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Productivity, Survival, and Movements of Female Moose in a Low-Density Population, Northwest Territories, Canada

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ABSTRACT. Moose (*Alces alces andersoni*) occur at low density (140–160 moose/1000 km^2) and are the most important game animal in much of the Mackenzie Valley, western Northwest Territories. Productivity and survival of 30 female moose (≥ 1.5 yr.) were studied from November 1985 through November 1988. Twenty-nine of these moose were radio-tracked for a total of 1039 relocations. Pregnancy rates were 96% for adult and 40% for yearling females. Most females returned to the same restricted area to calve each year. Mean newborn calf:female ratio and twinning rates were 1.2:1 and 31%, respectively. Mean annual female survival rate was 85%. Annual calf survival was high and stable (44 ± 0.02%). Individual total home range size varied from 40 km^2 to 942 km^2. Mean home range size for 29 moose was 174 ± 31 km^2 and 202 ± 59 km^2 for the 14 moose radio-tracked the entire three years of study. Fall home ranges were twice the size of winter and summer home ranges; seasonal ranges overlapped widely, indicating that these moose were non-migratory.

Key words: moose, low density, productivity, movements, Mackenzie Valley, Northwest Territories

RÉSUMÉ. L'orignal (*Alces alces andersoni*) est présent à faible densité (140-160 orignaux/1000 km^2) et constitue le gibier le plus important dans la plupart de la vallée du Mackenzie, dans la partie occidentale des Territoires du Nord-Ouest. On a étudié la productivité et le taux de survie de 30 orignaux femelles (≥ 1,5 ans) de novembre 1985 à novembre 1988. Vingt-neuf de ces orignaux ont été suivis par radio sur un total de 1039 déplacements. Les taux de gestation étaient de 96 p. cent pour les adultes et de 40 p. cent pour les femelles d'un an. La plupart des femelles retournaient chaque année mettre bas dans la même zone restreinte. Le rapport moyen mâle/femelle parmi les nouveau-nés était de 1,2 pour 1, et le pourcentage de jumeaux était de 30 p. cent. Le taux de survie annuel moyen des femelles était de 85 p. cent. Le taux de survie annuel des veaux était élevé et stable (44 ± 0,02 p. cent). Le territoire individuel total variait de 40 à 942 km^2. Le territoire moyen mesurait 174 ± 31 km^2 pour l'ensemble des 29 orignaux, et 202 ± 59 km^2 pour les 14 orignaux suivis par radio du début à la fin de la période triennale d'étude. Les territoires étaient deux fois plus étendus en automne qu'en hiver ou en été; les territoires saisonniers se recoupaient largement, ce qui indique que ces orignaux n'étaient pas migratoires.

Mots clés: orignal, faible densité, productivité, mouvements, vallée du Mackenzie, Territoires du Nord-Ouest

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INTRODUCTION

Moose have long been the most important ungulate to both aboriginal and sport hunters along the upper and mid-Mackenzie Valley in the western Northwest Territories (N.W.T.). Annual moose harvest has remained light at 4% to 5% of the total population largely because of the sparse human population and lack of road access. Aerial surveys using the stratified block design (Gasaway et al., 1982) indicated a low density of 155 moose/1000 km^2 on the study area (Government of the N.W.T., Department of Renewable Resources, Norman Wells, N.W.T., unpubl. data). This density is similar to portions of the northern boreal forest of the Yukon and central Alaska where moose are the major prey of lightly harvested wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) populations (Gasaway et al., 1992).

Hydrocarbon exploration and extraction have a long history in the mid-Mackenzie Valley. In the early 1980s, the oil field at Norman Wells underwent expansion, and exploration accelerated in outlying areas, raising concerns about possible effects on seasonal movements of moose in the Mackenzie Valley, especially during winter. Concerns also arose about

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increased hunting pressure stemming from a larger human population.

The present study of productivity and movements of female moose was initiated to obtain information necessary for managing this low-density moose population. Our study objectives were to determine the productivity, survival, home range size and seasonal movements of female moose. No such published data existed for moose in the extreme northern portion of the boreal forest typical of northwestern N.W.T. and central Yukon and Alaska.

STUDY AREA AND METHODS

The 2838 km^2 study area is situated in the Mackenzie Valley between the Mackenzie River and the front range of the Mackenzie Mountains (Fig. 1). The area lies within the northern boreal forest and has low relief with an average elevation of 250 m above sea level. The climate is subarctic with mean daily minimum temperature for the year of -11.2˚C and a mean maximum of -1.5˚C. Mean daily temperature in January is -28.9˚C and in July is +16.3˚C. Mean annual snowfall is 146.8 cm and rainfall is 183.3 mm (Environment Canada, Norman Wells, N.W.T., pers. comm. 1992).

Much of the area is poorly drained and consists of both open and partially closed black spruce (*Picea mariana*)-moss-lichen and black spruce-bog forests (Hare and Ritchie, 1972) interspersed with small lakes and streams. Better-drained upland areas and stream bottoms contain stands of white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), aspen (*Populus tremuloides*), willow (*Salix* spp.) and alder (*Alnus* spp.). Ice and flood action keep much of the vegetation along major river drainages in early successional stages. Periodic forest fires have also created areas of differing regenerative stages. Numerous abandoned exploration roads and lines cut for seismic exploration cross the study area. Potential predators of moose such as wolves, grizzly bears and black bears (*Ursus americanus*) exist at unknown densities.

Female moose (≥ 1.5 yr.) were located from a Bell 206B helicopter in November 1985 and 1986 and immobilized with 3 mg of carfentanil (Wildnil®, Janssen Pharmaceutical, Mississauga, Ontario) and 60 mg of xylazine hydrochloride (Rompun®, Cutter Laboratories, Mississauga, Ontario) administered by a pre-loaded 3 ml Pneudart (Box 1415, Williamsport, Pennsylvania) fired from a Cap-chur dart rifle (Palmer Chemical Co., Douglasville, Georgia). The antagonist was 140 mg of naloxone (Narcan®, E.I. du Pont de Nemors, Glenolden, Pennsylvania), 4 mg of diprenorphine (M50-50®, Cyanamid, Montreal, Quebec) and 35 mg of yohimbine (Antagonil®, Janssen Pharmaceutica, Mississauga, Ontario).

All moose were rectally palpated to identify pregnancy status (Glover, 1985; Howard, 1986). Blood samples were also taken, and serum progesterone levels (P4) as well as pregnancy specific protein B (PSPB) were analysed (Wood et al., 1986) to confirm the results of rectal palpation. An incisor tooth was obtained from each moose and we later determined

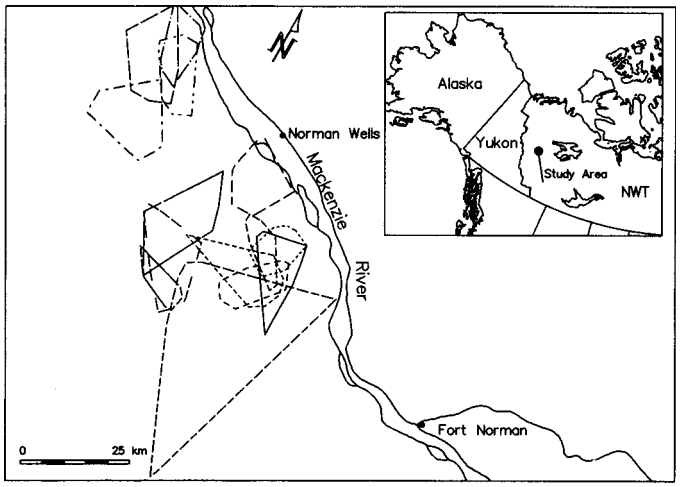

FIG. 1. Location of the study area in the Mackenzie Valley and the home ranges (100% minimum convex polygon) of 14 female moose radio-tracked during the entire study period (November 1985-November 1988).

their ages by counting cementum annuli (Sargeant and Pimlott, 1959). A radio-collar (151 mHz, Telonics, Mesa, Arizona; Lotek Engineering, Aurora, Ontario; Telemetry Systems, Mequon, Wisconsin) was attached to each animal. To facilitate location of dead moose, all transmitters were equipped with a mortality sensor that was activated after eight hours of inactivity.

Moose were relocated monthly using a Helio-Courier fixed-wing airplane during the first five months of study and a Bell 206B helicopter subsequently. We attempted to sight each moose and determine the sex and age of any accompanying individuals. During the late May calving period, we relocated moose every two to four days to determine postnatal mortality. A calf was considered to be dead if it was not sighted during the intensive surveys in late May or during two consecutive monthly surveys. Twinning rates were calculated by dividing the number of all females that gave birth to twins by the total number of all females that gave birth. If a moose was found dead, the carcass remains and surrounding area were examined to determine probable cause of death (Larsen et al., 1989).

Home range sizes were calculated using the computer program HOME RANGE (Ackerman et al., 1990). Home ranges were described by the minimum convex polygon method (Mohr, 1947). The following time periods were used for analysis of seasonal home ranges: January-April (winter), May-August (summer), and September-December (autumn).

Survival rates of all females and calves were calculated using the staggered entry-by-month design (Pollock et al., 1989). The population was lightly hunted year-round by aboriginal hunters and seasonally by sport hunters. Since we requested that hunters avoid harvesting collared cows, mortality of females in general may have been slightly underestimated.

All means are presented with standard errors or ranges. The relationship between home range size and number of relocations was investigated by simple regression. Student's t-tests were used to compare home range size of moose studied for the entire three years versus those studied for less

than three years as well as to compare post-calving movements of females that lost calves and those that retained calves. Seasonal home range sizes were compared by one-way ANOVA. Calf survival between years, early calf survival and twin survival were compared by means of 2×2 contingency tests (Sokal and Rohlf, 1969).

RESULTS

Capture and Relocation of Moose

In all, 32 female moose were radio-collared, 21 in November 1985 and 11 in November 1986. The average age of the collared moose was 6.5 yr. (range = 1.5–14.5 yr.). Two moose captured in 1985 died several days after capture. Since it was possible that this mortality was capture-related, they were excluded from the analysis. There were 48 relocation flights made during the three years and 1046 relocations were obtained on 30 moose. Visual sightings of the collared cows were made during 94% of these relocation flights. One moose was tracked for only seven months and was not included in the home range analysis.

Productivity

Pregnancy rates were 96% for adult females (≥ 2 yr., n = 27; Table 1) and 40% for yearlings (< 2 yr.; n = 5) captured during the study. Agreement between the results of rectal palpation and PP4-PSPB analysis was 97% for all female moose (n = 32). For one moose that calved, rectal palpation indicated that the individual was pregnant while both the PP4 and PSPB results had indicated she was not.

Of the pregnant females that survived to the calving period, each spring an average of 86% gave birth. The mean calf:female moose ratio immediately after the calving period, over the three years, was 1.3:1. The twinning rate varied from 25% to 36% (Table 1), with a total of 17 sets of twins produced by 13 cows. Two females had twins in two successive years and one produced twins in all three years. The youngest female to have twins was two years old while another had twins at 13 years old. Calves (11.5 months old) were not found with their mothers in early May, two to three weeks before their mothers gave birth. They were occasionally observed within 0.5 km of the female after she gave birth.

Newborn calves were first observed on 22 May 1986, 19 May 1987, and 22 May 1988, and median dates of calving were 29 May (n = 10), 25 May (n = 20), and 28 May (n = 17) each year respectively. Only two calves were born later than 15 June. Distance between calving locations in successive years averaged 4.3 km (n = 15 moose; range = 1–11 km). Four of the 14 females (29%) collared for three years returned to ≤ 1 km of the same calving location during the three years. One female gave birth at the same location in 1986 and 1987 and then in 1988 had her calf 11 km from that location. Females that lost a calf in either May or June (n = 6) moved a mean distance of 23 km (range = 15–31 km) between the loss and the next relocation (approximately one month). These movements were greater than movements of females that retained their calves ($p < 0.01$) during that same period; they also differed from the movements of these same females immediately prior to loss of their calf ($p < 0.01$). Females that lost one calf from twins did not display these movements.

TABLE 1. Productivity of adult female moose (≥ 2 yr.) in the western Northwest Territories.

Year	% Pregnant (November)	Total females with calves	Calves produced	Calf/female ratio	Twin rate (%)
1986	96	10	13	1.3:1	33
1987	96	18	24	1.3:1	33
1988	—	14	19	1.4:1	36
1989[1]	—	12	15	1.3:1	25
Total		54	71		
Mean				1.3:1	32

[1] One relocation flight made for calf survival determination in June 1989.

Survival

Mean annual survival rate of the 30 female moose was 85 ± 0.01% including hunting mortality and 88 ± 0.02% excluding hunting mortality (Table 2). The cumulative survival rate for the three years was 62% and 70%, including and excluding hunting respectively. Five of eleven mortalities (45.5%) were fed upon heavily by wolves and most were likely a result of direct predation. Three moose mortalities (27.3%) were caused by hunting and three moose (27.3%) died from unknown causes. We observed extensive infections of hydatid cysts (*Echinococcus granulosus*) in the heart, lungs and liver and on the intestines of the three animals that died of unknown causes.

TABLE 2. Annual survival of female (≥ 1.5 yr.) and calf moose in the western Northwest Territories.

Year	Adults		Calves
	Hunting included	Hunting excluded	
1985–86	0.85	0.85	—
1986–87	0.82	0.93	.40
1987–88	0.87	0.87	.48
Mean	0.85	0.88	.44
Cumulative (1985–88)	0.62	0.70	

Calf Survival

Calf survival during the first eight weeks did not differ significantly between years (80% and 93%; $p > 0.05$). During the first six months post-partum (June-October), calf survival was slightly lower than that of the following six months (63% vs. 67%). Mean first year survival was 44 ± .06%. Excluding

the five cases where calf mortality resulted after death of the mother, mean first year survival was 56%. Only 3 of the 17 (17.6%) sets of twins produced survived the first year together. The first-year survival rate for a calf with a twin (37%) was not significantly lower ($p > 0.05$) than that for a single calf (56%).

Home Range

Annual home ranges of collared moose overlapped considerably (Fig. 1). The home range of each collared moose overlapped those of at least two other collared moose. Home ranges varied considerably in size (Table 3: range = 40–942 km^2), but they were not significantly different in size between the 14 moose collared for the entire three years (202 ± 59 km^2) and 15 moose collared for three years or less (146 ± 23 km^2; $p > 0.05$). Mean range size for all moose (n = 29) was 174 ± 31 km^2 (mean relocations/moose = 34). There was no significant relationship between the number of relocations and home range size ($r^2 = 0.20$, $p > 0.05$).

Home ranges were largest during autumn at 132 ± 215 km^2 (summer: 68 ± 35 km^2; winter: 57 ± 58 km^2) but we could not detect differences among seasons ($p > 0.05$). Wide variability in individual home range size contributed to the lack of difference among seasons.

TABLE 3. 100% minimum convex polygon home range sizes of 29 radio-collared female moose in the western Northwest Territories.

Moose	100% polygon (km^2)	Number of relocations
1[1]	102	49
2	54	13
3[1]	205	48
4[1]	156	48
5	66	30
6[1]	71	48
7[1]	113	46
8[1]	174	33
9[1]	95	45
10[1]	145	45
11	90	18
12[1]	229	42
14[1]	942	48
16[1]	202	44
17[1]	59	47
18	140	15
19[1]	128	42
20[1]	210	49
21	150	18
22	131	34
23	40	20
24	102	34
25	70	16
26	337	34
27	208	34
28	88	34
29	249	22
30	226	34
31	248	20

[1] indicates moose radio-tracked for the entire study period (3 years).

DISCUSSION

The productivity of female moose in the Mackenzie Valley compared favourably with that of moose across North America (Boer, 1992). Their average pregnancy rate (96%) exceeded the North American average of 84% (Boer, 1992) and was higher than those reported from the Yukon (Larsen et al., 1989) and south-central and interior Alaska (Ballard et al., 1991; Gasaway et al., 1992). The average twinning rate (31%) was similar to both the North American average of 33% (Boer, 1992) and that of other northern boreal regions but lower than that observed in the southern boreal forest (Rolley and Keith, 1980; Mytton and Keith, 1981; Franzmann and Schwartz, 1985). Median calving dates were nearly identical to those observed in south-central Alaska (Ballard et al., 1991) and southern Yukon (Larsen et al., 1989) and more southerly areas (Hauge and Keith, 1981).

The average annual survival rate (hunting included) of female moose in the Mackenzie Valley (85%) was lower than that of hunted populations in south-central Alaska (95%) and southern Yukon (90%) (Larsen et al., 1989; Ballard et al., 1991). In more southerly regions of the boreal forest, it compared with the annual survival rates of female moose from a hunted population in Newfoundland (86%; Albright and Keith, 1987) and that of adults (males included) from an unhunted population in Alberta (84%; Mytton and Keith, 1981). It was higher than the annual survival rate for adult moose from a lightly hunted population in Alberta (75%; Hauge and Keith, 1981). Early (i.e., first eight weeks) and first year survival rates of calves were higher than those reported from Alaska and the Yukon, where predation was a major source of early calf mortality (Ballard et al., 1991; Gasaway et al., 1992). Mean first year survival of calves (44%) was approximately 30% higher in our study than that reported for other northern boreal regions (Larsen et al., 1989; Ballard et al., 1991). Albright and Keith (1987), however, estimated 69% annual calf survival in Newfoundland, where predator densities were low. Potential predators of calves, such as wolves, black bears and grizzly bears (see Gasaway et al., 1992), were present in the study area but at unknown densities. Furthermore, there were no alternate large prey (e.g., caribou, *Rangifer tarandus*) present in the study area. Under these conditions, some predation of calves would be expected (Gasaway et al., 1992). The greater movements of female moose immediately after losing a calf, as also reported by Ballard et al., (1991) and lower survival rates than where predators were few (Rolley and Keith, 1980; Mytton and Keith, 1981), were evidence that some predation of newborn calves occurred. However, mortality of calves during the first eight weeks in this study (14%) was low relative to the predation rates of 65% to 75% in Alaska and the Yukon (Larsen et al., 1989; Gasaway et al., 1992). Calculations based on an annual survival rate of 85% (including hunting), a birth rate of 86%, a 50:50 sex ratio at birth and an annual calf survival rate of 44% indicate that the female cohort would be increasing at 4% annually.

Female moose in the present study had total home ranges and seasonal ranges 2.5 times larger than the “adjusted”

ranges of nonmigratory moose reported by Ballard et al. (1991) from a latitudinally similar area in south-central Alaska (Table 4). In calculating the adjusted home ranges, Ballard et al. (1991) excluded the large areas of terrain (e.g., lakes, glaciers, high ground) which moose cannot use. Such terrain was not a factor in the near-continuous forest of the Mackenzie Valley. Average home range size of female moose in the Mackenzie Valley was smaller than average home range size of migratory moose in south-central Alaska (van Ballenberghe, 1977; Ballard et al., 1991). However, female moose in the study area were not migratory. They contracted and expanded their movements seasonally, which resulted in partial overlap between seasonal ranges. As in other areas, they appeared to be least mobile during winter and most mobile during fall (Risenhoover, 1986; Ballard et al., 1991). As discussed by Cederlund and Okarma (1988), uniformity of elevation and habitat homogeneity are more likely to result in a resident moose population than is more rugged terrain, which is subject to greater habitat and climatic variations (e.g., snowfall). The home ranges of female moose in the Mackenzie Valley were also considerably larger than those reported for nonmigratory moose elsewhere in North America and in Europe (Table 4). In those areas, moose densities were considerably higher than in the present study area. The large individual home ranges may indicate that forage abundance was lower than in many other regions in western and northern North America (Mace et al., 1984; Risenhoover, 1986).

TABLE 4. The mean home range sizes (minimum convex polygon) for adult moose in North America and Europe as determined by telemetry.

Location	Mean home range size (km^2)	Number of moose	Density (moose/km^2)	Source
Northwest Territories	174	29	0.16	this study
South-central Alaska	81[1]	13	0.71	Ballard et al., 1991
Northwestern Ontario	43	5[2]	—	Addison et al., 1980
Northern Alberta	97	10[2]	0.18	Hauge & Keith, 1991
Central Alberta	39[3]	177	1.20	Lynch & Morgantini, 1984
Minnesota	10	22[2]	1.00	Phillips et al., 1973
Sweden	13	14	> 1.00	Cederlund & Okarma, 1988
Southeast Alaska	40	14	2.30	Doerr, 1983

[1] adjusted for null habitats (290 km^2 without adjustment).

[2] both females and males.

[3] the largest seasonal range (winter).

Low density of moose in the Mackenzie Valley and home ranges larger than any reported previously for *A. a. andersoni* suggest these moose are likely not sensitive to the scattered and localized industrial activity that the area will probably experience in the foreseeable future. However, new access into previously remote areas by means of both winter and all-season roads that accompany such activity poses the greatest management concern. Moose management in the Northwest Territories should emphasize the control of hunting when new access, especially through important winter feeding areas, may expose moose to possible overharvest.

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