. New York: John Wiley and Sons, Inc.

BAILEY, A. M. 1944. Records of moose in Colorado. J. Mammal. 25:192-193.

BOWDEN, D. C., and R. C. KUFELD. 1995. Generalized mark-sight population size estimation applied to Colorado moose. J. Wildl. Manage. 59:840-851.

DUVALL, A. C., and G. SCHOONVELD. 1988. Colorado moose: reintroduction and management. Alces 24:188-194.

FRANZMANN, A. W., C. C. SCHWARTZ, and R. O. PETERSON. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44:764-768.

KUFELD, R. C., and D. C. BOWDEN. 1996. Movements and habitat selection of Shiras Moose (*Alces alces shirasi*) in Colorado. Alces 32:9-13.

LECHLEITNER, R. R. 1969. Wild mammals of Colorado. Pruett Publishing Co., Boulder, CO. 254pp.

OSBORNE, T. O., T. F. PARANGI, J. L. BODKIN, A. J. LORANGER, and W. N. JOHNSON. 1991. Extent, cause, and timing of moose calf mortality in western interior Alaska. Alces 27:24-30.

POLLOCK, K. H., S. R. WINTERSTEIN, C. M. BUNCK, and P.D. CURTIS. 1989. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7-15.

VAN BALLENBERGHE, V. 1987. Effects of predation on moose numbers: A review of recent North American studies. Swedish Wildl. Res. Suppl. 1: 431-460.

WARREN, E. R. 1942. The mammals of Colorado. Second revised ed. Univ. Oklahoma Press, Norman. 330pp.

YEVITIKOF, S. A. 1991. Natural mortality rate in European moose. *in* Global trends in wildlife management. B. Bobek, K. Perzanawski, and W. Reglin (eds). Trans. 18th IUGB Congress, Krakow 1987. Swiat Press, Krakow-Warszawa.