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Lack of effect of hot summer conditions in Canterbury on milk production of dairy cows

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ABSTRACT

The occurrence of hot weather in Canterbury over 90 days during the 2008/2009 summer provided an opportunity to investigate the effects of climatic heat challenge on milk production by cows on commercial dairy farms in that region. An analysis of daily milksolids production and the peak temperature-humidity index (THI) recorded on each previous day was conducted for 13 farms in mid-Canterbury using data from 1 December 2008 to 28 February 2009. There were 19 days when dry bulb air temperature exceeded 27°C and the THI was 72 or higher, conditions at which heat stress has been suggested to occur in dairy cows. However, there was no significant inverse relationship between THI and milksolids production (P ranged from 0.193 to 0.897) on any of the farms using either all the data or only the data for days on which THI exceeded 72. With relative humidity being strongly inversely related to dry bulb temperature in Canterbury summers, THI values rarely exceed 75 in this region. As there were no discernable effects on productivity of these dairy cows during the episodes of hot weather, it is also unlikely that there would be any animal welfare concerns that could be attributable to climatic heat challenge in these conditions.

Keywords: temperature humidity index; heat challenge; milk production; Canterbury.

INTRODUCTION

The relatively recent and large-scale expansion of dairying in Canterbury has raised questions about the suitability of this environment for high-producing dairy cows. Coupled with the possibility of occasional days with a high temperature-humidity index (THI) (G.K. Barrell, Unpublished data) and the relative lack of opportunity for cows to become acclimatised to heat challenge in this region, as compared with Australian conditions, there is likely to be speculation that both cow welfare and productivity may be compromised during spells of hot weather in Canterbury. Some very hot days occurred in Canterbury during January and February 2009. These provided a *post hoc* opportunity to examine milk production data for evidence of negative effects of climatic heat challenge. This study analysed data obtained from 13 dairy farms in the Selwyn district of Canterbury, to determine whether the hot days had influenced milk production in herds containing high-producing dairy cows.

Evidence from overseas shows that dairy cows respond to heat stress by reducing milk production (Kadzere *et al.*, 2002; West, 2003). In addition this evidence suggests that environmental conditions in Canterbury are likely to cause episodes of heat stress. The hypothesis underlying the present study was that milk production will fall in response to increasing THI due to the thermoregulatory demands generated by heat stress in cows on dairy farms in Canterbury.

MATERIALS AND METHODS

Weather data

Weather data from the Broadfields (National Institute of Water and Atmospheric Research (NIWA) national weather database) and Robindale (Synlait Milk Ltd., Rakaia, Canterbury) weather stations were collected over the 90 days between 1 December 2008 and 28 February 2009. These data were integrated into a temperature humidity index (THI) which has been demonstrated in overseas studies to be a robust indicator of dairy production losses due to high temperature and humidity (Dikmen & Hansen, 2009). This index was calculated as:

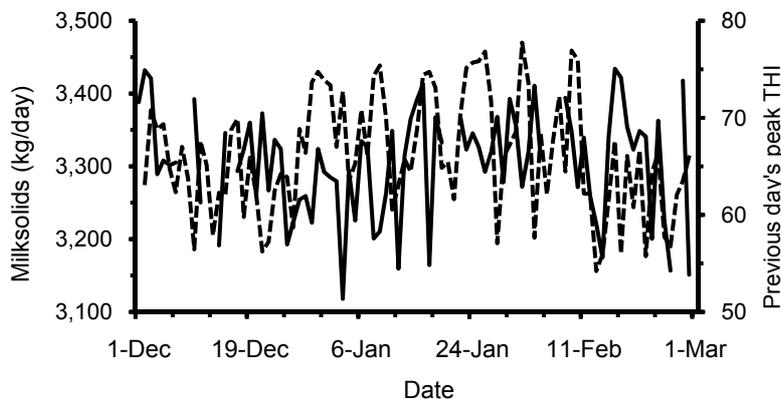
$$\text{THI} = \text{Dry-bulb temperature (}^{\circ}\text{C)} + 0.36 \text{ Dew-point temperature (}^{\circ}\text{C)} + 41.2 \text{ (Yousef, 1985).}$$

Daily peak THI was calculated using the maximum dry-bulb temperature recorded each day and its corresponding dew point temperature. Invariably, the maximum temperatures occurred during the afternoons.

Milk production data

Data for milksolids production were obtained from 13 dairy farms with 550 to 2,090 cows per herd and annual productivities ranging from 380 to 439 kg milksolids per cow, in the Selwyn district of Canterbury for the period from 1 December 2008 to 28 February 2009. These included 11 Synlait Milk Ltd. farms, the Lincoln University Dairy Farm and a farm owned by Mr M. Pangborn. In each case the data were supplied by courtesy of the owners from records provided by their milk processing

FIGURE 1: Day-to-day variation in seasonally adjusted milksolids production (—) and the previous day's peak temperature humidity index (THI) (----) recorded for a dairy farm milking 2,090 cows in Canterbury for 90 days over the middle of summer in 2008/2009.



companies from measurements of milk volume and milk composition.

Twelve farms were located between 0 and 20 km from the Robindale weather station. The Lincoln University Dairy Farm (LUDF) was closer to the Broadfields station at approximately 2 km distance. Data from the closest station was used in the analysis.

Data analysis

The main study compared daily milksolids production of each farm with the previous day's peak THI. Milksolids production data for each farm were adjusted to account for the effects of the decline in milk production at this period of the

season by fitting a linear regression of milksolids production by days-in-milk where Day 0 is 1 December 2008. Daily milksolids production for each farm was adjusted using the slope of the regression obtained for that farm. Any unusual observations identified by Minitab15 (Minitab Inc., State College, Pennsylvania, USA) that were greater than two standard deviation units, or any deviation from the fitted line of the milksolids curve greater than 15% was excluded from analysis.

Further regression analysis was undertaken to calculate the standard residual deviation in daily milksolids production and a regression analysis of deviations in milksolids and the previous day's THI, were carried out. More advanced analysis using Minitab15 was also undertaken after smoothing the THI and milksolids data in an attempt to identify any hidden relationships. Smoothing the data involved averaging blocks of five days. Other analyses were conducted to compare daily peak THI and the milksolids production data for the same day and for the following two, three, four, and five days using the same procedure. Milksolids production obtained when the previous day's THI exceeded 72 was analysed in the same manner for each farm.

RESULTS

There were large day-to-day fluctuations in THI and milksolids production within individual farms. The data shown in Figure 1, while recorded on one farm, were typical of the pattern on all farms in the study. Despite these wide fluctuations there were no significant inverse relationships between daily peak THI and milksolids production recorded the following day on any of the farms, using either the raw (Table 1) or the smoothed data.

There was a positive relationship ($P < 0.01$) for two of the farms (Ngamarua, Riverlands) in deviations in milksolids in relation to THI (Table 1). Figure 2 shows the raw data for one of these two farms, Riverlands. The spread of data, but not the positive trend in Figure 2, was typical of that of all farms in the study.

Analysis of a sub-set of the data utilising only days where THI exceeded 72 also showed no relationship between THI on a day and the next day's milksolids production on any of the farms. Comparison of daily THI with milksolids production on the same day or on subsequent Days 2, 3, 4, or 5 after the day, revealed significant

TABLE 1: Relationships (Slope and R^2), in order of decreasing slope, between deviations in milksolids (number of standard deviations from the mean) and the previous day's THI for 13 dairy farms in Canterbury recorded from 1 December 2008 to 28 February 2009.

Farm	Slope	R^2
Riverlands	0.062	0.14
Ngamarua	0.049	0.09
Marv Pangborn	0.014	0.01
Waitai	0.013	0.01
Beacon	0.008	0.004
Sakura	0.007	0.002
Morton Marsh	0.006	0.002
Lighthouse	-0.020	0.01
Lincoln	-0.003	0.000
Robindale	-0.005	0.001
Dunsandel Dairies	-0.006	0.001
Decade	-0.008	0.001
Tapatoru	-0.024	0.20

($P < 0.05$) inverse relationships in the case of one of the farms on the same day and Days 2 and 3 after the day, and on two of the farms on the same day and Days 4 and 5 after the day. On the other hand there was a positive relationship on one farm with production on the previous day, and a relationship on six farms between production on the previous day and production on Days 2 to 5 afterwards.

DISCUSSION

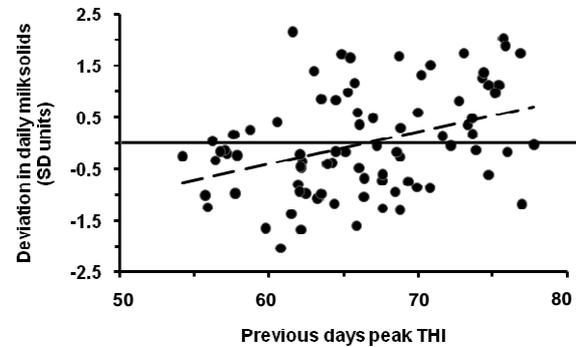
The results of this study reject the hypothesis that milk production in dairy cows in Canterbury will be reduced on days with high THI due to the thermoregulatory demands generated by heat stress. This finding must be restricted to the herds studied here, although they can be considered as representative of dairy farms in the Canterbury region experiencing typical summer weather conditions.

The over-riding pattern which has emerged from this study is that there is no detectable change in milksolids production due to a high THI on the day on which the milk was produced in the cows. The only significant relationships that were detected using the previous day's THI (Figure 2) or when the previous day's THI exceeded 72, occurred on two farms. The relationships were positive, not negative. This is counter-intuitive as it does not seem to be biologically possible and does not have any support in the literature. Likewise the occurrence of inverse relationships between daily THI and milksolids production on the same day, or on Days 2 to 5 following, was infrequent at two farms out 13, and was balanced by a similar occurrence of positive relationships which tends to indicate that these particular results are spurious. There is evidence (West *et al.*, 2003) for a lag phase of about two days for thermal stress to affect milk production in dairy cows. However, the low frequency of significant associations between THI and milksolids production two or three days later, that was recorded in this study, suggests that this delayed response did not occur in the cows studied here.

A New Zealand-wide analysis of dairy herd test data revealed a decline in milk production starting to occur at a 3-day average THI as low as 64.3 (Bryant *et al.*, 2007). Reductions greater than 10 g per day per unit increase in 3-day average THI occurred when the THI exceeded 68 to 75. However the present data are from within-herd comparisons conducted on a daily basis. It may be argued that this provides a more detailed picture than that obtained by the between-herd approach of Bryant *et al.* (2007). In Australia, use of within-herd comparisons similar to those of the present study revealed the occurrence of production losses only with THIs close to and above 80 (Mayer *et al.*,

FIGURE 2: Regression of the deviations in milksolids (number of standard deviations (SD) from the mean) and previous day's peak THI recorded for a dairy farm milking 1,590 cows in Canterbury for 90 days from 1 December 2008 to 28 February 2009.

Deviation in daily milksolids production (standard deviation units) = 0.062 Previous day's peak THI - 4.12 $R^2 = 0.14$



1999). Comparisons with overseas results may not be helpful. In many such cases, high THI values occur for long durations within a day and for several days without respite. This would provide far larger thermal loads than the short elevations of THI recorded here in Canterbury, although they might enable cows to acclimatise to the prevailing climatic conditions. The THI values recorded in the present study were based on the peak daily air temperature which was always transient, never maintained overnight, and rarely occurred for more than two consecutive days. This means that dairy cows in Canterbury rarely experience sustained heat loads. They invariably have a nightly cool respite in which to dissipate heat accumulated during the preceding day. Therefore, a high peak THI value recorded in Canterbury cannot validly be compared with the same value recorded at locations where it may remain elevated for a prolonged period. On the other hand, variability in the climate patterns experienced in Canterbury provides little opportunity for acclimation.

A feature of the climate data recorded here is the very strong negative correlation between temperature and relative humidity for the Robindale (Slope = -2.75 ; $R^2 = 0.76$) and Broadfields (Slope = -2.60 ; $R^2 = 0.66$) weather stations. It is clear that increases in ambient temperature are associated with a corresponding drop in relative humidity. This situation occurs as a result of the effect of the hot, dry north westerly föhn wind ("Nor'wester") which Canterbury experiences. This wind is unique to Canterbury and some limited regions of New Zealand, such as the Wairarapa. Analysis of weather stations from other dairying regions, such as Taranaki, Waikato and Northland, indicate a greater variation between temperature and relative

humidity. As evaporative cooling is an important heat loss mechanism for dairy cows it can be expected that the drop in relative humidity as air temperature rises mitigates against thermal stress. This may explain why cows in the herds studied here showed no evidence of any adverse impact of hot days on milk production.

While there is no empirical measure of the “welfare level” for cows, the absence of an effect of thermal load on milk production in Canterbury suggests that the climatic conditions over summer may only have minimal impact on welfare. However, a high level of milk production is no guarantee of high welfare (Von Keyserlingk *et al.*, 2009). An indication of thermal stress may be gained from elevations of core body temperature which occur when heat load exceeds thermoregulatory capacity. Dairy cows in Canterbury have been shown to not exhibit a relationship between body temperature and THI, until the latter exceeded 72 (Verwoerd *et al.*, 2006). In the present study THI values above 72 were relatively rare and transitory, thus there were only a few occasions when heat loads would have been excessive. This consideration plus the absence of decreases in milk production suggest that the hot days experienced in Canterbury during the 2008/2009 summer had little impact on welfare or productive performance of dairy cows in the region.

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