Original Research Article

Performance of Zebu Heifers under Heat Mitigation Measures in a Humid-Tropical Environment

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Abstract

Productivity of bovine species is drastically reduced when the animals are subjected to heat stress as often occurs in tropical regions. Although zebu cattle are considered to be heat tolerant, their productivity could improve when cooling measures are applied to mitigate the effects of heat stress. In this study, twenty four Sokoto Gudali heifers under mean ambient temperature of 27.4 °C and temperature humidity index (THI) of 78 were subjected to four cooling treatments: no cooling (control), fan, shower and shower with fan. Rectal temperature of heifers reduced from 39.3 °C (in the afternoon) to 39.2, 38.5, 38.5 and 38.0 °C for control, fan, shower and shower with fan, respectively, one hour after administration of treatments. Dry matter intake (DMI) and growth rate of heifers increased significantly ($P < 0.05$) when cooling measures were applied. DMI of heifers varied from 2.08 to 3.78% of body weight (BW) while average daily gain (ADG) varied from 0.38 to 0.86 kg/d with cooled animals having the higher values. Application of cooling measures significantly improved the performance of zebu heifers raised in a hot and humid environment.

Key words: heat stress; cooling; growth; feed intake; Sokoto Gudali breed.

INTRODUCTION

A large majority of the cattle population in Nigeria are zebu type (RIM, 1992). Productivity of these animals is limited by their inherently low genetic potentials resulting from long years of adapting to poor nutrition and a challenging environment. While these cattle are known to adapt better to hot and humid environments compared to exotic *Bos taurus* cattle, there is indication that their productivity could improve when measures are taken to mitigate the effects of high ambient temperature and humidity as occurs in tropical regions (Gaughan et al., 1999; Hansen, 2004).

Failure of exotic breeds to thrive in tropical regions is often blamed, among other things, on heat stress resulting from the direct effect of the hot and humid environment (Kadzere et al., 2002; West, 2003). Methods to mitigate the effects of heat stress in cattle include provision of shade, forced ventilation, wetting, air conditioning, etc. (West, 2003). These methods have been applied successfully on exotic cattle in tropical regions or temperate countries during hot weather. Some workers (Igono et al., 1987; Her et al. 1988; Marai et al., 1995) have shown that intake, growth rate and milk production of cattle improved during hot periods when evaporative cooling measures were applied. However, because zebu cattle are assumed to be heat-tolerant, the effects of heat stress and mitigation measures on their productivity have largely

been uninvestigated. This study was therefore conducted to assess the performance and response of zebu heifers to heat mitigation measures using fan or shower in a hot and humid 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 m above sea level. Annual rainfall varies between 1150 and 1500 mm. Minimum and maximum temperatures and relative humidity between March and May, 2013 were obtained from the Department of Geography, University of Ibadan.

Experimental animals, design and management

Twenty four Sokoto Gudali heifers approximately 18 months old, weighing 140 ± 24 kg were used for the study. Animals were grouped into four treatments with six replicates per treatment. The animals were housed in a barn measuring 30×12 m with dwarf walls and concrete floors. The roof was 4 m high at the middle and 3 m high at the sides. Individual pens were open sided and measured 1.5×2.5 m. Animals were allotted to one of the treatments as follows:

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

Six industrial fans (OX®, China) with air flow rate of 4500 m³/h and a speed of 1350 rpm were mounted at 2.1 m above the feeding area at an angle of 45°. The fans were fitted to serve twelve animals at a time. Animals were sprinkled manually with an average of 4 L of water each, at an estimated pressure of 12 psi, using a hose fitted with a spray pistol (Claber, Italy). Prior to commencement of the experiment, animals were given prophylactic treatment against trypanosomiasis, tick-borne and bacterial diseases using diminazene and oxytetracycline (LA). Animals were also treated with ivermectin (pour-on) fortnightly to take care of ticks, tsetse and worms. Each morning between 07:00 and 07:30 h, rectal temperature and respiratory rate of experimental animals were measured inside the pens, after which they were released into fenced pastures till 13:00 h when the sun was fully up. 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 one hour 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*.

Feed intake and analysis

Intake of animals at pasture was estimated using a quadrat. The quadrat measuring 1 × 1 m was thrown inside the paddock in a random manner (3 times) before cows were grazed and herbage within the quadrat was cut to 5 cm height. After grazing, the quadrat was thrown again and herbage measured. The difference between herbage on offer before grazing and after grazing (corrected to the size of the field and animal number) was assumed to be the daily pasture intake per animal. Silage intake was measured by deducting remnants from the quantity served. Samples of pasture and silage were taken monthly and analyzed for dry matter, crude protein, and detergent fibres using the general procedures of AOAC (2005). Dry matter concentration of the silage was determined using a forced draught oven at 65 °C for 48 h. Detergent fibre components were determined according to methods of Van Soest and Robertson (1985).

Weight gain and feed conversion ratio

Body weight of animals was estimated weekly from the girth width, using a calibrated tape. The accuracy of the tape was checked by measuring the girth width of 20 young female calves weighing between 30 and 60 kg against their actual weight on a scale. The accuracy of the tape was

estimated to be 90.8%. Average daily gain of animals was calculated from the weekly weights of the animals while feed efficiency was calculated as the dry matter intake divided by average weight of the animal.

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

Composition of pasture and silage

The chemical composition of pasture and silage offered to zebu heifers during the months of March, April and May 2013 are presented in Table 1. The dry matter and crude protein content were much higher in the silage than pasture while fibre components were higher in pasture than silage. The pasture and silage offered to heifers in this study played complementary roles to each other since cattle require high fibre content in their diets for effective rumen function and high protein for growth and production.

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

Parameter	Pasture*	Silage**
Dry matter	19.4	28.4
Crude protein	7.80	15.2
Neutral detergent fibre	67.5	56.6
Acid detergent fibre	36.2	28.5

*The 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%)

Meteorological indices

The ambient temperature, humidity and temperature-humidity index (THI) during the period of study are

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

Parameter	March	April	May
Ambient Temperature (°C)			
- 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

presented in Table 2. The mean daily temperature of the area varied between 28.3 and 26.5 °C between March and May 2013, while relative humidity varied between 77.3 and 82.1%. These figures which are typical of the humid tropics are considered to be harsh for high producing cattle (Armstrong, 1994; West, 2003).

The THI is used to measure the degree of heat stress on dairy cattle. When THI reaches the threshold of 72, high producing cows begin to show signs of discomfort and milk production declines (Fuquay, 1981; Igono et al., 1992; Ravagnolo et al., 2000). The threshold of discomfort for zebu cattle may, however, be higher than 72 since they are considered to be heat-tolerant (Gaughan et al., 1999; Hansen, 2004). The THI during the period of study varied between 77.5 and 78.5. This is high and may indicate some level of discomfort even for the heat-tolerant zebu, hence the need to apply some heat mitigation measures.

Rectal temperature and respiratory rates of heifers

The mean rectal temperature (RT) and respiratory rate (RR) of zebu heifers given different cooling measures

animals were equally subjected to heat stress (high ambient temperature of about 33 °C) during grazing and all animals had enough time during the night (ambient temperatures of 24 °C or less) to recover from the effects of heat stress. On the average, the RT of animals rose by 1.1 °C between morning and afternoon. However, one hour after application of treatments, there were significant reductions ($P < 0.05$) in rectal temperature of heifers under different cooling methods.

The RT of control animals was reduced by 0.1 °C one hour after they were 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 after animals were brought under shade, application of cooling treatments (fan or shower) rapidly reduced body temperature of the heat-stressed zebu cattle while shade alone (control), could not. Maximum benefit from the use of fan or shower as heat mitigation measures was obtained when both measures were combined in cooling the animals.

Table 3. Rectal temperature and respiratory rates of zebu heifers subjected to different cooling methods during the months of March, April and May 2013

Parameter	Control	Fan	Shower	Shower + Fan	SEM
Rectal Temperature (°C)					
Morning	38.1	38.1	38.1	38.1	0.33
Afternoon	39.3	39.2	39.3	39.2	0.40
1h after treatment	39.2 ^a	38.5 ^b	38.5 ^b	38.0 ^c	0.51
Respiratory Rate (breaths/min)					
Morning	20.9	20.8	20.9	20.9	0.21
Afternoon	34.0	33.9	33.4	33.8	0.53
1h after treatment	30.1 ^a	26.0 ^b	26.7 ^b	22.1 ^c	0.41

abc: means with different superscript within the row are significantly different ($P < 0.05$).

during the experimental period are presented in Table 3. There were no significant differences ($P > 0.05$) in RT of heifers in the morning or afternoon. This is because all

Performance of zebu heifers

The feed intake, weight gain and feed conversion ratio of zebu heifers given different cooling measures are presented

Table 4. Mean intake, weight gain and feed conversion ratio of zebu heifers subjected to different cooling methods during the months of March, April and May 2013.

Parameter	Control	Fan	Shower	Shower + Fan	SEM
Dry matter Intake (kg/d)					
- Pasture	2.33b	3.43a	3.40a	3.50a	0.20
- Silage	0.90c	2.77b	2.72b	3.51a	0.25
- Total	3.23c	6.20b	6.12b	7.01a	0.30
Dry matter Intake (% BW)	2.08c	3.28b	3.21b	3.78a	0.19
Average daily gain (kg/d)	0.38c	0.66b	0.65b	0.86a	0.06
Feed conversion ratio	11.13 ^a	9.39 ^b	9.42 ^b	8.15 ^c	0.76

abc: means with different superscript within the row are significantly different ($P < 0.05$).

in Table 4. Animals had equal access to pasture and were offered silage of same composition.

The total dry matter intake of zebu heifers varied significantly across the treatments. The highest intake was recorded for animals cooled with a combination of shower and fan and least for animals that were not cooled. Animals cooled with fan or shower had similar intakes, showing that fan and shower when applied singly had similar mitigation effects on intake of heat-stressed zebu heifers.

When the total DMI (kg/d) of control animals was taken as the baseline, intake of cooled animals was increased by 91.9, 89.5 and 117.0% for fan, shower and fan/shower combination, respectively. This demonstrates that when other factors have been taken care of, evaporative cooling has great potentials for increasing voluntary intake of zebu cattle during hot weather. The intake of heifers in this study varied from 2.08 to 3.78% of BW which is within the range of 2.29 and 4.40% BW reported for zebu cows in similar environments (Sebastian et al., 1970; Olorunnisomo, 2013; Olorunnisomo and Ibhaeze, 2013). The average daily gain (ADG) and feed conversion ratio (FCR) of zebu heifers under different cooling measures are presented in Table 4. The ADG varied from 0.38 to 0.86 kg/d. Heifers cooled with fan and shower had the highest growth rate and control animals, the least. This observation demonstrated that cooling of zebu heifers during hot weather had positive influence on performance of these animals. The growth rate of heifers in this study is comparable to the range of 0.55 and 0.85 kg/d reported for Sudanese zebu (Ahmed and Pollot, 1977). Feed conversion ratio, which is a measure of efficiency of feed utilization by the animal, reduced significantly when animals were cooled. The most efficient feed conversion was achieved when fan and shower were combined.

CONCLUSIONS

Physiological and performance indices showed that zebu heifers benefited from cooling during hot weather. Body temperature and respiratory rate of heifers were significantly lowered when animals were cooled while intake and growth rate of heifers increased. The feed conversion ratio also indicated that economic weight gain might accrue to heifers when they are cooled, however, this needs to be verified with a cost-benefit analysis.

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