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Case Study: Water budget of a dairy farm with a tie-stall barn for milk cows and summer pasturing of heifers and dry cows

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ABSTRACT

Water use (i.e., pumped water) was measured over a full year on a small dairy farm consisting of ~34 lactating and ~39 nonlactating animals (calves, heifers, and dry cows). Crop production was rain fed and was not included in the analysis. Animals were housed in a tie-stall barn during the winter and cool season (mid-October to mid-May) and outdoors in a yard or pasture during the warm season. Annual average water use was 5,180 L/d, with 82% being drinking water and 18% for milking system cleaning. Distinct diurnal patterns of drinking water intake were observed for each animal group, which differed when cows were located indoors or outdoors. Seasonal changes in water intake were significant. Nonlactating animals accounted for 27% of whole-farm water intake in the summer (July–September). In the warm season, herd-scale milk production declined while water consumption increased. As a result, the whole-farm water used per liter of milk had a strong positive correlation with monthly average temperature humidity index (THI) and could have been additionally influenced by other factors such as herd composition, precipitation, feed intake, forage quality and availability, and day length. When THI was below 50, water use ranged from 4.3 to 4.8 L/kg of milk, and it increased to a maximum of 6.7 L/kg at a THI of 68. The annual average water use was 5.35 L/kg of milk. This study demonstrates that the water used per kilogram of milk produced was affected not only by changes in water use but also by changes in herd-scale milk production.

Key words: water use, water budget, water footprint, dairy cattle, milk production

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INTRODUCTION

Dairy farms rely on water as an essential input for milk production, and the considerable amount being used has triggered the dairy sector at global and national levels to recognize the need to proactively manage freshwater resources (DFC, 2016; FAO, 2016; IDF, 2016). Sustainability indicators such as the water footprint (**WF**) are being reported in scientific literature and popular press; the public is interested in the environmental implications of their purchasing decisions. At the farm level, water resources are increasingly under scrutiny from regulatory agencies, and in several jurisdictions, dairy farms are required to report their water intake to governing bodies (Cornell University, 2017; NYDEC, 2017). All of these stakeholders are interested in a clear understanding of the whole-farm water use of dairy production per unit of milk produced. Measuring water use (i.e., pumped water) is also the first step to developing and implementing on-farm water conservation methods.

Dairy farms can take many forms: entirely pasture-based systems (e.g., New Zealand), traditional small-scale and entirely barn-based systems in Europe, 10,000-cow drylot farms (western United States), and many other forms worldwide. Although the general trend, globally, is toward increasing herd size and indoor housing, there are still many small dairy farms that operate small herds with a mix of indoor housing and pasture.

In eastern Canada, small operations are the most common dairy farm type (Sheppard et al., 2011; CDIC, 2015), and it is common to have all milking cows and all nonlactating animals in one location. Canadian dairy farmers strive to effectively manage the lactational and reproductive performance of their herds to maintain production levels that accurately meet the allocated monthly milk production quota for the farm to comply with the quota system in Canada.

Water is required mainly for drinking (e.g., maintenance, productivity, thermoregulation) and for cleaning the milking system, which is critical to ensure purity of the milk product. Tie-stall operations (one prevalent example for Canadian small-scale dairy operations) use a pipeline system whereby the cows are milked in their stalls, rather than in a milking parlor.

Although drinking water requirements for lactating cows have been studied previously, and predictive equations have been presented (e.g., Murphy et al., 1983; NRC, 2001; Cardot et al., 2008), there remains a need for scientific data to develop and verify farm-scale water budgets (Harner et al., 2013). It is important that these data capture all aspects of dairy farm water use and reflect local climatic conditions and specific dairy farm management practices. This type of data will benefit farmers by ensuring optimal water supply to their animals and provide data for ground truthing farm water-use models and WF assessments.

The objectives of this case study were to (1) determine the annual water budget and water used per kilogram of milk in a farm with a tie-stall barn for milking cows in winter and seasonal pasture for nonlactating animals and (2) partition the water budget among uses on a monthly and seasonal basis.

MATERIALS AND METHODS

Farm Site

The case study was conducted over a 12-mo period (October 2014 to September 2015) on a dairy farm in eastern Ontario, ~6 km outside the city of Ottawa, ON, Canada. Animals used in the experiment were cared for under guidelines comparable to those of the Canadian Council on Animal Care.

During the cool season (mid-October to mid-May), lactating Holstein cows were housed in a timber-framed tie-stall dairy barn with an adjoining milkhouse (Figure 1). During the warm season (mid-May to mid-October), milking cows were pastured in an adjacent 4-ha yard (Figure 1) and returned to the dairy barn for feed and milking twice daily at 0400 and 1600 h. Water was supplied to the barn by a 2.54-cm-diameter PVC line from a drilled well with a submersible pump. Water quality was analyzed at a commercial laboratory (SGS-Agri-Food Laboratories, Guelph, ON, Canada) with results as follows: pH, 7.6; electrical conductivity, 1.6 mS/cm; total dissolved solids, 1,065 mg/kg; nitrate-N, 9.0 mg/kg; total hardness, 350 mg/kg; chloride, 336 mg/kg; bicarbonate, 271 mg/kg; phosphorus, <1.0 mg/kg; potassium, 11.8 mg/kg; calcium, 72 mg/kg; magnesium, 40.0 mg/kg; zinc, <0.1 mg/kg; sulfate, 94 mg/kg; sodium, 179 mg/kg; iron, <0.1 mg/kg; copper, <0.1 mg/kg; manganese, <0.1 mg/kg; boron, 0.55 mg/kg; and silicon, 3.9 mg/kg. Milking cows had water bowls at the stalls connected by 2.54-cm-diameter pipe, and in summer a stock tank (~400-L capacity) was located in the yard supplied by a 1.27-cm-diameter hose from the tension fabric building.

Nonlactating animals were housed in a tension fabric building with pens during the cool season where water was supplied by a 2.54-cm-diameter PVC line to heated water bowls. During the warm season (mid-May to mid-October), calves (0 to 2 mo) and heifers (2 to 15 mo) remained in the tension fabric building, and dry cows and bred heifers (15 to 24 mo) were kept on a separate 7-ha pasture 350 m from the barn where water was supplied on demand using nose pumps with a 2.54-cm-diameter PVC

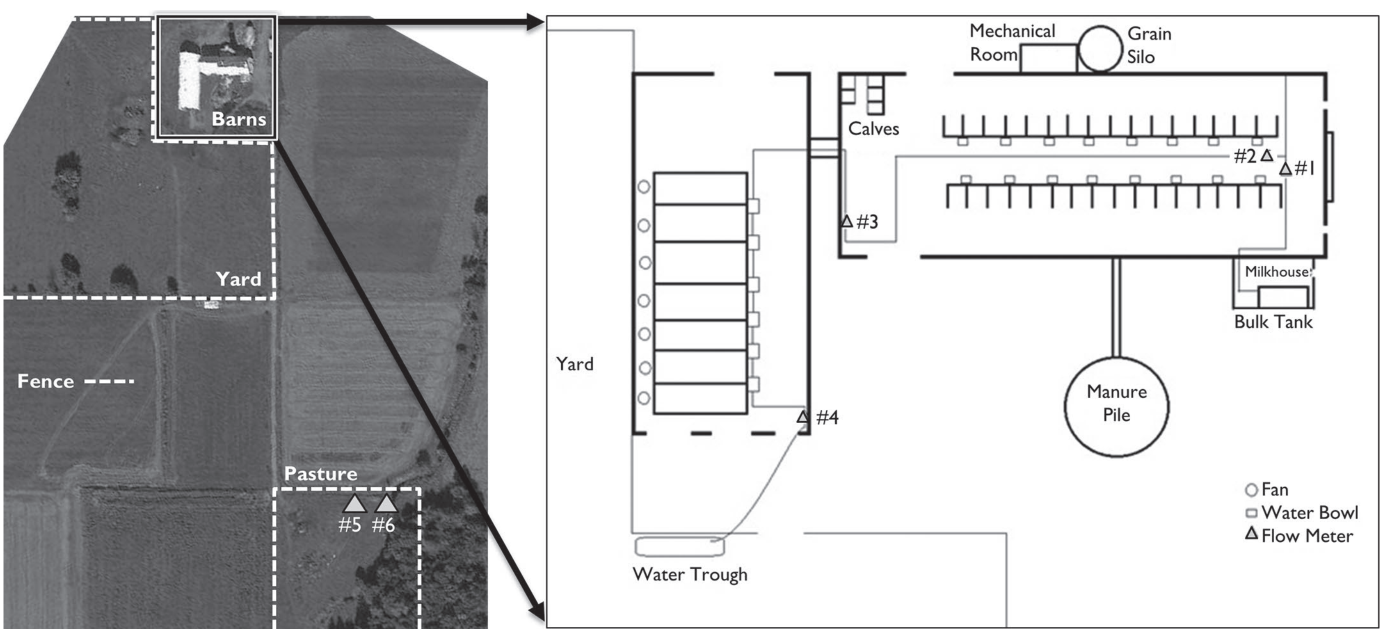

Figure 1. Schematic of study farm, highlighting the barns, yard, and pasture areas. Detailed barn layout is shown on the right, with locations of 4 flow meters and major water pipes. Two water meters in the pasture are shown on the left. Note that the 4-ha yard and 7-ha pasture areas extend beyond the area shown.