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Research Article

Response of Non-Gestating Zebu Cows to Different Cooling Measures in a Humid Tropical Environment

O.A. Olorunnisomo and E.O. Ewuola

Department of Animal Science, University of Ibadan, Ibadan, Nigeria

Abstract

In order to evaluate the response of zebu cows to heat mitigation measures, twenty four non-gestating Sokoto Gudali cows were subjected to four treatments; no cooling (control), cooling with fan, cooling with shower, cooling with fan and shower. Animals were grazed daily inside fenced pastures from 8 am to 1 pm (when the sun is overhead) after which cooling measures were applied under shade. Ambient temperatures, Relative Humidity (RH) and Temperature Humidity Index (THI) during study were determined. Rectal Temperature (RT), Respiratory Rates (RR) and blood profile of test animals were also measured. Mean daily temperature varied from 26.5-28.3°C, maximum temperatures from 32.2-33.6°C, RH from 77.3-82.1% and THI from 77.5-78.5. There were significant ($p<0.05$) reductions in RT and RR of cows 1 h after application of cooling measures. The RT was 39.2, 38.5, 38.5 and 38.0°C while RR was 30.1, 26.0, 26.7 and 22.1 breaths min^{-1} for control, fan, shower and fan+shower, respectively. Erythrocyte count was 11.1, 13.0, 13.1 and 18.0 ($\times 10^6$ μL^{-1}) while leukocyte count was 20.6, 16.6, 16.7 and 14.6 ($\times 10^3$ μL^{-1}) for control, fan, shower and fan+shower, respectively. It may be concluded that application of cooling measures reduced heat load and enhanced erythrogenesis in zebu cows. The best results were obtained when fan and shower were combined in cooling the animals.

Key words: Rectal temperature, respiratory rates, blood profile, evaporative cooling, zebu cows

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Corresponding Author: O.A. Olorunnisomo, Department of Animal Science, University of Ibadan, Ibadan, Nigeria

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Zebu cattle are reputed to be heat tolerant and adapted to the hot environment of tropical areas. Their productivity however remains low compared to their exotic taurine counterparts even when nutrition and management levels were high (Yilma *et al*., 2006). This may be attributed to their inherently low genetic potentials and the effects of the hot environment on physiological functions. Research efforts to improve productivity of zebu cattle have focused mainly on nutrition and upgrading of their genetic make-up through crossbreeding programmes (Cunningham, 1987; Tadesse and Dessie, 2003; Galukande *et al*., 2013). Their reputed adaptability to the hot tropical environment has shifted attention away from mitigation of heat stress in zebu cattle. However, the increasing harsh effects of global warming and rising ambient temperature in tropical areas suggests a need to apply some cooling measures to zebu cattle reared in hot regions to minimize the negative effects of heat stress on these animals (Kimaro and Chibinga, 2013).

Methods to mitigate heat stress in cattle include, among other things, the provision of shade, forced ventilation, wetting of animals and air conditioning (Armstrong, 1994; West, 2003). Although, these methods have been applied successfully on exotic cattle during hot weather, their application on zebu or indigenous tropical cattle has been minimal. Evaporative cooling (wetting and forced ventilation) has been shown to be effective and economical for tropical environments (Collier *et al*., 2006). The intake, growth rate and milk production of high producing dairy cattle improved during hot weather when evaporative cooling measures were applied (Marai *et al*., 1995; Collier *et al*., 2006). While zebu cattle are known to adapt better to tropical environments, there is indication that their productivity could improve when measures are taken to mitigate the effects of high ambient temperature and humidity (Gaughan *et al*., 1999; Hansen, 2004). This study therefore focused on evaluating the physiological and haematological response of zebu cows to application of fan or shower as heat mitigation measures in a tropical environment.

MATERIALS AND METHODS

Location and meteorological data: The experiment was conducted at the Dairy Farm of the University of Ibadan, Nigeria, located within 7°27' N and 3°45' E, at 220 masl. Annual rainfall varies between 1150 and 1500 mm. Minimum and maximum temperatures and relative humidity during the experimental period (March and May, 2013) were obtained from the Department of Geography, University of Ibadan.

Experimental procedures and management: Twenty four Sokoto Gudali heifers (18 months old, 140±24 kg) were used for the study. Animals were grouped into four treatments with six animals per treatment using a Completely Randomized Design (CRD). The animals were housed in individual, open sided pens and allotted to one of the treatments as follows:

- No cooling (control)
- Cooling with fan
- Cooling with shower
- Cooling with fan and shower

Prior to commencement of the experiment, animals were given prophylactic treatment against trypanosomiasis, tick-borne and bacterial diseases using diaminazene and oxytetracycline (LA). Animals were also treated with ivermectin (pour-on) fortnightly to take care of ticks, tsetse fly and worms. Each morning between 7 and 7.30 am, rectal temperature and respiratory rate of experimental animals were measured inside the pens, after which they were released to graze inside fenced pastures till 1 pm when the sun was overhead. Immediately after grazing, rectal temperature and respiratory rate of animals were again measured and experimental treatments (fan or shower) were applied (30 min for fan and 10 min for shower). The final daily reading for rectal temperature and respiratory rates were taken 1 h after application of experimental treatments. Inside the pens animals were offered a composite silage (elephant grass, brewer's spent grain and cassava peel), fresh water and salt lick, *ad libitum*.

Thermoregulatory parameters: Ambient temperature and relative humidity was measured using thermo hygrometer which was suspended in the cow's pen. Temperature-humidity index was estimated from the result of the ambient temperature and relative humidity as described by McDowell (1976). Rectal temperature was determined by manual insertion of a digital clinical thermometer in each cow's rectum till a constant reading was obtained. Respiratory rate was determined by counting uninterrupted movement of the flank for 60 sec using a stop watch.

Blood parameters: Blood was collected from the jugular vein using a 5 mL syringe. The blood withdrawn was dispensed into EDTA and EDTA-free bottles. The blood samples were analyzed for Packed Cell Volume (PCV), Red Blood Cells (RBC), haemoglobin (HB), White Blood Cells (WBC), lymphocyte counts, monocyte counts, neutrophil counts and blood glucose level using the methods of Schalm *et al.* (1975) and Ewuola and Egbunike (2008).

Experimental design/statistical analysis: The experimental design adopted for this study was the completely randomized design. Data obtained were subjected to analysis of variance and significant means were separated by Duncan's multiple range tests using the procedures of SAS (1995).

RESULTS AND DISCUSSION

The chemical composition of pasture and silage offered to zebu heifers during the experimental period are presented in Table 1.

The dry matter and crude protein contents were higher in silage than the pasture while fibre components were higher in pasture than silage. This suggests that the silage provided a higher nutrient density than pasture, however, the fibre mat required for effective rumen function in cattle (Preston and Leng, 2009) was provided by the pasture. Hence, nutrition of the animals was not a limiting factor during the period of study.

The meteorological data during the period of study are presented in Table 2. The mean daily temperature of the study area decreased from 28.3°C in March to 26.5°C in May, 2013 while relative humidity increased from 77.3-82.1%. Maximum temperature within the study period varied between 32.2 and 33.6°C. These figures are high and considered to be harsh for highly productive cattle (West, 2003), hence the need for heat mitigation measures.

The Temperature-Humidity Index (THI) is a measure of the degree of heat stress on dairy cattle. When THI reaches 72, dairy cattle will show signs of discomfort and production will decline (Ravagnolo *et al.*, 2000). This threshold of discomfort may however, not apply to zebu cattle which are considered to be heat-tolerant (Gaughan *et al.*, 1999; Hansen, 2004). The THI during the period of study ranged between 77.5 and 78.5. This range is very high compared to the standard set for dairy cattle and may indicate a level of discomfort for the apparently heat-tolerant zebu heifers, hence, the need to apply some heat mitigation measures.

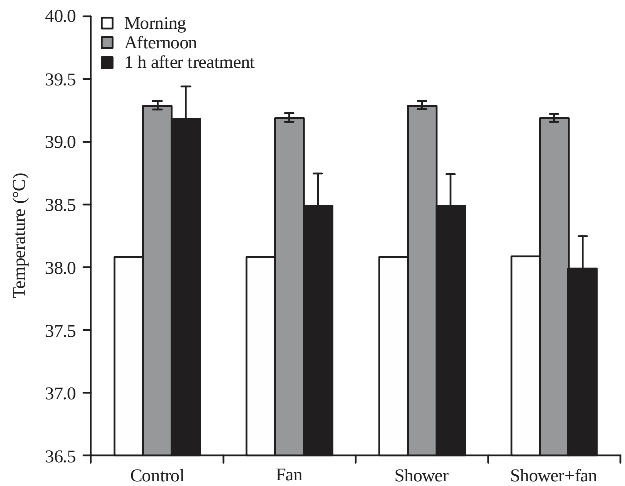

Fig. 1: Rectal temperature of zebu cows subjected to different cooling methods

Table 1: Chemical composition of pasture and silage fed to zebu cattle during experimental period

Parameters	Pasture*	Silage**
Dry matter	19.40	28.4
Crude protein	7.80	15.2
Neutral detergent fibre	67.50	56.6
Acid detergent fibre	36.20	28.5

*Predominant species in the pasture is *Panicum maximum* with traces of *Centrosema pubescens* and *Calopogonium mucunoides* **Silage consist of elephant grass (40%), brewer's spent grain (40%) and cassava peels (20%)

Table 2: Mean daily temperature, humidity and temperature humidity index of study area during March, April and May, 2013

Ambient temperature (°C)	March	April	May
Minimum	24.6	23.5	23.2
Maximum	33.6	33.4	32.2
Mean daily temperature	28.3	27.3	26.5
Relative humidity	77.3	80.7	82.1
Temperature Humidity Index (THI)	78.5	78.0	77.5

The mean Rectal Temperature (RT) of zebu cows given different cooling methods during the experimental period is presented in Fig. 1. All animals were equally subjected to high ambient temperatures up to 33°C in the afternoon and low temperatures of 25°C or less at night; hence, there were no significant differences in RT of cows in the afternoon (shortly after grazing) or morning (when the animals had sufficiently recovered from heat stress due to low night temperatures). The average rectal temperature of cows was 38.1°C in the morning and 39.3°C in the afternoon, showing that RT of animals rose by 1.2°C between morning and afternoon when they returned from grazing. Considering that cattle are homoeothermic in nature, this rise in RT was abnormal and indicates a high degree of stress on the animals

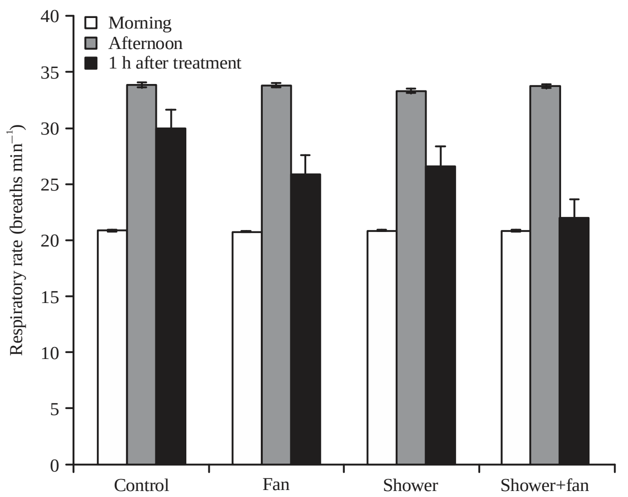

Fig. 2: Respiratory rates of zebu cows subjected to different cooling methods

Table 3: Blood profile of zebu heifers subjected to different cooling methods

Parameter	Control	Fan	Shower	Fan+shower	SEM
Before experiment					
Haematocrit (%)	28.30^{a}	28.00^{a}	28.60^{a}	27.30^{b}	1.02
Haemoglobin (g dL^{-1})	9.67^{ab}	9.27^{b}	10.10^{a}	9.10^{b}	0.24
Erythrocytes ($\times 10^{6}$ µL^{-1})	10.20^{a}	10.00^{b}	11.00^{a}	10.70^{b}	0.33
Leukocytes ($\times 10^{3}$ µL^{-1})	16.00^{b}	16.60^{a}	16.00^{b}	16.60^{a}	0.60
Lymphocytes (%)	67.30^{b}	66.30^{b}	68.70^{a}	65.30^{c}	1.69
Neutrophils (%)	31.30^{c}	32.30^{b}	32.30^{b}	33.30^{a}	1.04
Monocytes (%)	1.34^{b}	1.33^{b}	1.67^{a}	1.34^{b}	0.23
Glucose (mg dL^{-1})	51.00	50.50	50.20	51.00	1.60
After experiment					
Haematocrit (%)	34.20^{c}	37.30^{b}	37.70^{b}	39.20^{a}	1.04
Haemoglobin (g dL^{-1})	10.30^{c}	12.40^{b}	12.50^{b}	16.60^{a}	0.40
Erythrocytes ($\times 10^{6}$ µL^{-1})	11.10^{c}	13.00^{b}	13.10^{b}	18.00^{a}	0.65
Leukocytes ($\times 10^{3}$ µL^{-1})	20.60^{a}	16.60^{b}	16.70^{b}	14.60^{c}	0.52
Lymphocytes (%)	69.00^{a}	68.00^{a}	67.00^{a}	67.30^{a}	1.62
Neutrophils (%)	30.00^{a}	31.00^{a}	32.00^{a}	31.30^{a}	1.02
Monocytes (%)	1.00^{a}	1.00^{a}	1.00^{a}	1.33^{a}	0.24
Glucose (mg dL^{-1})	41.50^{c}	61.40^{b}	65.20^{ab}	68.00^{a}	1.53

$^{a, b, c}$Means with different superscript within the row are significantly different ($p<0.05$)

(Srikandakumar and Johnson, 2004). However, there was significant reduction ($p<0.05$) in RT of cows 1 h after application of cooling treatments.

The RT of control animals reduced by 0.1°C when they were merely brought under shade while animals cooled with fan or shower reduced their body temperature by 0.7 and 0.8°C, respectively. However, when fan and shower were combined, animals reduced their body temperature by 1.2°C. This indicates that shade alone was not as effective as fan or shower in reducing body temperature of heat-stressed cattle. Maximum benefit from the use of fan or shower as heat mitigation measures was obtained when both were combined in cooling the animals.

The respiratory rate (Fig. 2) of animals followed a similar trend with rectal temperature and did not vary significantly across the treatments either in the morning or hot afternoon but was significantly ($p>0.05$) reduced by the cooling measures 1 h after application.

The least RR was recorded for animals treated with a combination of shower and fan while the highest RR was recorded for animals without cooling treatments. Accelerated respiratory activity in cattle is associated with heat stress and thought to assist in dissipation of heat. Alteration in the blood profile of indigenous cattle under humid tropical environment (characterized by heat stress) has been reported (Ewuola *et al*., 2014). The RR recorded in this study varied between 20.8 and 34.0 breaths min^{-1}). These fell within the range of 17-48 breaths min^{-1} reported for zebu cattle by other researchers (Olbrich *et al*., 1972; Aggarwal and Upadhyay, 1997).

The blood profile of zebu cows given different cooling measures is presented in Table 3.

Hematological parameters were significantly ($p<0.05$) influenced by cooling treatments. The haematocrit, haemoglobin and erythrocytes of cows treated with fan or shower were significantly ($p<0.05$) higher than control animals. Values for these parameters were however highest when animals were cooled with a combination of fan and shower. This result indicates that cooling measures enhanced erythrogenesis, blood volume, oxygen-carrying capacity and performance of zebu cows. It may be inferred that the combination of fan and shower as a cooling measure assisted the animals to rapidly reduce heat load and return to thermoneutrality, hence, normal physiological processes in the body were enhanced for adequate blood formation (Soetan *et al*., 2013; Ewuola *et al*., 2014).

The leukocyte differential counts were not significantly different among animals before commencement of study. However, after application of cooling treatments, leukocytes count was significantly ($p<0.05$) higher in control animals than cooled cows. Animals cooled with a combination of fan and shower recorded the least value. The leukocyte count obtained for control cows in this study was higher than that reported by Ewuola *et al*. (2014) for indigenous cows at both pregestation and gestation in humid tropical environment. This may probably be attributed to the immune response of animals in this study to the challenge of heat stress in an attempt to maintain homoeostasis. Leukocytes have been reported to play active roles in body defense against pathogens, toxic substances or stress (Soetan *et al*., 2013).

CONCLUSION

High rectal temperature and respiratory rates recorded for zebu cows in this study during the hot afternoon indicate that zebu cows were negatively affected by heat stress. Application of fan or shower as cooling measures significantly reduced rectal temperature and respiratory rates. Cooling of zebu cows also enhanced erythrogenesis, oxygen-carrying capacity of the blood and boosted immune response of the animals. These effects have positive implications for animal welfare and performance of zebu cows in hot environments. Maximum benefit from the use of fan or shower as heat mitigation measures was obtained when both measures were combined in cooling the animals.

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