Does the source of drinking water (bore vs town supply) influence water intake, milk production and cow drinking preferences?

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Abstract

Cows are sensitive to drinking water quality, however, little is known about the perception of bore water that sometimes contain high concentrations of natural contaminants, such as iron and manganese. Our aim was to investigate if providing drinking water from town supply compared with unfiltered bore water would influence water intake, milk production and cow preferences. Four groups of cows (50 cows/group) milked once-a-day in autumn were offered either town supply water or unfiltered bore water for two weeks, before changing treatment for another two weeks in a cross-over design. Group water intake and individual milk production was measured daily (n=4 groups/treatment). Water source did not influence water intake or milk production ($P \geq 0.641$). A preference study on a subset of animals was undertaken after the initial trial period in which two groups of cows (n=2, 20 cows/group) had free access to both water sources simultaneously for three days. Cows preferred to drink the unfiltered bore water compared to town supply (descriptive data). It is likely that the cows' previous experience with drinking the unfiltered bore water influenced the results. The cows may also have perceived components of the town supply aversive compared to the bore water to which they were accustomed.

Key words: milk production; preference; water intake; water quality

Introduction

Drinking water is the primary source of water for cattle, however, depending on its source, water can sometimes contain various solutes and suspended particulate matter that can influence its appearance, smell, taste, and physical and chemical properties. Water consumption is positively associated with feed intake in both beef (Brew et al. 2011) and dairy (Stockdale & King 1983) cattle. Factors which limit the desire of cattle to drink water, in particular its quality and palatability, have the potential to not only reduce welfare, but limit growth and production. Willms et al. (2002) suggested that high salt content of water can influence its consumption level, and also feed intake and growth rates of beef cattle. Similarly, Grout et al. (2006) demonstrated that when water contains high levels of sulphates, particularly magnesium sulphate, palatability and quality is decreased and beef cattle will decrease their water consumption, even to the point of dehydration. Both beef and dairy cattle will, when given a choice of clean water, avoid water that is contaminated with manure (0.05 mg/g water, Willms et al. 2002, Schütz et al. 2019). Willms et al. (2002) demonstrated that water consumption was reduced at manure concentrations above 2.5 mg/g water and a reduction in feed consumption at concentrations greater than 5 mg/g water. Lardner et al. (2005) demonstrated similar results in a study when they tested different ways of treating contaminated water for beef cattle. In that study, as well as that by Willms et al. (2002), growth rates were linked to improvements in the palatability and quality of the water, as cattle drank more and consumed more solid feed. Water intake by dairy cattle was reduced when the water was contaminated with 1 mg manure/g water, however, this was not reflected in milk production (Schütz et al. 2021).

To date there has been no published work showing the relationship between drinking water from a bore, with natural contaminants such as iron and manganese, and milk production in New Zealand dairy cattle. High levels of iron in drinking water may reduce the palatability and therefore the intake of water. Too much free iron can cause oxidative stress which in turn can damage cell membrane structure, functions, and disturb biochemical reactions (Beede 2008). Iron toxicity and oxidative stress may result in compromised immune function, increased fresh cow mastitis and metritis, greater incidence of retained foetal membranes as well as diarrhoea, sub-normal feed intake, decreased growth, and impaired milk yield (Beede 2008). Iron can also interfere with the absorption of copper and zinc, the latter routinely given to dairy cattle as prevention of facial eczema. There is little information about the effects of manganese, this micromineral element is often considered along with iron when addressing water quality. In general, a concentration greater than 0.05 ppm (equal to mg/L) is thought to affect water intake because of effects on palatability (Beede 2008).

The aim of this project was to investigate if providing treated town supply water to cows would increase water intake and milk yield compared to when the drinking water was unfiltered bore water.

Materials and methods

Animals and experimental design

The main study was undertaken at the DairyNZ Lye Farm, Hamilton, New Zealand (37˚76'S 175˚37'E) during March and April 2021 (Southern Hemisphere autumn). All procedures involving animals in this study were approved by the Ruakura Animal Ethics Committee under the New Zealand Animal Welfare Act 1999 (AE#15182). Two hundred lactating, pregnant and non-pregnant Friesian and Friesian-cross dairy cows were divided into two replicates of 100 cows, each replicate was further divided into two treatment groups, each consisting of 50 cows. Groups were randomised based on age (5.7±2.61 years), days in milk (229± 0.5 days in milk), and pregnancy status (51 were non-pregnant). The cows were habituated into their groups and were transitioned to once-a-day milking regime for a period of 3 to 7 days before measurements began. During habituation, cows had access to unfiltered bore water as this is what cows normally have access to on the research farm.

After the main study was completed two groups of cows (20 cows/group randomly selected from the main study, 10 from each original group) were managed as in the main study (below), however, with access to the two water sources simultaneously for three days. Water intake on a group level was recorded in the morning using the same set up and methodology as in the main study (below).

Each replicate of cows was grazed for each 24-hour period in a one-hectare paddock, which had been divided in half with electric fencing to accommodate two groups (one of each treatment, 0.5 ha/group). Cows were offered 14 kg dry matter (DM) per cow and day and consumed approximately 12 kg DM/day overall. The amount of pasture offered and consumed was estimated daily by measuring the compressed pasture height using a rising plate meter following a W pattern over the whole paddock. A plate reading was obtained every 2nd step and over a break at least 100 sampling points were obtained. The pasture was supplemented with either pasture silage or maize silage to reach the requirement of 14 kg DM/cow/day. Daily pasture samples were also taken to determine the DM content of the pasture. The samples were obtained in the morning before 11:00 h and were refrigerated and processed straight after collection. Pasture samples were collected using "hand shears" and the pasture was cut at grazing height (30 to 40 mm). The pasture was walked in a W shape taking a sample cut about 15 cm long at every 10 steps across the whole paddock. The aim was to have about 1 kg of grass collected for each paddock. The DM content of the pasture was on average 20.1% (*range:* 13.4 to 29.6%). Silage samples (pasture silage and maize silage) were obtained twice weekly for DM content and NIR analyses. The DM content of the silage was on average 32.6% (*range:* 19.6 to 41.3%) and 26.1% (*range:* 18.0 to 32.8%) for maize and pasture silage, respectively. The nutritional composition of the pasture and silage is provided in Table 1. Cows were milked once-a-day at approximately 06:00 h and during this time the water treatments were set up in their fresh paddock and supplements fed along the fence line. Pasture and maize silage made up 50 to 75% of the cows' intake. Each group had access to one of the two water treatments (two groups/treatment) for 14 days before changing treatment for another 14 days (Period 1 and 2). The design was therefore a cross-over design (n=4 groups, 50 cows/group).

There were two treatments: 1. Town supply, which is routinely treated with chlorine at source, and 2. Unfiltered bore water, which originated from a deep bore on the farm (Table 2 for water analyses). The bore water had particularly high levels of iron, manganese but also magnesium, compared to town supply (Table 2). Cows always had free access to drinking water while at pasture.

Each treatment group's water was supplied from five 1000 L Industrial Bulk Containers (IBC) which were secured to existing farm tractor trailers. The containers were connected using 50 mm alkathene pipe and fittings to form one pipe to the trough. The trough pipe was then reduced to 25 mm diameter and a water meter was connected into the pipeline. Water was then delivered into a commercially available 500 L trough which had a protected ballcock. The treatment water on each trailer was replenished each morning during milking and then taken to the new paddock and reconnected to the trough. An electric fence was placed around the trough so that no cows could gain access to drink until the trough was filled and the meter reading had become stable. A reading from the water meter was then taken and the fence removed. The water troughs were unprotected from the weather.

Water intake

Voluntary (trough) water intake was measured daily at group level, volume consumed being measured through Zenner RNK-RP-N water meters (MICO TeRapa, Hamilton). The meter was read after the cows left the paddock for milking. Water samples were collected once in the middle of the trial period and sent to Hill Laboratories in Hamilton for water quality analyses (Table 2). These water samples were collected from the pipes before filling up the plastic water containers. Images of the two water sources are provided in Figure 1. Water intake obtained from the feed was estimated based on the DM content of

Table 1 Mean (± SEM) nutrient composition of feeds offered throughout the experiment.

	Pasture	Pasture silage	Maize silage
Dry Matter (DM, g/100g)	20.1 (0.9)	26.1 (1.1)	32.6 (1.5)
Ash (g/100g)	10.2 (0.2)	9.1 (0.4)	4.4 (0.2)
Crude Protein (CP, g/100g)	20.2 (0.6)	17.0 (0.5)	7.0 (0.4)
Neutral Detergent Fiber (NDF, g/100g)	45.0 (0.6)	50.8 (1.7)	47.0 (2.2)
Acid Detergent Fiber (ADF, g/100g)	24.2 (0.5)	35.8 (0.6)	28.6 (0.8)
Fat (g/100g)	3.8 (0.1)	3.0 (0.1)	3.7 (0.1)
Starch (SSS, g/100g)	10.3 (0.3)	3.3 (0.3)	28.4 (1.7)
Metabolisable Energy (ME, MJ/kd DM)	11.0 (0.1)	11.2 (0.2)	10.3 (0.1)
Organic Matter Digestibility (OMD, g/100g)	76.5 (0.6)	70.1 (1.1)	-
pH	-	4.1 (0.1)	3.8 (0.03)
NH4N (mg/100g DM)	-	237.2 (4.6)	108.0 (9.8)

Table 2 Water quality analyses of the two sources of drinking water (bore water and town water). Note: The Guideline Values and Maximum Acceptable Values (MAV) are taken from Drinking-water Standards for New Zealand 2005 (Revised 2018), Ministry of Health.

	Bore Water	Town Water	Guideline Value	MAV
Escherichia coli (MPN/100ml)	<1	<1	-	<1
Turbidity (NTU)	73	0.17	<2.5	-
pH (pH Units)	6.8	7.4	7.0-8.5	-
Total Alkalinity (mg/L as CaCO3)	157	41	-	-
Free Carbon Dioxide (mg/L at 25°C)	53	2.9	-	-
Total Hardness (mg/L as CaCO3)	91	46	<200	-
Electrical Conductivity (EC) (mS/m)	31.2	19.3	-	-
Electrical Conductivity (EC) (µS/cm)	312	193	-	-
Approx. Total Dissolved Salts (mg/L)	210	129	<1000	-
Total Arsenic (mg/L)	0.0045	0.002	-	0.01
Total Boron (mg/L)	0.022	0.25	-	1.4
Total Calcium (mg/L)	13.7	13.5	-	-
Total Copper (mg/L)	<0.00053	<0.00053	<1	2
Total Iron (mg/L)	13.9	<0.021	<0.2	-
Total Lead (mg/L)	<0.00011	<0.00011	-	0.01
Total Magnesium (mg/L)	13.8	3.0	-	-
Total Manganese (mg/L)	1.42	0.00061	<0.04 (staining) <0.10 (taste)	0.4
Total Potassium (mg/L)	3.5	3.2	-	-
Total Sodium (mg/L)	39	19.5	<200	-
Total Zinc (mg/L)	0.050	0.0011	<1.5	-
Chloride (mg/L)	8.3	16.7	<250	-
Nitrate-N (mg/L)	0.06	0.29	-	11.3
Sulphate (mg/L)	<0.5	20	<250	-

Figure 1 The two water treatments used in the experiment; unfiltered bore water to the left and town supply to the right.

the feed samples and estimated intakes (on group level).

Milk production

Cows were milked through a 30-bail rotary platform and using a GEA milking plant (Hamilton, New Zealand). Milk production for each cow was recorded daily.

Environmental conditions

Air temperature (°C), and rainfall (mm) were recorded at 10-minute intervals using two portable weather station (Fan-Aspirated Vantage Pro2™ Plus Stations, model 6163, Davis Instruments Hayward, California, USA). The weather stations were located in an unsheltered and nonshaded area in the proximity of the paddocks being used.

Statistical analysis

A linear mixed model was used to investigate the fixed effect of body condition, liveweight, pregnancy status, days in milk, age group, and water treatment (bore/town supply) on milk production (kg milk per cow per day). The random effects were cow nested within group, date, and a group by day random intercept. Period (1 and 2) was used as a fixed effect. Body condition, liveweight and days in milk were centered by deducting each value by their respective mean. A linear mixed model was used to investigate the fixed effects of water treatment, average daily temperature and daily rainfall on water intake per cow. Rainfall was categorised into three categories (0-9, 10-19, 20+ mm/day). The random effects were the date, and the group. Period was used as a fixed effect. Water intake during the preference study is presented descriptively due to the limited number of groups (n=2) tested.

Results

During the first half of the study (Period 1), average daily air temperature was 16.8°C *(range:* 14.7 to 19.6°C), average daily maximum air temperature was 23.3°C *(range:* 21.0 to 25.1°C) and average daily rainfall was 9.0 mm/day (*range:* 0 to 80.8 mm/day). During the second half of the study (Period 2), average daily air temperature was 16.0°C *(range:* 12.5 to 19.6°C), average daily maximum air temperature was 21.4°C *(range:* 18.3 to 24.6°C) and average daily rainfall was 1.8 mm/day (*range:* 0 to 16.8 mm/day). There were 11 days of rainfall in total; 6 days had rainfall between 0-9 mm/day, 3 days between 10-19 mm/day, and 2 days had more than 20 mm/day.

Voluntary (trough) water intake was not influenced by the water source (P=0.641, Figure 2) or air temperature (P =0.940), however, rainfall and period did influence water intake (P<0.001) with rainfall decreasing water intake. Cows consumed on average 33.1 and 33.5±3.93 L (SE) of town and bore water, respectively, per cow and day (*range:* 14 to 78 L/cow/day for town supply, and 14 to 77 L/cow/day for bore water). On the day with the lowest voluntary water intake (14 L/cow/day) there was 81 mm of rainfall. Cows consumed approximately on average 9 L of water/day through their feed (calculated from estimated average intakes and the DM content of the feeds). Voluntary water intake was lower in the second half of the experiment (Period 2, Figure 2).

Milk production was not influenced by the water source provided to the cows (P=0.699). Cows produced on average 8.9 and 8.8±0.20 L (SE) of milk per cow and day from town and bore water sources, respectively.

The results from the preference study are provided descriptively in Figure 3 and indicate that the cows preferred to drink the bore water over the town supply.

Discussion

Voluntary (trough) water intake was not influenced by the source of drinking water or air temperature, however, rainfall influenced water intake. Cows consumed on average 33.1 L/cow/day and 33.5 L/cow/day of town and

Figure 2 Daily water intake (L/cow) of dairy cattle provided either with drinking water from town supply or unfiltered bore water (n = 4 groups/treatment in a cross-over design, 50 cows/group) throughout the experiment. Days with rainfall greater than 10 mm/day are indicated by arrows.

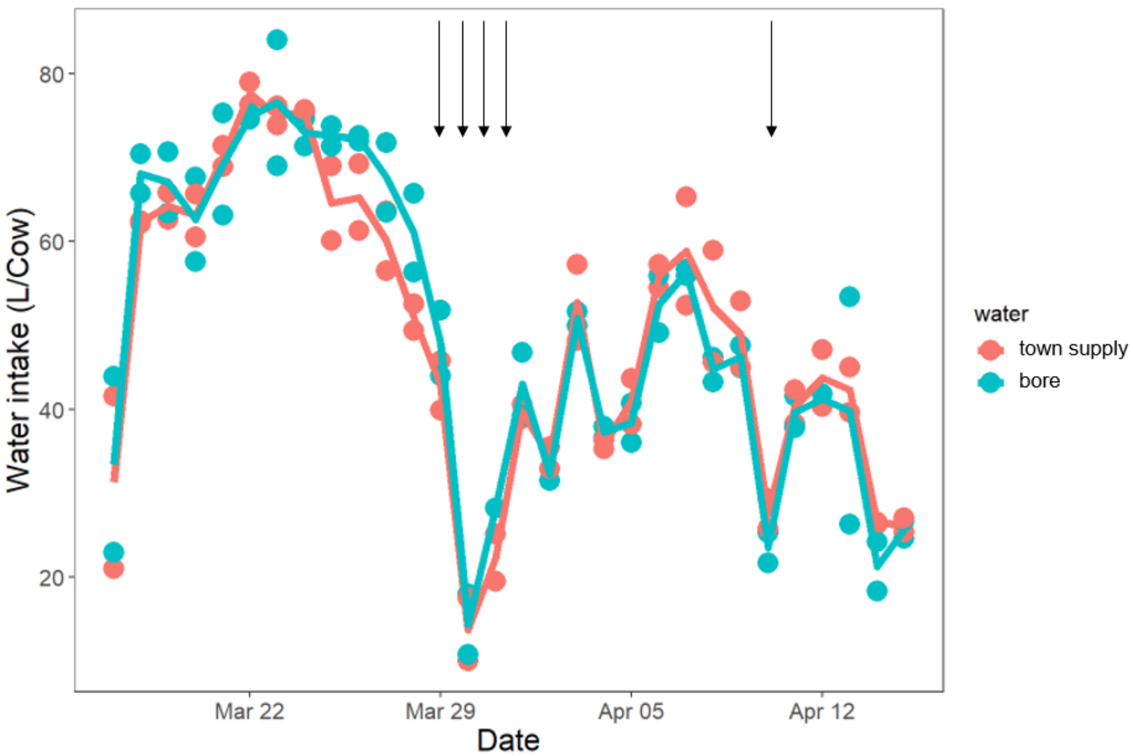
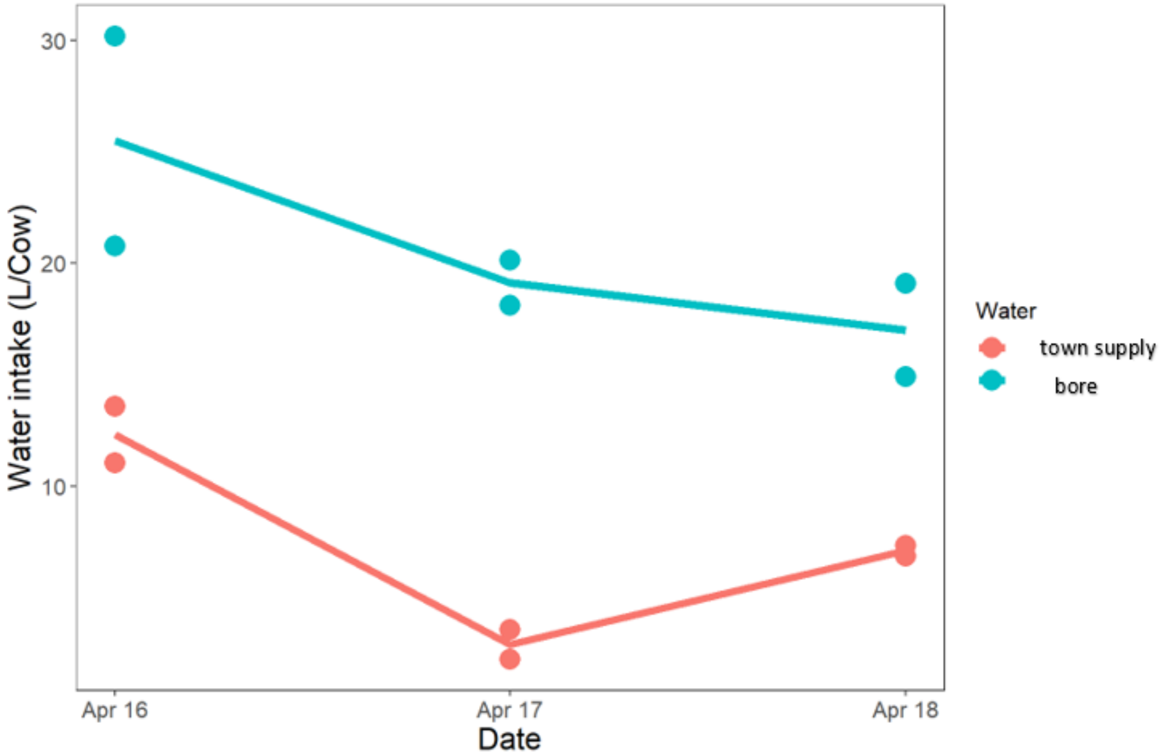


Figure 3 Preference for drinking water source (town supply vs. unfiltered bore water) by lactating dairy cattle (n = 2 groups, 20 cows/group) when given a free choice of both water sources over three days.



bore water, respectively. Not surprisingly, the rainfall decreased voluntary water intake, likely due to water intake through the feed being greater. Cows consumed approximately on average 9 L of water/day through their feed. It has previously been shown that 26.4 mm of rainfall on one day decreased voluntary water intake by pastured dairy cattle by 62% (Morris et al. 2010). It is also likely that the voluntary water intake was underestimated on rainy days since the troughs had no roof and thus rain would fall into the trough. The water intake was lower during the second half of the study and we speculate that rainfall and cows drying themselves off, which is normal for this time of year, may have contributed to this. Overall, the voluntary water intake was low compared to cows milked once-a-day in mid lactation on the same farm (average 86 L/cow/day, Schütz et al., unpublished data) and this is likely due to the time of year including different environmental conditions, and production level. Milk production was not influenced by the water source provided to the cows.

The results (descriptive only) from the preference study indicate that the cows preferred to drink the bore water over the town supply. The bore water may have contained some components that were attractive to cows, for example, ruminants have a recognised appetite for sodium (Grout et al. 2006). However, the bore water was also higher in magnesium, which cows seem to avoid (Grout et al. 2006). The cows in the study were used to drinking the unfiltered bore water as this was the main source of drinking water on the farm. Other studies have shown that previous exposure or experience to a particular resource, such as lying substrate, influence animal preferences (Tucker et al. 2003). It is also possible that the cows found the taste or smell of the town water to be more aversive than the bore water, due to for example the presence of chlorine in town water.

The definition of water quality typically encompasses physiochemical factors (e.g., turbidity, taste, smell), micro- and macro-mineral elements, organic matter, and microbial contaminants, as well as potential risk from anthropogenic pollutants and contaminants. Most measures of water quality in the present study were within the recommended levels for what is considered safe for humans and livestock, except for high concentrations of iron and manganese in the unfiltered bore water. The iron levels at the study farm were much higher than what has previously been found on the North Island (13.9 mg/L vs. 0.32 mg/L water, Abacus Biotech 2005), and is much higher than what has previously been recommended safe for humans and livestock (0.2 mg/L water, Beede 2012). The levels of manganese on the study farm were also higher (1.42 mg/L) than what is deemed safe for humans and livestock (0.05 mg/L water, Beede 2012). Cows did not seem to mind drinking the bore water and in fact showed a preference (not statistically tested) to drink this water. Considering the well-known negative effects of high iron levels on dairy cattle health (e.g., compromised immune function, increased fresh cow mastitis and metritis, greater incidence of retained foetal membranes as well as diarrhoea, sub-normal feed intake, decreased growth, and impaired milk yield), studies investigating the long-term effects on the health and productivity of cows drinking water high in iron, and also manganese, are warranted. It is unclear at this stage whether the preference to drink the unfiltered bore water over town supply is due to previous experience and/or palatability of the drinking water. We encourage future studies to investigate water intake and animal preference for town supply and unfiltered and filtered bore water using cows that are used to different water sources.

Acknowledgments

This study was a collaboration between Livestock Improvement Corporation (LIC), DairyNZ, and AgResearch Ltd. and funded by Our Land and Water (contract reference: RPF 2). Shen Hea (AgResearch Ltd) undertook all statistical analyses. We are very grateful to DairyNZ Lye and Scott farm staff Stu Morgan, Bruce Sugar, Ben Fisher, Matt MacDonald, Johannes Nagel and Olivia Jordan for their assistance during the trial.

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