INGESTION OF SNOW BY CATTLE[1]

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Summary

Tritiated water was evaluated and used for determining snow and water intake by cattle. This method yielded results comparable to those obtained via simultaneous gravimetric measurement of snow and liquid water intake after adjustments were made for preformed and metabolic water from feed; the correlation coefficient was .96 and the standard error of the estimate was ± 1.28 kg/day, or ± 5.8% of the mean intake. Two steers were maintained in a covered, open-ended stable and were offered a maintenance diet and *ad libitum* liquid water. Distressed behavior was observed in these steers when they were abruptly denied liquid water and given snow in its place. They started ingesting snow after approximately 35 hr and subsequent switching from water to snow or *vice versa* was without apparent distress. In another study, eight pregnant beef cpws were used in a 4 x 4 Latin square design consisting of four 15-day periods. The cows were either penned and given once-a-day access to water (pen water) or *ad libitum* access to snow only (pen snow), or they were kept in a snow-covered field and given once-a-day access to water (field water) or access only to the snow in the field (field snow). The pen water cows consumed 23.6 kg/day, the pen snow cows 20.6 kg/day, the field water cows 26.1 kg/day and the field Snow cows 23.6 kg/day of water and (or) snow. In a subsequent experiment, the same pregnant cows were given 0, 5, 10 kg or free access to water for 15 mm once each day and kept in a snow-covered field. The total daily water-plus-snow intake was similar for each of the four groups, ranging between 50 and *55* g/kg/day.

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Introduction

It is often difficult and expensive to provide liquid drinking water for livestock. In addition, it has been known for cattle watered via a hole cut in a frozen lake or water course to fall through and die, Feral animals often do not have access to liquid water and must rely on other sources such as snow to meet their needs. Some domestic animals such as horses (Dieterich and Holleman, 1973) and sheep (Butcher, 1974; Sims and Butcher, 1973) also can survive when snow is available as their only source of water. There is, however no published information on the ingestion of snow by cattle. The ability of livestock to obtain adequate water from snow would, if practical, add a management option. As well as possibly avoiding the expense of providing liquid water, this management procedure might also make possible better use of grazing lands deficient in water but where snow is available.

The use of tritiated water (TOH) in studies of water kinetics is well established (Macfarlane and Howard, 1970; King *et al.* 1978). In the present study, TOH turnover was evaluated and used as a means of estimating snow and water intake by cattle.

Materials and Methods

Three experiments were conducted during the winter of 1978 - 1979 at the University of Alberta farm, Edmonton. The first experiment examined the adjustment of cattle to ingestion of snow. The second and third experiments examined the method used to estimate snow and water intake and the ability of free-ranging cattle to obtain their water needs from snow when the supply of liquid water was denied or restricted. The Edmonton region is characterized by long, cold winters and there is usually snow on the ground from December to April.

Exp. 1. Two mature steers (Angus x Galloway), each weighing approximately 800 kg, were maintained in a covered, open-ended stable for 17 days. The animals were offered a maintenance diet of brome grass hay and given liquid water (about 10 C) free choice. Water was then abruptly denied and the steers were offered snow in large containers. Before the study, the steers had always been given water free choice, and this was the first occasion that snow was provided as the sole water source. After 1 week of access to snow only, the steers were offered water, snow, water, snow for successive 3-day periods. The steers were observed frequently and their behavior and snow consumption was noted.

Exp. 2. Eight beef cows born in the spring of 1975 or 1976 were used. The cows were from a synthetic crossbred line (Berg, 1975) and had calved previously. They were in their sixth month of pregnancy at the start of the trial (January 1979). Before the study, the cows were placed for 7 days in a snow-covered field with no liquid water supply to accustom them to eating snow.

A duplicated 4 x 4 Latin square design was used in which each cow was subjected to four treatments, each lasting 15 days. The cows were fed between 0800 and 1000 hr daily in covered, individual, adjacent stalls. They were offered a near maintenance diet consisting of 4.5 kg of alfalfa pellets (IRN 1-00-063, DM = 93.4%, crude protein = 16.4%, acid detergent fiber = 29.7%, DM digestibility = 59%) and 4.5 kg of brome grass hay (IRN 1-00-890, DM = 90.3%, crude protein = 11.4%, acid detergent fiber = 32.1%, DM digestibility = 50%), and any feed remains were weighed daily.

The four treatments were:

(1) *Pen water.* Cows were offered weighed liquid water once daily for about 15 mm immediately after feeding. The two cows on this treatment during each period were kept in a snow-free covered pen (8 m^2).

(2) *Pen snow.* Cows were kept individually in covered pens (each pen was 4 m^2) and allowed continuous access to weighed snow in large containers. Snow volatilization was found to be neglible.

(3) *Field water.* Cows were given access to weighed liquid water as in treatment 1 and were kept in a snow-covered field (2 ha) with no access to liquid water,

(4) Field snow: Cows were not given access to liquid water and immediately after feeding they were placed in the same field as the cows in treatment group 3.

On the day before the start of period 1 and on the 15th day of each period, the cows were denied water and (or) snow after feeding, and urine samples were collected 9 hr later (at 1700 hr) for determination of background specific radioactivity. Urination was induced by light manual stimulation immediately ventral to the labia. Each cow was then injected intramuscularly with 2 mCi of TOH[4] in sterile saline. Fifteen hours were allowed for TOH equilibrium (Siebert, 1971), and a urine sample was collected (at 0800 hr) for estimation of TOH space. The cows were then weighed, fed and offered water and (or) snow according to treatment. Urine samples were taken just before feeding (at 0800 hr) the next day (day 1), every second day thereafter and on day 10. Dry matter (DM) content of all urine samples was determined by drying of the samples at 68 C for 4 to 5 days. Duplicated .2-ml samples of urine were added to 10 ml of scintillation cocktail (Aqueous Counting Scintillant[5]), and counted for 20 min; counts were corrected for DM content of the urine and for quenching. The decline in specific activity was followed so that TOH half-life (T½) and TOH turnover (TOH space x .693/T½) during each 15-day period could be estimated. The mean TOH space at the beginning and end of each period was used.

The penned animals given weighed snow were used to establish a relationship between (1) snow and (or) water intake and (2) TOH turnover minus preformed plus metabolic water from feed. We used this relationship to estimate snow and (or) water intake by the field cows. Snow intake by the field cows that also were given weighed liquid water (field water; treatment (3) was calculated as total snow and water intake estimated from this relationship minus the weighed liquid water intake. Metabolic water production was calculated as .29 g/g DM intake, a value derived on the basis of diet composition and digestibility and from constants for metabolic water production suggested by van Es (1967). As metabolic water contributed only about

[4] New England Nuclear.
[5] Amershem.

6 to 9% of the total water intake, a variation in metabolic water would have had minimal influence on estimated water intake.

Osmolalities were determined on all urine samples by the freezing-point depression method[6]. Rectal temperatures were taken before feeding on every fifth day of each period with a thermistor probe and telethermometer[7].

Exp. 3. For 2 days after completion of Exp. 2, the cows were given free access to liquid water (10 C) and then assigned to one of four treatments (two cows per treatment). The cows were offered (1) 0, (2) 5 or (3) 10 kg liquid water or (4) were given free access to liquid water for 15 mm daily immediately after feeding. Feeding was carried out as in Exp. 2. After feeding and watering each day, the cows were turned out into a single field, where ground snow was available as the only source of water. Injection schedule, TOH space and turnover measurements were as in Exp. 2.

Results

Environmental Condition. The mean air temperatures for the three experiments are presented in table 1. The snow cover on the field was between 20 and 40 cm deep, except during the last few days of Exp. 2 and throughout Exp, 3, when there was rapid melting of snow and bare spots appeared in the field. Appearance of ground water and the possibility of consumption of liquid water by the cows while in the field necessitated the termination of Exp. 3 after 6 days.

Exp. 1. The steers showed behavioral disturbances such as frequent bellowing and searching during the first 2 days after access to liquid water was denied. They started consuming snow from the containers approximately 35 hr after denial of water; the two steers started within 30 mm of each other. During the next few days, the steers readily and rapidly consumed snow and their distressed behavior subsided. Subsequently, the steers switched quickly from snow to water and *vice versa* without apparent distress.

Exp. 2. All cows remained healthy and calved normally in the spring. The cows were observed to consume snow throughout daylight hours, and they consumed little snow during hours of darkness. They appeared to prefer the snow in a powder form and swept it into their mouths with a circular motion of their tongues.

All cows increased in live weight during the experiment. Much of this increase could be accounted for by an increase in TOH space and presumably was associated with fetal and uterine development. There was no difference between cows on the different treatments with respect to live weight, total body water or feed intake. The pen snow cows had a longer TOH half-life and an elevated urine osmolality. Although the rectal temperature of all individual cows remained within the range of 37.1 to 39.6 C, the field snow cows had a lower rectal temperature than the cows in the two pen treatments (table 2).

The gravimetrically measured snow and liquid water intake (I; kilograms per day) of individual penned cows varied between 17.2 and 29.5 kg/day and were related rectilinearly to estimates of water intake based on TOH turnover minus preformed plus metabolic water from feed (E). There was no significant difference between the relationship for snow and that for water intake. The combined regression equation, standard error of the regression coefficient (SEb) and correlation coefficient (r) of the 16 observations were:

$$I = 1.76 + .932\,E;\quad SEb = \pm .077;\quad r = .96.$$

[6]Osmette A, Precision System Inc.
[7]Yellow Springs Instruments.

TABLE 1. AIR TEMPERATURE DURING THE THREE EXPERIMENTS (1978 TO 1979)

Exp. no.	Dates	Mean min., C	Mean max., C	Daily mean[a], no. of days >0 C	0 to –15C	<-15C
1	Dec 19 to Jan 23	-19.2	-13.5	0	17	19
2	Jan 11 to Mar 16	-16.0	-11.9	9	23	33
3	Mar 18 to Mar 23	-2.5	+9.1	6	0	0

[a] ½ (mean min. + mean max.).

TABLE 2 MEAN LIVE WEIGHT, DRY MATTER INTAKES OF ALFALFA PELLETS AND BROME GRASS HAY, WATER (TOH) SPACE AND HALF-TIME URINE OSMOLALITY AND RECTAL TEMPERATURE OF PREGNANT BEEF COWS KEPT IN PENS OR A SNOW-COVERED FIELD AND GIVEN ACCESS TO LIQUID WATER OR SNOW (EXP. 2)

Measurement	Pen water	Pen snow	Field water	Field snow	SEM
Live weight, kg	429	430	427	428	20.2
Pellets intake, kg/day	4.20	4.20	4.20	4.20	.00
Hay intake, kg/day	3.73	3.72	3.77	3.68	.03
TOH space,kg	322	324	320	322	14.6
TOH half-time, days	8.9[a]	9.8[b]	7.7[a]	8.6[a]	.44
Urine osmolality, mOsm/kg	873[ab]	1002[a]	673[b]	861[ab]	58.1
Rectal temperature, C	38.6[a]	38.5[a]	38.4[ab]	38.2[b]	.09

[a,b] Means in the same row with different superscripts are different *(P<.05)*.

The standard error of estimate was ± 1.28 kg/day, which was 5.8% of the mean intake.

Mean water and snow intakes for Exp. 2, as estimated by TOH turnover, are summarized in table 3. The snow pen cows had the lowest water intake, and although the field water cows consumed only 19.4 kgiiquid water/day, they also ingested 6.7 kg snow from the field and, in total, consumed the most water.

Exp. 3. Water turnover, snow intake and total snow and water intake for the 6 days of Exp. 3 are shown in table 4. The total water intake plus snow intakes per kilogram live weight were not affected by the amount of water offered.

Discussion

The TOH turnover method yielded reliable estimates of water intake, be it in the form of snow or liquid water. Other workers (Cameron *et al.* 1976; King *et al.* 1978) have also reported reasonable agreement between estimates of water intake obtained by means of TOH and measured water consumption.

It is common for sheep in the intermountain area of Utah to use snow as the only source of water (Butcher, 1973), and, apparently, some ranchers (at least in the state of Utah) use snow for about 1 month each year as the only source of water for cattle (J, E. Butcher, *personal communication).* Butcher suggested that sheep adapt more readily to snow as a water source than do cattle and that some cattle breeds are more adept in eating snow than others. The present study has shown that pregnant crossbred beef cows can apparently obtain adequate water when snow is available as the only free water source. The penned cows did consume less snow than those in the field. This may have been due in part to the more limited choice of snow available to the penned cows. The cows preferred snow in a powdered form, as was previously reported for sheep (Butcher, 1973), and less of this form was available in the pens.

This study also demonstrated that cattle will consume snow within 2 days after being denied

TABLE 3. WATER TURNOVER AND WATER AND SNOW INTAKES BY PREGNANT COWS IN SHELTERED PENS AND IN A SNOW-COVERED FIELD (EXP. 2)

Measurements	Pen water	Pen snow	Field water	Field snow	SEM
Water turnover, kg/day	26.5[a]	23.2[b]	29.2[a]	26.7[a]	.77
Water drunk, kg/day	23.6[a]	---	19.4[b]	---	.26
Snow intake, kg/day	---	20.2[a]	6.7[b]	23.6[c]	.22
Snow and water intake,					
kg/day	23.6[a]	20.2[b]	26.l[a]	23.6[a]	.77
g/kg/day	58.4[a]	47.2[b]	6l.5[a]	54.7[ab]	3.0

[a,b,c] Means in the same row with different superscripts are different *(P<.05)*.

TABLE 4. SNOW INTAKE AND TOTAL SNOW AND LIQUID WATER INTAKE BY PREGNANT COWS RECEIVING DIFFERENT VOLUMES OF DRINKING WATER (EXP. 3)

Water offered, kg/day	Live weight, kg	Snow intake, kg/day	Total snow and water intake	
			kg/day	g/kg/day
0	450	23.7	23.7	52.6
5	490	21.9	26.9	54.8
10	465	12.9	22.9	50.2
15.4[a]	392	5.6	21.0	53.6

[a]*15.4* kg *was ad libitum* intake during 15-min, once-daily access to liquid water.

water and that, after being accustomed, they can readily switch without apparent distress from snow to water and *vice versa.* In addition, cattle receiving a limited water supply will supplement their water needs with snow (Exp. 3). The field water cows in Exp. 2, which had access to daily water, also consumed snow. There may have been a tendency for the field water cows to consume snow by association with the field snow cows, since the four cows were in a single field.

Of importance is the caloric expenditure involved in melting snow and raising the water temperature to body temperature. Daily consumption of 20 to 24 kg of snow with an initial temperature of -10 C (the average value for the present study) would theoretically require between 2.5 and 3.1 Mcal, or 15 to 20% of the cow's total daily metabolizable energy intake. The periods in the present study were not long enough for us to use live weight and body water changes as indices of a change in the cows' energy status.

Cameron and Luick (1972) suggested that a reduction in water intake (as snow) would help conserve nutrient and body energy reserves, as less metabolic heat would be required for melting the ingested snow and raising it to body temperature. These authors also observed that reindeer in Alaska reduced their water turnover and presumably water intake during the winter months. Dieterich and Holleman (1973) found no difference in hematological, metabolic or body fluid parameters between horses given snow and those given liquid water, and they concluded that their study did not substantiate any additional caloric requirements with the ingestion of snow. 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." If this is the case for cattle, or if cattle can reduce their heat loss when consuming snow, then the additional metabolic energy needed to melt snow and raise it to body temperature could be minimal.

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