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WATER ECONOMY IN RUMINANTS

III. Drinking water consumption in growing calves on dry feed

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Introduction

Nutritional and physiological importance of water supply for domestic animals has been well recognized^{2,9}. Publications on calf raising have universally emphasized the importance of supply of water^{3,4,7,9}. Water, however, is something which is often neglected in the nutrition of growing calves.

The data have been published in a relatively small amount of reports. ATKESON *et al.*¹ showed that the amount of water drunk by calves receiving liquid milk had little importance for animals up to at least 8 weeks of age when they were fed liquid skim milk for 26 weeks. The free water intake, however, increased at 6 weeks after birth when liquid milk was removed from the ration at 8 weeks of age. When feeding liquid skim milk was discontinued at 4 months of age, the consumption of drinking water nearly doubled comparing to that of calves receiving liquid skim milk. Wisconsin trials⁷ showed that the calves getting 14 lbs. of skim milk per head daily drank water an average of 2,535 lbs. up to 6 months of age. While calves raised on a dry feed ration ingested about 4,900 lbs. of water up to 6 months of age.

Several assumptions of water requirement for dairy cattle have been presented in this decade using a limited amount of data published. These suggested that the water intakes have been lacking a thorough consideration on consumption of drinking water in calves.

The measurements of drinking water for calves on a dry feed ration were carried out to acquire knowledges on water intake of calves on dry ration after weaned from liquid feed.

Experimentals

The experiment consisted of 2 trials to measure water consumption by calves raised on a dry feed ration.

Trial 1

The experiment was carried out to estimate the amounts of drinking water consumed by calves on a calf starter-hay feeding.

Seven Holstein bull calves were used. Calves were divided into two groups. First group of 4 calves (Group 1) was weaned in 8 weeks of age. Group 2 of 3 calves was continued to feed milk replacer up to 11 weeks of age. Rations were fed twice daily with equal proportion of daily allowance. Calves in group 1 were fed calf starter up to 2.5 kg. daily with free choice of second cutting hay. Those in group 2 were allowed to receive daily maximum amount of 3.5 kg. of calf starter with *ad libitum* feeding of second cutting hay. Daily amount of water drunk was measured prior to morning and evening feeding. Drinking water was provided with pails. Using the same type of pail, check records were measured for evaporation. Daily water consumption was measured for 25 weeks.

Trial 2

The effect of type of liquid feed during suckling period on consumption of drinking water was evaluated in growing calves on a dry feed ration.

The experiment was carried out using 4 Holstein bull calves. Two calves of them were fed milk replacer (Replacer group) and the other 2 calves received whole milk (Whole milk group) until they reached to 6 weeks of age. After weaning, only calf starter and hay were offered. Maximum allowance of calf starter was 2.5 kg. Calves were allowed to free access of second cutting hay throughout the experiment.

Measurement of drinking water consumption was carried out in the manner similar to trial 1.

Results

Trial 1

Table 1 shows the means of drinking water consumption in calves raised on a dry feed ration with standard deviation and coefficient of variation.

Statistical significant differences among means were testified using Duncan's new multiple range test.

Intake of drinking water for calves weaned at 8 weeks of age (Group 1) increased gradually with age up to 13 weeks of age, thereafter it increased

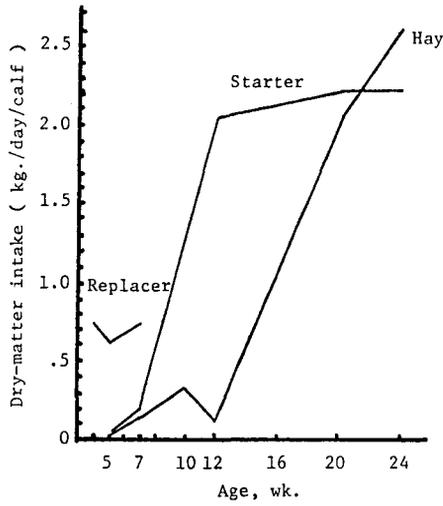


Fig. 1. Changes in dry-matter intake for different feeds in calves fed a dry feed ration with 2.5 kg. of maximum daily allowance for the starter after weaned at 8 weeks of age (Group 1)

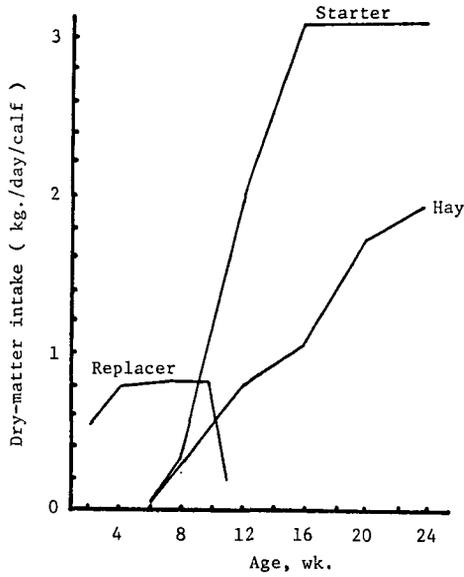


Fig. 2. Changes in dry-matter intake for different feeds in calves fed a dry feed ration with 3.5 kg. of maximum daily allowance for the starter after weaned at 11 weeks of age (Group 2)

in a step-wise manner. Calves fed milk replacer for 11 weeks (Group 2) increased the consumption of free water toward the end of feeding of milk replacer. When they were weaned, drinking water consumption continued to increase up to 15 weeks of age. Thereafter, drinking water consumption increased in the similar manner to those for group 1. The pattern for an increment of drinking water consumption was similar in both groups. After weaning, it increased in a rapid rate for 4 to 5 weeks, then changed to a stepwise increment. This change in the pattern of drinking water consumption coincided with the period when calves consumed approximately the maximum daily allowance of calf starter (Fig. 1 for group 1 and Fig. 2 for group 2).

Variations in drinking water consumption were found to be a relatively

TABLE 1. Average daily consumption of drinking water in calves raised on a dry feed ration

Age (wk)	Average daily consumption of drinking water (g./calf)		Coefficient of variation (%)	
	Group 1	Group 2	Group 1	Group 2
9	4436 ^{a,1)} ±1108 ²⁾	2398 ^{a,1)} ±1118	25.0	46.6
10	5736 ^b ±1716	5828 ^b ±1256	29.9	21.6
11	7012 ^c ±1344	7730 ^c ±2850	19.2	36.9
12	8716 ^d ±1521	9480 ^d ±2291 ⁴⁾	17.5	24.2
13	10528 ^e ±1475	11279 ^e ±1580	14.0	14.0
14 ^{**3)}	11458 ^e ±1501	13012 ^f ±1614	13.1	12.4
15	13886 ^f ±1051	15012 ^g ±3058	7.6	20.4
16	16298 ^g ±1458	16581 ^{g,f} ±2249	9.0	13.6
17 ^{**}	15644 ^g ±1334	17916 ^{h,j,k} ±2044	8.5	11.4
18 ^{**}	16280 ^g ±1551	18611 ^{i,j,k,l} ±3004	9.5	16.1
19	17595 ^h ±1427	19113 ^{k,l} ±3603	8.1	18.9
20	18595 ^h ±2713	16965 ^{h,j} ±3031	14.6	17.9
21	18008 ^h ±2246	19412 ^{k,l} ±3123	12.5	16.1
22	18196 ^h ±1480	19406 ^{k,l} ±4133	8.1	21.3
23 [*]	18225 ^h ±2488	19995 ^l ±2038	13.7	10.2
24 ^{**}	20018 ⁱ ±2129	23969 ^m ±3088	10.6	12.9
25 ^{**}	20447 ⁱ ±2386	22967 ^m ±2126	11.7	9.3

1) Means in the same column with different superscript are significantly different (P<.05), 2) Standard deviation, 3) Ages with asterisk have significantly different means between group 1 and group 2 (**, P<.01; *, P<.05), 4) Milk-replacer feeding was discontinued.

larger in the period just after weaning for both groups. Then, it reduced to less than 10 to 20% in both groups. It was observed, however, that variation in group 2 tended to be higher in some extent than that in group 1.

When the drinking water consumptions in both groups were compared in a corresponding age, differences were found a statistical significance in several week-age. At 9 weeks of age, calves in group 1 drank more water than those in group 2. This difference in drinking water intake was considered to be resulted from an effect of the type of a feeding regime for calves.

Calves in group 1 received only a dry feed ration, but those in group 2 were allowed to have an access to liquid feed at 9 weeks of age. After liquid diet feeding was discontinued, calves in group 2 tended to drink more free water than those in group 1. At the ages of 14, 17, 18, 23, 24 and 25 weeks, the significantly higher consumption of drinking water was observed in calves in group 2. Calves in group 1 consumed the starter approximately at the maximum daily allowance of 2.5 kg. in 12 to 13 weeks of age, but those in group 2 were allowed to consume at the highest rate of 3.5 kg. a day. Thus, total intake of dry matter might have been higher in group 2 than group 1 (Figs. 1 and 2). The dry-matter intake might have an effect on drinking water consumption.

Trial 2

Table 2 summarizes the means of drinking water consumption in calves fed a dry feed as a ration after weaned from the different types of liquid diet offered in suckling period. The test of statistical significance was examined using Duncan's new multiple range test.

Drinking water consumption in the replacer group increased in a stepwise fashion just after weaning and reached to a steady level, then increased again. In the whole milk group, it also increased in a somewhat stepwise manner, but not so clear as in replacer group, to attain to a constant level in 16 weeks of age. The constant level of drinking water consumption was similar in both groups. In this trial, a rapid increase in drinking water consumption was not observed after weaning, unlike the phenomenon observed in the previous trial.

As dry-matter intake of calves in this trial was only measured in 7, 12 and 20 weeks of age, its influence on water consumption was unable to make it clear. Dry-matter intake in 7 weeks of age totaled 1681 g./day for replacer group and 1212 g./day for whole milk group. In 12 and 20 weeks of age, it increased to 2827 g. and 4001 g./day for replacer group and 2541 g. and 4150 g./day for whole milk group. Amounts of dry matter consumed

from a dry feed in different ages are shown in table 3. It might be inferred to be partially responsible for the reaction by calves to consume drinking water after weaning from different types of liquid feed.

Calves in whole milk group drank significantly less free water than those

TABLE 2. Average consumption of drinking water by calves fed a dry feed ration after weaned from the different types of liquid diet offered in suckling period

Age (wk)	Milk replacer fed			Whole milk fed		
	Av. FWI ¹⁾ (g./day/calf)	SD ²⁾	CV ³⁾ (%)	Av. FWI (g./day/calf)	SD	CV (%)
7 ^{**} , ⁴⁾	7994 ^{a,5)}	1390	17.4	4628 ^a	939	20.3
8 ^{**}	7864 ^a	1041	13.2	5765 ^b	969	16.8
9 ^{**}	9982 ^b	1113	11.2	7228 ^{c,d}	489	6.8
11 ^{**}	9598 ^b	1240	12.9	6765 ^e	1022	15.1
12 ^{**}	11649 ^c	1340	11.5	7948 ^d	1120	14.1
13 ^{**}	12686 ^d	1223	9.6	9104 ^e	602	6.6
14 ^{**}	12613 ^d	1197	9.5	10208 ^f	1879	18.4
15 [*]	13010 ^d	1036	8.0	11826 ^g	1359	11.5
16	12807 ^d	1067	8.3	13292 ^h	1815	13.7
17	13332 ^d	1015	7.6	13812 ^h	1115	8.1
18	13680 ^d	1725	12.6	13836 ^h	1390	10.0
19	14688 ^e	881	6.0	14268 ^h	1167	8.2

1) Average free water intake, 2) Standard deviation, 3) Coefficient of variation, 4) Ages with asterisk have significant different means between replacer group and whole milk group (**, $P < .01$; *, $P < .05$), 5) Means in the same column with different superscript are significantly different ($P < .05$).

TABLE 3. Average consumption of dry matter for calves raised by different types of a liquid feed in suckling period

Age (wk)	Group	Average dry-matter intake (g./day)		
		Starter	Hay	Total
7	Replacer fed	1269	412	1681
	Whole milk fed	1024	188	1212
12	Replacer fed	1974	853	2827
	Whole milk fed	1847	694	2541
20	Replacer fed	1974	2027	4001
	Whole milk fed	1974	2176	4150

in replacer group for several weeks after weaning. In whole milk group, animals consumed a fairly small amount of drinking water compared with those in replacer group in the first week after weaning. Calves in whole milk group consumed about 2-3 kg. less drinking water than those in replacer group for 8 weeks, and then they brought drinking water consumption up to the same level of that observed in replacer group till 16 weeks of age. When the consumption of drinking water became about identical to both groups, the level of the consumption has been almost in plateau for a month thereafter.

Variation in drinking water consumption tended to be larger in a period immediately after weaning than the period in more advanced ages. Coefficient of variation was observed less than 10% in an advanced age with some exceptions. Drinking water consumption was considered to be more variable in whole milk group than in replacer group. Variation in drinking water consumption in the trial seemed to be smaller than that in the previous one.

Discussion

Drinking water consumption for calves on the starter-hay feeding regime

Increase in drinking water consumption has been observed in calves fed a dry feed ration. This is the case, even though the term of milk-replacer feeding has been extended from 8 to 11 weeks. The changes in drinking water consumption have been found to be similar in both groups of calves after weaning. Thus, the drinking response of calves may be influenced by consumption of a dry feed.

Drinking water consumption in group 1 increased gradually up to 13 weeks of age, but in group 2 it continued to increase up to 15 weeks of age. The intake of the starter for calves in group 1 reached to the maximum daily allowance at about 12 to 13 weeks of age, while for calves in group 2, it continued to increase and attained to the maximum daily allowance at about 16 weeks of age. The time required to attain the maximum allowance for the starter has been 4 to 5 weeks after weaning in both groups.

The response of drinking water consumption by calves has suggested to be affected by a rapid increment of dry matter supplied from the starter.

After the maximum daily allowance of the starter was attained by calves in both groups, drinking water consumption increased in a stepwise fashion. Amounts of hay consumed increased gradually throughout the experiment. An increase in total intake of dry matter, therefore, has paralleled to the increase in hay intake after 12-13 weeks in group 1 and after 16 weeks of age in group 2.

The pattern of drinking water consumption in calves attaining the maximum consumption of daily allowance of the starter may be influenced with the amounts of hay ingested by calves, and thus, turned out to be an effect of total dry-matter intake. Amounts of drinking water consumed may be considered to increase when hay intake has exceeded over a certain amount to be effective in drinking water consumption. Otherwise an increase of a certain amount of total dry-matter intake might be responsible for the increase in the consumption of drinking water.

Studies done by ATKESON *et al.*⁹ showed that free water intake increased from 5.1 kg. at weaning to 9.3 kg./day at 5 weeks after weaning and thereafter a rate of an increment in free water intake was considered to be in stepwise fashion when their data were examined.

Comparison of drinking water consumption between the groups revealed that calves in group 2 drank more water than those in group 1. This tendency may have resulted from amounts of dry matter consumed, for in any weeks of age, calves consumed more dry matter in group 2 than in group 1. Several significant differences were observed in drinking water consumption between the groups after when an increment of dry-matter intake occurred.

It might be inferred that the difference in dry-matter intake exceeded over a certain amount affected significantly on drinking water consumption.

In the extensive reviews of literatures on water consumption rates in farm animals,^{5,11,8)} water intake has been considered to be a function of dry matter ingested and such other factors as nitrogen and salt intakes. Calves ingested different amounts of the starter and thus, amounts of nitrogen ingested would have been different between the groups. Therefore, it might have partially influenced on drinking water consumption. Factors responsible for these phenomena, however, have been unable to be clarified.

The effect of the type of liquid feed

Data obtained by ATKESON *et al.*⁹ in calves weaned at 8 weeks of age showed that drinking water consumption has been almost similar among ages from 17 to 20 weeks. Amounts of free water drunk by calves in those age ranged from 13.1 to 13.8 kg./day which very well agreed with the results obtained in trial 2 of the present study.

Calves suckled whole milk consumed much less drinking water than those fed milk replacer for several weeks after weaning, and then caught it up to the level attained by the opposite group. Digestibility of whole milk is higher than that of milk replacer and nutrients in whole milk would be almost completely utilized by calves.¹⁰⁾ Thus, calves fed whole milk would

rely on it for nutrients supply and would not ingest an appreciable amount of dry feed in suckling period. For these reasons, they were not well accustomed to an intake of considerable amount of dry feed after weaning. When dry-matter intake were measured at 7, 12 and 20 weeks of age, the intakes at 7 and 12 weeks were clearly less in whole-milk-fed group, but at 20 weeks, it was almost equal for both groups.

Thus, drinking water consumption in whole milk fed group in the first several weeks after weaning could have been influenced with the amounts of dry matter ingested by animals.

Summary

Measurements of amount of water drunk by calves on a dry ration were carried out to evaluate the effects of the level of daily allowances of calf starter and the type of liquid feed offered in the suckling period. After weaning, drinking water consumption increased in a rapid rate for 4 to 5 weeks, then changed to a stepwise increment. A higher allowance of calf starter caused a greater consumption of drinking water at the same age. Calves weaned from whole milk drank significantly less free water than those from milk replacer for several weeks after weaning. Drinking water consumption for calves weaned from whole milk reached to the same level of that observed in replacer group in 9 weeks after weaning. Dry-matter intake of calves weaned from whole milk is lower for several weeks after weaning than those from milk replacer, and thus, this may result in a lesser amount of drinking water in calves weaned from whole milk.

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