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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

Effect of supplemental water source on performance of calves during milk feeding and their cross-sucking after weaning*

Jan Broucek[1], Michal Uhrincat[1], Marie Sistkova[2], Miloslav Soch[2], Anton Hanus[1]**

[1] National Agricultural and Food Centre, Research Institute of Animal Production Nitra, Slovakia

[2] South Bohemia University, Ceske Budejovice, Czech Republic

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The aim of this work was to evaluate effects of water receiving method on the growth, feed intake, health condition, and social behaviour of calves. 62 calves were reared in hutches from the 2nd day to weaning at the age of 8 weeks. Calves received colostrum and mothers milk *ad libitum* 3 times a day from a bucket with nipple, from the second to fourth day. From the fifth day they received 6 kg of milk replacer per day divided into 2 portions in 12 h intervals. From the second day until weaning the calves were offered concentrate mixture and alfalfa hay *ad libitum.* All calves were divided according to the water delivery into 3 groups – nipple sucking from bucket (N), drinking from bucket (B), and without water delivery (WW). We did not found significant (p≤0.05) differences among groups in the average daily gains (N 0.46±0.13 kg, B 0.43±0.12 kg, WW 0.43±0.10 kg,). The N group drank up more water to weaning than the B group (69.39±66.91 kg vs. 50.72±51.95 kg, p≤0.05), and group N had the highest intake of starter mixture (N 14.43±8.82 kg, B 11.30±5.45 kg, WW 13.31±6.86 kg, p≤0.05). The highest alfalfa hay consumption was found in group WW (N 21.34±6.91 kg, B 22.26±7.52 kg, WW 23.59±8.76 kg, p≤0.05). No calf died or was culled for health problems; no water delivery effects for blood measurements were found, neither. We did not find significant differences between groups in the cross-sucking after weaning. The acceptance to be sucked was significantly higher in calves from the group N (N 10.50±0.77, B 5.10±0.80, WW 5.25±0.80, p≤0.001). However, we cannot recommend to partly substituting the water with the milk replacer. Drinking water has simply to always be available.

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**Corresponding author: broucek@vuzv.sk

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Water is required for all of life's processes – transport of nutrients and other compounds to and from cells; rumination, digestion, and metabolism of nutrients; elimination of metabolites and digestion waste (urine, respiration, and faeces); body temperature (perspiration) control; preservation of proper fluid and ion balance in the body [Houpt 1984, Murphy 1992, Davis and Drackley 1998, West 2003, Beede 2005, Casamassima *et al.* 2008, Amaral-Phillips *et al.* 2015].

Calves satisfy their water requirements from three sources: water consumed voluntarily, water contained in the feed and the metabolic water formed in the body [Sekine *et al*. 1986, Murphy 1992]. Many environmental factors affect water consumption, including water quality and temperature, drinker design, dry matter intake (DMI), weather conditions, and housing [Thickett *et al.* 1981, Sekine *et al.* 1994, Davis and Drackley 1998, Quigly *et al.* 1998, Quigley 2001, Hepola *et al*. 2008, Amaral-Phillips *et al*. 2015]. Water loss from the body occurs via urine and faeces; through sweating and evaporation from the lungs and body surfaces [Davis and Drackley 1998, West 2003]. When the body water loss reaches to 8-10%, the calf also loses electrolytes and blood viscosity increases. As water loss continues death results from heart failure [Bianca 1970, Kertz *et al*. 1984, Costello 2011].

However, little information is available on how much water calves fed milk or milk replacer consume. Practices vary from the extremes of offering water from the 1st day to complete lack of water until the calves are weaned [Thickett *et al*. 1981]. Apparently, it is important how much milk or milk replacer the calves receive. Restrictively fed calves have to make up for their fluid requirements that exceed the water daily supply from milk with an additional water intake. Furthermore, restrictively-fed animals may have higher water need due to hunger [Borderas *et al*. 2009, Passillé de *et al*. 2011]. Calves consumed very little water or dry feeds when they had an *ad libitum* access to milk replacer. After weaning off milk, calves rapidly began to consume 8 to 9 L of water per day [Hepola *et al.* 2008].

Calves deprived of drinking water decreased starter intake and decreased weight gain compared to calves provided water free-choice [Chester-Jones 2014, Amaral-Phillips *et al*. 2015]. In a study by Kertz et al. [1984], calves not offered supplemental water gained less body weight and consumed less concentrate as compared with calves with an *ad libitum* access to water. Wenge *et al.* [2014] found that the ratios of daily water intake to total DMI were 1.6 $L.kg^{-1}$ for the restrictively-fed and 0.9 $L.kg^{-1}$ for the *ad libitum*-fed calves.

Little information exists about different water sources for calves on water intake before weaning. Only Hepola *et al.* [2008] found that the water source (open bucket or nipple) did not affect the amount of water consumed.

Calves very often showed cross sucking of other calves or equipment. Cross-sucking by dairy calves occurs most commonly before weaning in group housing, but is of concern in older animals [Lidfors 1993, Debreceni and Juhas 1999, Keil *et al*. 2000, Juhas *et al*. 2001, Hepola *et al.* 2008, Passille de *et al*. 2010, Leruste *et al.*

2014]. Generally, the calves rapidly increased frequency of cross-sucking with age [Juhas and Debreceni 1998], especially after weaning [Keil and Langhans 2001, Keil *et al*. 2001, Passille de *et al*. 2011]. Other authors [Nielsen *et al.* 2008, Roth *et al.* 2008, Vaughan *et al.* 2016] noted that gradual weaning reduces cross-sucking, but low levels of this behaviour still persist.

Sucking between calves is considered to be an abnormal behaviour and is also considered harmful for the calves [Loberg and Lidfors 2001] and has many similarities with stereotypic behaviour [Passille *et al*. 2011]. Cross sucking can be influenced by the management system [Lidfors 1993, Debreceni *et al.* 2000, Fröberg *et al.* 2008].

The aim of this work was to evaluate effects of water receiving method on the performance and behaviour of calves. We tested hypotheses that the growth, feed intake and health condition during milk-feeding period as well as the social behaviour after weaning are influenced by the method of drinking the water.

Material and methods

Sixty two Holstein calves were reared in individual hutches from the second day of life to weaning at the age of 8 weeks. The same conditions of nutrition were ensured. Calves received colostrum and mothers milk *ad libitum* three times a day from a bucket with nipple from the second to fourth day. These consumptions of colostrum and mothers milk were not registered until the age of 4 days. From the fifth day they received 6 kg of milk replacer per day divided into 2 portions (3 kg in the morning, 3 kg in the afternoon) in 12 h intervals. Calves always drank the entire portion without leaving residues. From the second day until weaning the calves were offered concentrate mixture and alfalfa hay *ad libitum*. Feed and water refusals were removed and weighed each morning prior to feeding. The experiment lasted from April to November. All calves were divided according to the way of watering into 3 groups – nipple sucking from bucket (N), drinking from bucket (B), and without water delivery (WW).

The meteorological data were recorded continuously by the weather station. Temperatures and relative humidity were taken for each hour of the day. The number of summer days (maximum daytime temperature above 25.0ºC) and tropical days (maximum temperature above 30.0ºC) from 24 h records were determined.

The temperature-humidity index (THI) was calculated as proposed by Nienaber *et al*. [1999]. Blood samples for analysis of white and red blood pictures were taken every second week. The classical method of Larson *et al.* [1977] for the evaluation and health expression was used.

After weaning at the average age of 56 days the calves were moved from the calf barn to the experimental barn. They were kept in loose housing pens. Approximately ten calves were kept in a pen of 9x4.5 m. Feed was available round the clock. The calves were fed alfalfa hay, maize silage and concentrate mixture. Their behaviour was observed for two 24 h periods (first and seventh day) after moving to the new

facility. Other ethological observations were performed until the age of 6 months (once a week between 8:00 and 20:00). Behavioural data were obtained by video observations and electronic measurements.

The social activity of each of the animals was recorded using following categories: licking/sucking barn equipment (tongue or mouth touching an object); self-licking/sucking (tongue or mouth touching own body); cross-sucking (sucking on any body part of another calf); accepting to be sucked. The data were analysed using a General Linear Model ANOVA by the statistical package STATISTIX, Version 9.0.

Results and discussion

From April to November we recorded 60 summer days with a maximum daytime temperature above 25.0ºC and 15 tropical days (maximum temperature above 30.0ºC). Sixty-six days with the value of the temperature-humidity index (THI) above 72.0, which is already a stressor, were recorded during the period. The total number of days with THI values higher than 78.0, which was a substantial stress, was 26 for the whole experiment.

The N group of calves drank up more water to the weaning than the B group (69.39±66.91 kg vs. 50.72±51.95 kg, $p \leq 0.05$). The N group had the highest intake of starter mixture (N 14.43±8.82 kg, B 11.30±5.45 kg, WW 13.30±6.88 kg, $p \leq 0.05$). The highest alfalfa hay consumption during the milk drinking period was found in group WW (N 21.82±5.35 kg, B 22.36±7.07 kg, WW 23.79±7.52 kg, $p \leq 0.05$ – Table 1). However, this is the result of a precise experiment; the consumption of feed was accurately recorded.

Table 1. Basic statistics of daily water and feed consumption to weaning (kg)

Group	n	Mean	SE	Min.	Max.	Significance
			water			
N	22	69.39	14.27	7.57	217.36	
B	20	50.72	11.17	4.57	239.05	WW:N,B***
WW	21	0	0	0	0	
			concentrate			
N	22	14.43	1.88	1.46	36.09	
B	20	11.30	1.22	3.18	28.13	N.S.
WW	21	13.30	1.50	3.77	27.58	
			alfalfa hay			
N	22	21.82	1.14	13.10	30.80	
B	20	22.36	1.58	8.65	35.20	N.S.
WW	21	23.79	1.64	10.80	35.05	

***P<0.001; SE − standard error of the mean.

The calves in the treatments N and B consumed 1.33 kg and 0.97 kg of water daily between 5th and 56th d of age, which is similar to the amounts reported by Kertz *et al*. [1984], Quigley [2001], and Wenge *et al*. [2014]. According to Hepola *et al.* [2008] and Passillé de *et al.* [2011], during the milk-feeding period, the calves drank very

little water. Water intake in all treatment groups increased rapidly following weaning, which is in accordance with the results of Hepola *et al.* [2008]. However, the variation between calves in water intake was great.

We did not found significant differences among groups in the average daily gains. Daily gains were highest in group N (N 0.45±0.13 kg, B 0.43±0.11 kg, WW 0.43±0.09 kg, $p \leq 0.05$) from birth to weaning. Differences were not recorded in the 180-day growth assessment (Tab. 2).

Table 2. The live body weight gains from the birth to 180 days (kg)

Group	n	Mean	SE	Min.	Max.	Significance
from birth to 56 days						
N	22	0.45	0.03	0.17	0.68	
B	20	0.43	0.02	0.23	0.62	N.S.
WW	21	0.43	0.02	0.27	0.61	
from birth to 180 days						
N	22	0.75	0.05	0.47	1.04	
B	20	0.75	0.04	0.58	0.93	N.S.
WW	21	0.74	0.04	0.56	1.02	

SE − standard error of the mean.

Several investigators have studied the effects of water deprivation on growth in calves [Cunningham and Albright 1970, Thickett *et al.* 1981, Kertz *et al*. 1984, Amaral-Phillips *et al.* 2015]. Their results indicate that decreased water intake could have long-term negative effects on growth of dairy calves. Therefore, any limited water supply would inevitably disrupt the productive process in dairy calves. In addition, water restriction for any reason can intensify heat stress of animals [Marai *et al.* 2007, Ghasemi Nejad *et al.* 2014].

It could be assumed that the WW group evoked a water saving mechanism which might attenuate body water losses. It suggests that calves are able to accumulate water in reserve to be used in periods of reduced water supply. Due to limited availability of water, calves developed ability of more efficient water utilization resulting in preserving of sufficient feed intake and growth levels, as noted by Silanikove [1994], Ghasemi Nejad *et al.* 2014]. Ghasemi Nejad *et al.* [2015] suggested that ruminants are able to accumulate water in reserve to be used in periods of reduced water supply.

The water needed by pre-weaned calves depends on the amount of milk replacer and starter intake and on the environmental conditions [Chester-Jones 2014, Igbokwe 1997]. According to other authors [Cunningham and Albright 1970, Thickett *et al*. 1981, Kertz *et al.* 1984, Amaral-Phillips *et al.* 2015], calves receiving water *ad libitum* ate more concentrates than calves not receiving water. However, in the present study, restricting water intake in the first 56 d did not result in any obvious effect on feed intake. This is confirmed by the results of the investigation of the health status and blood indicators.

The amount of liquid in milk replacer fed also affects the amount of water consumed. It is very possible that this relationship is due to the fact that increased

water in milk replacer will reduce the need for additional water to be fed as liquid or free water [Manthey *et al*. 2011]. Cunningham and Albright [1970] found that calves that had water freely available gained 2.63 kg more from 4 to 40 days of age than calves not receiving water in addition to milk replacer. Also Quigley [2001] wrote that feeding of milk replacer should not be construed as providing "enough water". Our results are difficult to justify. It was probably enough for our calves to get the water in a 6 kg milk replacer daily. Perhaps this is the case for the practical reason that calves receive most of their water requirements from milk consumption.

With the exception of the Hepola *et al.* [2008] study, no other results are known about different water sources for calves in terms of water intake, calf behaviour, and performance before and after weaning from milk. In the present work the way of water supplying had no impact on the amount of water calves consumed from the 5th d to weaning. However, the calves tended to drink more water daily from nipples than from buckets (1.33 kg vs. 0.97 kg). Water source (nipple or bucket) did not affect concentrate or alfalfa hay intake.

In the present study, neither a calf died or was culled for health reasons. There were no water delivery effects for blood parameters. It is known from the literature that the hemoconcentration caused by prolonged water deprivation leads to changes in blood composition. The erythrocyte count, haematocrit and haemoglobin concentration often increase while the neutrophil and lymphocyte counts decrease [Igbokwe 1997]. During water deprivation, there were increases in the hematocrite, erythrocyte count and hemoglobin concentration of cattle [Bianca 1970, Shaefer *et al*. 1990]. However, there were no water delivery effects upon measurements of red blood picture (hematocrite, hemoglobin, erythrocytes). We did not find any significant differences among observed groups in the number of leukocytes or percentage of basophiles, monocytes, and neutrophils.

The faeces had liquid consistency during the first weeks, rather than a firm one. Colour showed a steadily trend from yellow to green and consistency changed smoothly from liquid to normal.

Freedom from thirst is one of the most indisputable welfare requirements. According to the Council Directive [2009] calves over 2 weeks of age have to be allowed *ad libitum* access to water. Prior to this age they must supply their daily need for fluid through the intake of milk or milk replacer. It is recommended to provide free choice water to calves receiving liquid diets to enhance growth and dry matter intake.

Cross-sucking is a problem in Slovakia dairy herds where it has recently gained importance [Debreceni and Juhas 1999, Juhas *et al*. 1998]. However, our problem is more difficult. Within the first 24 h observation after weaning, activities of social behaviour as licking/sucking barn equipment, self-licking/sucking, and cross-sucking were not differentiated among the observed groups (Tab. 3). The highest number of sucking of barn equipment was recorded in calves, which received water from nipple (N). Number of cross-sucking activities tended to be highest in calves from group N (N 7.68±0.82, B 6.10±1.09, WW 5.90±0.94, $p \leq 0.05$). The calves supplied

Table 3. Social behaviour after weaning (number of activities)

Group	n	Mean	SE	Significance
licking/sucking barn equipment				
N	22	7.95	0.91	
B	20	7.15	0.95	N.S.
WW	20	8.05	0.95	
self-licking/sucking				
N	22	5.22	0.57	
B	20	5.25	0.60	N.S.
WW	20	5.45	0.60	
cross-sucking				
N	22	7.68	0.82	
B	20	6.10	1.09	N.S.
WW	20	5.90	0.94	
willingness to be sucked				
N	22	10.50	0.77	N:B,WW ***
B	20	5.10	0.80	
WW	20	5.25	0.80	

***P<0.001; SE − standard error of the mean.

with water from the bucket (B) and the water-free group was sucked at a minimum. The acceptance to be sucked was significantly higher in calves from group N (N 10.50±0.77, B 5.10±0.80, WW 5.25±0.80, p≤0.001). No significant differences were found among the groups neither in the second 24-hour observation nor in subsequent observations.

Cross-sucking is related to milk feeding and usually disappears after the milk-feeding period [Lidfors 1993, Keil and Langhans 2001, Roth *et al*. 2008, Nielsen *et al*. 2008, Passille de *et al*. 2010].

Calves in our study also exhibited a considerable number of other oral behaviours, such as licking structures or other calves. This might be explained by that the calves had only a restricted possibility for social contact before weaning, they were kept in hutches. However, cross-sucking of calves is probably not associated with the way of water intake. Cross-sucking may reflect characteristics of individual calves or be the result of habit formation [Laukkanen *et al.* 2010, Passille de *et al*. 2011, Vaughan *et al.* 2016].

Water receiving method did not result in any significant effect on growth, feed intake and health condition in the observed experimental calves.

We cannot recommend the water intake just as part of the milk replacer on the basic of this experiment. Drinking water has to be always at the disposal.

Nevertheless, the welfare implication of water deprivation in the special situations remains unclear. There is a lack of understanding of the welfare implication when an animal cannot access water, and particularly of the length of time after which welfare can be considered compromised.

More research is needed for using a water source on water-drinking behavior before and after weaning. No information exists about different water sources for calves in terms of behavior before and after weaning from milk.

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