Heat stress in dairy cows and the effect of a shade structure

C.J.C. Muller[1,2#] & J.A. Botha[2]
[1]Department of Animal Sciences, University of Stellenbosch, Stellenbosch 7600;
[2]Western Cape Department of Agriculture, Research Technology Development and Services, Directorate Animal Sciences, Private bag X1, Elsenburg 7607

Abstract

Heat stress in dairy cows is an increasing problem because of climate change. Even though South Africa has a warm to hot climate, little research on this topic has been done locally. Currently, while intensive housing is increasing being used in large dairy production systems, a shade structure provides the first step to protect cows against heat stress improving production performance and welfare. This paper provides results on the production performance, physiological parameters and behaviour of Holstein-Friesian cows with and without access to a shade structure during summer. The effects of heat stress on primiparous Holstein-Friesian and Jerseys cows in a breed comparison study are also shown. The milk yield of Holstein-Friesian cows with access to shade was significantly higher than that of cows without shade. Although the difference in milk yield was small (5.5%), the difference between the accumulative milk yield between shade and no shade cows increased over time for each of the three summer seasons, indicating a decreasing ability of cows without shade to withstand heat stress conditions. The internal rate of return on the capital outlay for the construction of a shade structure showed a positive return on investment within three summer seasons. Jersey cows displayed a higher tolerance to heat stress than Holstein-Friesian cows suggesting that they would be more suitable for a hot environment. However, the large difference (*ca* 30%) in production performance should be taken in account when considering a change in breed. Ways to alleviate the effect of heat stress on dairy cows are suggested.

Keywords: Breed differences, economic evaluation, feed intake, heat tolerance indicators, water intake
[#]Corresponding author: careljcmuller@gmail.com

Background

Dairy breeds being used in South Africa originated in the United Kingdom and Western Europe. Both regions have a wet and cool to cold climate. Therefore, the environmental comfort zone for dairy cows varies between -5 and 21 °C. Anatomical features that help cows withstand cold conditions include a thick skin, a dense hair coat, subcutaneous fat layers, large muscles and a digestive system that is based on fermentation processes in the rumen creating internal heat. These features, however, make dairy cows highly sensitive to a warm to hot environment. The climate in South Africa is in comparison warm and drier with more actual sunshine hours because of less cloud cover. Direct and indirect solar radiation is the cause of heat stress. Cows will avoid direct sunlight seeking shade of any kind while also using water to cool down seeking out wet places to stand or to lie down. Heat is also lost through panting, i.e. increasing the respiration rate. As cows have limited means to reduce the effect of heat stress, environmental manipulation is required to help cows maintain production levels under hot conditions. Heat stress may be long term (seasonal) or short term (heat waves). Although there are different ways to alleviate heat stress on dairy cows, a shade structure is the most simple and cost-effective way to reduce the effect of heat stress.

Aim

In this paper results on the effect of a shade structure on the production, physiological parameters and behaviour of Holstein-Friesian cows is provided as well as the effect of heat stress on primiparous Holstein-Friesian and Jerseys cows. Ways to alleviate the effect of heat stress are suggested.

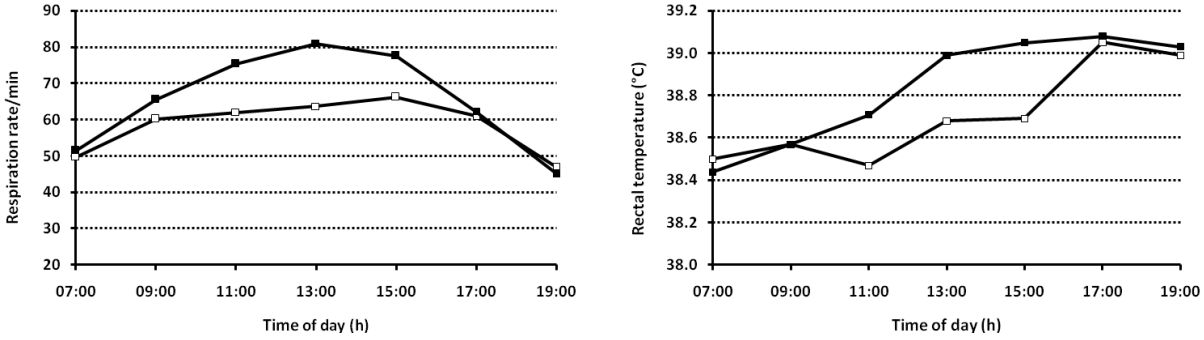
Results and Discussion

Even though South Africa has a hot climate, only a few studies have been done locally on the effect of the environment on the production of dairy cows. At Elsenburg the production performance, stress levels and behaviour of Holstein-Friesian cows with and without access to a shade structure during summer was compared (Muller, 1991). The shade structure was 3.65m high, orientated lengthwise north to south and provided at least

4 m² of roof space per cow. Summer days were characterized by high day-time temperatures, about 28 °C, and cool nights with minimum temperatures of about 14 °C. Ambient temperatures were higher than 21 °C for about 11 hours per day. Black globe temperatures integrating the net effects of solar radiation from the sun, ground surface and other objects close-by underneath the shade structure and in the sun differed (P<0.01) being 30 and 40 °C, respectively.

Cows with access to shade had higher (P<0.05) feed intakes during the day. The daily free-water intake of cows without shade was higher (P<0.05) than that of cows with access to shade, being 114 vs. 97 liters per cow per day, respectively. Overall, cows with access to shade produced 5.5% (P<0.05) more milk than cows without shade. Although linear regression analyses showed that the average daily milk yield of cows was not affected (P>0.05) by increasing maximum temperatures, the difference in the cumulative milk yield for shade and no-shade cows increased (P<0.05) for each experimental period indicating an increasing negative effect as summer progressed probably indicating the long term effect of heat stress. Cows maintained their daily feed intake as they had adapted their feeding pattern towards the cool times of the day. About 55% of the total daily feed intake was at night when ambient temperatures were below 24 °C. Most cows would also complete most of their daytime feed intake before 09:00 in the morning. Only a small number of cows would eat again during the hot time of the day from 11:00 to 13:00.

Providing shade resulted in reduced (P<0.05) stress levels as observed in lower cortisol levels. Thyroxine levels were reduced (P<0.01) by increasing maximum temperatures with no-shade cows showing a greater reduction. The rectal temperatures and respiration rates of cows using shade was lower (P<0.05) than that of cows without shade. In Figure 1 the mean respiration rate and rectal temperatures of Holstein-Friesian cows with access to and without shade on hot days when maximum temperatures exceeded 25 °C. Rectal temperatures similarly increased (P<0.05) during the day for both shade and no shade cows although being lower for shade cows. The rectal temperature of shaded cows was higher at 17:00 probably because of the activity associated with the afternoon milking process. It is for this reason that it is generally recommended that, during summer, the afternoon milking session be moved closer towards the evening when ambient temperatures are expected to be lower than at 15:00.



(a) (b)

Figure 1 The average (a) respiration rate and (b) rectal temperature of Holstein-Friesian cows with access to shade (□) and without shade (■) on hot days (day-time maximum temperature >25.0 °C)

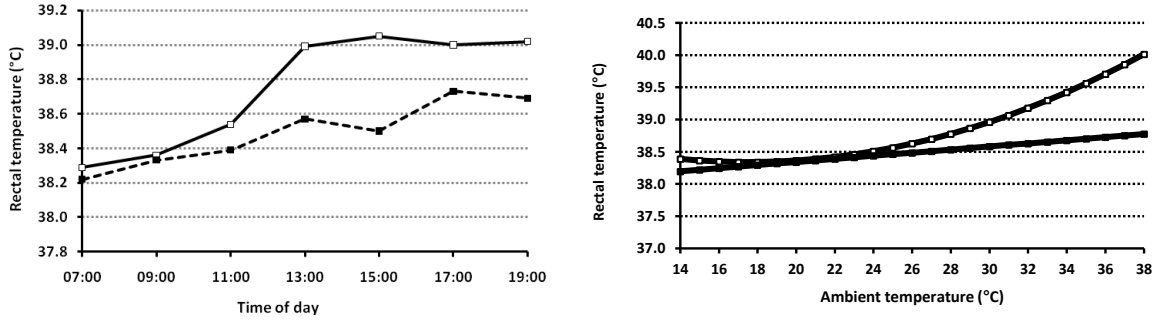
Cows without shade also adapted their daily behaviour to cope with heat stress. They converged at the water trough with some cows standing with their front feet inside the trough while other cows would use another cow's body to shield their heads from the sun.

In this study the positive milk yield response to shade was relatively small (5.5%) in comparison to studies conducted in other parts of the world. The reason for this is because of cool conditions at night, i.e. ambient temperatures below 21 °C. This cooler period allowed cows to recover from the day-time heat stress. However, even at this modest increase in milk yield, the construction cost of putting up a shade structure was recovered within three summers.

In a later study at Elsenburg (Muller & Botha, 1993), the effect of summer conditions on heat tolerance indicators in Holstein and Jersey cows was compared. In this study, first lactation Holstein-Friesian and Jersey

cows were kept in open camps with no protection against summer heat. They were fed a total mixed ration twice a day. The heart rate, respiration rate and rectal temperature of cows were recorded at two-hourly intervals from 07:00 to 19:00 on 15 days during summer when the maximum temperature was expected to be higher than 27 °C.

In this study, the rectal temperature in Holstein-Friesian and Jersey cows was about 38.3 °C at 07:00 similar to thermo-neutral conditions. Rectal temperatures increased during the day with a noticeable sharp increase from 11:00 to 13:00 in Holstein-Friesian cows (Figure 2).

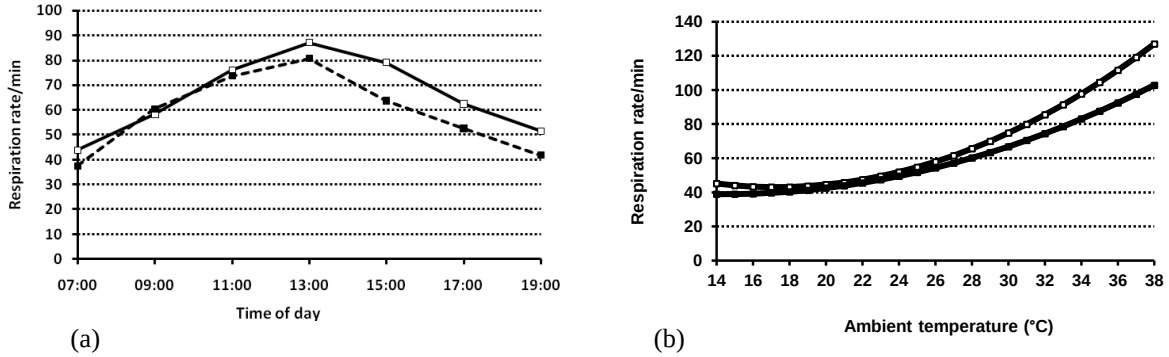


(a) (b)

Figure 2 The rectal temperature in Holstein (□) and Jersey (■) cows as affected by (a) time of day and (b) ambient temperature

Rectal temperatures increased during the morning reaching 39.0 °C at 13:00 in Holstein-Friesians and 38.6 °C at the same time in Jerseys. High rectal temperatures were maintained in Holstein-Friesian while Jerseys showed an increase up to 19:00. The difference in rectal temperature between the two breeds was the highest at 13:00 and 15:00. The rectal temperature of Holstein-Friesian cows showed a sharper increase from 23 °C while, in Jersey cows, a linear trend was maintained over the overall temperature range up to 38 °C. The variation in rectal temperature because of ambient temperature was 63 and 30% for Holstein-Friesian and Jersey cows, respectively indicating that Holstein-Friesian cows were more influenced by increasing ambient temperatures than Jersey cows.

Respiration rate increased during the morning as ambient temperatures increased to 13:00 decreasing again in the afternoon (Figure 3). Differences between breeds were the highest at 15:00 and 17:00 being higher in Holstein-Friesians in comparison to Jerseys. The respiration rate of Holstein-Friesian and Jersey was similarly affected by increasing ambient temperatures although lower for Jerseys.



(a) (b)

Figure 3 The respiration rate in Holstein (□) and Jersey (■) cows as affected by (a) time of day and (b) ambient temperature

Cows show an increased respiratory rate at higher ambient temperatures as this enables cows to dissipate about 30% of their heat by respiratory vaporization. Excessive respiratory activity, however, increases internal

heat production and may also lead to respiratory alkalosis. Initially it was thought that a higher respiration rate indicated a better adaptability to high temperatures. This, however, actually shows the opposite effect as an increased respiration rate is accompanied by a fall in tidal volume. A high respiration rate is therefore regarded as an early indicator of cows experiencing heat stress.

Conclusion/Recommendation

The internal rate of return for the capital outlay of the construction of a shade structure showed a positive return on investment within three summer seasons. A well-build shade structure has a lifetime of more than 30 years showing its long-term benefit. Jersey cows displayed a higher tolerance to heat than Holstein-Friesians suggesting that they would be more suitable for a hot environment. However, the large (*ca* 30%) difference in milk yield between these breeds should be considered before changing breeds. Other ways than providing shade to reduce the effect of heat stress include forced air movement using fans, wetting cows before and after milking, evaporative cooling systems, intensive housing systems, zone cooling, air conditioning and diet adjustments. The economic benefit of each of these environmental manipulation inputs should be investigated separately specifically with regards to the expected increase in ambient temperature in South Africa because of climate change.

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