ACTIVITY PATTERNS OF CAPTIVE CALIFORNIA BIGHORN SHEEP (Ovis canadensis californiana) AT PENTICTON, B.C.

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ABSTRACT

A captive California bighorn (Ovis canadensis californiana) maternal group ranging within a 40 ha. enclosure at the Okanagan Game Farm near Penticton, B.C., was observed from May 1977 to December 1977. Estimates of the average daily time devoted to various activities by the herd members were made for each month of observations. Time devoted to feeding during daylight showed no seasonal trend, remaining relatively constant from May to November, but decreasing in December. Bedding time during the day proved to be highly correlated to day length (r^2 = .85). The times devoted to feeding and bedding by different age classes of animals were determined and compared each month. A preliminary analysis indicated no consistent differences existed between different classes of sheep. The diurnal patterns of the herd were monitored each month, and showed considerable variation from one season to the next. Winter storms caused significant changes in activity patterns, even on a day to day basis.

INTRODUCTION

In attempts to maximize the productivity of domestic grazing animals, researchers, for several decades, have studied the daily activity patterns and movements of many domestic species. Such studies have provided a wealth of information on the forage and habitat preferences and potential daily energy expenditures of free ranging live-

stock (Arnold 1960a, 1960b, Brody 1945, Graham 1964, Meyer et.al., 1957, Squires 1974). This information has been employed in intensive range and animal management.

Similar studies on many wild ungulates are difficult because of the poor viewing conditions afforded by the animals' natural habitat. Mountain sheep, for example, have been intensely studied in North America and yet little quantitative data is available on their daily activity patterns and potential energy expenditures. Various researchers (Mills 1937, Davis 1938, Blood 1963, Geist 1971) have described herd behaviour from relatively few days of observations, giving the time of occurrence and duration of active and non-active periods for several different herds. Van Dyke (1978) completed a more thorough study of this kind, examining the activity patterns of ewes, lambs and rams and comparing the activity budgets of the different sex and age groups within seasons. However, researchers of wild populations are usually forced to observe different animals on different days and even fluctuating numbers on the same day. This obscures individual animal behavior, resulting in average data being collected even for specific age and sex classes of animals. Animal scientists working on domestic grazers have reported that great variation in daily behaviour exists between conspecifics subjected to the same environmental conditions, not only because of age and sex differences, but because of differences in the physiological conditions, genetics, weights and forage selection of the animals as well. Therefore, to fully understand and assess the activity budgets and possible energy expenditures of herd members, identifiable individuals must remain under observation throughout the study to enable their daily behaviour to be interpreted in lieu of the fac-

tors mentioned above.

This paper presents a preliminary analysis of the daily activity patterns of a captive group of California bighorn sheep from May, 1977 to December, 1977. The same indivduals were observed for the entire study period, enabling accurate comparison of daily behaviour to be made between individual animals and age classes. Feeding and bedding durations were used for this preliminary comparative analysis. Seasonal changes in general herd activity are also presented and interpreted in terms of weather and range phenology.

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METHODS

Animals for the study were trapped in January and February, 1977 from the Vaseux Lake population, 30 km. south of Penticton. The captive herd was originally composed of 16 ewes (2 years or older), 2 female lambs, 1 male lamb and a yearling ram. Each animal was marked with a distinct collar for identification and then released into a 40 ha. enclosure, situated on steeply sloping grassland adjacent to the Okanagan Game Farm. Data collection began in May 1977 on the original group members. The 18 lambs born on site were trapped and collared in October, and monitored with the remainder of the herd from November on.

The sheep were dependent on the mature bluebunch wheatgrass (Agropyron spicatum) - big sage (Artemisia tridentata) plant community within

the enclosure as a food source. Therefore, their daily activity patterns were considered to reflect those of free ranging animals on a similar range, particularly those populations not exhibiting seasonal, vertical migrations.

Observations were made through a 20-40 power binocular spotting scope from a point 200 meters outside the enclosure to eliminate disturbance to the animals. During sampling periods, between dawn and dusk, the study site was scanned every fifteen minutes and the activity of each individual was noted, together with its location using co-ordinates of a gridded map of the area. Activities were categorized as feeding, bedding, travelling without feeding, standing and other (interacting, suckling, nursing, playing, salting, watering, and body care behaviour). Five to eight observation days were completed for each month.

Using a high intensity spot lamp and the spotting scope, the activity of the herd was occasionally monitored well into darkness until all herd members appeared to be bedded. However, all night observations were not attempted because of the poor viewing conditions offered by this system.

The visibility of the animals depended on their study site location. Animals disappeared from view if they moved into the northwest corner of the enclosure because of relief and timber cover. Certain individuals repeatedly used this area and, as a result, were excluded from behavioural analyses. Therefore, data from only 12 of the original 20 herd members and 6 of the 18 lambs are presented in this report.

Adult ewes were aged by horn annuli (Geist 1966) and fell into 1 of 2 age categories: 1) 4 years or older; 2) 3 years. Yearlings made

up group 3 and lambs were introduced as group 4 for November and December. Analysis of variance and single degree of freedom contrasts were used for comparing the daily foraging and bedding times of the 4 groups. The statistical significance of day to day variation in the herd's behaviour was also evaluated. The level of significance was 5%.

On some days, the entire herd was visible throughout the sampling period. Data collected on such days were used to describe the temporal distribution, frequency and approximate duration of active and non-active periods for the herd in general under various seasonal influences (lambs not included).

RESULTS

1) Foraging and bedding behaviour

Table 1 lists the average daily time devoted to feeding and bedding each month by members of the individual age groups and by the combined members of the herd as a whole. Significant group differences are indicated with small case letters.

a) Monthly trends for the herd

Average daylight hours devoted to feeding by the herd members ranged from 5.52 hours in December to 9.49 hours in September. Means for the remaining months showed only slight month to month variation, indicating a low correlation between feeding time and length of observation day ($r^2 = 0.24$). The proportion of daylight hours spent foraging varied considerably, increasing monthly from a low of 0.48 in May and June to a high of 0.81 in November. In December, only 64% of available daylight was used for feeding.

TABLE 1: AVERAGE DAYLIGHT HOURS DEVOTED TO FEEDING AND BEDDING

		MEAN LENGTH OF OBSER-VATION DAYS	MEAN FEEDING TIME (HRS)					MEAN BEDDING TIME (HRS)				
			HERD	GR.1	GR.2	GR.3	GR.4	HERD	GR.1	GR.2	GR.3	GR.4
MAY		15.00	7.29(0.48)[1]	7.46a[2]	7.00b	6.69b	-	5.57(0.37)[1]	5.41b	5.77a	5.70a	-
	S.D.±	0.0	0.84	0.90	0.69	0.80	-	0.59	0.56	0.52	0.64	-
JUNE		16.04	7.85(0.48)	7.81a	8.00a	7.79a	-	5.81(0.36)	5.81a	5.74a	5.90a	-
	S.D.±	0.70	1.41	1.22	1.07	1.07	-	1.03	1.03	1.26	0.80	-
JULY -AUG		16.35	8.54(0.52)	8.50a	8.65a	8.52a	-	5.40(0.32)	5.48a	5.34a	5.31a	-
	S.D.±	0.59	0.99	1.05	0.96	0.97	-	0.91	0.93	0.91	0.89	-
SEPT		12.70	9.49(0.74)	9.52a	9.07b	9.85a	-	1.54(0.12)	1.59a	1.92a	1.05b	-
	S.D.±	0.48	1.18	1.33	1.20	0.68	-	0.80	0.78	0.66	0.73	-
OCT		10.75	7.83(0.72)	7.90a	7.93a	7.54b	-	1.34(0.12)	1.29b	1.64a	1.17b	-
	S.D.±	0.42	0.94	0.96	0.92	0.88	-	0.64	0.64	0.64	0.56	-
NOV		9.39	7.68(0.81)	7.73a	7.55a	7.70a	6.92b	0.67(0.07)	0.55a	0.87a	0.70a	0.73a
	S.D.±	0.49	0.77	0.87	0.68	0.66	1.05	0.52	0.52	0.59	0.38	0.71
DEC.		8.56	5.52(0.64)	5.54a	5.29a	5.69a	5.23a	1.33(0.15)	1.39a	1.38a	1.17a	0.58b
	S.D.±	0.24	1.36	1.40	1.50	1.23	0.90	1.14	1.25	1.11	1.00	0.47

[1]proportion of daylight hours

[2]a is significantly greater than b ($p<.05$)

GR. 1 = 6 ewes; 4 years or older
GR. 2 = 3 ewes; 3 years of age
GR. 3 = 3 yearlings (2 females, 1 male)
GR. 4 = 6 lambs (4 female, 2 males)

Average daylight hours devoted to bedding by herd members peaked in June (5.81 hours) and decreased monthly to a low of 0.67 hours in November. Regardless of the increased December value (1.33 hours), mean bedding time of the herd members proved to be highly correlated to daylength ($r^2 = 0.85$). As foraging occupied a greater and greater proportion of the day, the proportion of time spent bedded decreased accordingly, dropping from a high of 0.37 in May to a low of 0.07 in November. In December, bedding time increased to occupy 15% of the day.

For every month, there was significant day to day variation in the mean bedding and feeding times of the herd members ($p < 0.05$). However, for this preliminary report, no attempt has been made to interpret these daily fluctuations in detail.

b) Monthly age group comparisons

The foraging and bedding behaviour of the different age groups showed no consistent differences. In the June and July-August sampling periods, there were no significant between group differences. In May, group 1 ewes fed significantly longer and bedded significantly less than other herd members while yearlings (group 3) bedded the fewest hours. In October, yearlings fed significantly fewer hours than adult ewes and, with group 1 ewes, bedded less than group 2 ewes. With the indtroduction of the lamb group in November, the analysis showed that lambs devoted less time to foraging than other herd members. Bedding time was similar for all 4 groups. December data indicated no group differences in feeding time. However, lambs bedded less than other animals.

2) General Herd Activity Patterns

Considering that the proportion of the daylight hours spent actively foraging by the herd members increased dramatically from May to November, it is not surprising that the number and duration of active and non-active periods varied from one season to the next. Figure 1 represents the activity patterns demonstrated by the herd for May, July, September and November. Although there were some day to day fluctuations in the herd's behaviour, the patterns described in Figure 1 are considered to be representative for that month.

In May and July, the herd members followed a cyclic synchronous pattern with activity peaks occurring before dawn and at midmorning, mid-day, mid-afternoon and late evening. The most extensive activity peak was in mid afternoon when the majority of animals were active for almost 4 continuous hours. In May, the final active period did not extend far into darkness. However, in July, night monitoring with the aid of a high intensity spot lamp showed that most animals continued to feed 30 to 90 minutes after dusk.

In September and November, the herd's activity pattern was no longer clearly synchronous or cyclic. A majority of the herd was active throughout the day, with activity peaking at or shortly after dawn and continuing well after dark. Inactive periods were short and involved only a few herd members at a time. In November, it became apparent that some animals were remaining active for entire observation periods (9 hours).

Figure 2 shows the activity patterns of the herd for 2 days in December. On December 7, the first major activity peak did not occur until 10:00 hours and lasted only an hour before the majority of the

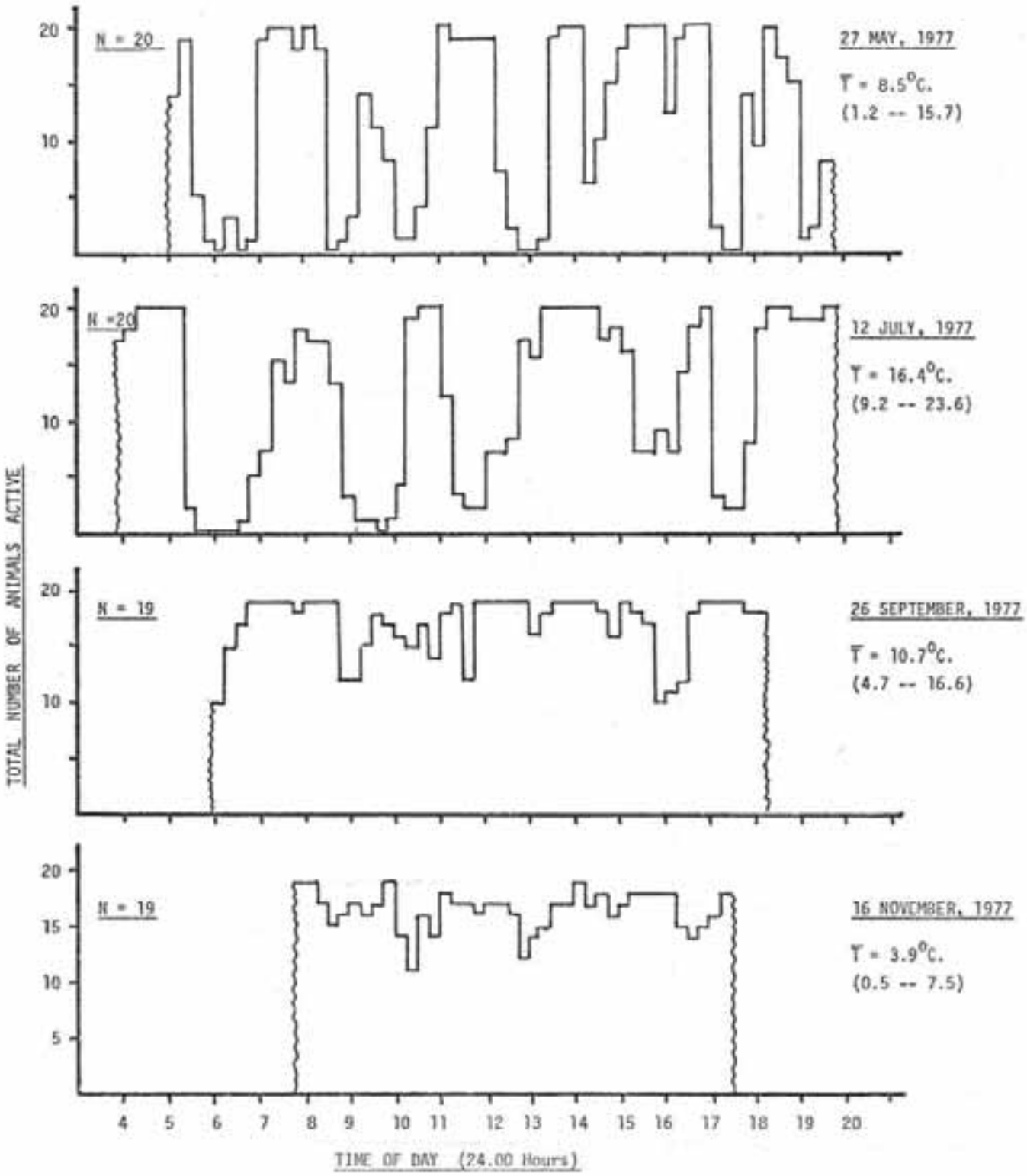

FIGURE 1. Activity of adult California bighorn sheep during daylight hours, for 4 selected days. (N = Total number of adults present; T̄ = mean daily temperature; minimum and maximum temperatures are in parentheses).

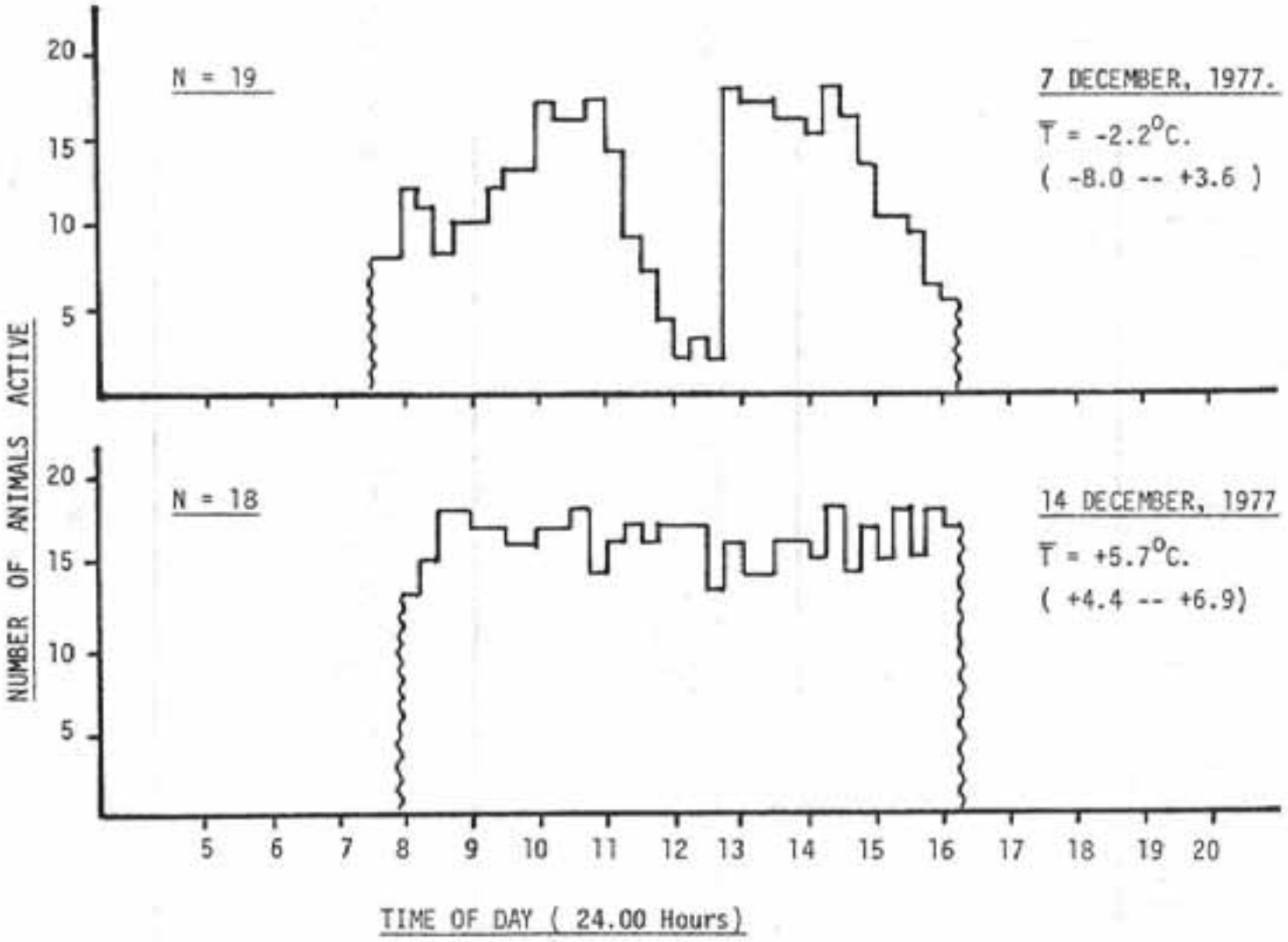

FIGURE 2. Activity of adult California sheep during a "cold" day (7 December) and during a "warm" day (14 December).

herd bedded for an extensive mid-day break. This synchronized bedding was the first observed since the summer. The entire herd was again active by 12:45 hours with the majority foraging until 14:30 hours when bedding again commenced. By dusk, 2/3 of the animals were inactive. On December 14, the herd's activity pattern converted back to it's November form, with the majority of animals being active almost continuously throughout the day.

DISCUSSION

1. Foraging and bedding behaviour

a) Analysis of herd behavior

The overall mean grazing time of the herd members for the duration of the study was 7.74 hours per day. Had observations extended over a 24 hour period, this value would have increased. With the exception of September and December values, monthly means varied only slightly around this figure, showing no seasonal trends. The increased foraging effort in September was probably an attempt by the herd to build up winter energy stores, utilizing the high quality fall regrowth of that month. The low feeding time and elevated bedding time of December appeared to be related to cold, inclement weather in the first 10 days of that month. Since movement and foraging would have been energetically costly in the deep snow and cold, windy conditions, the animals seemed to be minimizing their energy expenditures rather than attempting to maximize their energy intake.

Domestic studies have reported mixed findings on the foraging behaviour of domestic sheep. Hughes (1951) found no seasonal trends in daily grazing time other than a suppression of foraging during the

winter months. However, Arnold (1960b) showed that grazing time increased and ruminating time decreased as pasture quality and quantity declined. Arnold (1962) also noted that, as pasture condition and photoperiod decreased with the progression of the seasons, a larger proportion of the sheeps' total grazing time occurred at night. As previously mentioned, monthly grazing means for this study showed no such increase. Therefore, if such a compensatory response was necessary for our captive sheep to maintain an acceptable level of nutrient consumption in the fall months, the animals must have increased their night time feeding. Some night activity was evident from changes in the bedding location of animals at dusk and dawn on consecutive observation days but could not be quantified to indicate seasonal frequency. Night movements appeared to stop during early December when stormy, cold conditions would have made activity too costly.

Other authors have reported on some night activity in bighorns. Woolf(1970) noticed feeding at intervals throughout the night but suggested that movements were "limited to the immediate vicinity of the bedground". Van Dyke (1978) also noticed night movements in Oregon. bighorns.

b) Age group comparisons

The inconsistent behavioural differences of the various age groups were difficult to interpret. All adult ewes (groups 1 and 2) had lambed in the spring and were subjected to the increased energy demands of lactation. This may partially explain why group 1 ewes grazed longer and bedded less than yearlings. The ewes of group 2, which did not behave differently than the yearlings in May, might have entered spring in slightly better condition than the ewes of group 1 because of their

younger age. As a result, they were able to cope with lactation demands without increasing their foraging time. Had lambs been monitored in May when they were almost entirely dependent on milk as a nutrient source, the data would have certainly shown a small foraging time and high bedding time for this age group. Van Dyke (1978) found the foraging time of lambs to be less than adult ewes in the spring. He did not compare activity budgets of adults and yearlings.

Although no group differences appeared during the summer months, the inclusion of lamb data would again have shown foraging times of this age group to be smaller than that of other herd members. The lambs had developed some foraging habits by this time but were still suckling regularly for a portion of their diet.

From October to December, rams were present in the herd for breeding purposes. However, none of the group differences for this period can be interpreted in terms of courtship activities. Adult ewes showed no major behavioural changes as a result of harassment from rams.

Reasons for significant day to day variations in the feeding and bedding behaviour of the herd were not clear. The length of observation day remained relatively constant within a month and could not have been a major contributing factor. Weather had obvious effects on herd behaviour during December. However, during periods of consistent weather patterns, day to day variation continued to be evident, indicating that even more subtle factors were at work.

2. General Herd Activity Patterns

Changes in the foraging behaviour of the herd from season to season have been attributed largely to the plant phenology of the range. The cyclic nature of the herd's activity pattern for the spring and

summer months likely reflects range condition for that season. Preferred ephemeral grasses and forbs were abundant and high in crude protein (Wikeem 1977, pers. comm.). Forage in this phenological state has been shown to be highly digestible (Hebert, 1973). Therefore, the animals were able to procure and digest this preferred vegetation relatively quickly. Since the rate of passage of ingesta varies directly with its intake rate and digestibility (Blaxter et.al., 1961), the turnover rate for the ingested forage was probably high. This rapid turnover rate combined with the long photoperiod of spring and summer days enabled the sheep to fill their rumens and ruminate several times during daylight in the cyclic fashion demonstrated.

Several researchers of wild mountain sheep populations have noticed fewer activity peaks for bighorns during the summer months than reported here. Mills (1937) and Davis (1938) both found 3 peaks of activity for bighorns in Yellowstone National Park, occurring at dawn, mid day and in the late afternoon. Davis and Taylor (1939) found a bimodal activity pattern in Texas bighorns with foraging peaks extending throughout the morning and late afternoon. A single rest period occurred at mid day. Van Dyke (1978) found only two consistent activity peaks for bighorns, one in early morning and one in late evening. It is difficult to interpret such between site discrepancies since foraging behaviour responds to several environmental factors. However, it is probable that differences in range condition between areas would largely explain such variable observations.

The change from a cyclic pattern of successive feeding and bedding periods to a more continuous foraging behaviour in September and November by the herd seemed to coincide with the late season maturation and

fall regrowth of the range plants. Many of the forbs and grasses that were highly preferred in the spring and summer had disappeared or cured to a relatively low nutritive state. However, fall regrowth of the remaining plants, particularly bluebunch wheatgrass, provided a high quality but limited forage and was selected for by the sheep (Wikeem 1977, pers. comm.). But this regrowth, often shrouded by less palatable plant parts, was not readily accessible to the animals and required a considerable degree of foraging selectivity to procure it. It is postulated that the time required to express this selectivity reduced intake rates, enabling the animals to forage throughout most of the day without repeatedly filling their rumens. As a result, bedding periods were infrequent. Several domestic studies support this hypothesis. Meyer et.al., (1957) and Arnold (1960a) both reported that selection by sheep for new growth is very pronounced in mature vegetation. Furthermore, Arnold (1960b, 1964) showed that intake rates decrease for domestic sheep as pasture quality and quantity declines.

Reports on the fall activity patterns of wild sheep differ from the results reported here. Geist (1971) found an average of four activity peaks for Stone rams in October and at least 1 bedding period at mid-day which involved almost all visible animals. Hoefs (1974) found that a captive herd of Dall's sheep also demonstrated a major bedding period at mid-day throughout the fall months. However, he concluded that the number of activity peaks was dependent on day length. Van Dyke (1978) again noticed only single early morning and evening activity peaks.

Herd activity in December (Figure 2) demonstrated the rapid and drastic effect of weather on the diurnal pattern of the captive sheep.

On December 7, the mean daily temperature dropped to -2.2 C and a storm the previous 2 nights had deposited 20 cm. of snow, raising the snow accumulation on the site to approximately 30 cm. As a result, foraging conditions were difficult. The extensive bedding observed in the early morning was likely an energy conserving strategy of the sheep to avoid this coldest portion of the day when activity would have been energetically most costly. It is suggested that the bimodal activity pattern observed for the remainder of the day was the result of a change in feeding behaviour. The deep snow covered any remaining fall regrowth and the sheep, although cratering to some extent, seemed content to feed largely on stems and seed heads of bluebunch wheatgrass and on browse species which were above the snow. This high fibre forage, being less digestible and slowly processed would have forced the herd to bed and ruminate after short foraging periods. Hoefs (1974) offered a similar explanation for the mid-day "siesta" observed in his captive Dall's sheep herd.

Other researchers found similar winter activity patterns for mountain sheep. Geist (1971) noted that Stone rams and ewes fed very little in the morning with peak activity occurring at noon and mid afternoon. Blood (1963) presented similar results for California bighorns but showed a third activity peak at dusk.

However, Van Dyke (1978) found no avoidance of the morning hours by bighorns in Oregon.

On December 14, the mean daily temperature was 5.7 C with the minimum temperature being a mild 4.4 C. Several mild days previous to this had removed the snow cover from most of the study site. With foraging conditions again being more favourable, the sheep reverted back

to a more continuous foraging behaviour. The animals were observed feeding low to the ground, presumably selecting the most recent growth of the plants. With intake rates remaining low but quality of the diet improving, it is postulated that animals were again able to forage continuously throughout the daylight hours without resting to ruminate.

CONCLUSIONS

Studies of the diurnal patterns and activity budgets of bighorn populations can provide information important for the management of these animals and their range. Sampling intensity during such studies largely dictates the nature and usefulness of the information provided.

In this study, animal activities were recorded at 15 minute intervals for the entire observation day. Five to 8 days were spent observing per month. At this sampling intensity, it appeared that seasonal changes in the range phenology were readily detected in the animals' daily behaviour. It also became apparent that certain weather patterns were very influential on the animals' behaviour. Estimating the average daily foraging time of animals within months with moderate precision was also possible at this intensity.

If detailed information on the daily energy expenditures of animals is required from such a study, sampling intensity would have to increase considerably. More sampling days per month would be required to properly interpret the day to day fluctuations in behaviour observed in this study. The sampling interval would have to be reduced to 5 minutes or less to adequately estimate the duration of short term activities, such as running, interacting, suckling, etc.

REFERENCES

ARNOLD, G.W. 1960a. Selective grazing by sheep of two forage species at different stages of growth. Aust. J. Agric. Res. 11:1026-33.

_____ 1960b. The effect of the quantity and quality of pasture available to sheep on their grazing behaviour. Aust. J. Agric. Res. 11: 1034-43.

_____ 1962. The influence of several factors in determining the grazing behaviour of Border Leicester x Merino sheep. J. Brit. Grassl. Soc. 17: 41-51.

_____ 1964. Factors within plant associations affecting the behaviour and performance of grazing animals. From "Grazing in Terrestrial and Marine Environments". Blackwells Scientific Publications 1964.

BLAXTER, K.L., F.W. WAINMAN, R.S. WILSON. 1961. The regulation of food intake by sheep. Animal Prod. 3: 51-61.

BLOOD, D.A. 1963. Some aspects of behaviour of a bighorn herd. Can. Field-Natur. 77(2): 77-94.

BRODY, S. 1945. Bioenergetics and Growth. Rheinhold Pub. Co.

DAVIS, W.B. 1938. Summer activity of mountain sheep on Mt. Washburn, Yellowstone National Park. J. Mammal. 19(1): 88-94.

DAVIS, W.D. and W.P. TAYLOR. 1939. The bighorns heep of Texas. J. Mammal. 20: 440-445.

GEIST, V. 1966. Validity of horn segment counts in aging bighorn sheep. J. Wildl. Mgmt. 30: 634-636.

_____. 1971. Mountain sheep: a study in behaviour and evolution. Univ. of Chicago Press, Chicago. 383 pp.

GRAHAM, N. McC. 1964. Energy costs of feeding activities and energy expenditure of grazing sheep. Aust. J. Agric. Res. 15: 969-73.

HEBERT, D.M. 1973. Altitudinal migration as a factor in the nutrition of bighorn sheep. Ph.D. Thesis, University of B.C.

HOEPS, M. 1974. Food selection by Dall's sheep (Ovis dalli dalli Nelson) I.U.C.N. Pub. 24 Vol. 2: 759-786.

HUGHES, G.P. and D. REID. 1951. Studies on the behaviour of cattle and sheep in relation to the utilization of grass. J. Agric. Res. 41: 350-366.

MEYER, J.H., G.P. LOFGREEN, J.L. HULL. 1957. Selective grazing by sheep and Cattle. J. Animal Sci. 16: 766-772.

MILLS, H.B. 1937. A preliminary study of the bighorn of Yellowstone National Park. J. Mammal. 18(2): 205-212.

VAN DYKE, W.A. 1978. Population characteristics and habitat utilization of bighorns hseep, Steins Mountain, Oregon. M.S. Thesis, Oregon State Univ.

WOOLF, A., T. O'SHEA and D.L. GILBERT. 1970. Movements and behaviour of bighorn sheep on summer ranges in Yellowstone National Park. J. W.M. 34(2): 446-450.