SEASONAL ACTIVITY PATTERNS OF MOOSE IN THE SWAN HILLS, ALBERTA

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Abstract: Activity data and an index to distance moved were obtained from 7262 radio signals monitored for 43 radio-collared moose. Activity was most intense at dawn and dusk and was lowest and most variable on winter nights. Fall activity patterns differed greatly from the rest of the year and reflected breeding behavior and increased social contacts. Nighttime activity by moose was most prevalent during lunar phases providing sufficient lighting by which to browse. Insufficient lighting was compensated for by increased daytime activity. Moose activity was controlled by light and triggered daily by sunrise and sunset. These controls maintained a synchrony in feeding periods throughout the daylight hours. We suggest that nighttime peaks in foraging are similarly triggered and synchronized. Such a system of controlled activity allows for 24 hour exploitation of food resources and provides moose with behavioral flexibility in the boreal environment. The index to distance moved showed that moose moved at all times of the day and night, but distance was greatest at dusk in the spring. We suggest that the increase in distance moved in the spring is a result of movements from winter to summer range and to visits to mineral licks.

The existence of a diurnal activity pattern for moose has been noted in past studies. Murie (1934) recorded that moose were most

DESCRIPTION OF STUDY AREA

The study site (center - 54° 45' N lat., 115° W long.) comprised approximately 600 sq. km. of the lower east face of the Swan Hills, an eastern extension of the Canadian Rocky Mountains. The area was a semi-wilderness with human activity limited to the cutting of seismic lines, preliminary oil exploration, hunting, and trapping. Vehicular access was restricted to a single dirt road reaching the western side of the study area.

Lowland muskegs and sedge meadows with black spruce (Picea mariana) and tamarack (Larix laricina) comprised 32.1 percent of the study area. Penetrating the lowlands were a convoluted series of forested ridges (60.3 percent of the study area). Aspen (Populus tremuloides), white spruce (Picea glauca), and lodgepole pine (Pinus contorta) were found in pure and mixed stands and in various combinations of stand heights and densities. The shrub understory in most upland forests was composed of green alder (Alnus crispa), willow (Salix sp.) and small aspens. Willow thickets were located along streams and in narrow well-drained valleys between the forested ridges. Lakes were scattered and of small occurrence (1.3 percent of study area).

METHODS

Moose were captured during the early summer in corral-type live traps located along the margins of natural mineral licks (LeResche and Lynch 1973). After immobilization and the removal of an incisor for aging purposes, each moose was fitted with a radio-collar (150-151 mHz.). A total of 23 and 21 moose were radio-collared in the summers of 1975 and 1976 respectively. An additional seven moose were darted from a helicopter and radio-collared during the intervening winter.

Locations were obtained by triangulation of radio signals from 60-foot towers, each equipped with paired yagi antennas. Two of the towers were on the east side of the study area and two were on the west side. Tracking operations were grouped into sets covering 22 hours of the day from 0300 hrs. to 2400 hrs.. Each set covered a span of 3 to 4 days with intensive daily sessions lasting 5 to 9 hours. An attempt was made to locate each moose once every hour.

Moose activity was determined from the quality of the radio signals. During the time (average of 5 minutes) when the degree bearings were determined for each animal, the modulation and strength of each radio signal was recorded. A constant signal was interpreted as a non-active moose, whereas a modulating signal indicated that the moose was performing some activity, such as feeding, walking, running, agonistic behavior, and comfort activities. The activity may or may not have been associated with a movement from one place to another.

An index to distance moved was obtained from the distance between two successive locations that were obtained between 45 minutes and 3 hours of each other. Calculations were limited to moose that were in areas with small error polygons. A moose was not considered to have moved if the distance of the move was less than the sum of the two error radii (error radii derived from a circle with area equal to that of the error polygon for that location). The mean time for each pair

of successive locations labelled the calculated distance.

The index to the distance moved was calculated by dividing the number of time intervals with measurable distances by this number plus the time periods when zero distance was recorded. This index was used rather than actual distances because the time intervals between successive relocations were not constant and because the straight line distance between points may or may not have reflected actual distance moved.

Activity and the index to distances moved were summarized by season, time of day, and, for winter only, lunar phase. Seasonal boundaries were for summer 1975 and 1976, June 8 to August 31; fall 1975, September 1 to November 30; winter 1975-1976, December 1 to March 31; and spring 1976, April 1 to June 7. Time of day was divided into five periods. The periods of dawn and dusk extended 2.5 hours± the time of sunrise and sunset respectively. Day was between these two periods while early morning preceded dawn and early evening followed dusk. Early morning and evening periods were also combined into a night category. Duration of night and day periods varied from two to twelve hours respectively in June to the reverse in December. These broad time categories were used because of the rapidly changing sunrise and sunset times and because of sample sizes. This method does not permit determination of exact time of activity but should give a realistic comparison of amounts of moose activity during respective seasons and periods of the day.

Activity determined from radio signals was also calculated for each hour of the day for the period of October through February and for the period of April through August. These periods represent short-day and active around daybreak and nightfall with intervening periods of resting and foraging. Both Peterson (1955) and deVos (1958) agreed with these peaks in activity at sunrise and sunset, although added that moose were seldom seen moving at midday. But the observations of Geist (1959, 1963) and McMillan (1954) found additional active periods during the daylight hours. Geist stated that a single activity peak occurred between the daybreak and nightfall peaks of winter and was accompanied by a second peak during the expanded daylight hours of summer.

Most authorities agree that increased activity around sunrise and sunset is primarily related to feeding. Murie (1934), Peterson (1955), and deVos (1958) obtained their data at aquatic feeding sites where conditions for observation were optimal. Murie (1934) and Altmann (1956) also suggested that moose feed at night.

This paper presents activity patterns for moose obtained during a telemetry study of habitat selection by moose in the Swan Hills Alberta from June 1975 to August 1976. Since moose activity may be in one place, such as the activity of feeding, or may involve movements of considerable distance, we have also obtained an index to the distance moved during various time periods. Our analyses investigate both the seasonal effects of changing solar photoperiods and the influence of lunar light conditions on activity patterns. We would add here that little is known of the timing of movements from one place to another since most activity data is based on feeding activities. Most authors conclude that moose move little during midday if undisturbed. Hosley (1949) mentioned that movements during the summer are night oriented. Geist (1963) also suggested that moose move at night.

long-day seasons.

Since it appeared from our nighttime tracking during the winter that moose were more active during moonlight nights, we compared activity during the periods around the four lunar phases. To increase sample sizes of the number of locations for each time period, the true lunar phase alignment ± 131 hours was used. Since the mean time between midpoints of the four lunar phases was 179 hours (range 160-221 hours), there was an overlap of about 48 hours with both the preceding and following lunar phase sample periods. Comparisons were therefore limited to periods of mew moon versus full moon and first quarter versus last quarter.

Differences in the distributions of signal activity and index to distances moved were examined by Chi-square contingency table analysis. When significant differences were found ($p < 0.05$), distributions were further inspected to determine which value contributed most to the Chi-square value.

RESULTS

Activity

A total of 7262 radio signals were monitored for 43 radio-collared moose from June 8, 1975 to August 14, 1976. In all seasons except fall, diurnal peaks in activity were found (Table 1). The period around sunset was the time of greatest activity and was always significantly more active than the preceding day period. Daytime and dawn were more comparable but activity around sunrise was always greater. The fall period showed a reversal in this trend with sig-

Table 1. Moose Activity Index in Relation to Time of Day and Season. Activity Index was Determined by the Proportion of Active Radio Signals to All Radio Signals.

		Dawn[1]	Day	Dusk[2]	Early Evening	Night[3]	Early Morning	All Times of Day
Winter	Activity	.457	.433	.502	.317	.325	.336	.424
	N[4]	652	735	624	463	781	318	2792
Spring	Activity	.568	.511	.705		.432		.569
	N	333	827	438		81		1679
Summer	Activity	.583	.525	.642				.538
	N	211	1522	193				1926
Fall	Activity	.438	.523	.371		.360		.439
	N	144	342	143		236		865
All Seasons	Activity	.502	.499	.572	.343	.341	.336	.490
	N	1340	3426	1398	661	1098	437	7262

[1] Sunrise ± 2.5 hours.
[2] Sunset ± 2.5 hours.
[3] Combined Early Morning and Early Evening Periods.
[4] Number of Radio Signals Monitored

nificantly greater activity during the day than around dawn and dusk.

Overall activity was greater during spring and summer than during fall and winter. This may be a result of the longer daylight during spring and summer, since moose appear to be more active during daylight than at night. Greater activity during spring and summer could also be related to insects since a moose shaking its head because of insects would show a modulated radio signal similar to other movements.

Activity at night was significantly less than other times of the day during fall, winter, and spring. No summer activity at night was obtained, since summer nights were extremely short at this latitude.

During the winter when daily photoperiod was at a minimum, lunar light conditions affected moose activity. Significant differences in activity were found between full moon and new moon periods (Table 2). Overall activity was greater during time of full moon than during new moon and night contributed most to the observed increase. There were no significant differences in activity for the times of day during the full moon phase, while diurnal peaks were again seen in the new moon period.

First and last quarter lunar phases represented intermediate light conditions between new and full moon. Activity for moose during these quarter phases was also intermediate (Table 2). But this conclusion must be viewed in general terms since there was an approximate 48 hour overlap of lunar phase sample periods. Diurnal activity peaks were also found during these quarter phases, with the dusk periods showing the highest activity. Although the first quarter moon was visible during the early evening and the last quarter moon was visible during early morning hours, no activity peaks were associated with the times.

Table 2. Winter Moose Activity Index in Relation to Time of Day and Lunar Phase. Activity Index was Determined by the Proportion of Active Radio Signals to All Radio Signals.

		Dawn[1]	Day	Dusk[2]	Early Evening	Night[3]	Early Morning	All Times of Day
New Moon	Activity	.387	.445	.490	.181	.188	.198	.380
	N[4]	243	344	239	171	257	86	1083
Full Moon	Activity	.527	.463	.481	.442	.425	.393	.468
	N	148	160	187	165	249	84	744
First Quarter	Activity	.481	.406	.523	.332	.311	.278	.423
	N	285	251	266	208	341	133	1143
Last Quarter	Activity	.473	.413	.505	.368	.372	.377	.437
	N	146	230	186	106	191	85	753

[1] Sunrise ± 2.5 hours.
[2] Sunset ± 2.5 hours.
[3] Combined Early Morning and Early Evening Periods.
[4] Number of Signals Monitored.

The hourly activity summaries revealed the possible existence of two nighttime peaks and a single daytime peak in activity for the short-day seasons, as well as two daytime peaks for the long-day seasons (Figure 1). Activity was also shown at a higher and more uniform level during the long-days from April to August than the short-days of October through February. It is possible that peaks do exist but are masked by combining data for a 5-month period.

Movements

The analysis of the indices to distance moved revealed few significant trends (Table 3). Since we could only use locations from moose in good position in relation to the towers and only those locations for which there was another location 45 minutes to 3 hours before or after, our sample sizes for determining the index to distance moved were considerably smaller than the sample sizes for determining activity.

Moose moved greater distances during spring and summer than in winter. Sample sizes during the fall were too small to make meaningful determinations. During spring and summer greatest movement occured at dusk. Spring and summer indices to distance moved showed peaks at dusk. Lunar phases did not appear to influence the distances moved by moose during the winter. (Table 4)

DISCUSSION

Moose activities of principle interest are foraging and moving from place to place. Since there were no major changes in seasonal or daily

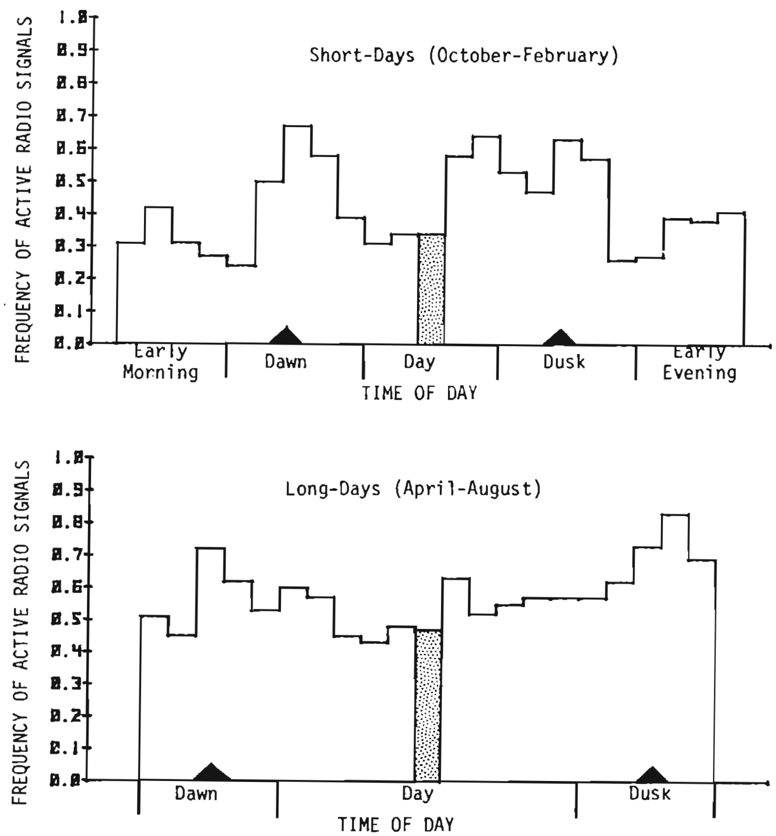

Figure 1. Moose activity in Swan Hills Alberta for short-day and long-day seasons. Distributions based on hourly frequency of active radio signals. Time of sunrise and sunset indicated by (▲). Stipled area is the mean frequency for a midday period of varying duration.

Table 3. Index to Distance Moved by Moose in Relation to Time of Day and Season. This Index Obtained by Measuring the Proportion of Moose Moving a Significant Distance. Significant Distance was Defined as a Distance Greater Than the Sum of the Two Error Radii Involved for All Successive Locations Between 45 Minutes to 3 Hours of Each Other.

		Dawn[1]	Day	Dusk[2]	Night	All Times of Day
Winter	Activity	.548	.391	.450	.401	.427
	N[3]	84	197	109	257	647
Spring	Activity	.456	.490	.688	.667	.539
	N	57	157	77	6	297
Summer	Activity	.460	.523	.563		.515
	N	50	151	32		233
Fall	Activity		.500	1.000	.714	.643
	N		6	1	7	14
All Seasons	Activity	.497	.462	.553	.419	.474
	N	191	511	219	270	1191

[1]Sunrise ± 2.5 hours.
[2]Sunset ± 2.5 hours.
[3]Number of pairs of successive locations used in the calculation of a distance.

Table 4.
Index to Distance Moved by Moose in Winter in Relation to Time of Day and Lunar Phase. This Index Obtained by Measuring the Proportion of Moose in Winter Moving a Significant Distance. Significant Distance was Defined as a Distance Greater Than the Sum of the Two Error Radii Involved for All Successive Locations Between 45 minutes to 3 hours of Each Other.

		Dawn[1]	Day	Dusk[2]	Night	All Times of Day
New Moon	Activity	.611	.378	.442	.434	.443
	N[3]	36	82	43	83	244
Full Moon	Activity	.364	.357	.381	.375	.370
	N	11	28	21	48	108
First Quarter	Activity	.533	.350	.448	.329	.385
	N	30	60	29	73	192
Last Quarter	Activity	.700	.423	.500	.471	.475
	N	10	52	24	51	137

[1] Sunrise ± 2.5 hours
[2] Sunset ± 2.5 hours
[3] Number of pairs of successive locations used in the calculation of a distance.

periods in the indices of distance moved, with the possible exception of twilight hours in spring, the major changes in activity probably were a result of changes in foraging pattern. Geist's (1963) observation that 79 percent of summer activity involved feeding supports this conclusion. The observed dawn and dusk peaks in activity thus reflected foraging periods. Since activity was not excluded from any time of day or season, some feeding appeared to continue throughout the day and night. The existence of midday and nighttime activity peaks, similar to the midday peaks observed by McMillan (1954) and Geist (1963), further suggested a reoccuring pattern to foraging by moose during these times.

Fall activity was also influenced by the rut. Dawn and dusk periods of foraging continued, but even higher daytime activity frequencies were thought to reflect greater social contact. Rutting activities, including breeding and agonistic behaviors, were enhanced by pre-rut and post-rut activity. At these times moose are known to be most sociable and often form large aggregations (Altmann 1959, Peek et. al. 1974). Since we had few time periods from which to calculate an index to distance moved for this season, we do not know if the high daytime activity was related to greater distances moved.

Activity at night was variable and always significantly lower for all seasons than in other periods of the day. In the winter months, foraging was influenced by lunar light conditions. Similar effects by lunar lighting on the occurence of mule deer at salt licks have been recorded (Buss and Herbert 1950). In the Swan Hills, a full moon triggered increased foraging that resulted in a relatively constant daily activity pattern. In new moon periods, moose exhibited strong active diurnal peaks. Foraging at dawn following a new moon was particularly high. This suggests that moose may compensate for short nighttime browsing periods during a new moon with increased browsing at dawn and during the rest of the day.

Since there was little change in distance moved from one moon phase to another, visual discrimination did not seem to be necessary for movements. Nighttime browsing probably required greater visual acuity. The need to distinguish between species, twig diameters, and heights may have necessitated good light conditions at night. It follows that moon light would aid in night browsing and increase its frequency. To maximize feeding time is particularly important in winter when a browse diet is imposed and thermoregulatory stresses arise when temperatures fall below - 40°C (Gasaway and Coady 1974).

The index to the distance moved was higher in spring than in summer and winter. Sample sizes were too small in fall for meaningful indices. Our previous work suggested that increased distances moved in spring were a result of movements from winter to summer range and to possible visits to mineral licks in the area (Best et. al. 1977). At this time of year forage conditions are most favorable as foods become more plentiful, diverse, nutritious, and digestable. Thus less time is needed to feed, as maintenance energy requirements are greatly exceeded (Gasaway and Coady 1974), and longer movements can be made.

Aschoff (in Geist 1963) stated that midday peaks (which varied seasonally with the length of the daily photoperiod) were synchronized by an endogenous feeding rhythm triggered by the active period around dawn. Our results confirm that activity patterns are under control of

changing light conditions with sunrise and sunset initiating dawn and dusk activity periods. We speculate that nighttime activity in winter is triggered by the change in light conditions at sunset with peaks synchronously controlled by endogenous feeding rhythm. The synchronization of nighttime peaks is no doubt weak and only in full control under optimal light conditions. The occurence and number of daytime and nighttime activity peaks in our hourly summaries give support to this control mechanism. The indistinctness of these peaks may indicate the flexibility of the system to other influences such as the weather.

A system of light-triggered activity periods with synchrony from endogenous feeding rhythms allows for a 24 hour exploitation of food resources. This is particularly adaptive to winter survival when an already limited amount of low energy browse initiates a negative energy balance and weight loss in moose.

REFERENCES

Altmann, M. 1956. Patterns of herd behavior in free ranging elk of Cervis canadensis nelsoni. Zoologica. 41:65.

Altmann, M. 1959. Group dynamics in Wyoming moose during the rutting season. J. Mammal. 40(3):420-424.

Best, D.A.,G.M. Lynch and O.J. Rongstad. 1977. Annual spring movements of moose to mineral licks in Swan Hills, Alberta. Proc. Thirteenth N. Am. Moose Conf. and Workshop. p. 215-228.

Buss, I.O. and F.H. Herbert. 1950. Relation of moon phases to the occurence of mule deer at a Washington salt lick. J. Manual. 31(4):426-429.

deVos, A. 1958. Summer observations on moose behavior in Ontario. J. Mammal. 39(1):128-139.

Gasaway, W.C. and J.W. Coady. 1974. Review of energy requirements and rumen fermentation in moose and other ruminants. Naturaliste can. 101(1-2):227-262.

Geist, V. 1959. Diurnal activity of moose. Memoranda Societalis pro Fauna et Flora Fennica. 35(1):95-100.

Geist, V. 1963. On the behavior of the North Americna moose (Alces alces andersonii Peterson-1950) in British Colombia. Behavior. 20(3-4):377-415.

Hosley, N.W. 1949. The moose and its ecology. U.S.D.I. Fish and Wildlife Service, Wildlife Leaflet No. 312. 51 p.

LeResche, R.E. and G.M. Lynch. 1973. A trap for free-ranging moose. J. Wildl. Mgmt. 37(1):87-89.

McMillan, J.F. 1954. Some observations on moose in Yellowstone Park. Am. Midl. Natl. 52(2):392-399.

Murie, A. 1934. The moose of Isle Royale. Univ.Mich. Mus. Zool. Misc. Publ. No. 25, 44 p.

Peek, J.M., R.E. LeResche and D.R. Stevens. 1974. Dynamics of moose aggregation in Alaska, Minnesota, and Montana. J. Mammal. 55(1): 126-137.

Peterson, R.L. 1955. North American moose. Univ. Toronto Press. 280 p.