RESPONSE OF LACTATING EWES TO SNOW AS A SOURCE OF WATER

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Eight Suffolk-cross ewes, each nursing a ram-lamb, were kept in a snow-covered field and were individually offered 2 kg of dehydrated alfalfa pellets daily. Half the ewes were denied water from the 4th to 14th wk of lactation but had access to snow as a water source (snow ewes), while the others were offered water during the daily feeding period (water ewes). The ewes readily accepted snow as their source of water. The total water turnover of the snow ewes was approximately 35% less than that of the water ewes; however, this reduced water intake did not affect their milk yield, total body water, or hematocrit. The liveweight and total body solids of the ewes and energy content of the milk were not significantly different in the two groups. The weight gain of the lambs from the two groups of ewes was not significantly different, averaging 118 and 105 g/day for lambs from the water and snow ewes, respectively.

Huit brebis croisées Suffolk, chacune allaitant un agneau mâle, ont été gardées dans un champ enneigé et ont reçu chaque jour une ration individuelle de 2 kg d'agglomérés de farine de luzerne. La moitié des brebis a été privée d'eau d'abreuvement à partir de la 4[e] jusqu'à la 14[e] semaine de lactation, mais elles pouvaient utiliser la neige comme source d'eau (brebis de neige). Les autres recevaient de l'eau tous les jours (brebis à l'eau). Les brebis n'ont pas eu de mal à s'adapter à la neige comme source d'eau. La consommation totale d'eau chez ces brebis était d'environ 35% moindre que celle des brebis à l'eau, mais cela ne semble pas avoir eu d'effet négatif sur le rendement laitier, la teneur du corps en eau ou l'hématocrite. Le poids vif des brebis et les teneurs corporelles en extraits totaux (solides totaux), ainsi que la valeur énergétique du lait étaient sensiblement du même ordre dans les deux groupes expérimentaux. Le gain de poids réalisé par les agneaux associés aux deux groupes de mères ne différait pas de façon significative, s'établissant respectivement à 118 et 105 g/jour dans le groupe des brebis à l'eau et celui des brebis de neige.

Wethers and non-lactating and pregnant ewes can rely solely on snow as their source of water (Weeth et al. 1959; Butcher 1973). However, there appear to be no published data available to indicate whether lactating ewes, with their higher requirements for water (Agricultural Research Council 1965), can obtain sufficient water, and without detrimental effects, when water is denied and only snow is available. This experiment was designed to study lactating ewes with access only to snow as their water source and to compare their performance with ewes receiving water.

MATERIALS AND METHODS

Animals and Management

Estrus was synchronized in 15 Suffolk-cross ewes using vaginal pessaries (Syncro-Mate; G. D. Searle & Co., Chicago) which contained 20 mg of cronolone (flugoestone acetate). The pessaries were maintained for 11 days and on the

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day of removal, the ewes received an intramuscular injection of 500 IU PMSG. The ewes were then mated to one to two Suffolk rams 2–5 days later. Thirteen of the ewes were pregnant, eight of which had at least one ram-lamb. These eight lambed over a 5-day span (23–28 Nov. 1979) and these ewes, each nursing one ram-lamb, were used in the study. Excess lambs were cross-suckled onto spare ewes.

The ewes were kept outdoors as a single group and were provided with wind shelter and straw bedding. During the 4th and 5th months of pregnancy, the ewes were group-fed once daily in the morning, 2 kg per ewe of dehydrated alfalfa pellets (dry matter (DM), 91.6%; protein, 14.2%; acid detergent fiber, 30.8%). From the 2nd wk of lactation (mean 11.1 days on 6 Dec. 1979) the ewes were individually fed their 2-kg ration indoors while separated from their lambs. Any feed not eaten was weighed. Weighed water, at 10°C, was offered during the feeding period which lasted about 45 min.

No permanent snow cover was available in the outside pens until after mid-December. During the 4th wk of lactation (20 Dec. 1979) the eight ewes were divided into two groups matched for liveweight and lambing date and thereafter until the 14th wk of lactation one of the groups (snow ewes) was denied water and had access only to snow in the field as their source of water. The second group (water ewes) continued to be offered weighed water during the feeding period as above. All ewes were observed in the field following their feeding period.

From the 10th to 14th wk of lactation, the lambs were given access to creep feed at the same time as the ewes were being fed. The ration offered the lambs was 185–250 g/lamb of a prepared concentrate mixture (barley, 48.5%; soybean meal, 22.3%; alfalfa meal, 19.4%; wheat, 4.9%).

Milk Yield and Composition

Milk yield of the ewes was estimated bi-weekly using the oxytocin method (Doney et al. 1979). The ewes and lambs were separated and each ewe received an intravenous injection of 5 IU oxytocin (Dominion Veterinary Laboratories Ltd., Winnipeg) and was hand-milked to empty the udder. The second oxytocin injection and milking was 3 h later. Duplicate aliquots of the second milking sample were analyzed for percentages of fat, protein and lactose using an infra-red milk analyzer. The energy content of the milk was calculated assuming 38.49 kJ/g fat, 24.52 kJ/g protein and 16.53 kJ/g lactose (Kleiber 1975).

Liveweight, Tritiated Water (TOH) Space and Water Turnover

TOH space was determined in both the ewes and lambs simultaneously when milk yield measurements were made. While the ewes and lambs were separated, heparinized venous blood samples were collected from all animals for determination of background tritium activity in body water. Each ewe and lamb then received an intramuscular injection of 5 μCi/kg TOH (New England Nuclear City) and were denied access to feed, water or snow for 6 h, after which time a second blood sample was collected for TOH space estimation. The sheep were then weighed. To estimate total water turnover by the method of Till and Downes (1962), an additional five blood samples were taken from the ewes prior to their daily feeding over the next 2 wk. Total water and snow intake were estimated from TOH turnover measurements minus estimated preformed and metabolic water from feed as described by Young and Degen (1980).

For counts of tritium activity by liquid scintillation 0.2-mL plasma samples were added to 10 mL of scintillation cocktail (Aqueous Counting Scintillant, Amersham) and counted for 20 min. Counts were corrected for 7% DM of plasma and for quenching.

Hematocrit and Plasma Osmolality

The two blood samples collected from each sheep for TOH space estimations were also used to determine the hematocrit by centrifugation in microhematocrit capillary tubes and the mean of these two values was used for statistical analysis. Osmolalities of the ewes' plasma were determined using the freezing-point depression method (Osmette A, Precision Systems, Inc., City).

Analysis of Data

The experimental design consisted of repeated measurements (time) on the sheep. The time effect in the analysis was partitioned into orthogonal polynomials as outlined by Rowell and Walters (1976). Each parameter was tested to see if the fit over the time was in the linear, quadratic or other form.

RESULTS

Ambient temperatures during the study are presented (Table 1). Except for several cold days during weeks 2–4 and 6–8 of lactation, the winter was considered relatively mild for the Edmonton region.

The ewes that were denied water readily accepted snow within 24 h and no unusual or distressed behavior such as bleating was noted. After a few days on treatment, the snow ewes ingested snow immediately after the feeding period whereas the water ewes nursed their lambs. On occasion the water ewes were observed to eat snow as well.

Liveweight, TOH space, hematocrit and plasma osmolality of the ewes are presented (Table 2). There were no significant differences between the snow and water ewes in any of these measurements. All ewes decreased their liveweight over the lactation period and showed linear increases in absolute TOH space and in TOH space as a percentage of liveweight. TOH space as a percentage of liveweight increased from about 62 to 76% for all ewes.

Peak milk yield of 1.49 kg/day for the water ewes and 1.47 kg/day for the snow ewes were found during the 4th wk of lactation. Table 3 presents the milk yield, its composition and its energy content. No significant difference was found between ewe groups. There was a linear decrease in milk yield, percent lactose and total energy of the milk in all ewes, and a linear increase in the percent protein and total energy content per volume of milk.

Table 1. Ambient temperatures during the study

Week of ewe lactation	Mean minimum (°C)	Mean maximum (°C)
2 to 4	−17.3	8.5
4 to 6	−11.0	+0.5
6 to 8	−22.6	−17.1
8 to 10	−13.5	−6.7
10 to 12	−8.7	+0.9
12 to 14	12.7	−4.8

Water turnover, TOH half-life and feed intake values are presented in Table 4. The water turnover of the snow ewes averaged 3.68 kg/day or about 34% lower than the 4.93 kg/day in the water ewes. The snow ewes consumed an average of 3.15 kg/snow per day. At an average snow temperature of −10°C found in this experiment it would require 1.70 MJ to melt this snow and raise its temperature to body temperature of 39°C. The water ewes consumed an average of 3.47 kg water at 10°C and an additional 0.90 kg snow per day. This would require 0.91 MJ to melt the snow and raise all the water to body temperature. While no significant treatment difference was found in feed intake, there was a linear increase in intake with time for all ewes.

Results for the lambs are summarized in Table 5. There was no significant difference between the groups for any of the measurements. Overall, there was a linear increase for liveweight and TOH space and a quadratic increase for average daily liveweight gain (ADG). The ADG over the treatment period was 117.8 g and 105.0 g for the lambs from the water and snow ewes, respectively.

DISCUSSION

Feral animals often have to rely on snow as their only source of water in the winter. Reindeer apparently preferred snow over water when offered a choice (Luick 1977).

Domestic animals such as horses (Dieterich and Holleman 1973), cattle (Young and Degen 1980) and sheep (Weeth et al. 1959; Butcher 1973) can also survive when denied water and only snow is made available. When water was available once a day to cattle in winter, the cattle tended to ingest snow (Young and Degen 1980), a phenomenonom also observed in the ewes in the present experiment. It has been noted that sheep can adapt to ingesting snow more readily than cattle (J. E. Butcher, pers. commun.) and it is common for sheep in the intermountain area to use snow as the only

Table 2 Liveweight (LW), tritiated water (TOH) space, hematocrit and plasma osmolality of the lactating ewes having access to water (water) or only snow (snow) as a water source

	Ewe treatment	Week of lactation 2†	4†	6	8	10	12	14	SEM	Period‡	Treatment§
Liveweight (kg)	Water	50.6	49.3	46.7	38.8	47.1	46.6	48.8	0.38	**	NS
	Snow	51.3	50.2	48.1	48.5	46.8	46.9	49.1			
TOH space (kg)	Water	32.0	33.8	34.2	36.8	36.0	34.5	36.9	0.27	**	NS
	Snow	31.1	33.1	33.2	34.6	33.9	34.3	37.4			
TOH space (% LW)	Water	63.3	68.6	73.2	75.7	76.0	74.1	76.0	0.32	**	NS
	Snow	60.8	66.1	69.5	71.8	73.6	73.3	76.3			
Hematocrit (%)	Water	34.5	34.5	30.7	29.7	29.1	30.4	30.7	0.50	**	NS
	Snow	36.8	34.1	30.7	30.4	30.9	32.0	33.0			
Plasma osmolality (mOsm/kg)	Water	305.3	297.0	295.0	291.5	286.3	293.3	294.5	0.94	**	NS
	Snow	305.8	301.0	297.3	290.0	286.5	289.8	298.8			

†All ewes received liquid water.
‡Level of significance among periods for all ewes.
§Level of significance between treatment groups during experimental period (after week 4).
$**P < 0.01$; NS not significant.

Table 3. Yield, composition and energy content of milk from lactating ewes having access to water (water) or only snow (snow) as a water source

	Ewe treatment	Week of lactation 2†	4†	6	8	10	12	14	SEM	Period‡	Treatment§
Milk yield (kg/24 h)	Water	1.35	1.49	1.35	0.93	0.83	0.67	0.59	0.04	**	NS
	Snow	1.33	1.47	1.33	0.86	0.79	0.69	0.64			
Fat (%)	Water	–	10.83	10.59	10.97	11.09	11.73	12.37	0.28	NS	NS
	Snow	–	11.73	10.62	11.41	11.89	12.27	12.66			
Protein (%)	Water	–	4.35	4.30	4.73	5.43	7.48	6.92	0.10	**	NS
	Snow	–	4.25	4.53	5.24	5.50	6.64	6.49			
Lactose (%)	Water	–	4.93	5.18	4.73	4.80	4.47	4.54	0.04	**	NS
	Snow	–	4.83	5.10	4.52	4.91	4.46	4.46			
Energy (MJ/kg milk)	Water	–	6.05	5.99	6.17	6.40	6.94	7.02	0.11	**	NS
	Snow	–	6.35	6.04	6.42	6.74	7.09	7.20			
Total energy (MJ/24 h)	Water	–	9.03	8.06	5.71	5.27	4.61	4.20	0.23	**	NS
	Snow	–	9.09	7.61	5.52	5.16	4.86	4.51			

†All ewes received liquid water.
‡Level of significance among periods for all ewes.
§Level of significance between treatment groups during experimental period (after week 4).
$**P < 0.05$; NS not significant.

Table 4. Water turnover, TOH half-life and feed, water and snow intake of lactating ewes having access to water (water) or only snow (snow) as a water source

	Ewe treatment	Week of lactation 2 to 4†	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	SEM	Period‡	Treatment§
Water turnover	Water	4.12	4.81	4.85	4.89	5.14	4.96	0.10	NS	*
(kg/24 h)	Snow	3.96	3.57	3.34	3.50	4.04	3.93			
TOH half-life	Water	5.41	4.94	4.93	5.36	5.04	4.88	0.13	NS	*
(days)	Snow	5.48	6.61	7.00	7.18	5.81	6.02			
Feed intake	Water	1.23	1.61	1.81	1.78	1.81	1.95	0.03	**	NS
(kg)	Snow	1.32	1.55	1.50	1.52	1.79	1.87			
Water intake (kg/24 h)										
Water//	Water	3.10	3.10	3.79	3.53	3.41	3.51			
	Snow	2.97	–	–	–	–	–			
Water¶	Water	3.73	4.30	4.28	4.34	4.56	4.35	0.09	NS	*
and/or snow	Snow	3.54	3.07	2.86	3.02	3.47	3.34			

†All ewes received liquid water.
‡Level of significance among periods for all ewes.
§Level of significance between treatment groups during experimental period (after week 4).
//Measured gravimetrically during individual feeding, see text.
¶Measured by TOH turnover method; see text.
$*P < 0.05$; $**P < 0.01$. NS not significant.

Table 5 Liveweight, tritiated water (TOH) space and hematocrit of the lambs suckling ewes having access to water (water) or only snow (snow) as a water source

	Ewe treatment	Week of lactation 2†	4†	6	8	10	12‡	14‡	SEM	Period§	Treatment//
Liveweight	Water	6.4	9.0	11.8	13.0	13.6	15.1	17.2	0.21	**	NS
(kg)	Snow	5.7	8.6	11.0	12.0	12.5	14.6	16.2			
TOH space	Water	4.9	6.7	8.5	9.3	9.9	10.7	12.7	0.17	**	NS
(kg)	Snow	4.5	6.5	8.1	8.6	9.1	10.6	11.8			
TOH space	Water	77.3	75.2	72.3	71.7	73.0	73.5	73.7	0.36	**	NS
(% LW)	Snow	80.1	75.9	73.5	71.3	73.2	73.7	73.1			
Hematocrit	Water	34.3	32.7	34.4	33.6	32.5	33.0	32.5	0.36	NS	NS
(%)	Snow	33.5	30.1	34.5	35.4	36.1	34.6	33.6			

†All ewes received liquid water.
‡Creep feed available; see text.
§Level of significance among periods for all lambs.
//Level of significance between treatment groups during experimental period (after week 4).
$^{**}P < 0.01$; NS not significant.

source of free water in the winter (Butcher 1973).

The lactating ewes in the present study adapted quickly, without apparent distress, to ingesting snow. Despite the reduced water turnover of 34% in the snow ewes, there was no difference between treatment groups in milk yield, TOH space, haematocrit and plasma osmolality. These snow ewes, therefore, did not reduce their total body water in order to maintain their milk yield and apparently were able to consume sufficient water from the snow. The absence of any effect on hematocrit or plasma osmolality in pregnant ewes consuming snow vs. controls on liquid water has been reported previously (Weeth et al. 1959).

Cameron and Luick (1972) observed that reindeer in Alaska reduced their water turnover and presumably water intake (in the form of snow) during the winter months. These authors suggested a reduced water intake as snow would be beneficial for conservation of nutrient and body energy reserves as less metabolic heat would be required for melting the snow and raising it to body temperature. However, Butcher (1973) has suggested that, at least in sheep, the heat produced "from digestion and feed utilization is more than adequate to melt snow and raise it to body temperature." The present results support Butcher's statement, for although all ewes lost liveweight there was no difference between treatment groups. Better than simply a measure of liveweight is the measurements of body composition. Changes in TOH space indicate changes in body solid and energy content of lactating ewes (Foot et al. 1979). In the present study, all ewes increased their TOH space, but with no significant difference between treatment groups. This would further indicate that ewes in both treatments mobilized their body solids, presumably lipid tissue, at approximately the same rate and no increased energy reserves were being used by the ewes depending upon snow as their main water source.

Not only were the milk yields of the two groups of sheep similar, but also composition and energy content of the milk were similar. All ewes had an increased protein content and decreased lactose content of milk with duration of lactation. Such trends have been previously reported to occur in ewes (Brett et al. 1972). The liveweight gain and energy retention as estimated by TOH space (Donnelly and Freer 1974) was similar for the lambs from the two ewe treatment groups, providing further evidence of similar milk yield and energy content.

In summary, lactating ewes relying on snow as a source of free water reduced their total water turnover by approximately 35%. However, this decrease did not affect their milk yield or total body water. No significant amounts of additional food or tissue energy were required to melt the snow and raise its temperature to body temperature. The energy content of both groups of ewes was similar as was the energy content of their milk. It appears that high producing ruminants such as lactating sheep have sufficient "metabolic heat" available to melt the snow and raise it to body temperature and therefore are able to rely on snow as a source of water.

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AGRICULTURAL RESEARCH COUNCIL. 1965. The nutrient requirements of farm livestock. No. 2 Ruminants. Agric. Res. Counc., London.

BRETT, D. J., CORBETT, J. L. and INSKIP, M. W. 1972. Estimation of the energy values of ewe milk. Proc. Aust. Soc. Anim. Prod. **9**: 286–291.

BUTCHER, J. E. 1973. Snow as the only source of water for sheep. Pages 205–209 *in* H. F. Mayland, ed. Proceedings of Symposium on Water–Animal Relations. University of Idaho Press, Kimberly, Ida.

CAMERON, R. D. and LUICK, J. R. 1972. Seasonal changes in total body water, extracellular fluid and blood volume in grazing reindeer. Can. J. Zool. **50**: 107–116.

DIETERICH, R. A. and HOLLEMAN, D. F. 1973. Hematology, biochemistry, and physiology of environmentally stressed horses. Can. J. Zool. **51**: 867–873.

DONEY, J. M., PEART, J. N., SMITH, W. F. and LOUDA, F. 1979. A consideration of the techniques for estimation of milk yield by suckled sheep and a comparison of estimates obtained by two methods in relation to the effect of breed, level of production and stage of lactation. J. Agric. Sci. (Camb.) **92**: 123–132.

DONNELLY, J. R. and FREER, M. 1974. Prediction of body composition in live sheep. Aust J. Agric. Res. **25**: 825–834.

FOOT, J. Z., SKEDD, E. and McFARLANE, D. N. 1979. Body composition in lactating sheep and its indirect measurement in the live animal using tritiated water. J. Agric. Sci. (Camb.) **92**: 69–81.

KLEIBER, M. 1975. The fire of life. R. E. Krieger Publishing Co., Huntington, N.Y.

LUICK, J. R. 1977. Preference of reindeer for various physical and chemical forms of water. Pages 66–88 *in* Industrial development in Alaska and its effects on the nutritional and physiology status of arctic animals — Progress report. Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska.

ROWELL, J. G. and WALTERS, D. E. 1976. Analysing data with repeated observations on each experimental unit. J. Agric. Sci. (Camb.) **87**: 423–432.

TILL, A. R. and DOWNES, A. M. 1962. The measurement of total body water in the sheep. Aust. J. Agric. Res. **13**: 335–342.

WEETH, H. J., TORELL, C. R. and CASSARD, D. W. 1959. Effects of simulated snowbound stress condition on ewes. J. Anim. Sci. **18**: 694–700.

YOUNG, B. A. and DEGEN, A. A. 1980. Ingestion of snow by cattle. J. Anim. Sci. **51**: 811–815.