GROWTH RATES OF ROCKY MOUNTAIN BIGHORN SHEEP ON RAM MOUNTAIN, ALBERTA

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ABSTRACT

Rams grew rapidly until 4 years old after which annual weight increments decreased considerably. Ewes reached most of their maximum weight by age 2. Lambs and yearlings of both sex classes had slow growth until early June and then increased linearly until early September after which rate of gain decreased. Summer weight gain for older animals was relatively more rapid through most of the summer and also declined by September. Summer weight gain of lambs to 2-year-olds was more rapid in rams than ewes. Growth rates of ewes declined after 2 years with a small constant increment up to 5 years of age. There were no differences between years in individual growth rates despite considerable interyear differences in primary production as measured by summer precipitation. Growth rates were more rapid in ewes that were not lactating compared to ewes with lambs. Lambs appeared to gain slightly in weight over winter while older animals progressively lost more weight over winter. Energy costs associated with gestation were reflected in greater winter weight losses of pregnant ewes after parturition. Interannual differences in overwinter weight loss were evident and highly correlated with late winter snowfall and mean temperature from January to May.

INTRODUCTION

Body weights of bighorn sheep (Ovis canadensis) and other ungulates have been used as a measure of population quality when comparing herds (Geist 1971, Shackleton 1973, Nievergelt 1966). Expanding populations of sheep have been characterized by large horn and body size, rapid growth, short life expectancy and high fecundity, while smaller horn and body sizes, slower growth rates, longer life expectancies and lower fecundity characterize declining or stable herds. Bunnell (1978) documented interannual differences in horn growth and found them to correlate with differences in precipitation and with yearly differences in recruitment in a Yukon Dall sheep (Ovis dalli) population. For bighorn sheep, however, there has been very little data published on annual growth rate patterns in free ranging sheep and on growth rates of individuals during the summer from which comparisons could be made with other herds.

The inability to capture and recapture free-ranging Rocky Mountain bighorn sheep on a regular basis has apparently limited the availability of individual weight gain data in the literature. Blood et al. (1970) reported weights of winter captured bighorn rams and ewes of different ages in Alberta as well as weight gains of lambs over one year. Age and sex specific winter weight loss data have also been recorded for Dall sheep (Bunnell and Olsen 1976). Hoefs (1974) reported changes in weight of a single captive Dall ram over a 17 month period.

The purpose of this paper is to examine weights and rates of weight gain for comparison with other herds. Patterns of summer weight gain and individual growth rates for males and females of different ages are presented. Interannual differences in growth rates are documented, as well as, the effects of energy expenditures such as winter survival and reproduction on body size and growth rates.

STUDY AREA

Ram Mountain (52º 25'N, 115º 45'W) occupies the southern half of the Brazeau Range in west central Alberta. The mountain is geographically isolated in surrounding conifer covered foothills on three sides while the north Saskatchewan River provides a significant barrier on the north side. The area ranges in elevation from 1082 m - 2173 m above sea level with treeline at approximately 1830 m. The terrain is varied with bare rock summits, talus slopes, wooded slopes, low relief alpine tundra and rugged escarpments and cliffs. The alpine and subapline vegetation of Ram Mountain are described in detail by Johnson (1975) and are characteristic of the eastern slopes of Rocky Mountains in Alberta north of the Bow River.

METHODS

Sheep were captured and tagged in a corral-like structure baited with salt (Wishart et al. 1980). The bighorns were individually marked with various combinations of colored, lettered and numbered collars and ear tags. Weights, horn measurements and standard body measurements were recorded for each capture. Only the weight data will be reported in this paper. Trapping extended from approximately 25 May to the first week of October between 1978 and 1983. Capture frequency per individual ranged from one to seven times. Weights of individuals were taken every two weeks whenever possible.

Summer weight gain patterns were determined by calculating the mean of all weights for a particular sex-range class every two weeks. Individual growth rates were calculated by including all weights obtained for a specific animal between 1 June and 1 September (25 May = X_1 for regression). A Mann-Whitney U test (Siegal 1956) was employed to test for differences between years, sexes, and age classes.

To calculate overwinter weight changes, it was necessary to know the growth rates of an individual for two consecutive years. This requirement effectively eliminated many animals from the sample. The difference between the 1st September (x_1 coordinate = 100) estimated weight in year (i) and the estimated weight on 1st June (X_2 coordinate = 8) in year (i + 1) gave an estimate for overwinter weight loss. Weight loss estimates would be minimum values for all animals since weight continued to increase at a slow rate past 1 September and by 1 June the following spring, some weight gain would already have occurred. Thus, maximum pre-winter and minimum post-winter weights for individuals were not know.

To compare interannual differences, it was necessary to eliminate the effects that age might have upon weight loss. An index similar to the "quality index' used by Bunnell (1978) to assess interannual differences in horn increment was utilized here for weights. Essentially the index measures the difference between the average weight loss for individuals of similar age in a particular year and the average weight loss for all individuals (of that same age) in all years. Thus one could determine the amount of deviation above or below the average age specific weight loss for all years by dividing the index by the standard deviation of weight loss within a year.

Meteorological data were obtained from the Nordegg Ranger Station that was located 19 km northwest of the study area at 1326 m in elevation. High winds were common and snow could fall during any month of the year on Ram Mountain.

RESULTS

June weights were plotted for ewes and rams from approximately 3 weeks of age to 7 years of age (Fig. 1). A very rapid linear increase was noted in rams up to 4 years after which weight gain decreased considerably. Ewes, however, had generally reached most of their adult weight by 2 years.

The contribution to weight gain from horn and skull growth in rams was most significant in rams 4 years and older. Average skull and horn weights of central and northern ram specimens from the Wildlife Branch museum for yearlings, 2-year-olds, 4-year-olds, and 7 years and over were 0.7 kg (N=2), 1.6 kg (3), 4.5 kg (6) and 8.0 kg (4) respectively. The difference in horn and skull weight between 1 and 4-year-old rams was 3.8 kg while the difference in body weight was about 50 kg. Therefore, less than 10 percent of the weight gain between 1 and 4-year-old rams could be attributed to increasing skull mass. However, between ages 4 and 7+ years a difference in skull weight of 3.5 kg was accompanied by only a 10 kg increase in body weight. In older rams therefore, as much as 35 percent of the increasing body weight could be attributed to horn and skull growth.

Rams weighed more than ewes in all age classes, except lambs where the difference was not significant (P 0.10) and amounted to only 1.1 kg. The difference in weight of yearling ewes and rams was significant (P 0.05), but the average difference was only 4.6 kg.

SUMMER WEIGHT GAIN

Rate of weight gain during the field season (25 May - 11 October) was determined for rams up to 2 years and ewes up to 4 years. Capture frequency for older individuals was too low to make similar comparison.

Weight gain for lambs and yearlings of both sexes appeared to follow a logistic growth curve (Fig. 2 and 3). Weight gain was relatively slow up to the first week in June and then maintained a highly linear (r^2 = 0.98 rate of increase until the beginning of September after which weight gain appeared to slow. A more dramatic decrease in weight gain after September would probably have been recorded had it been possible to weigh more sheep at that time.

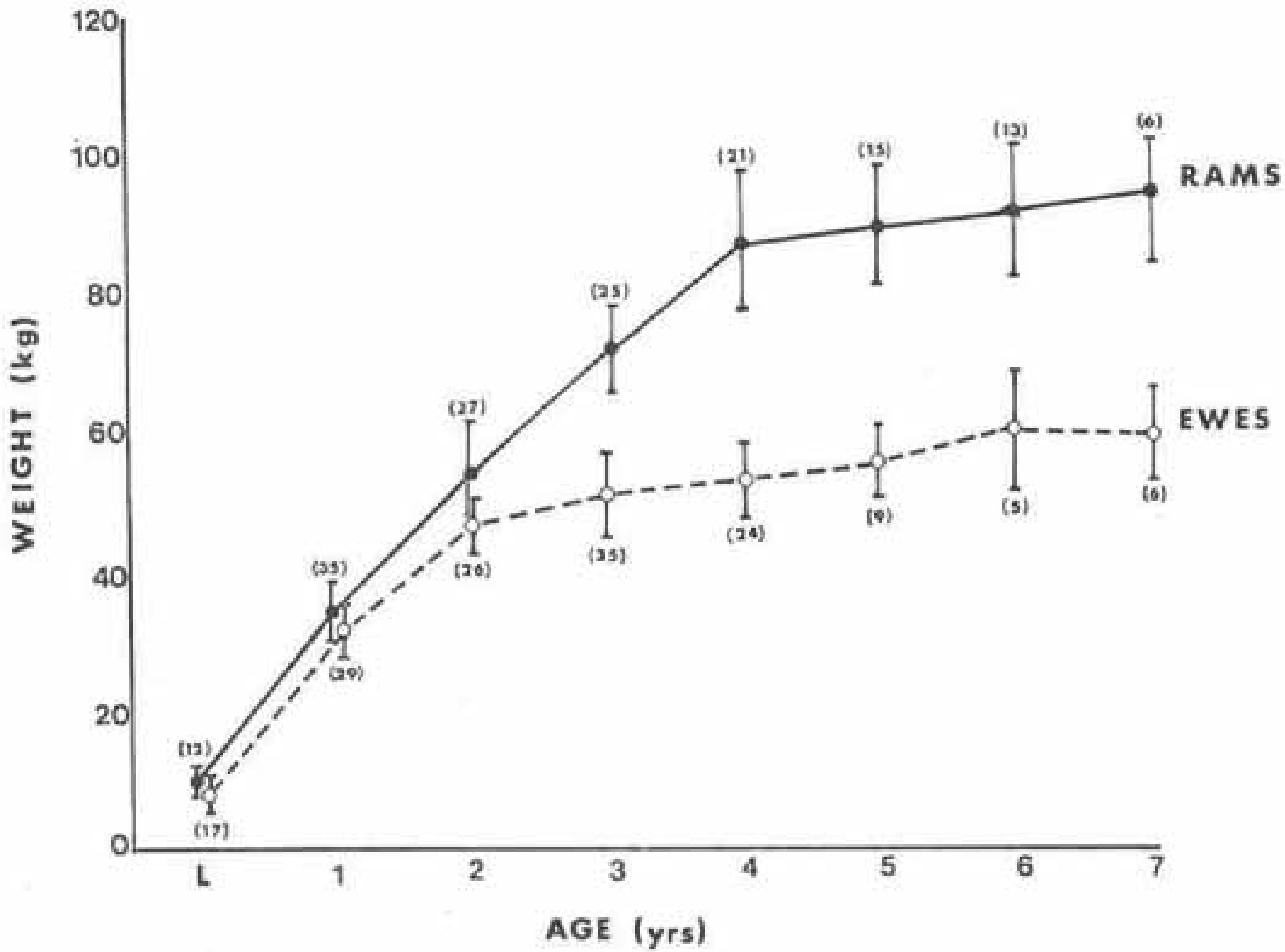

Figure 1. Spring weights of ewes and rams (lamb-7 years) from Ram Mountain, 1978-1983. (Dots, vertical lines and parentheses represent means, standard deviation and sample size respectively).

Compared with lambs and yearlings, summer weight gain by ewes and rams older than 1 year followed a logarithmic curve with weight gain being more rapid during the first 6 weeks of summer and then declining thereafter (Fig.3). The proportion of variability in weight with time for these age classes was 94 percent or greater assuming a logarithmic function and 87 percent assuming a linear function.

The slope of each age-sex specific summer growth pattern may be taken to represent an average rate of weight gain. Actual average rates of weight gain (as measured by the linear slope of each regression) were 0.29 kg/day and 0.25 kg/day for male and female lambs respectively (Table 1). Yearling and 2-year-old males progressively put on weight considerably faster than their female counterparts. Ewes more than 2 years old maintained a relatively stable rate of weight gain at least up to 5 years. Though sufficient data was not available for comparable analysis, 3 year-old rams appeared to maintain a very high rate of growth compared to the same aged ewes (Fig.1). After 4 years, summer growth rates for rams appeared to slow considerably.

INDIVIDUAL GROWTH RATES

The number of animals for which individual growth rates could be determined were limited depending on age class and capture frequency within age classes. Therefore, reliable statistical comparisons often could not be made. With growth having been shown to be linear only up to late summer (Fig.2), individual rates of weight gain were calculated between 8 June - 1 September. Though average growth of 2, 3 and 4-year-old ewes was closer to a logarithmic growth function, it was assumed to be linear for purposes of calculating individual weight gain for these age classes.

Within age classes, growth rates between years were significantly different (P 0.05) in only a few instances (Tables 2,3). Generally, there were no consistent interannual differences particularly when all age classes were combined. Small sample sizes made statistical comparisons less valid in many cases. Within age classes and within years,there was little individual variation in growth rates for lambs and yearlings. For older age classes, individual variation became greater.

GROWTH RATES AND REPRODUCTIVE SUCCESS

To examine the impact of reproduction on growth rates, weight gains in non-parous ewes and ewes that lost lambs shortly after parturition were compared with weight gains of parous ewes. Parous 2-year-old ewes which bred as yearlings gained weight throughout the summer at a significantly slower (P 0.05) rate than their unproductive counterparts (Table 4). Parous ewes over 2 years also experienced a slower growth rates than the few (N=2) barren ewes for which individual growth rates could be calculated.

Ewes that lost their lambs shortly after birth would probably be spared the added energy expense of lactation and would be expected to gain weight faster than ewes with lambs. Indeed, ewes that lost lambs gained weight at an average 0.22 kg/day (N=10) compared with 0.16 kg/day (N=111) for ewes with

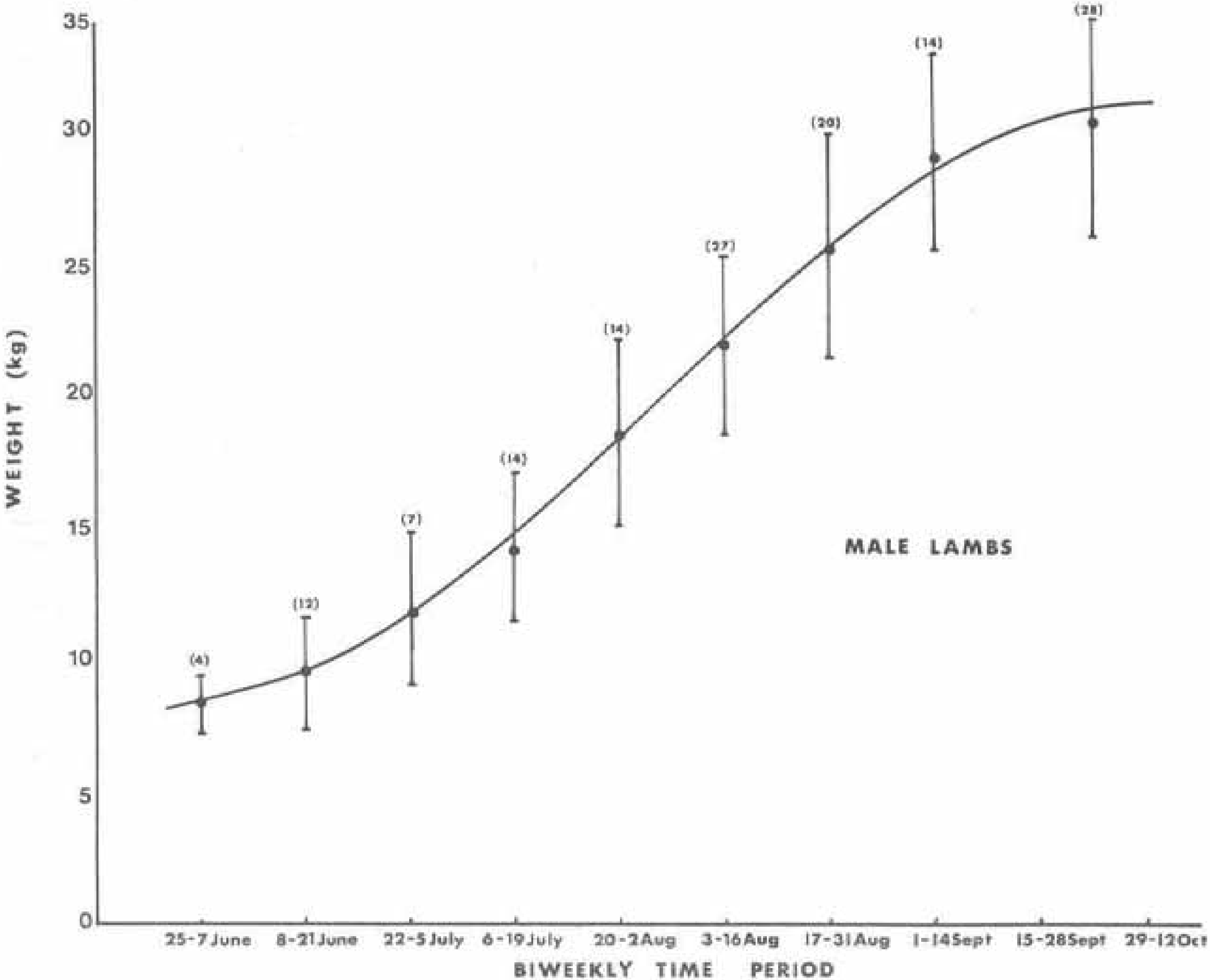

Figure 2. Summer weight gain of male lambs (1978-1983). (Dots, vertical lines, parentheses represent biweekly means, standard deviation and sample size respectively).

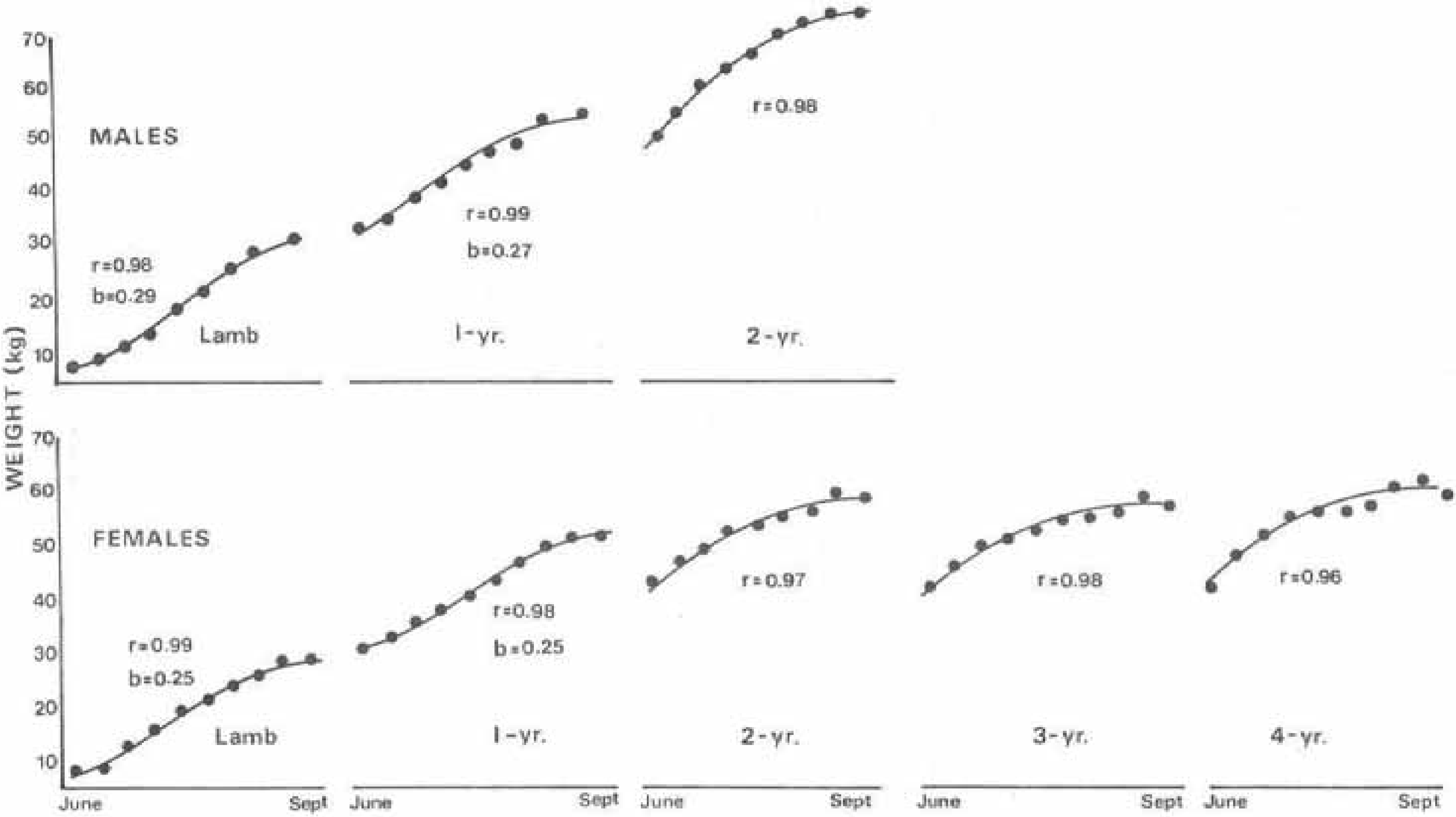

Figure 3. Summer weight gain of rams (lambs-2 years) and ewes (lambs-4 years) from Ram Mountain, 1978-83. (Dots represent biweekly mean weights).

Table 1. Average rates of weight gain for ewes and rams aged 1 to 5 years (1978-1983).

Age	Average rate of weight gain (kg/day) Rams	Ewes
Lambs	0.29	0.25
Yearlings	0.27	0.25
2-Years	0.31	0.19
3-Years	N/A	0.17
4-Years	N/A	0.18
5-Years	N/A	0.19

Table 2. Mean individual growth rates (kg/day) of bighorn rams from Ram Mountain (1978-1983).

Age		YEAR 1978	1979	1980	1981	1982	1983
Lambs	$\overline{x}$	0.24	0.24	0.25	N/A	0.24	0.24
	SD	0.02	0.02	0.25		0.05	0.01
	N	7	5	6		5	3
Yrlgs	$\overline{x}$	0.20	0.23	0.23	0.18	0.20	0.18
	SD	0.03	0.03	0.03	0.05	0.05	0.04
	N	5	8	7	12	9	5
2-Yrs	$\overline{x}$	0.23	0.31[a]	0.20[a]	0.23	0.27	0.22
	SD	0.04	0.07	0.04	0.03	0.03	0.05
	N	2	5	3	4	10	9

[a]Significantly ($P<0.05$) different.

N/A = Not available.

Table 3. Mean individual growth rates (kg/day) of bighorn ewes from Ram Mountain (1978 - 1983).

Age		Year					
		1978	1979	1980	1981	1982	1983
	$\overline{x}$	0.20	0.23	N/A	0.19	0.22	0.21
Lambs	SD	0.01	0.05			0.03	0.01
	N	3	6		1	6	2
	$\overline{x}$	0.19	0.22	0.19	0.17	0.19	0.19
Yrlgs	SD	0.05	0.03	0.02	0.03	0.03	0.03
	N	5	11	6	2	6	9
	$\overline{x}$	0.18	0.19	0.16	0.12	0.15	0.13
2-Yrs	SD	0.04	0.04	0.03	0.05	0.06	0.05
	N	8	6	10	4	7	6
	$\overline{x}$	0.22[a]	0.18	0.17	0.16	0.16	0.12[a]
3-Yrs	SD	0.05	0.05	0.10	0.08	0.04	0.05
	N	5	10	5	8	6	5
	$\overline{x}$	0.12	0.17	0.14	0.20	0.20[a]	0.12[a]
4-Yrs	SD	0.01	0.04	0.04	0.03	0.06	0.07
	N	2	3	5	2	10	6

[a]Significantly ($P<0.05$) different within age group.

N/A = Not available.

lambs (Table 4). Weight gain in ewes that lost lambs was comparable to weight gain of barren ewes.

Table 4. Growth rate comparisons between parous, non-parous, and ewes losing lambs (1978-1983).

	2-year-olds			3-year-olds		
	Parous	Non-parous	Lost Lamb	Parous	Non-parous	Lost Lamb
Growth Rate	0.15	0.16	0.23	0.16	0.24	0.22
N	15	22	4	96	2	10
Standard Deviation	0.04	0.04	0.01	0.06	0.01	0.04

OVERWINTER WEIGHT LOSS

Overwinter weight loss is a significant factor affecting subsequent weights of bighorn sheep. Not only does the weight loss leave a base weight on which to add the current seasons growth, but it also reflects the condition of an animal coming out of the winter and this in turn determines the weight of the animal going into the next winter. Average overwinter weight changes from 6 October to 1 June indicate that lambs (males and females) increase slightly in weight, while older animals progressively lose more weight with age over winter (Fig. 3). Data on rams more than 2 years old and ewes older than 5 years was insufficient to make comparisons. After parturition, 3 and 4-year-old ewes had lost an average of 14 kg or approximately 23 percent of their pre-winter body weight. Some ewes lost as much as 20 kg.

The total weight of fetus, fetal membranes and amniotic fluids which is expelled at birth is unknown for bighorn sheep. However, in domestic ewes about 37 percent of the weight of the reproductive tract (term) consists of fluids and associated structures (Rattray et al. 1974). The average bighorn lamb weighs about 4.0 kg at birth (Geist 1971) and if the percentage of the conceptus consisting of non fetal material is similar to domestic ewes, then the total weight lost at parturition would be approximately 6 kg. This would account for about one half of the average overwinter weight loss of 3 and 4-year-old ewes.

Minimum overwinter weight losses for individuals were calculated from 1 September to 1 June. Though weight changes in male and female lambs were similar, female yearlings lost more weight than yearling males. This

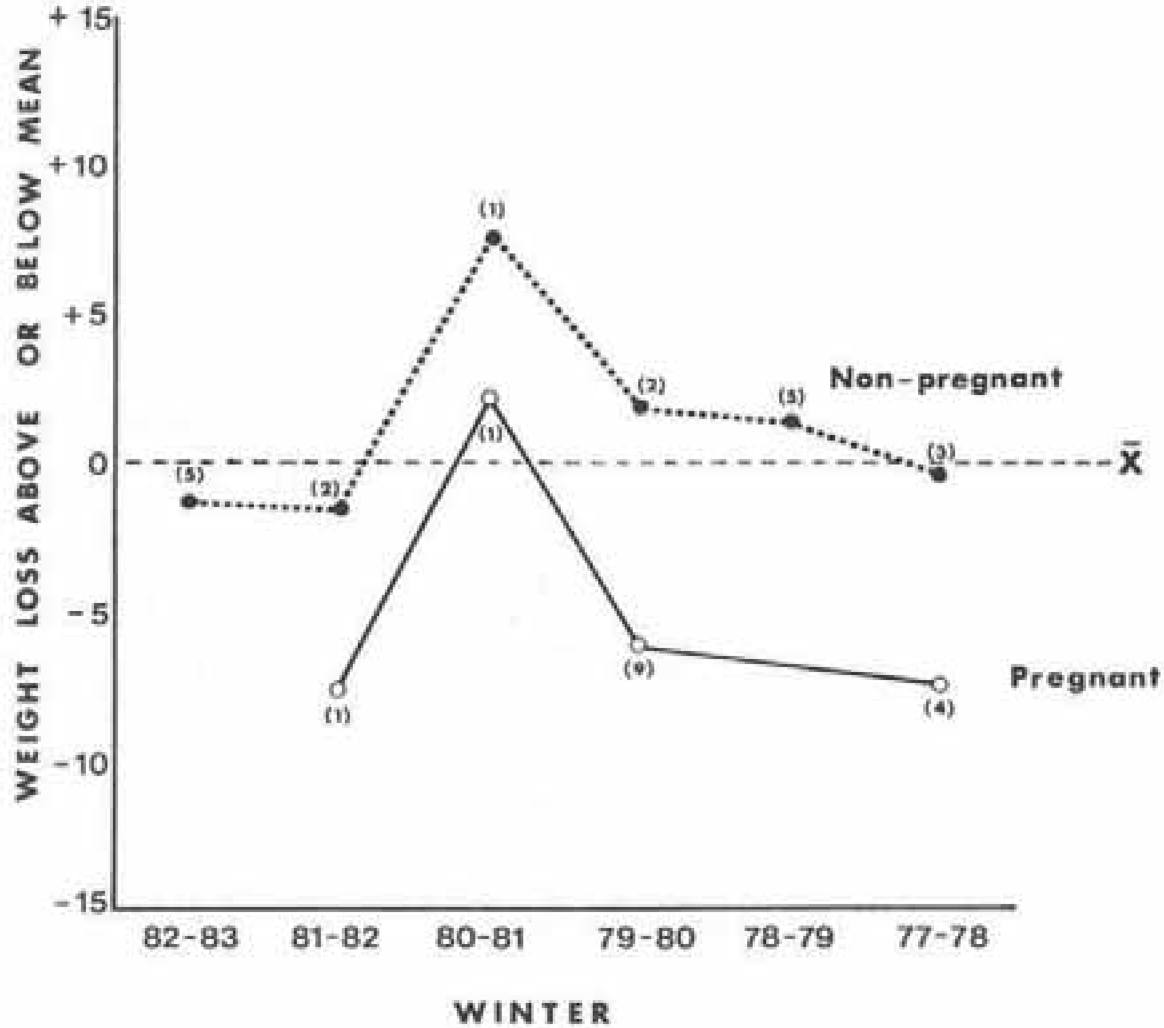

Figure 4. Winter weight loss of pregnant and non-pregnant yearling ewes.

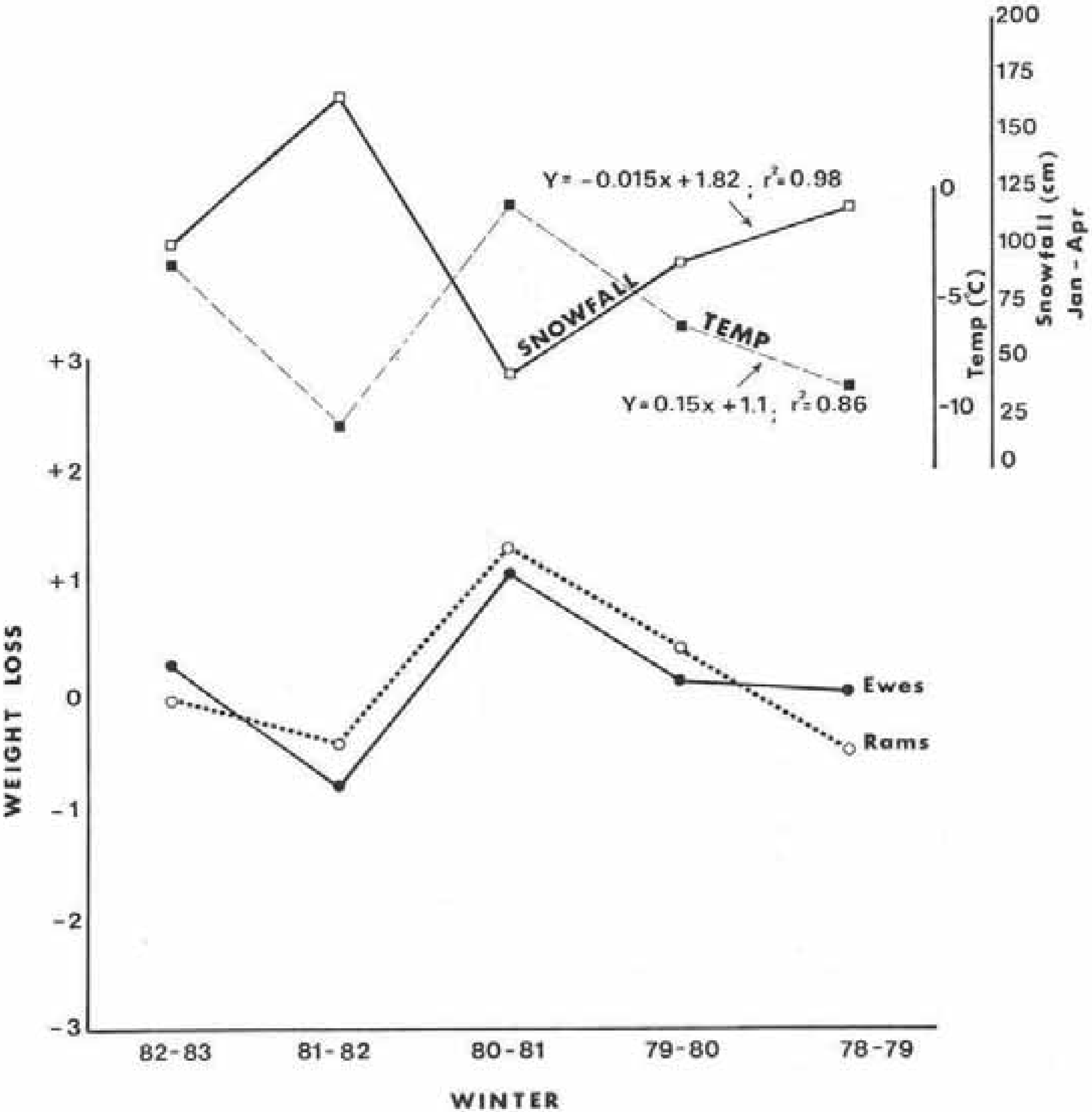

Figure 5. Overwinter weight loss and winter severity for bighorns from Ram Mountain (1978-1983).

difference was accountable by the inclusion of pregnant yearling ewes which lost more weight than non-pregnant yearlings (Fig. 4). There were too few barren ewes in the older age classes to make a similar comparison.

Interannual differences in overwinter weight change were examined in rams from lambs to 2-year-olds and in ewes from lambs to 4 years using the weight-loss index. Since pregnancy rates in yearling ewes were variable and weight loss of pregnant yearling ewes was shown to be greater than non-pregnant yearlings (Fig. 4), pregnant yearlings were not included. Ewes older than 2 years for which weight losses could be calculated were all pregnant and thus equally affected. During the winter of 1981/82 a greater than average weight loss was observed in both ewes and rams while only rams lost more weight than average in the 1978/79 winter (Fig. 5). During the 1980/81 winter, ram and ewe weight losses were 1.1 to 1.3 standard deviations below average.

Overwinter weight loss appears to be influenced greatly by the severity of the winter with late winter conditions contribution the most. Regressing both mean monthly temperature (°C) and total snowfall (cm) between January and April with the weight loss index, yields a highly significant relationship for both rams and ewes (Fig. 5). Snowfall was positively correlated with weight loss while mean monthly temperature was negatively correlated.

DISCUSSION

Compared with bighorns from southern Alberta (Blood et al. 1970), Ram Mountain sheep appeared to stop growing at an earlier age. Rams from Waterton Park continued increasing in weight up to 7 years while those from Ram Mountain gained only slightly past 4 years. Southern rams and in particular ewes, were considerably heavier than Ram Mountain sheep. Weight differences were probably even greater, since those reported by Blood et al. (1970) was taken in late winter after winter loss was at a maximum, whereas, sheep on Ram Mountain were weighed in June following a brief period of weight recovery. Sheep from southern Alberta have been shown to exhibit greater horn and skull growth than their northern counterparts (Wishart and Brochu 1982).

Summer growth was observed to be more rapid in older animals ($\geq$ 2 years) than in lambs and yearlings. This change in growth rate appears to be compensatory to an increasing weight loss over winter for older sheep. Older individuals seem to have the capacity to recover from greater weight loss with rapid early summer growth. Such ability to make up weight losses has been noted in orphaned bighorn sheep (Jorgenson et al. in prep.), white-tailed deer fawns (McEwan et al. 1957) and in domestic livestock (Pomeroy 1955). Rapid recovery from winter weight losses would be most advantageous for lactating ewes who need to care for newborn lambs. The added energy expenditure of lactation would tend to slow this recovery which was reflected by faster growth rates of ewes that did not produce a lamb and those that lost their lambs soon after parturition. Clutton-Brock et al. (1982) demonstrated lower body weights, lower kidney fat and lower rump fat in lactating red deer compared with barren females.

The energy costs of reproduction were further documented by greater weight loss suffered over winter by pregnant ewes. The difference noted in ewes that bred as yearlings may have been greater than that seen in older females because yearling ewes on Ram Mountain normally do not breed and they are smaller than older ewes. Older, non-pregnant ewes would also be expected to lose less weight than pregnant ewes though the difference may not be as great.

Extreme weight losses could affect the survival of both ewe and fetus which would be compounded during severe winters. However, survival and lamb production remained high on Ram Mountain (unpublished data) even after the relatively hard winter of 1981/82 when overwinter weight losses were the greatest. Apparently, weight losses would have to be greater than what was recorded in 1981/82 for survival to be affected. Possibly a poor quality herd may be affected sooner than one of higher quality like Ram Mountain.

The weight that a bighorn attains each year would be dependent on the previous winter weight loss, summer rate of weight gain and on the length of the growing season. Winter weight loss has been shown to be dependent primarily on the severity of the winter. Stelfox (1974), similarly found large overwinter weight losses in ewes of Alberta's National Parks. Weight losses ranged from 7 to 22 percent of pre-winter body weight in ewes. Average growth rates for individuals of each age and sex did not vary from year to year regardless of interannual differences in spring and summer precipitation which Bunnell (1978) and Nievergelt (1966) found to correlate with interannual differences in horn growth. It appears that for weights, rate of gain is fairly constant and that any interannual differences observed in body weights would depend on the length of the growing season which would be dependent on the timing of spring green up.

In terms of productivity, survival and life expectancy the Ram Mountain sheep herd is one of high quality (Jorgenson and Wishart 1983). However, compared to bighorns in southern Alberta, the Ram Mountain herd is of poor quality relative to body size and horn growth. Wishart (1969) attributed the larger horn and body sizes of southern sheep to an optimum combination of climate, soil and vegetation. Since growth rates appear to be constant from year to year on Ram Mountain, it is probable that differences in body size observed in other herds may be the result of longer growing seasons and a larger overwinter weight base on which to add the next seasons growth. A long growing season followed by low winter weight losses appear to be factors influenced by more advantageous bioenergetic conditions. Rates of growth may also be faster in southern Alberta sheep herds, but until they can be trapped frequently at regular intervals their growth rates remain unknown.

LITERATURE CITED

Blood, D. A., D. R. Flook, and W. D. Wishart. 1970. Weights and growth of Rocky Mountain bighorn sheep in western Alberta. J. Wildl. Manage.34: 451-455.

Bunnell, F. L. 1978. Horn growth and population quality in Dall sheep. J. Wildl. Manage. 42:764-775.

____________, and N. A. Olsen. 1976. Weights and growth of Dall sheep in

Kluane Park Reserve, Yukon Territory. Can. Field Nat. 90:157-162.

Cutton-Brock, T. H., F. E. Guinness and S. D. Albon. 1980. Red Deer Behavior and Ecology of Two Sexes. Univ. of Chicago Press: Chicago. 378 pp.

Geist, V. 1971. Mountain sheep: A study in behavior and evolution. Univ. of Chicago Press: Chicago. 383 pp.

Hoefs, M. 1974. Food selection by Dall's sheep (Ovis dalli dalli Nelson). Pages 759-786 In V. Geist and F. Walther, eds., The behavior of ungulates and its relation to management. IUCN Publ. New Series 24. Morges, Switzerland.

Johnson, J. D. 1975. An evaluation of bighorn sheep range on Ram Mountain, Alberta. M.S. Thesis. Univ. of Calgary. 136 pp.

Jorgenson, J. T. and W. D. Wishart. 1983. The Ram Mountain bighorn sheep study. Progress report. Alta. Fish and Wildl. Div. Edmonton, Alberta. 28 pp.

McEwen, L. C., C. E. French, N. D. Magruder, R. W. Swift and R. H. Ingram. 1957. Nutrient requirements of the white-tailed deer. Trans. N. Amer. Wildl. Conf. 22:119-132.

Nievergelt, B. 1966. Der Alpensteinbock (Capra ibex L.) in seinem Lebensraum. Mammalia depicta. Verlag Paul Parey, Hamburg and Berlin. 85 pp.

Pomeroy, R. W. 1955. Live weight growth. In J. Hammond, Progress in the Physiology of Farm Animals, Vol. 2:395-429.

Rattray, P. V., W. N. Garnett, N. E. East and N. Hinman. 1974. Growth, development and composition of the ovine conceptus and mammary gland during pregnancy. J. of Anim. Sci. 38:613-626.

Shackleton, D. M. 1973. Population quality and bighorn sheep (Ovis canadensis canadensis Shaw). Ph.D. Thesis. Univ. of Calgary. 226 pp.

Siegal, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill, New York. 312 pp.

Stelfox, J. G. 1974. Range ecology of Rocky Mountain Bighorn sheep. Can. Wildl. Serv. Rep. Ser. No. 39. 50 pp.

Wishart, W. D. 1969. Bighorns and "Littlehorns". Alberta Lands, Forests, Parks, Wildlife, Vol. 12, No. 3:4-10.

__________, and D. Brochu. 1982. An evaluation of horn and skull characters as a measure of population quality in Alberta bighorns. Bienn. Symp. North. Wild Sheep and Goat Counc. 3:127-142.

__________, K. Smith, J. T. Jorgenson and G. Lynch. 1980. The evolution of capturing bighorns in Alberta. Bienn. Symp. North. Wild Sheep and Goat Counc. 2:590-600.