

Requirements for maintenance and live weight gain of moose and wapiti calves during winter

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Abstract: Energy requirements of moose (*Alces alces*) and wapiti (*Cervus elaphus*) calves were compared from December to February to determine whether metabolic requirements were lower in a boreal-adapted than in a parkland-adapted wild cervid. Eight calves of each species were divided equally into groups given high or low quality diets. Regression of metabolizable energy intake on liveweight gain provided estimates for maintenance and gain. Metabolizable energy requirements for liveweight maintenance were 560 kJ/kg^{0.75}.d and for gain were 27 kJ/g. Neither value was significantly different between moose and wapiti nor between genders within species. This similarity in winter metabolism and consistency with the interspecies mean suggests that winter metabolic dormancy is not necessarily an important part of a seasonal energetic strategy. The main difference was that moose calves maintained appetite and continued to grow throughout the winter.

Key words: energy requirements, metabolism, weight change, cervid, *Alces alces*, *Cervus elaphus*.

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Introduction

Northern wild ruminants have strong seasonal cycles of energy metabolism, feed intake and growth (Renecker & Hudson, 1986; Schwartz *et al.*, 1988). These cycles are usually interpreted in terms of adaptation to harsh winter conditions. However, two observations question this conventional wisdom. First, what is unusual about winter metabolic rates is not that they are low relative to the interspecies mean but rather that summer metabolic rates are high (Hudson & Christopherson, 1985). Second, seasonal cycles of energy expenditures may

simply reflect feed intake (Nilssen *et al.*, 1984) or thermoregulation and activity (Mautz *et al.*, 1992).

One approach to solving the first problem is to compare boreal and parkland-adapted species under the same winter conditions. The second problem is obviated by estimating requirements directly from the amount of feed energy required to maintain body weight rather than measuring energy expenditures. We used this methodological approach to compare requirements of moose and wapiti, two large northern wild cervids. The winter adaptation hypothesis predicts that winter energy requirements

of moose would be lower than less northerly-adapted wapiti.

Methods

Animals and management

Eight moose calves (4 males, 4 females) were obtained from the wild at 3 to 25 days of age. Eight wapiti calves (4 of each gender) were obtained between the ages of 2 to 60 days from resident hinds at the Ministik Wildlife Research Station. The calves were reared on a 1:1 mixture of bovine whole milk and lamb milk replacer (on a 20% dry matter basis) from the date of acquisition until September. Milk intakes peaked at 45 days of age with 4 litres/day for wapiti and 5 litres/d for moose. Weaning was completed by September. Calves had free access to water, mineral blocks and alfalfa-barley pellets (17% crude protein). About 100 kg of fresh cut aspen and willow browse was provided once per week until trials began in November.

To create a range of nutrient intakes and rates of gain, two diets were designed to approximate the quality of seasonal diets of wild ruminants in cen-

tral Alberta, Canada where the calves were obtained (Table 1). Two males and two females of each species (HP groups) were fed diets containing 16.6-20.3% crude protein ad libitum. Groups of the same number and gender (LP) were fed diets designed to reduce digestibility and protein content to half the HP diets. To achieve a greater range of daily gains, the feed allowance was restricted 30 g/kg^{0.75}.d from 22 January to 3 March for LP groups.

Management of animals complied with the guidelines of the Canadian Council on Animal Care and the following protocol was approved by the local animal policy and welfare committee.

Energy requirements

Digestion trials were conducted monthly from December to February following a three-week dietary adjustment. Each trial feeding period ended with two 24-hour determinations of feed intake and fecal output. These measures were used to estimate digestibility and were related to average daily gains over the preceding approximately 2-week period when group-fed in pens. Acid-insoluble ash ratios (Van Keulen & Young, 1977) confirmed the reliability of direct determination of apparent digestibility during the short collection period required by the animal welfare committee ($y=0.05+0.93X$, $r=0.9$).

Rations and feces were analyzed for crude protein (nitrogen content X 6.25) by the macro Kjeldahl procedure (A.O.A.C., 1965). Lignin, neutral detergent fibre and acid detergent fibre were determined following Goering & Van Soest (1970). Gross energy was determined by bomb calorimetry.

Metabolizable energy requirements for maintenance (MEM, kJ/kg^{0.75}.d) and live weight gain (kJ/g) were obtained from the y intercept and slope of regressions of metabolizable energy (MEI=GE x 0.82 x digestible dry matter) against average daily gain (ADG, g/kg^{0.75}.d). The constant of 0.82 is a conversion factor estimated for sheep and cattle and was assumed to apply to these cervids (Blaxter *et al.*, 1966). Data from 3 monthly trials were pooled to provide an estimate of energy requirements representative of the winter period.

Results

Liveweight change

Moose were larger than wapiti at the beginning of the experiment in November and continued to grow faster throughout the winter (Fig. 1). Despite the lower quality, LP groups of both species gained

Table 1. Ingredients and composition (% of dry matter) of high (HP) and low plane (LP) diets fed to moose and wapiti calves.

Trial Periods	Dec		Jan		Feb	
	Both	HP	LP	HP	LP	
Ingredients						
Soya meal	21.2	21.2	-	21.3	-	
Barley	24.6	24.6	14.2	24.7	-	
Beet pulp	30.0	30.0	30.0	30.0	30.0	
Oat hulls	-	-	29.5	20.0	65.0	
Aspen	20.0	20.0	20.0	-	-	
Perma pel	1.0	1.0	1.0	1.0	1.0	
Mineral mix	3.2	3.2	5.3	3.0	4.0	
Composition						
Crude protein	16.6	20.3	9.6	18.6	8.1	
Neutral detergent fibre	29.5	29.5	44.0	32.0	56.5	
Acid detergent fibre	17.5	16.8	24.0	16.1	28.2	
Lignin	1.7	2.6	3.5	2.7	4.5	
Gross energy (kJ/g)	17.1	17.1	17.9	16.8	16.7	

- = ingredient not included in diet

NDF = neutral detergent fiber

ADF = acid detergent fiber

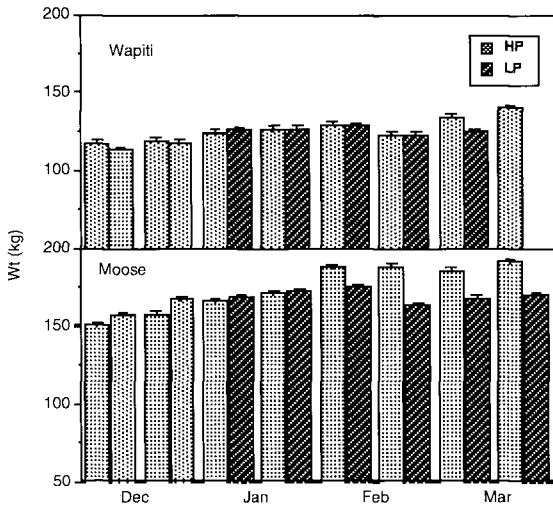


Fig. 1. Bi-monthly live weights of 8 penned wapiti and 8 penned moose calves from early December 1990 to late March 1991. The data (mean±SE) were significantly different ($P=0.05$) in early March for wapiti and from early February to late March for moose.

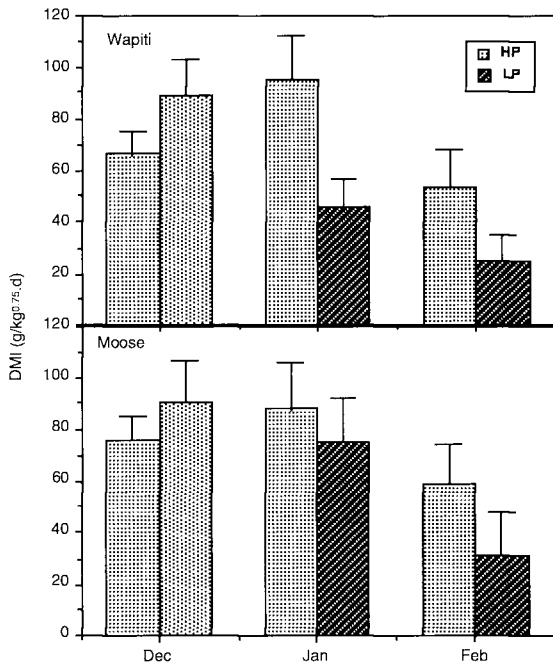


Fig. 2. Dry matter intakes (DMI, $g/kg^{0.75}.d$) of moose and wapiti calves. Diet quality of the LP groups was reduced in January and feed allowances were reduced to 50% *ad libitum* in February.

weight until the end of January when feed allowances were restricted.

Intake and digestibility

Dry matter intake (DMI) relative to metabolic weight differed little between species (Fig. 2). Although on the same diet in December, groups of both species destined to be placed on restricted diets tended for no apparent reason to consume more than ones destined to continue on the high plane. Intake declined sharply particularly among wapiti when placed on low quality diets in January and fell further to controlled feed allowances of about $30 g/kg^{0.75}.d$ in February.

The apparent dry matter digestibility of the HP diets was 72% (SE=4.0) for moose and 78% (SE=5.0) for wapiti. Apparent digestibility of LP diets was 46% (SE=5.0) for wapiti and 34% (SE=6.0) for moose. Although moose digested the low quality diet less well they were able to maintain higher feed intakes than wapiti.

Requirements for maintenance and gain

Metabolizable energy for maintenance (MEI at zero ADG) and liveweight gain (slope) were not significantly different between wapiti and moose (Fig. 3) nor between genders (although numbers of animals were small). Metabolizable energy requirements for maintenance and gain estimated from the pooled regression for the two species were $561 kJ/kg^{0.75}.d$ (SE=55.0) and $27 kJ/g$ (SE=5.0), respectively.

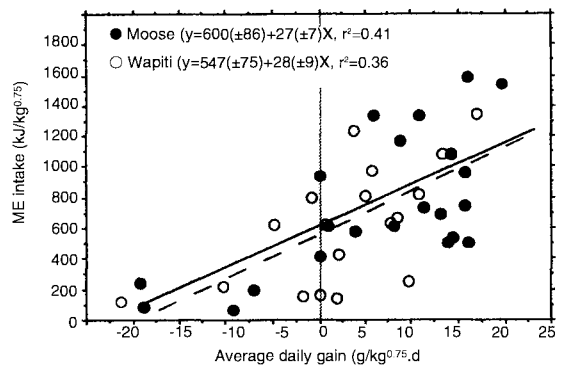


Fig. 3. Estimation of energy requirements for liveweight maintenance (intercept) and gain (slope) from the relationship between average daily gain and metabolizable energy intake of moose (solid line) and wapiti (broken line) calves using pooled data from trials conducted in December, January and February.

Discussion

This paper provides estimates of winter energy requirements for liveweight maintenance and gain. This is not precisely energy requirements to maintain body energy content or energetic efficiency of growth. Beyond complications of gut fill that may occur on contrasting diets or levels of intake, changing body composition may affect the energy content of gain. If fat is mobilized to support lean tissue growth, it is possible to actually gain weight while losing body energy. Because complete energy balance studies are methodologically demanding, most work has been based on liveweight changes. Using pelleted diets and limiting comparisons to specific seasons minimizes complications due to gut fill and body composition.

Debate continues on forces driving circannual cycles of energy metabolism. Mautz *et al.* (1992) even question their existence, attributing seasonal differences in white-tailed deer to thermoregulation and activity. Although it was once assumed that metabolic rate drove the cycle, recent evidence suggests that it may simply respond to variation in feed intake (Nilssen *et al.*, 1984). The difficulty with several earlier studies is that energy expenditures are not exactly equivalent to energy requirements because of the complication of previous nutrition. The most direct way to resolve this problem is to determine the amount of feed energy required to maintain weight and to achieve various daily gains.

Metabolizable energy requirements for maintenance for wapiti and moose of 561 kJ/kg^{0.75}.d fell within the range of published estimates. Maintenance requirements of adult moose are 550 kJ/kg^{0.75}.d for penned animals (Schwartz *et al.*, 1988) and 585 kJ/kg^{0.75}.d for free-ranging animals (Renecker & Hudson, 1985). Heat production and presumably maintenance requirements are higher in calves than adults but not different between male and female calves (Regelin *et al.*, 1985; Schwartz *et al.*, 1991). For penned wapiti calves, winter estimates are 493-572 kJ/kg^{0.75}.d (Jiang & Hudson, 1992; 1994). In New Zealand, published winter estimates are 520 kJ/kg^{0.75}.d for penned adult red deer hinds and 570 kJ/kg^{0.75}.d for stags (Fennessy *et al.*, 1981; Suttie *et al.*, 1987). Winter requirements of white-tailed does also are about 550 kJ/kg^{0.75}.d (Ullrey *et al.*, 1970).

Metabolizable energy requirements for live-weight gain (27.0 kJ/g) for wapiti and moose were similar to winter values reported for wapiti (Jiang & Hudson, 1992; 1994). Higher values (33-40 kJ/g)

are typical of summer (Jiang & Hudson, 1992; 1994; Wairimu *et al.*, 1992). Winter estimates for red deer are 37 kJ/g for stags and 55 kJ/g for hinds (Fennessy *et al.*, 1981; Suttie *et al.*, 1987).

At least during their first winter, moose and wapiti show no obvious species-specific metabolic adaptation and differed little from the interspecies mean (Hudson & Christopherson, 1985). This suggests that the adaptiveness of the metabolic cycle may not be in relation to winter scarcity but rather the pulse of vegetation growth in the brief northern summer. Winter energetic dormancy appears limited to high arctic ungulates such as Svalbard reindeer (Cuyler & Øritsland, 1993) and muskoxen (Adamczewski *et al.*, 1994).

The main difference between moose and wapiti is heavier pre-winter weights and greater absolute winter liveweight gains of moose calves. Larger body size may be an advantage for a tall-shrub browser living in a snowy environment. This sustained seasonal growth of moose also may be related to their larger genetic mature body size and the advantage of early reproductive maturity (Geist, 1987).

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