

## **SKIN TEMPERATURE AND SWEATING RATE RESPONSES ON THE BLACK AND WHITE SKIN AREAS OF FRIESIAN BULL CALVES**

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### **SUMMARY**

The study examined skin temperature (ST) and sweating rate (SR) responses on the black and white skin areas associated with rectal temperature (RT) and respiratory rate (RR) of 2 Friesian bull calves, aged 5 months and weighing 115 kg. The animals were assigned to 2 climatic environments; one group was tested under indoor housing, the second one was under indoor-outdoor-indoor conditions. In each test period half hourly physiological measurements were taken from 1100h to 1600h indoors, whereas the second group was tested indoors from 1100h to 1200h and then exposed to the sun without any shade for an outdoor physiological responses from 1230h to 1430h, then moved indoors till 1600h. The calves in this experiment were subjected to either hot dry or hot humid environments and were long-wooly coated animals with 60% of black skin. Mean RT and RR under outdoor conditions were highly significant higher ( $P < 0.01$ ) than those under indoor housing (39.8 v. 39.1°C; 134.7 v. 74.2 breaths/min, respectively). Mean ST and SR under outdoor conditions on both black and white skin areas were also highly significant greater than their indoor counterparts (36.7 v. 33.9°C; 77.6 v. 35.6 g/m<sup>2</sup>/h, respectively). Under both indoor and outdoor conditions, ST and SR on the black skin areas appeared to be more sensitive to environmental changes than those in the white one. This study shows that cutaneous evaporation is closely controlled by ST and that the proportion of black skin area has an important role in both heat absorption and heat dissipation which affect thermoregulation and, indirectly, production. Future studies should investigate differences in sweat gland density and the innervation of the black skin areas.

*Keywords:* black and white skin areas, skin temperature, sweating rate, Holstein bull calves.

### **INTRODUCTION**

Coat colour is an important mediator of the impact of solar radiation and high temperature on cattle and also affects the ability of cattle to resist the effects of heat stress associated with high incident solar radiation (Finch 1986). For a breed such as the Holstein, coat colour can be described as the proportional surface area covered by hair of different colours (Becerril and Wilcox 1992). The amounts of black and white hair in the coat influence the absorption of incident solar radiation through the coat (Finch *et al.* 1980). Variations in the heat load from solar radiation with the different coat colour contribute to the greater ST and RT and the higher rate of evaporative water loss from dark as compared to light coloured cattle (Finch *et al.* 1984). The question remains, however, as to possible heat regulatory differences between the black and white coat areas within individual Holstein animals. The current study was designed to answer this question under a number of environmental conditions.

### **MATERIALS AND METHODS**

#### *Study site and climate*

The animal house was available in the Department of Animal Science, School of Rural Science and Natural Resources, the University of New England, Armidale, Australia (30° 31' S Lat., 151° 39' N Long, altitude 1046 m). Hourly meteorological data of ambient temperature and wind velocity (by COMPUFLON, Thermo-anemometer, Alnor Instrument Co., Skokie, IL.), black globe (BG; by Vernon globe) and relative humidity (RH; by the conversion of dry and wet bulb temperatures measured by a clockwork Assmann aspirating psychrometer) were daily recorded from 0900h till 1600h in either indoor or outdoor locations on each test day. Recordings were also made of maximum and minimum temperatures at 0900 h in a Stephenson screen located outdoors near the animal house.

#### *Experimental design and treatments*

Four Friesian bull calves, aged 5 months and weighing an average of 115 kg with different black and white skin areas, were allocated to one of two treatment groups. Each calf was held in an individual pen (140 x 120 cm) in the animal house when not subjected to the test treatment, and fed 2 kg of commercial concentrate containing 21% crude protein, along with an *ad libitum* supply of lucerne

chaff and hay, plus fresh water. The animal house (barn) was an open-sided barn with galvanised metal walls and roof. Group 1 (n=2), the control treatment, was housed indoors for the duration of the study. Group 2 (n=2), the indoor-outdoor-indoor treatment, was maintained in the barn till 1200h, then moved outdoors for 2 and a half hours and back indoors at 1430h for an overnight stay in the pen. The outdoor treatment was in a yard adjacent to the barn where the animals were exposed to the sun without any shade and but protected from prevailing winds. Animals were temporarily restrained in individual crushes in either the indoor or outdoor locations while physiological measurements were taken between 1100h and 1600h.

#### *Animal measurements*

Each treatment was carried out over 7 days in March, 2001. Half-hourly physiological measurements were made between 1100 and 1600h; respiratory rate (RR; flank movements counted for 1 min), and rectal temperature (RT; clinical thermometer inserted 10 cm for 1 min) in all animals. Simultaneously, skin temperature on different coloured skin patches [ST; measured by an infra-red surface thermometer (Everest Interscience Inc., Fullerton, California)] and sweating rate (SR; by the cobalt chloride disc method of Schleger and Turner 1965) were done on a black skin area on the middle of the back, and a white skin area on the sacral region of the back, which were chosen as convenient sites of measurement not subject to interference when cattle were in the crush. Coat score of each animal was assessed by the method of Turner and Schleger (1960). The proportion of black and white hair on each calf was determined by the method of Becerril and Wilcox (1992). During test measurements, the animals received neither food nor water. Differences between the physiological and climatic means were evaluated using the t-test (Steel and Torrie 1980).

## RESULTS

#### *Meteorological data*

Mean maximum ( $25.0 \pm 2.5$  vs.  $22.9 \pm 2.8^\circ\text{C}$ ) and minimum ( $9.1 \pm 3.5$  vs.  $12.1 \pm 1.9^\circ\text{C}$ ) temperatures for Groups 1 and 2, respectively, were not significantly different. The hourly readings of ambient temperature and wind velocity were not significantly different between group due to their high variations during the test days, though higher values were found in Group 2 from 1200h to 1600h, as shown in Table 1. The BG temperatures at 0900h ( $P < 0.05$ ) and from 1200h to 1400h ( $P < 0.01$ ) in Group 2 were significantly greater than those in Group 1 (Table 1). The significantly higher readings ( $P < 0.05$ ) of hourly RH, which were found in Group 1 relative to Group 2 from 1000h to 1600h, are shown in Table 1.

**Table 1. Ambient and black globe temperatures, wind velocity and relative humidity under indoor (G1) and outdoor (G2) conditions**

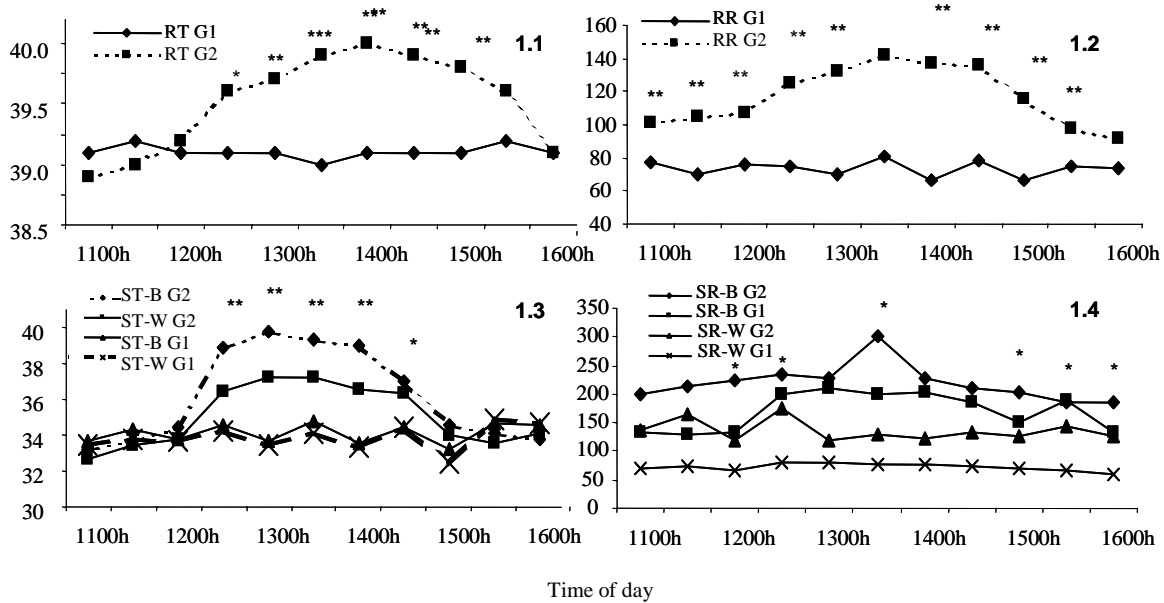
Time	Ambient temp. ( $^\circ\text{C}$ )		BG temp. ( $^\circ\text{C}$ )		Wind velocity (m/s)		RH (%)	
	G1	G2	G1	G2	G1	G2	G1	G2
0900h	18.2 $\pm$ 1.8	16.9 $\pm$ 1.7	26.3 $\pm$ 4.9	30.2 $\pm$ 7.5*	0.1 $\pm$ 0.1	0.1 $\pm$ 0.1	71.4 $\pm$ 6.5	63.3 $\pm$ 12.3
1000h	18.9 $\pm$ 1.5	16.6 $\pm$ 1.7	23.2 $\pm$ 2.6	22.7 $\pm$ 3.3	0.1 $\pm$ 0.1	0.1 $\pm$ 0.1	74.9 $\pm$ 9.2	51.0 $\pm$ 11.2*
1100h	20.2 $\pm$ 2.7	21.1 $\pm$ 2.4	23.4 $\pm$ 3.1	23.0 $\pm$ 2.6	0.2 $\pm$ 0.1	0.1 $\pm$ 0.1	69.1 $\pm$ 11.5	51.0 $\pm$ 16.1*
1200h	21.2 $\pm$ 2.9	23.5 $\pm$ 3.0	23.0 $\pm$ 2.8	40.9 $\pm$ 6.3**	0.1 $\pm$ 0.1	0.3 $\pm$ 0.1	69.6 $\pm$ 13.2	50.7 $\pm$ 17.5*
1300h	21.6 $\pm$ 2.9	24.9 $\pm$ 3.1	23.1 $\pm$ 3.2	40.7 $\pm$ 6.5**	0.1 $\pm$ 0.1	0.2 $\pm$ 0.1	64.3 $\pm$ 16.9	44.7 $\pm$ 15.2*
1400h	21.9 $\pm$ 3.1	25.4 $\pm$ 2.9	22.1 $\pm$ 2.9	24.6 $\pm$ 4.1**	0.2 $\pm$ 0.1	0.4 $\pm$ 0.3	67.0 $\pm$ 17.1	43.3 $\pm$ 12.3*
1500h	21.7 $\pm$ 3.0	24.9 $\pm$ 3.1	22.1 $\pm$ 3.1	24.6 $\pm$ 2.9	0.1 $\pm$ 0.1	0.1 $\pm$ 0.1	68.6 $\pm$ 17.7	43.3 $\pm$ 13.7*
1600h	21.7	24.9 $\pm$ 3.2	21.8 $\pm$ 2.7	24.1 $\pm$ 2.8	0.1 $\pm$ 0.1	0.1 $\pm$ 0.1	65.6 $\pm$ 16.6	40.3 $\pm$ 13.1*

Means in row of each parameter and of a time period with different superscripts are significantly different \* $P < 0.05$ ; \*\* $P < 0.01$

#### *Physiological responses*

The calves in Group 2 responded to the solar exposure with a statistically higher RT ( $P < 0.05$ ) at 1230h and highly significantly higher RTs ( $P < 0.01$ ) from 1300h to 1500h than those in Group 1, as shown in Figure 1.1. The RTs in Group 2 after one hour under shade following outdoor exposure to the sun were not significantly different to those in Group 1. The RRs in Groups 1 and 2 were markedly lower in the indoor animals (Group 1); all differences over the test period being highly significant ( $P < 0.01$ ) as indicated in Figure 1.2. Panting was frequently observed and was noted to occur during exposure to the sun. Means of ST on either the black or white area were not significantly different under indoor conditions from 1100h to 1200h and from 1500h to 1600h, as shown in Figure 1.3. When exposed to the sun, from 1230h to 1430h, both black and white skin areas experienced highly significant greater ST values ( $P < 0.01$ ) than under indoor housing.

SRs on both the black and white skin areas were higher in Group 2 relative to those in Group 1, as shown in Figure 1.4. However, some SRs on the black skin area of the animals in Group 2, both indoors and outdoors, were statistically higher ( $P<0.05$ ) than those in Group 1 (ie. 1130h, 1200h, 1330h, 1500h, 1530h, and 1600h) while all the recorded SRs on the white skin area of the calves in Group 2 were statistically higher ( $P<0.05$ ) than their counterparts in Group 1.



**Figure 1. Responses of RT (1.1), RR (1.2) of bull calves and their ST (1.3) and SR (1.4) on the black (B) and white (W) skin areas under indoor (G1) and outdoor (G2) conditions. \* $P<0.05$ ; \*\* $P<0.01$  of each parameter within a time period**

**DISCUSSION**

Mean diurnal variation of ambient and BG temperatures and RH give an indication that Groups 1 and 2 were under hot-humid and hot-dry environments, respectively, and wind velocity in both groups was under the level of air movement (of 1.39m/s; Gates 1968) which would be expected to reduce heat stress through increased convective heat loss. However, the increasing air and BG temperature during exposure to the sun in Group 2 from 1200h to 1430h would be expected to adversely affect physiological responses in the calves, particularly the solar heat load and BG temperature (Bond and Kelly 1955), and that was the response observed.

Mean coat score of the current calves was 5.5, a value which corresponds to winter coat type with long-woolly hair (Turner and Schlegler 1960). The mean white percentage of the calves was 39.5%, indicating that greater heat absorption from the black skin area would occur during exposure to the sun (Finch *et al.* 1984). However, differences in solar absorption between black and white skin areas disappear when the animals are shaded from the sun (Finch *et al.* 1980). With a relatively high proportion of black skin and a long-woolly hair, the calves would be associated with high body temperature through increased heat absorption (Finch *et al.* 1984) and in addition the insulating properties of the coat would tend to reduce the rate of heat loss (Turner 1964).

Under indoor housing from 1100h to 1200h, RTs in Groups 1 and 2 were within the normal range of 38.3 to 39.1°C (Yousef 1985) while higher RRs in Group 2 were markedly influenced by a rising ambient temperature at 1100h (Beakley and Findlay 1955). Furthermore, the BG temperature of 32.1°C at 0900h would presumably have been reflected in solar heat radiation to the white skin area (Hutchinson and Brown 1969). This amount of penetrating heat would be the sensible heat flow into the animal and, together with a higher ambient temperature at 1100h, would be expected to impose thermoregulatory demands on the animals (Hutchinson and Brown 1969) by means of greater RR and SR. The increase in RR that occurs when cattle are subjected to environmental temperatures exceeding 20°C has been observed and much higher RRSs are attained by calves during thermal polynea (Beakley and Findlay 1955). Panting is complementary to sweating and is a mechanism that permits the animal to increase evaporative heat loss from its respiratory system as soon as an increase in the heat content of the body occurs (Blight 1957). Both RR and RT declined with a fall in ambient and BG

temperatures due to the reduction of radiant heat load by 30% or more (Bond *et al.* 1967) when animals were kept under shade.

When the calves were immediately exposed to the sun, ST on both coloured skin areas in Group 2 increased with the rising ambient and BG temperatures, indicating a marked effect of solar radiation on heat absorption (Finch *et al.* 1980). Such a stimulus is known to be capable of initiating sweating in cattle (Murray 1966) and the rate of which is controlled by thermoreceptors located in both the skin and hypothalamus (Ingram *et al.* 1963). However, SR on the black skin areas (Figure 1.4) in Group 1 between 1200h to 1430h markedly increased, possibly due to a relatively high indoor RH of 65-70% restricting evaporative cooling (Yousef 1985). However, lower ST on either the black or white skin areas in Group 2 under indoor housing after exposure to the sun, was due to a larger amount of moisture on the skin surface as a carry-over from sweating during prior exposure to the sun (Klemm and Robinson 1955).

After completion of exposure to the sun, the calves in Group 2 experienced a decline in ST and SR on the black and white skin areas under indoor conditions due to the decreasing ambient and BG temperatures from 1500h to 1600h (Allen 1962). A lower ST on both black and white skin areas was also partly due to a relative high rate of cutaneous evaporation (Klemm and Robinson 1955). However, RT did not drop immediately, suggesting that cutaneous evaporation is more closely controlled by ST than RT (Taneja 1959; Ingram *et al.* 1963). Since higher ST and SR on black skin areas relative to the white skin were affected by the increasing ambient and BG temperatures (Allen 1962) under either Group 1 or Group 2 condition, there was unlikely to be any difference between coat colours in the absorption rate of short wave radiation from the sun when the animals were kept indoors (Finch *et al.* 1980). There might be a higher sweat gland density or a more sensitive autonomic nerve supply on black skin areas that are particularly sensitive to a rise in ambient temperature. Detailed histological and neurological studies are needed on this point.

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