Winter ecology of the Porcupine caribou herd, Yukon: Part III, Role of day length in determining activity pattern and estimating percent lying

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Abstract: Data on the activity pattern, proportion of time spent lying and the length of active and lying periods in winter are presented from a 3 year study on the Porcupine caribou herd. Animals were most active at sunrise and sunset resulting in from one (late fall, early and mid winter) to two (early fall and late winter) to three (spring) intervening lying periods. Mean active/lying cycle length decreased from late fall (298 min) to early winter (238 min), increased to a peak in mid winter (340 min) then declined in late winter (305 min) and again in spring (240 min). Mean length of the lying period increased throughout the 3 winter months from 56 min in early winter to 114 min in mid winter and 153 min in late winter. The percent of the day animals spent lying decreased from fall to early winter, increased throughout the winter and declined in spring. This pattern was related, in part, to daylength and was used to compare percent lying among herds. The relationship is suggested to be a means of comparing quality of winter ranges.

Key words: caribou , *Rangifer tarandus*, activity, winter range, daylength, lying period.

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Introduction

The winter activity of *Rangifer* has been the subject of numerous studies in recent years (Segal, 1962; Gaare *et al.*, 1975; Skogland, 1978; Roby, 1978, 1980; Boertje, 1981; Thing, 1984) and comparisons among herds are beginning to emerge (Roby 1978; Russell and Martell, 1984.) Knowledge of the activity pattern (the short-term alternation between active and resting periods) and activity budget (the tabulation of the proportion of time in various activities) enables researchers or managers to assess the relative condition of the winter range, determine the energetic relationship and nutritional status of the herd and, by understanding the factors that determine activity budget, more accurately analyze the influence of human disturbance (Klein and White, 1978).

It is generally accepted that the proportion of time spent lying is inversely related to range quality in relation to either forage quality or availability (Gaare *et al.*, 1975; Roby, 1978; Boertje, 1981; Russell and Martell, 1984). Animals ingesting poor quality forage require longer periods for rumination than those ingesting high quality forage (Blaxter, 1962). When food is scarce (because of either low biomass or adverse snow conditions), animals face an energetic trade-off between the high energy expenditure of obtaining food and low energy intake by increasing lying time. By comparing percent lying (percent of the observation period animals spend lying) among herds or temporally for the same herd, an indirect method of assessing range quality is available.

One factor that complicates a direct comparison of percent lying among studies is the observation that *Rangifer* cue their activity to sunrise (Gaare *et al.*, 1975; Thomson, 1977;

Roby, 1978; Erriksson *et al.*, 1981), and that day length (percent of a day occurring between sunrise and sunset) affects activity pattern (Erriksson *et al.*, 1981). Thus, since winter ranges are located at different latitudes and winter studies have occurred at different times, our objective in this paper is to define the relationship between day length and percent lying and compare studies based on this relationship.

The winter ecology of the Porcupine caribou herd was the subject of a cooperative study between the Canadian Wildlife Service and the Yukon Department of Renewable Resources between 1979 and 1982. Among the study's objectives was to assess the quality of the winter range both on a seasonal basis and in relation to other herds. A thorough treatment of the winter activity budget of the herd will be presented elsewhere (Martell and Russell, unpublished data).

Methods

For the purpose of comparison among seasons, the field season was divided into six periods:

1. early fall: In 1980 field work was conducted October 10-13 to coincide with the rut.
2. late fall: November 6-13 when snow depths were very shallow or snow was absent.
3. early winter: December 5-15 to coincide with the shortest daylight hours.
4. mid winter: January 26-February 6 to coincide with the period of moderate snow accumulation.

Table 1. Length of lying and active periods and active/lying cycle during the study.

Period	Total cycle (min)		Lying period (min)		Active period (min)	
	1st*	2nd	1st	2nd	1st	2nd
Early fall						
1980-81	206	285	38	102	168	183
Late fall						
1979-80	270		56		214	
1981-82	325		100		225	
Mean	298		78		220	
Early winter						
1979-80	255		54		201	
1980-81	230		47		183	
1981-82	230		68		162	
Mean	238		56		182	
Mid winter						
1979-80	310		93		217	
1980-81	375		101		274	
1981-82	335		147		188	
Mean	340		114		226	
Late winter						
1979-80	360	315	180	98	180	217
1980-81	270	240	124	87	146	153
1981-82	285	—	156	—	129	—
Mean	305	278	153	93	152	185
Spring						
1979-80		195		55		140
1980-81		225		112		113
1981-82		300		132		168
Mean		240		100		140

* Length of 1st and (if applicable) 2nd period from Fig. 1.

5. late winter: March 5-12 to coincide with maximum snow accumulation and increasing day length.
6. early spring: April 5-25 when snowmelt begins and movement rate increases.

We observed caribou with 15x-60x zoom spotting scopes at 17 field camps during the winters of 1979-80 through 1981-82. A band of caribou was defined as a socially interacting group of animals spatially distinct from other bands in the area. Activity data were collected using the instantaneous scan method (Altmann, 1974). We scanned each band at 15-minute intervals and tallied the number of caribou engaged in each of five general activities which were identified primarily by posture. An animal was defined as lying if observed bedded on the ground in a resting or ruminating position, either upright or lying on its side.

For each camp, activity data were pooled and the proportion of caribou lying was plotted in relation to time since sunrise. The length of the active/bedded cycle was calculated as the time between consecutive activity peaks. The area under the curve between activity peaks, when divided by the length of time between the activity peaks, was used to calculate the mean percent of time spent lying during that cycle. This mean was multiplied by the length of the active/bedded cycle to yield the mean length of the lying period.

The proportion of time spent lying for each camp was calculated as a single ratio for each camp with confidence limits as described in Cochran (1977:156). Values were considered significantly different if confidence limits were non-overlapping.

Results

Activity pattern

During the six time periods examined, caribou were most active at sunrise and sunset (Fig. 1). The number of lying cycles was directly related to day length with periods of similar day length yielding similar cyclic patterns. Thus, early winter (15% day length) yielded one indistinct lying period (assessed visually from Fig. 1), late fall and mid winter (25%) yielded one distinct lying period, early fall and late winter (45%) yielded two full lying periods and, through extrapolation, in spring (60%), animals exhibited three lying periods.

The mean length of the active/bedded cycle varied from 238 min in early winter to 340 min in mid winter (Table 1). The mean length of the lying period decreased from late fall to early winter, then increased throughout the winter (Table 1).

Activity budget

The seasonal trend in percent lying was consistent for all years, decreasing from fall to early winter, increasing throughout the winter and decreasing again in spring. In each year values for percent lying in fall and early winter were significantly lower than those from mid winter to spring (Table 2). Furthermore, year three (1981-82) tended to have the greatest percent lying (significantly different from years one and two in mid winter and from year one in spring).

Since activity pattern appeared greatly influenced by day length, we examined the effect of daily observation time on our estimates of percent lying (Table 2). Some of our original observations extended from before sunrise to

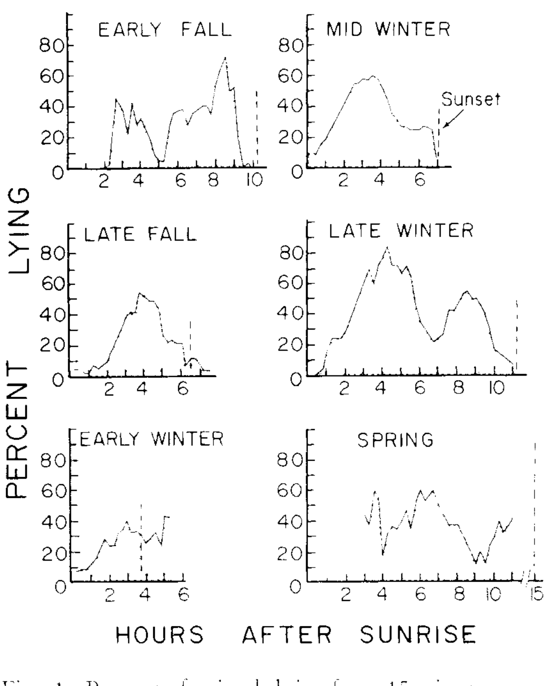

Fig. 1. Percent of animals lying from 15 minute scans in relation to hours after sunrise for the six study periods: early fall (10-13 Oct.), late fall (6-13 Nov.), early winter (5-15 Dec.), mid winter (26 Jan. - 6. Feb.), late winter (5-12 Mar.), spring (5-25 Apr.).

Table 2. Estimation of percent lying[1] from data of different time intervals (n=number of scans).

Period	All data n	%	±95%CI[2]	Sunrise to sunset n	%	Hour after sunrise to hour before sunset n	%
1979-1980							
Late fall	82	20	3.9[a]	80	20 (0)[3]	64	21 (+1)
Early winter	61	15	8.5[a]	54	15 (0)	27	20 (+5)
Mid winter	89	30	5.9[b]	88	30 (0)	69	35 (+5)
Late winter	111	45	5.5[c]	107	47 (+2)	98	51 (+6)
Spring	110	33	5.5[b]	110	33 (0)	110	33 (0)
1980-81							
Late fall	175	28	14.2[a,b]	175	28 (0)	159	30 (+2)
Early winter	216	21	6.8[a]	176	20 (—1)	111	23 (+2)
Mid winter	320	29	5.5[a,b]	278	31 (+2)	196	39 (+10)
Late winter	155	42	13.0 [b]	155	42 (0)	150	44 (+2)
Spring	74	33	13.8[a,b]	74	33 (0)	74	33 (0)
1981-82							
Late fall	183	28	6.4[a]	172	29 (+1)	131	33 (+5)
Early winter	154	26	6.9[a]	104	28 (+2)	47	32 (+6)
Mid winter	293	40	3.7[b]	279	40 (0)	206	45 (+5)
Late winter	149	47	5.7[b]	149	47 (0)	149	47 (0)
Spring	94	44	4.4[b]	94	44 (0)	94	44 (0)

[1] Percent of the observation period animals spent lying (that is, for each winter period, percent lying=total number of animals lying/total number of animals observed in scans x 100).
[2] The 95% confidence interval is based on a single estimate on each band of caribou observed. Within each winter, values with the same subscript are not significantly different at the P=0.05 level.
[3] Bracketed value equals change from «all data» estimation.

after sunset. When we excluded data collected before sunrise or after sunset, the estimates changed little, but using only those data collected between 1 hour after sunrise to 1 hour before sunset we reduced our original sample size by 25% and consistently increased our estimate of percent lying for all time periods (Table 2). The change was not significant, however, for any period. Each spring and in late winter 1981-82 all our observations occurred well after sunrise or well before sunset.

Discussion

Other authors have noted that caribou cue their activity to sunrise producing a conspicuous «midday» peak in lying (Gaare *et al.*, 1975; Roby, 1978; Erriksson *et al.*, 1980). In the present study this «midday» peak generally occurred about 3.5 to 4.5 hours after sunrise, regardless of day length. The pattern of active and bedded cycles for the remainder of the day, however, is constrained by day length since caribou also appear to exhibit another peak in activity at sunset.

Researchers normally employ the «50% rule» when determining mean length of lying and active periods (Roby, 1978; Boertje, 1981). By this method a lying period starts when 50% of animals lie down and ends when over 50% get up again. Utilizing the area under the curve method in our study the length of the lying period increased throughout the winter from 56 min (early winter) to 153 min (late winter). Other researchers maintain that the length of the lying period is consistent throughout the winter (Segal, 1962; Roby, 1978; Boertje, 1981). In fact, Boertje (1981) concludes that his observed differences in percent lying among winter periods must be related to changes in the length of activity periods rather than the length of the lying periods. However, data in Tables 1 and 2 indicate that percent lying is significantly related to the length of the lying period ($r=0.83$, $n=15$) and not significantly related to the length of the active period ($r=-0.43$, $n=15$). We feel that the

«50% rule» is inappropriate for individual bands during short day length sampling times. Animals are normally active at sunrise and sunset and therefore complete active periods are seldom observed or if they are observed they are biased toward shorter periods. For example, using the «50% rule» we calculate for our study that the mean length of the active period over all winter periods is 109±11.1 min (mean ± SE, n=16) However, we had to disregard 42 incomplete active cycles (mean 200 min). By the area under the curve method the estimate of mean active period for all winter periods is 184 min. The major disadvantage of the area under the curve method is that no estimate of variation is possible.

In contrast, many complete lying periods were observed during the «midday» period. However the 50% rule is not appropriate when lying periods are short and animals are somewhat asynchronous. The combination of these two factors normally results in observers seldom noting 50% of the band lying. The bias in this case is towards longer lying cycles. From our observations these two factors do occur in the early winter period. Using the 50% rule we would estimate a lying period length of 108 min compared to 56 min using the area under the curve.

The fixed and thus predictable pattern of activity/lying peaks in relation to sunrise and sunset must be taken into consideration when comparing activity budgets between studies. In particular, the latitude, date, and time of daily observations are important when comparing winter activity among different herds. For example, comparing our results in early and mid winter to data presented by Gaare *et al.* (1975) could be misleading. They observed Norwegian herds at approximately 60°N compared to 65°N for our study. The day length in early and mid winter in Norway is 25% and 38%, respectively, compared to 15% and 25% in central Yukon. It is not surprising, therefore, that Gaare *et al.* (1975) presented an early winter cycle similar to our mid winter cycle (one very distinct lying peak) and a mid winter cycle similar to our late winter cycle (two distinct lying peaks). Furthermore, Gaare *et al.* (1975) indicated that their observation period in mid winter was only from 1.5 hours after sunrise to 1.5 hours before sunset, thus yielding an overestimate of percent lying compared to our estimates.

An examination of the literature indicates that few studies provide enough data points to compare winter activity patterns (percent lying as the indicator) to day length. However the available data indicate that larger seasonal

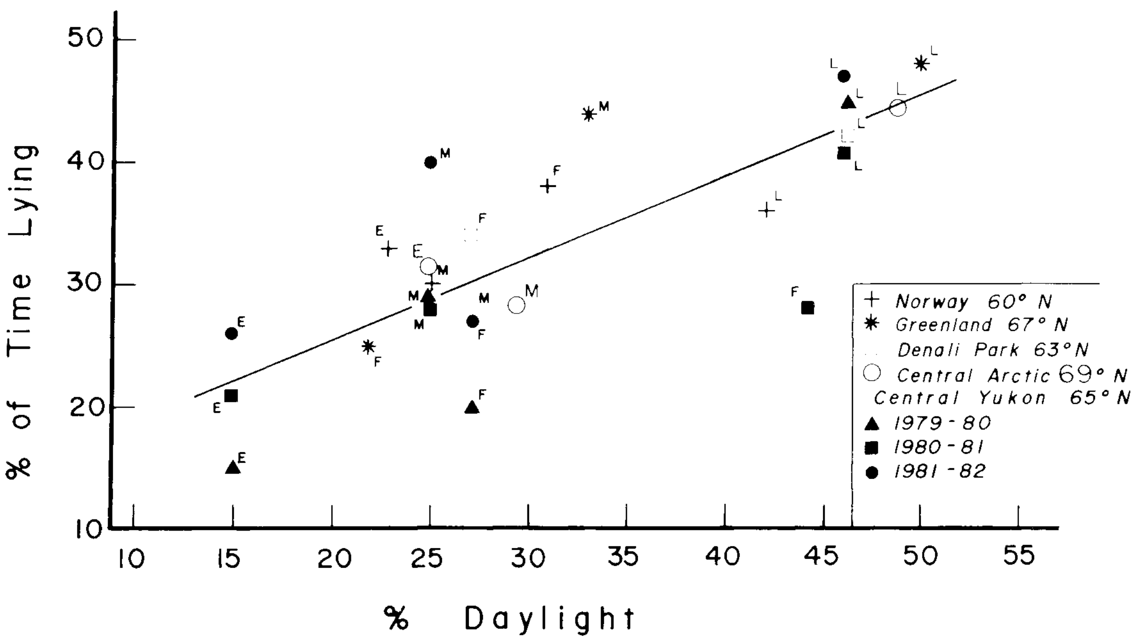

Fig. 2. Relationship between day length and percent lying from various studies for fall (F), early (E), mid (M), and late (L) winter. *Note:* Early fall 1980 for central Yukon not included in estimation of the line since observations occurred during the rut.

fluctuations in day length (i.e., higher latitudes) correspond to larger fluctuations in percent lying (Fig. 2). Herds in Norway (Gaare *et al.*, 1975), which exhibited the least variation in percent lying, were located at the most southerly latitudes. Our data (65°N latitude) generally exhibit a lower early winter minimum in lying and a higher late winter maximum. At even higher latitude, Roby (1978) recorded the greatest increase in percent lying from mid to late winter for the Central Arctic Herd.

The overall relationship between percent lying and day length appears linear for daylight values of less than 50%. Although a straight line has been drawn through the data in Fig. 2, we do not provide an equation because we do not know the exact observation dates for most studies. In Roby's (1978) study, for example, a 5 day change in the midpoint of his observation period could result in a 5% shift in day length.

An important factor that contributes to the variation in percent lying for each day length (Fig. 2) is range quality, as indicated by food availability and/or food quality. Our data indicate that percent lying increases in severe snow conditons (Martell and Russell, unpublished data). Because of this and the fact that diet did not vary significantly between years in our study (Martell and Russell, unpublished data), we hypothesize that this increase in percent lying results in most cases from a decrease in forage availability rather than forage quality. This hypothesis is based on R.G. White's (University of Alaska, pers. comm.) contention that caribou can physiologically reduce rumen volume at times of low food availability, thus requiring less feeding time to fill the rumen. Reduced rumen volumes in winter have been documented for field killed animals (Staaland *et al.*, 1979). Increased lying time therefore should be caused by either longer rumination time (to extract the maximum amount from limited food supply) or by an energy conservation strategy whereby the lying period exceeds time necessary for rumination, as documented by Erriksson *et al.* (1981). Forage quality can also affect percent lying since ingestion of poor quality forage requires longer rumination times for digestion thus longer lying periods (Blaxter, 1962; Cammell and Osborn, 1972). With standardized observations plotted as in Fig. 2, the points above the line should correspond to poorer quality or less available forage and points below the line should indicate higher quality or more available forage.

Studies that indicated poor range conditions do tend to fall above the line in Fig. 2. Roby (1978) indicated that preferred forage (lichens) had low availability on the range of the Central Arctic Herd in northern Alaska. Range quality on Greenland was very poor and animals were near starvation (Roby, 1980). Gaare (1968) indicated that a significant decline in lichen biomass had occurred on the Snøhetta range in southern Norway (fall value for Norway, Fig. 2). As well, estimates of percent lying from the present study indicate poorer quality range in deep snow years (e.g., 1981-82) than shallow snow years (e.g., 1980-81 (Martell and Russell, unpublished data)). Another indication that lower food availability results in higher values is illustrated by comparing values for fall and mid winter for animals on the same range. At similar day length, fall values tend to be lower than mid winter values.

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