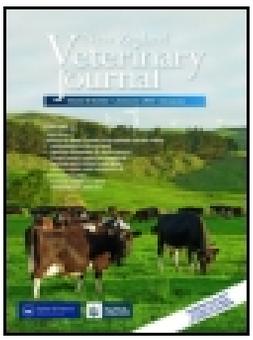

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Short Communication

In situ provision of drinking water to grazing dairy cows improves milk production

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Abstract

AIMS: To determine the effect of providing water within the area grazed by dairy cows on milk yield and quality, compared to requiring cows to walk to a distant water trough, on a dairy farm in the Pampa region of Argentina during summer.

METHODS: Holstein dairy cows were allocated to two herds with similar parity, days in milk and milk production. They were grazed in one paddock that was divided in two, with a fixed water trough at one end. Cows were moved twice daily to grazing plots within the paddock. Control cows (n=66) could only access water from the fixed trough, whereas supplemented cows (n=67) also received water from a mobile trough within the grazing plot. Milk production of each cow, and water consumption of the two herds were measured daily over 62 days. Milk composition for each herd was determined weekly from Days 18 to 60 of the study, and grazing behaviour was observed between 08:00 and 16:00 hours on Days 11–15, 19–22 and 39–43.

RESULTS: Over the 62 days of the study, supplemented cows produced 1.39 (SE 0.11) L/cow/day more milk than Control cows (p=0.027). Estimated mean daily water intake was 50.4 (SE 2.1) L/cow/day for supplemented cows and 58.2 (SE 2.7) L/cow/day for Control cows (p=0.004). Percentage total solids in milk was higher for supplemented (12.5 (SE 0.06)%) than Control (12.4 (SE 0.04)%) cows (p=0.047). During the periods of behavioural observation, a higher percentage of cows in the water supplemented than the Control herd were observed in the grazing area (p=0.012).

CONCLUSIONS AND CLINICAL RELEVANCE: This preliminary study demonstrated that provision of water to dairy cows within the grazing plot was beneficial for milk production and composition, and may be associated with longer periods spent within the grazing area, during hot weather in the Pampa region of Argentina.

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KEY WORDS: *Dairy cow, water supply, milk production, grazing, hot weather*

Introduction

Water should be considered the most important nutrient for the health and productive development of dairy cattle, as the daily water turnover rate of dairy cows is among the highest recorded in mammals (Murphy 1992). Water represents about 70% of a cow's body composition and milk is 87% water (Andrew *et al.* 1994). Water intake varies with environment, production, and diet, and affects digestion and nutrient absorption (Murphy *et al.* 1983; Fraley *et al.* 2015). Improving the diet to meet the high energy requirements of cows during lactation is usually the focus when trying to improve milk production, and the need for unrestricted availability of drinking water is generally ignored because it is supposed to be obvious.

Water requirements depend on factors related to the animal, including physiological state, milk production, physical activity; factors related to diet, including the amount and chemical composition of the ingested food; and factors related to the environment, including temperature, humidity, wind speed and availability of shade (Beede 2005). Losses through evaporation and sweat are greater when the temperature rises, or when there is more physical activity, such as walking to and from pastures and fodder crops, especially in hot weather (Beede 2005). In a recent systematic review of the effects of drinking frequency on performance of cattle, reduced frequency of drinking was found to result in decreased milk yield and milk fat percentage in the majority of studies, although the reductions were small (Williams *et al.* 2016).

In dairy production systems which include high grazing activity of cows, as in many Argentine farms, drinking water may not be accessed as frequently as the producer believes. Water troughs are generally placed in the corner of large (50 Ha or more) paddocks, within which animals are allowed to graze on successive plots, delimitated by electric wires which are moved daily. To reach the water trough, cows must walk along lateral lanes, which may be >1,000 m in length, frequently under high temperature conditions. Moreover, due to the patterns of cattle social behaviour, the departure of the first cows to the trough is immediately followed by the rest of the herd, which stop eating and then stays around the water troughs for several hours (Craig 1986; Bavera 2001). The aim of the current study was to determine the effect of providing water within the area grazed by dairy cows on milk yield and quality, compared to requiring cows to walk to a distant water trough, on a dairy farm in the Pampa region of Argentina during summer.

Materials and methods

The study was conducted at the dairy farm of the Experimental School of Inchausti, 25 de Mayo, Province of Buenos Aires, Argentina (35°36′ S, 60°32′ W), over 62 days of summer, between 29 November 2012 (Day 0) and 30 January 2013. All procedures involving the experimental use of animals were approved by the Animal Ethics Committee of the Inchausti Experimental School (Buenos Aires, Argentina).

For this study, 133 Holstein cows were allocated to two herds (water supplemented and Control) with similar mean parity (3.1 (SE 0.2) and 3.2 (SE 0.2)), days in milk (148.6 (SE 8.6) and 153.4 (SE 9.7)), and daily milk production in the previous 30 days (30.1 (SE 0.7) and 30.5 (SE 0.9) L/day). Both herds grazed on the same pasture which was divided into two equivalent strips, and cows were moved morning and evening to graze a new plot, as shown in Figure 1. The size of each plot was between 0.7 and 0.8 Ha. Two paddocks were used during this study, one measuring 400 m wide by 500 m long, and the other measuring 400 m wide by 600 m long. The Control herd (n=66) was managed according to normal practice with a drinking trough that was 12 m in length at one end of the paddock, accessible by a lateral lane. From Day 6, the water supplemented herd (n=67) received drinking water inside the grazing plot, by means of a mobile trough. This trough was 1 m in length with a capacity of 190 L, was mounted over skates and filled by a pressurised system of buried pipes, with a flow of 3 m^3/hour. The mobile trough was moved daily from plot to plot along with the herd. Both herds had access to an artificial sun shade net and fixed drinking troughs, at the end of the paddock.

All the cows were milked twice a day, and given 6 kg/day of corn silage after afternoon milking and 4 kg/day of a commercial concentrate (17% crude protein, 7.11 MJ ME/kg DM) equally distributed twice daily in the milking parlour. Drinking water was not provided in the milking parlour. Individual daily milk production was recorded by means of an Alpro-Milking (DeLaval, Buenos Aires, Argentina) computerised system. Milk from both herds was preserved in separate tanks. The ambient temperature was recorded daily. To estimate the water consumed, flowmeters were placed in every drinking trough and the total consumption of each herd was recorded daily between Days 6 and 62. From Day 18 onwards, once a week, samples of bulk tank milk of each herd were taken for measurement of total solids, fat, protein, lactose, somatic cell count and colony forming units. The analyses were performed at the commercial laboratory of the dairy (Lavima, Villa María, Córdoba, Argentina). On Days 11–15, 19–22 and 39–43, from Monday to Friday, every hour from 08:00 to 16:00 hours (thus a total of 135 observations), the number of cows inside the grazing plots for both herds and the number of cows drinking in the mobile trough of the water-supplemented herd were recorded.

Statistical analysis

Production data and percentage of cows in the grazing plot were compared between herds by two-way ANOVA for repeated measures where factors were treatment and time (day for milk production, hour for cows in the plot). If the interaction was significant, *post hoc* comparisons were carried out using Fisher's LSD. Water intake, milk composition and milk quality were compared between herds by one-way ANOVA. Analyses were carried out using R version 3.1.0 (R Development Core Team, 2014; R Foundation for Statistical Computing, Vienna, Austria).

Results

The mean daily milk production of cows in both herds is shown in Figure 2. The water supplemented herd produced more milk than the Control herd (p=0.027), and for both herds milk yield decreased with time (p=0.002). There was a tendency for a treatment by time interaction (p=0.058). The mean difference in milk production for the 62 days of the study was 1.39 (SE 0.11) L/cow/day, which represented an overall increase of 86.2 L/cow during the period.

Estimated mean daily water intake by cows from all troughs between Day 6 and 62 was 50.4 (SE 2.1) L/cow/day for supplemented cows and 58.2 (SE 2.7) L/cow/day for Control cows (p=0.004). The volume of water consumed per litre of milk produced was 1.88 (SE 0.07) L/L for supplemented cows and 2.30 (SE 0.10) L/L for Control cows (p<0.001).

Mean air temperature oscillated between 21.5 and 38.0°C, and only 3 days had a mean temperature below 25°C. No correlation was found between difference of milk yield between herds and air temperature (data not shown).

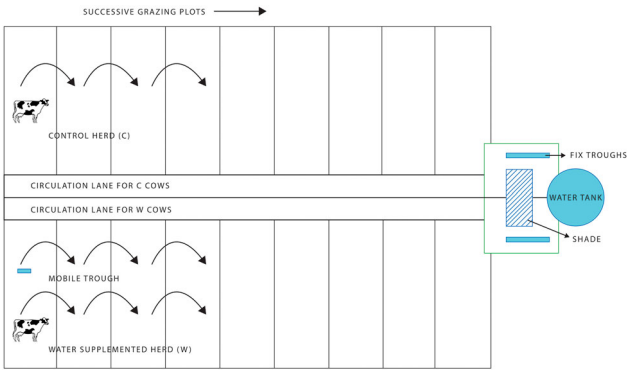

Figure 1. Diagram illustrating the arrangement of grazing plots and provision of water troughs for dairy cows supplemented, or not (Control), with water while grazing in the Pampa region of Argentina. Both herds had access to shade and water at the end of the paddock. Supplemented cows had an extra water trough inside the grazing plot which was moved with the cows.

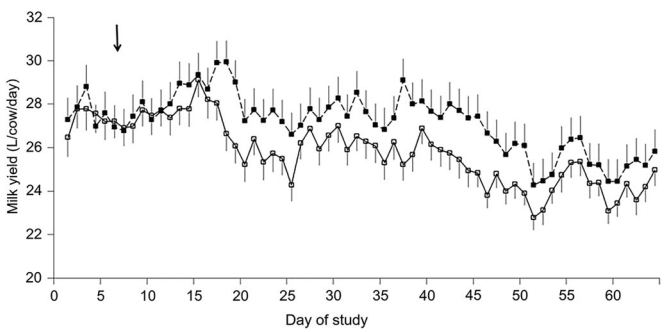

Figure 2. Mean (±SE) daily milk yield (L/cow) of dairy cows supplemented (closed circles; n=67), or not (open circles; n=66), with water while grazing in the Pampa region of Argentina between November 2012 and January 2013. The vertical arrow on Day 6 marks the beginning of *in situ* water supplementation.

Table 1. Percentage of total solids, fat, protein and lactose in the milk of dairy cows supplemented (WS; n=67), or not (Control; n=66), with water while grazing in the Pampa region of Argentina between November 2012 and January 2013, measured in bulk tank milk between Days 18 and 60 of the study.

	Total solids		Fat		Protein		Lactose	
Day	WS	Control	WS	Control	WS	Control	WS	Control
18	12.56	12.45	3.47	3.46	3.27	3.19	4.95	4.93
25	12.43	12.4	3.46	3.44	3.18	3.16	4.92	4.99
32	12.9	12.47	3.63	3.6	3.29	3.2	5.07	5.01
39	12.42	12.15	3.46	3.25	3.15	3.1	4.94	4.94
46	12.47	12.29	3.52	3.25	3.23	3.17	5.02	5.11
53	12.48	12.39	3.5	3.44	3.2	3.23	5.03	5.01
60	12.5	12.43	3.45	3.32	3.18	3.13	5.14	5.22
Mean ±SE	12.54±0.06	12.37±0.04	3.5±0.02	3.40±0.05	3.21±0.02	3.17±0.02	5.02±0.03	5.03±0.04
P-value [a]	0.047		0.079		0.097		>0.1	

[a] Significance of difference between herds

Mean composition of milk measured between Days 18 and 60 for the two herds is shown in Table 1. Percentage total solids in milk was higher (p=0.047) and percentage fat and protein tended to be higher (p<0.1) for water supplemented than Control cows. There were no differences (p>0.1) in mean colony forming units or somatic cell counts between herds (data not shown).

During the periods of behavioural observation, the percentage of cows in the grazing plots differed between herds (p=0.012) and over time (p<0.001; treatment by time interaction p=0.003). A higher percentage of cows in the water supplemented than the Control herd was observed in the grazing area, especially at 10:00, 11:00, 12:00 and 13:00 hours (Figure 3). Of the cows in the water-supplemented herd, at least one cow was drinking at the mobile trough during 66/135 observations (1 cow 16 times, 2 cows 17 times, 3 cows 7 times, 4 or 5 cows 16 times).

Discussion

The results of this study showed that providing drinking water in the grazing area of dairy cows improved cow performance. The longer time spent by the cows in the grazing plot may be in part responsible for the improvement. More of the cows in supplemented herd were observed in the grazing plot than Control cows, which may be indicative of higher time spent grazing and perhaps a higher pasture intake. The increase in milk production may be also accounted for by a beneficial effect on the animals' well-being, as it has been shown that cows prefer to alternate, if given the chance, grazing with short periods of drinking (Sporndly and Wredle 2005). However, there are not many studies which examined the drinking behaviour of grazing animals. Most of the studies have been conducted in Europe or the United States of America, with animals in barn systems. It has been observed that the periods of greater water intake are those close to milking and feeding, though cows seem to prefer to alternate eating with drinking water (Cardot *et al.* 2008). Observations during our experiment showed that a 1-m-wide trough was enough for 70 cows as they drank sporadically and then returned to graze or lay ruminating. Only in half of the observations were cows drinking at the supplementary trough. These cows left the pasture plot to search for shade mostly after 13:00 hours, which was later than the Control herd.

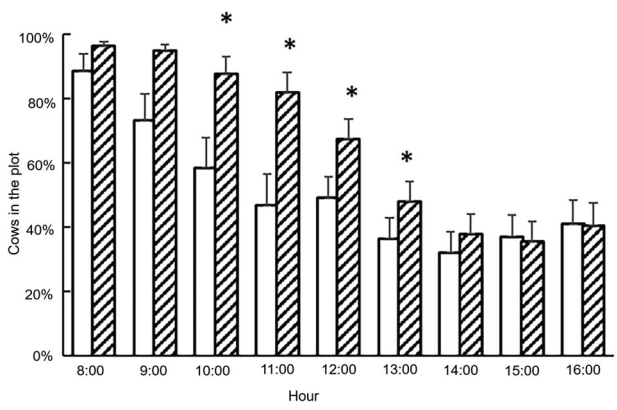

Figure 3. Mean percentage (±SE) of cows observed in grazing plots between 8:00 and 16:00 hours on Days 11–15, 19–22 and 39–43 of a study comparing milk production of dairy cows supplemented (open bars; n=67), or not (hatched bars; n=66), with water while grazing in the Pampa region of Argentina, between November 2012 and January 2013. *Means differed between herds (p<0.05).

The increase in milk production observed in the supplemented cows cannot be explained by a greater water intake; on the contrary, cows without water in the pasture consumed more water, and water consumption per litre of milk produced was higher in the Control than supplemented herd. Changes in water intake and dry matter intake during lactation have been examined using different models of adjustment, and have been related to milk production (Kramer *et al.* 2009). The total intake of water per litre of milk produced for dairy cows was reported to be between 2.6 and 4.2 L/L (Sporndly and Wredle 2005). In our study, this ratio was lower in both experimental groups, but we did not measure water in the pasture consumed, as no estimation of forage intake was performed. Water content of pasture can vary highly depending on species of legumes or grass, time of day, and on the different stages of plant growth and maturity (Riedo *et al.* 1998). In this study forage quality and availability were similar for both herds. On the other hand, voluntary water consumption also depends on the saline concentration of the drinking water (Grout *et al.* 2006), but as both herds obtained water from the same source differences in consumption resulting from salt content may be ruled out.

The fact that there was no correlation between temperature and difference in milk production between herds was surprising. Preliminary studies during the previous summer on the same farm had suggested a positive correlation between both variables,

with a higher difference in milk production between herds on the hottest days. Moreover, studies conducted in Uruguay, showed that the difference between herds with treatments comparable to those in this study were higher in summer-spring than in autumn-winter (Piaggio and García 2004). The continuous high temperatures observed during the two months of the present experiment may be disguising the effect, as there was little variation in temperatures. More studies under different environmental conditions are needed to understand the temperature effect.

Milk composition depends on a variety of factors including cow genetics, nutrition and environmental factors (Schwendel *et al.* 2015). Breed, season, diet and their interaction are the most important factors influencing fatty acids profile and protein concentration in milk (Bargo *et al.* 2003; Adler *et al.* 2013). Studies on water intake restriction have demonstrated either an increase (Bjerg *et al.* 2005), or no effect (Steiger Burgos *et al.* 2001) on milk fat content. Management and animal welfare have also been found to influence not only milk yield but also milk quality and composition (de Vries *et al.* 2011). In the present study, percentage total solids in milk were higher in the herd that received supplementary water in the grazing plot and spent a greater percentage of time there, however further research is needed to clarify the relationship between behaviour and milk composition.

In conclusion, provision of water to dairy cows within the grazing plot was beneficial for milk production and composition, and may be associated with longer periods spent within the grazing area, during hot weather in the Pampa region of Argentina. Further studies are needed in other seasons to better understand the interaction with environmental factors.

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