COMPARISM OF TWO METHODS OF HEAT STRESS PREDICTION IN THREE INDIGENOUS BREEDS OF COWS IN IBADAN

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ABSTRACT
Increasing evidence has been shown by meteorologists of a consistent rise in air temperature globally. Among other side effects, heat stress will be induced in livestock species reared in the tropics. The tropics include all the areas on the Earth where the sun reaches a sub solar point, a point directly overhead at least once during the year. It is hot almost year round in these areas and Ibadan, lies in this zone with extended periods of high ambient temperature and humidity. Stress induced by heat severely depresses optimum productivity in all farm animals. In cows, milk secretion, growth rate, reproduction and efficient feed utilization are some of the productive processes impaired. Heat stress has traditionally been measured by physiological data (rectal temperature, respiratory rate, pulse rate, heart rate) while climatic data (temperature, relative humidity) has been used as well either singly or in combination with the former. This study assessed the better predictor of heat stress in indigenous cows using either physiological or climatic data singly and a combination of both methods. Pulse rate, heart rate and rectal temperature in each of the breeds were not significantly different. Average respiratory rate in N'Dama cows (39.54 beats/minute) was however significantly ($P<0.05$) lower than that in White Fulani (46 beats/minute) and Sokoto Gudali (48.74) cows respectively. This however did not reflect any form of heat stress as it was within the normal physiological range for cows (26-50 beats/minute). The temperature humidity index was 80.73 which showed a mild heat stress condition. It was observed from this study that use of both data gave a more reliable prediction than single use of either. In order for more precise evaluation however, it is suggested that climatic features like solar radiation, day length, wind speed and movement be incorporated into climatic data.
Keywords: Comparison, cows, heat stress, indigenous breeds, prediction.

INTRODUCTION
Cattle trade is a heavily capitalized and profitable sector of the livestock industry on a worldwide basis yielding huge sums to investors and helping to blight cycles of poverty through job provision etc. Much development in productivity of indigenous cattle breeds has however not been made in sub Saharan Africa. This has limited the margin of profit that could have been accrued from this critical sector of the livestock industry. Two perennial challenges facing indigenous cattle breeds are inadequate feed resources and inclement weather conditions. Weather conditions appear to have a modulating effect on feed resources and animal productivity respectively. The deleterious effects of weather conditions are felt both during wet and dry seasons in the tropics. In the dry season, pasture may be unavailable for cattle and since the bulk of the world's 971 million cattle is extensively reared (Cook, 2016) these effects are more telling. Seasonal weight loss in farm animals especially ruminants is thus a common phenomenon as well as reduced milk secretion and delayed attainment of sexual maturity in offspring due to stunted growth. It is thus important to take more than a cursory look at the effect of weather conditions on productivity of cattle in the tropics. The tropics include all the areas on the Earth where the sun reaches a sub solar point, a point directly overhead at least once during the year. This region of the earth is almost hot all the year round and solar radiation exerts a noticeable effect on most living organisms including plants, animals and humans. Though indigenous cattle breeds are well

adapted to withstanding high temperatures, and are farmed throughout tropical countries, as homeotherms, they operate within a temperature range of 30-42^{0}C (Speakman, 2004). Any temperature below or above this range predisposes them to some kind of stress with impairment of bodily functions. High temperature is however not a stand-alone factor. This is because in hot climates, the potential for non-evaporative heat loss is reduced and animals rely on water evaporation (panting and sweating) to dissipate any excess heat generated by metabolism. Also, efficiency of evaporative cooling declines with an increase in relative humidity. Basal respiratory rate in cattle is between 25-50 breaths per minute (Latimer *et al.* 2003).

Relative humidity is a measure of the moisture present in the air divided by the maximum amount of moisture that could exist in the air at a specific temperature and is expressed as a percentage. When high heat is impacted on the body of cows through solar radiation, a set of bodily reactions are set off in a bid to adapt to the changing environmental condition. Some of these include exhalation (panting), sweating, lying under shade etc. These actions help to transfer some of the heat impacted on their bodies to the environment. Since the atmosphere is humid already however, there is a limit to the additional moisture that can be held. Thus, heat stress may be more pronounced in livestock species reared in the humid tropics. It is against this background that temperature and humidity are measured daily so as to obtain temperature-humidity index. Temperature humidity index is a measure of the inter-relation between air and temperature from the point of view of animal welfare (Herbut and Angreka. 2012). The temperature humidity index (THI) was originally developed by Thom (1958) and extended to cattle by Berry *et al.* (1964). It is currently used to estimate cooling requirements of cattle in order to improve management strategies to alleviate heat stress. A study by Smith *et al.* (2012) revealed that heat stress in dairy cattle (not significant) commences when THI is >67, mild heat stress at 72-80 THI while an emergency situation occurs at THI between 90-98. Additionally, responses from animals are measured in order to ascertain if they are stressed or not. Responses such as respiratory rate, heart rate, pulse rate, rectal temperature are objectively determined. This study was conducted to determine if either climatic variables or physiological responses were sufficient or a combination of both were required for ascertaining if heat stress is induced in some indigenous cattle breeds.

MATERIALS AND METHODS

The study was carried out at the Dairy Unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. The cows totaling 16 with ages ranging from 2.0-2.5 years and weight, 270-300kg were housed under similar conditions and provided same feed for a period of 3 months (January-March). The animals were randomly allotted into three treatments on breed basis: N'Dama, White Fulani and Sokoto Gudali cows respectively. The thermoregulatory parameters were determined twice on a daily basis; 8:00 a.m. (before grazing) and 3:00 p.m. (after grazing) throughout the experimental period. Respiratory rate was determined by counting uninterrupted movement of the flank for 60 seconds using a stop watch. Pulse rate was determined by counting uninterrupted rhythmic movement of the jugular vein for 60 seconds using a stop watch. Heart rate was determined with the aid of a stethoscope placed at the heart region with the beats for a period of 60 seconds recorded, while rectal temperature was done by manual insertion of a digital clinical thermometer in each cow's rectum till a constant reading was obtained. Ambient temperature and relative humidity were monitored daily with the aid of a thermo hygrometer. THI was calculated from ambient temperature and relative humidity readings respectively via the equation:

$THI= 0.8 \times T\ (^0C) + RH\ (T-14.4) + 46.4$ as described by Mader *et al.* (2006)

Where T is ambient or dry bulb temperature

RH is Relative Humidity expressed as a proportion

Data Analysis

All data was subjected to analysis of variance in a completely randomized design using General Linear model of SAS (2005).

RESULTS AND DISCUSSION

Table 1 shows the average thermoregulatory response of three indigenous cow breeds. Pulse rate, heart rate and rectal temperature were not significantly different. Average respiratory rate in N'Dama cows (39.54 beats/minute) was however significantly ($P<0.05$) lower than that in White Fulani (46.00 beats/minute) and Sokoto Gudali cows (48.74 beats/minute) respectively. The physiological data were within the normal physiological range for cattle as documented by Latimer *et al* (2003). Respiratory rate was however significantly ($P<0.05$) higher in White Fulani (46.00 beats/minute) and Sokoto Gudali (48.74 beats/minute) cows than N'Dama cows (39.54 beats/minute). This may be due to the size of the developing fetuses in the former compared with N'Dama. Another reason may be due to the fact that N'Dama cows are better adapted to the humid tropics. Table 2 shows that the temperature-humidity index (80.73) calculated from the climatic data (average temperature of 29.3^{0}C and 77.7% relative humidity) gave an indication that the cows were mildly heat stressed. This is a clear departure from results obtained through physiological data. It must be emphasized however that Latimer *et al* (2004) did not indicate if the physiological range recommended is applicable to gravid cows. Also, a significant number of the studies preceding recommendation of physiological range for various indices in livestock species are conducted in temperate regions. The true picture might not always reflect under tropical conditions. In addition, some contradictions exist; for example, calculation of temperature-humidity index for a single livestock species varies as described by several authors (NRC, 1971; Yousef, 1985). Detweiler and Erickson (2004) estimated the optimum ambient temperature to range between 10-30°C while relative humidity was 40-80%. The average ambient temperature and relative humidity readings obtained from this study places the animals in a zone of comfort. Heat stress should therefore not have been experienced going by the recommendation. It must be taken into account however that other factors such as surface area of animal, temperature of surroundings, air velocity, vapour pressure of air, conductivity of surrounding surface, shape of radiation source all influence the heat, emissivity of animal body surface determine the heat load an animal retains. This corroborates the finding of Zimbelman *et al* (2006) who noted that the physiological effects based on THI predictions on milk yield are currently underestimating the severity of heat stress in contemporary cattle. It therefore appears that it might be more helpful to accurately predict heat stress objectively by combining physiological data with climatic data. Incorporating other significant measures into climatic data as well as experienced visual observations will also be of help.

CONCLUSION

It was observed from this study that combination of physiological and climatic data was more effective in heat stress prediction in cows compared with use of either singly. Based on findings from this study and literature, it is recommended that studies determining recommended physiological ranges for thermoregulation in cattle reared in the tropics should be conducted. This will help in putting in place proper heat abatement measures that will maintain near optimum productivity in tropically raised cattle and other livestock species.

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Table 1: Average Daily Thermoregulatory Response of different cow breeds during gestation (Means±SEM)

Parameters	**N'Dama**	**White Fulani**	**Sokoto Gudali**
Pulse Rate (Beats/Minute)	56.42±0.40	56.10±0.29	56.39±0.37
Heart Rate (Beats/Minute)	56.60±0.16	56.79±0.43	57.43±0.25
Respiratory Rate (Beats/Minute)	39.54±0.47^{b}	46.00±0.69^{a}	48.74±0.63^{a}
Rectal Temperature (^{0}C)	38.25±0.09	38.35±0.12	38.14±0.13

ab: Means on same row with different superscripts are significantly (P<0.05) different

Table 2: Average Daily Reading of Ambient Temperature, Relative Humidity and THI

PARAMETER	**VALUE**
Temperature (^{0}C)	29.30±2.36
Relative Humidity (%)	77.70±1.11
THI	80.73

THI= Temperature-Humidity Index.