SEASONAL DYNAMICS OF FOOD INTAKE IN MOOSE

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Abstract: The seasonal dynamics of dry matter intake were measured with 12 tame moose (*Alces alces*) fed a pelleted ration from 1979-83. Composition and digestibility of the diet were constant, so changes in dry matter intake reflect changes in physiological appetite of moose. Dry matter intake (DMI) in adults (age >1 year) paralleled seasonal changes in metabolic rates with peak consumption (104-142 g DMI/body weight ($BW^{0.75}$ /day) occurring during summer months (June-September) with a nadir in late winter (50-59 g DMI $BW^{0.75}$/day) (March-April). Complete fasting was observed in bulls during the rut and lasted as long as 18 days. Cows reduced intake during part of the breeding season (54-58 g DMI/$BW^{0.75}$/day) with lowest intakes similar to those observed during late winter. Information presented serves as a baseline for comparison to other studies where dry matter digestibility and rate of passage vary seasonally with diet quality.

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The ability of ruminants to utilize energy resources from their environment is dependent upon their food intake, forage digestibility, and the rate of passage of materials through the digestive tract. Voluntary food intake is controlled by physiological mechanisms of the animal and physical capacity and function of the digestive system (Church 1971, Van Soest 1982, Robbins 1983). As summarized by Robbins (1983) and demonstrated for white-tailed deer (*Odocoileus virginianus*) by Ammann et al. (1973), regulation of intake changes from primarily physical (i.e., bulk limitation) to physiological (i.e., caloric or self limitation) as food nutritive value increases. At very low nutritive values, limited gastrointestinal capacities and passage rates may prevent an animal from meeting its energy requirements. As nutritive value increases, the animal is ultimately able to ingest enough dry matter to meet its energy requirements. Once nutritive value is high enough to overcome physical limitations, physiological regulation maintains a constant energy intake at increasing nutritive values by decreasing dry matter intake.

For most northern cervids, there also appears to be a decreased voluntary intake during late winter associated with a seasonal decline in metabolic rate (McEwan and Whitehead 1970, Ozoga and Verme 1970, Westra and Hudson 1981, Wheaton and Brown 1983, Regelin et al. 1985). This apparent voluntary reduction in food consumption coincides with a time when forage quality is low, but also occurs in animals on high quality diets under controlled situations.

Intake of forage can be expressed as organic matter intake or dry matter intake (DMI) relative to body weight (BW), as a percentage of BW, or simply in kilograms per animal per day (Cordova et al. 1978). Adjustment of animal intake to that of BW can be expressed mathematically in two ways: intake of feed per unit metabolic size (g/BW $kg^{0.75}$) and as percentage of BW. The justification of the former is based on the assumption that metabolic requirements are related to metabolic weight. The direct expression is easier to use and is favored by those who observe little advantage in relating intake behavior to metabolic weight (Van Soest 1982). Intake per unit of metabolic weight is not routinely used by researchers in the United States, but there is an international trend to express intake on a metabolic body weight basis (Cordova et al. 1978).

Presented here are seasonal intake data for moose fed an isocaloric diet. The diet quality was constant, so changes in intake reflect changes in physiological appetite with digestion of dry matter and rate of passage unaffected by changes in diet quality.

MATERIALS AND METHODS

Studies were conducted at the Moose Research Center, on the Kenai Peninsula, Alaska, a cooperative facility of the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service. DMI was measured between 1979-83 with 12 tame moose (Regelin et al 1978) fed a pelleted ration (Schwartz et al. 1985a) *ad libitum*. Age of moose ranged from 1 month to 3.7 years. To quantify DMI, moose were held in individual holding pens (3.1 x 15.2 m) while daily food consumption was measured for a 4-10 day trail. Data represent a total of 44 trials with one to seven animals per trial. Dry matter of feed and orts was determined daily on a subsample dried at 60°C for 48 hours. Trials were timed to quantify DMI on a seasonal basis and during expected periods of change in DMI (i.e, rut, parturition).

Moose weights were obtained weekly by walking the animals onto a counter-balance scale. The tame moose were accustomed to the weighing routine and stood quietly on the scale.

In most cases, moose were weighed in the morning prior to feeding. $DMI/BW^{0.75}$ for each trial was calculated by dividing the mean daily intake of dry matter by the animals' mean trial weight raised to the 0.75 power. We chose the 0.75 power function because of its universal usage (Van Soest 1982), although other power functions (0.5-0.8) may more closely approximate the best fit for moose. Plots of $DMI/BW^{0.75}$ are not mathematical fits, and only represent our best estimate of expected change between sampling points.

We tested differences between intake for two females that we had repeated measures for years 1980 and 1981 using multiple regression analysis with indicator variables on animal, year and month (Draper and Smith 1981: 241-257). We tested differences between intake levels for three males from June, 1979 through October, 1981 using a randomized block design with animals as blocks and trials as treatments (Ostle and Mensing 1982: 375-411). Treatment differences were determined according to Scheffe's test (Ostle and Mensing 1982: 320-322).

RESULTS

Seasonal Changes

Dry matter intake for the pelleted ration was dynamic seasonally with animal age and during some periods sex was an influence (Table 1). Although seasonal intake varied between sex and age classes of moose, a general seasonal pattern was established (Fig. 1). A seasonal low in DMI occurred in late winter (late February to early April) with lowest consumption rates ranging from 1.2-1.3% BW (50.5-59.1 g/kg $BW^{0.75}$/day) depending upon animal age. Intakes rose rapidly from this nadir and peaked during summer (June-August), remaining high at 2.6-3.2% BW (116.5-142.3 g/kg $BW^{0.75}$/day). DMI declined sharply during the rut, with females reaching levels near the winter low of 1.2-1.3% BW (54.5-58.9 g/kg $BW^{0.75}$/day), but were generally lower than the midsummer peak; males fasted for part of the rut. DMI then declined back to the seasonal low in late winter. This seasonal decline in DMI corresponded to a reduction in fasting metabolic rates (Regelin et al. 1985) observed for the same moose.

Difference Between the Sexes

Although we have only limited data to compare males to females, some differences in DMI were apparent (Fig. 2). Most striking was the complete fasting in males during the rut. We observed this phenomenon

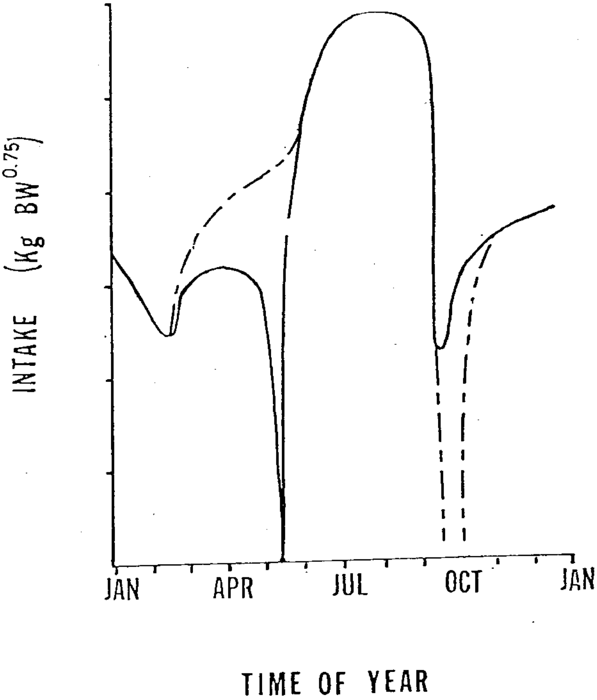

Fig. 1. Schematic drawing of seasonal intake in moose; females are represented by solid line, males by dashed line when they differ from females.

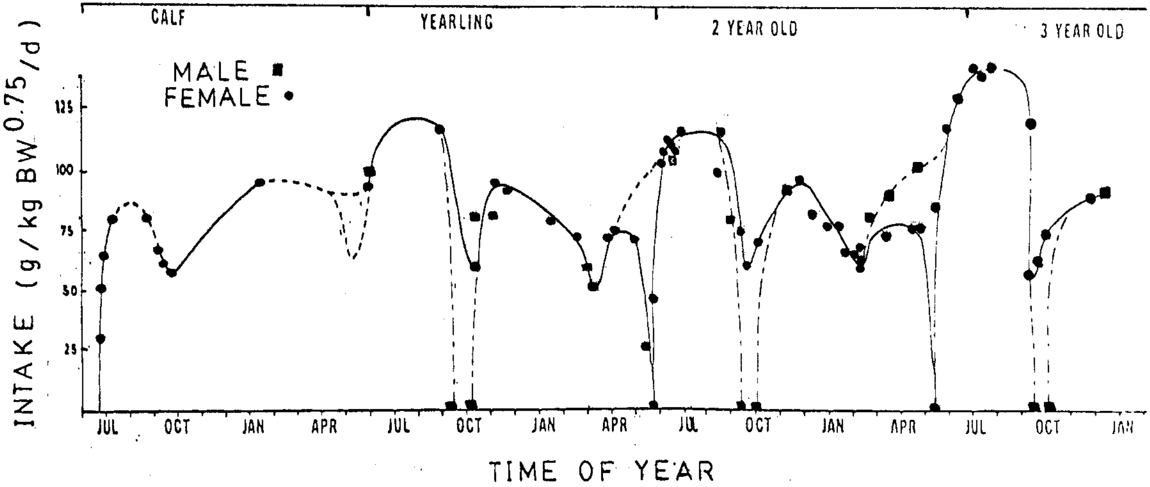

Fig. 2. Seasonal intake rate of dry matter for a pelleted ration by moose.

in all age classes of males except calves. Yearling males in this study were sexually active (Schwartz et al. 1982) and ceased eating, similar to older males. Duration of fasting lasted for 14-18 days ($\bar{x}$=16±SE0.9, n=5) with a gradual decline/increase in DMI preceding/following the fast (Fig. 3). Females reduced their intake during part of the rut, with lows ranging from 54.5-58.9 g/kg $BW^{0.75}$/day (1.2-1.3% BW). The length and timing of this food intake reduction was not as pronounced as for males.

A second separation of DMI between males and females occurred immediately following the late winter nadir (Fig. 1). DMI increased at a much faster rate for males and continued through the summer peak. For females, DMI increased following the winter nadir, but leveled off in April and early May. This difference in DMI may reflect differences in gut capacity between sexes. During this period, cows are in their third trimester of pregnancy and fetal mass probably imposes restrictions on rumen capacity. Females also reduced DMI a day or two prior to parturition and usually did not eat the day they gave birth.

We do not have midsummer intake measurements for males because excessive antler growth precluded using the holding facilities and feeders. Although we can only speculate, we would expect DMI to be similar between sexes. During the summer period, females have a high energy demand of lactation. During this same time period, males are probably depositing large quantities of fat in preparation for the breeding season. In addition, there is an increased energy demand in males associated with antler development.

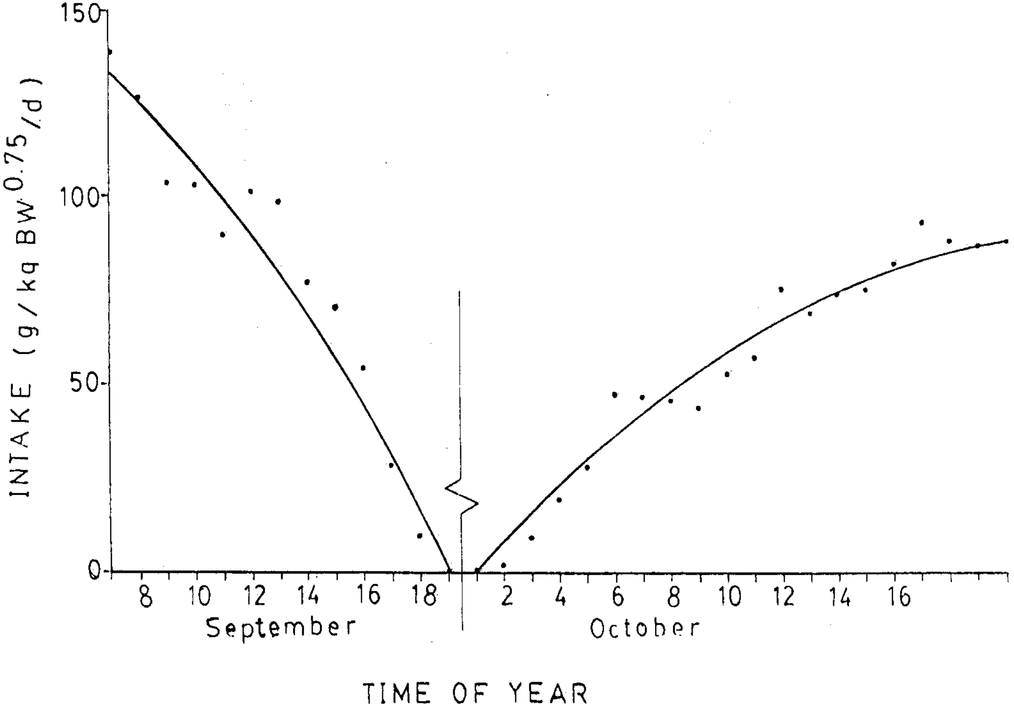

Fig. 3. Dry matter intake for a 2-year-old male moose during the breeding season.

Age Differences

Calves born to captive cows in late May ($\bar{x}$ = birthday = May 20, n = 9) began testing the pelleted ration when about 2 weeks of age. Consumption rates rose rapidly through June and early July (2.8% BW, 80.3 g/kg $BW^{0.75}$/day) and probably remained high or increased above this level until the breeding season. As with adults, DMI declined during the rutting season (1.6% BW, 57.2 g/kg $BW^{0.75}$/day) even though calves were not sexually mature and did not breed. Early winter DMI increased above June measurements (2.62% BW, 94.3 g/kg $BW^{0.75}$/day). No measures of DMI were made during late winter, but for calves DMI likely remained high. Although adults (>1 year) reduced DMI and lost weight during the nadir, calves continued to gain weight (Fig. 4).

Body Weight and DMI

Seasonal changes in weight for a typical female and male are presented (Fig. 4). Weight dynamics were closely associated with DMI although the rate of change for weight was slower. The most dramatic changes in weight occurred during the rut for the male, and pre to post-partum for the female. Slight declines in weight are also apparent from mid to late winter and coincides with the yearly low in DMI.

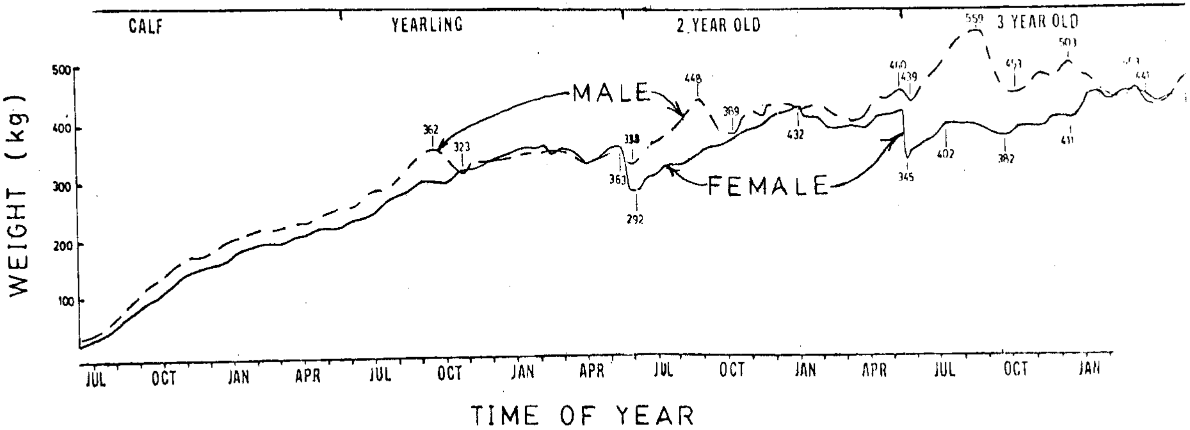

Fig. 4. Weight change for a typical male and female moose fed a pelleted ration.

Statistical Tests

Regression analysis of female data indicated a significant ($P<0.05$) animal x year x month interaction precluding tests on lower interactions. The two females were not treated as replicates because in 1980 one female (Lucy) produced a calf and the other did not breed. In 1981, both females bred, but Lucy produced twins while the other cow produced a single calf. We expected intakes to differ because of reproductive stature. This was apparent for Lucy during the summer of 1981 when she was nursing twin calves (high energy demand), and during late winter 1980-81 when her consumption was low (imposing fetal mass).

Results of the ANOVA for males indiacted a significant ($P<0.01$) treatment effect. Differences between treatment means (Fig. 5) indicated that peak summer intake (July) in 1979 was significantly higher ($P<0.05$) than late winter (March), early spring (April) and post-rut (October) 1980, and that all rut intakes (September through early October) were significantly ($P<0.01$) lower than all other measured values.

DISCUSSION

These data depict the seasonal dynamics of DMI for moose of various ages and for both sexes fed a pelleted ration. The pelleted diet has an apparent dry matter digestion of 56%, contains 2.1 kcal/g of digestible energy, and is 82% organic matter (Schwartz et al. 1985a). Therefore, DMI can easily be converted to caloric intake or organic matter intake for comparative purposes.

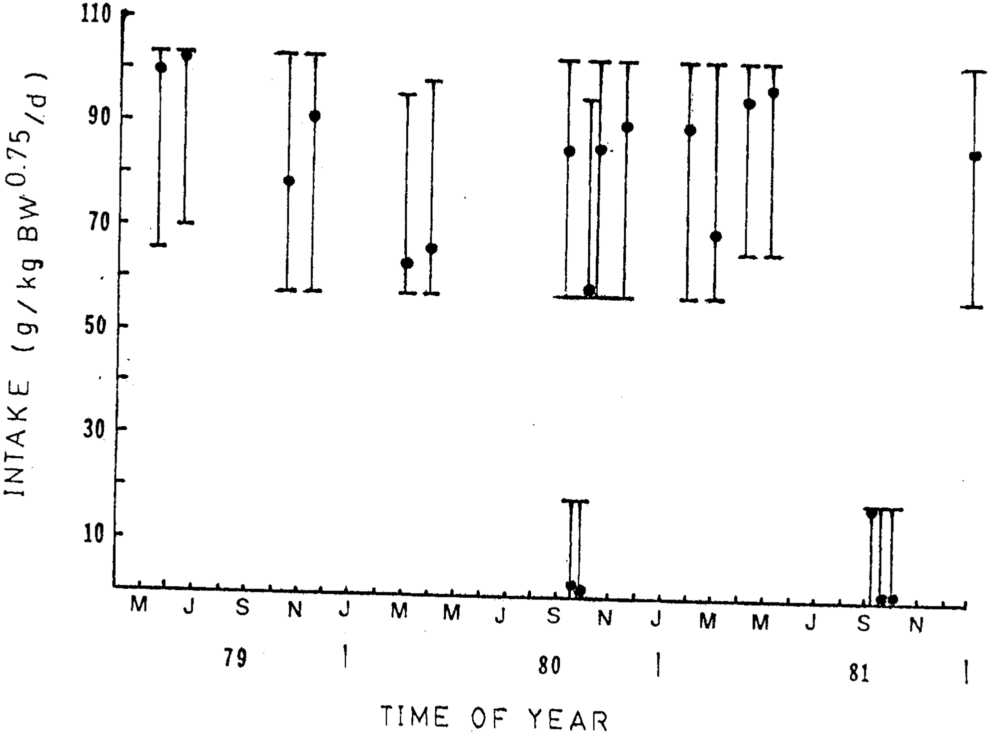

Fig. 5. Mean seasonal intake rate for three male moose born in May, 1978. Any mean which is not contained within the brackets of any other mean is significantly ($P<0.05$) different from that mean according to Scheffe's method.

The dynamics of DMI with the pelleted ration probably depict a different pattern than what might be expected in the wild. As discussed earlier, DMI in ruminants is controlled by physical factors of digestion and rates of passage for forage with a low nutritive value. Winter browse fits this category. Dry matter digestion estimates for several species of winter browse range from 48.6 to 27.7% with a rumen turnover time from 21.3 to 33.9 hours (Hjeljord et al. 1982). Estimates of digestion of dry matter for the pellets was 56±SE 1% (Schwartz et al. 1985a) with a rumen turnover time of 17.6±SE 1.5 hours (Schwartz et al. 1985b). Reduced digestion coupled with increased passage time for natural winter diets would probably result in lower intakes than those presented here. This is further supported, at best with calves, when weight changes for moose on the pelleted ration are compared to wild moose. As discussed by Schwartz et al. (1985a), after November moose calves on the ration continued to gain weight. However, wild moose calves from the same area lost weight (Franzmann et al. 1978). Weight loss probably reflects a reduction in caloric intake associated with lower digestibility and passage rates.

We need comparative summer data from field studies. Although no *in vivo* estimates of dry matter digestion of summer browse are available, *in vitro* estimates range from 40 to 56% for leaves of paper birch (*Betula paperifera*), willow (*Salix* sp.), and aspen (*Populus tremuloides*) depending upon site and stage of maturity (W. Regelin, unpub. data). Rates of passage for summer forage are unavailable but are probably similar to the pellets.

These data provide a basis for comparing DMI from other populations under controlled conditions, or to wild moose eating natural foods. They illustrate the dynamics of intake in moose and demonstrate how food consumption changes with seasonal demands, breeding, and changes in fasting metabolic rates. Further research is needed to establish relationships among DMI, fasting metabolic rates, and seasonal requirements of moose. Data presented here should provide a base for further investigation.

ACKNOWLEDGMENTS

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Table 1. Age, date, sex, and dry matter intake for moose fed a pelleted ration from 1979-83.

Sex	Start of trial (Date)	Trial length (day)	No. of animals (n)	Body weight (BW) (kg)	Dry matter intake g/kg $BW^{0.75}$ ±1 S.D.	Dry matter intake % BW
			CALVES			
F	6-17	5	1	43	28.3±0	1.10
F	6-22	9	1	51	51.7±0	1.93
F	7-01	8	1	61	62.1±0	2.22
F	7-09	8	1	72	80.3±0	2.76
F	9-08	7	2	66	68.5±0	2.02
F	9-15	8	2	73	58.5±0	1.68
F	9-23	8	2	79	69.0±0	1.94
F	10-01	4	2	80	57.2±0	1.60
F	1-23	10	1	167	94.3±0	2.60
			YEARLINGS			
F	6-01	10	2	246	91.7±7.8	2.32
M	6-01	10	3	264	97.9±4.0	2.43
F	9-07	10	1	319	116.8±0	2.76
M	9-19	7	2	340	0.0±0	0.00
F	10-13	10	1	326	58.9±0	1.39
M	10-13	10	3	315	80.3±7.8	1.91
F	11-10	10	1	323	94.9±0	2.24
M	11-10	10	3	330	83.4±2.8	1.96
F	11-19	8	1	343	91.2±0	2.12
F	1-23	9	1	374	81.4±0	1.85

Table 1. Continued.

Sex	Start of trial (Date)	Trial length (day)	No. of animals (n)	Body weight (BW) (kg)	Dry matter intake	
					g/kg $BW^{0.75}$ ±1 S.D.	% BW
F	2-23	10	1	379	75.3±0	1.71
F	3-05	4	2	344	50.5±1.1	1.17
M	3-05	4	3	349	55.8±3.3	1.29
F	4-06	10	1	384	74.6±0	1.69
F	5-03	10	1	405	68.6±0	1.53
				TWO-YEAR-OLDS		
F	5-17	7	1	403	24.3±0	0.55
F	5-24	8	1	348	58.0±0	1.34
F	6-01	10	1	351	103.7±0	2.40
F	6-11	10	1	363	108.9±0	2.49
F	6-21	9	1	372	114.1±0	2.60
F	7-01	7	1	379	109.6±0	2.48
F	7-02	10	1	328	107.8±0	2.53
M	7-02	10	3	373	102.8±9.9	2.34
F	7-09	8	1	388	116.5±0	2.63
F	9-07	10	2	360	112.4±4.2	2.58
M	9-07	10	3	431	78.3±14.9	1.72
F	9-08	7	1	412	94.3±0	2.09
F	9-15	8	1	412	72.9±0	1.62
F	9-18	10	3	430	0.0±0	0.00
F	9-23	8	1	412	57.9±0	1.29

Table 1. Continued.

Sex	Start of trial (Date)	Trial length (day)	No. of animals (n)	Body weight (BW) (kg)	Dry matter intake g/kg BW$^{0.75}$ ±1 S.D.	Dry matter intake % BW
F	10-01	4	1	408	65.8±0	1.46
M	11-19	8	1	403	90.4±0	2.02
M	11-20	8	1	420	93.3±0	2.06
F	11-20	8	2	408	89.7±0.7	2.00
F	1-23	10	2	403	77.8±18.0	1.74
M	1-23	10	3	401	92.5±4.2	2.07
F	2-12	10	1	448	59.1±0	1.28
F	2-23	10	1	404	67.7±0	1.51
M	2-23	10	3	402	70.1±8.5	1.57
F	2-24	9	1	413	77.4±0	1.72
M	3-12	10	1	455	87.3±0	1.89
F	4-06	10	2	414	72.7±14.7	1.61
M	4-06	10	3	403	96.5±7.7	2.15
M	5-03	10	3	422	99.1±4.7	2.19
F	5-03	10	2	424	77.2±4.7	1.70
				THREE-YEAR-OLDS		
F	5-17	7	2	400	42.4±6.7	0.95
F	5-24	8	2	364	87.5±16.2	2.00
F	6-01	10	2	373	114.1±5.1	2.66
F	6-11	10	2	386	127.3±10.5	2.87

Table 1. Continued.

Sex	Start of trial (Date)	Trial length (day)	No. of animals (n)	Body weight (BW) (kg)	Dry matter intake	
					g/kg $BW^{0.75}$ ±1 S.D.	% BW
F	6-21	10	2	392	140.4±24.5	0.95
F	7-01	8	2	399	139.0±26.6	3.11
F	7-09	8	2	408	142.3±18.11	3.17
F	9-08	7	2	412	94.3±0.5	2.09
F	9-15	8	2	403	54.5±27.6	1.21
M	9-17	17	3	483	0.0±0	0.00
F	9-23	8	2	403	66.9±0.6	1.49
F	10-01	4	2	404	74.7±6.4	1.67
F	12-05	10	2	409	89.0±4.0	1.98
M	12-05	10	3	452	90.8±9.0	1.97
F	12-18	10	1	454	92.6±0	2.01
M	1-15	10	1	466	67.3±0	1.45

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[1] Intake average of 2 animals in one pen, therefore no standard deviation available.