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EFFECT OF SEASON ON PHYSIOLOGICAL PARAMETERS OF THREE BREEDS OF CATTLE RAISED IN SUDAN SAVANNA ZONE

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ABSTRACT
This study was conducted to test the effect of season and breed on thermoregulatory parameters of three Nigerian indigenous breeds of cattle raised in Sudan Savanna Zone. A total number of nine (9) cattle aged between 4-5 years were used for this study. Data were taken for sixteen weeks across two seasons; Cold and Hot Season from three indigenous breed of cattle. Rectal temperature was recorded using digital thermometer, pulse rate was determined using stethoscope and respiratory rate was determined by counting of the respiratory movements of flank area. Data of ambient temperature and relative humidity were recorded on daily basis and temperature humidity index was calculated. All data obtained were subjected to analysis of variance using SAS software. Seasons significantly ($P < 0.05$) affect all the thermoregulatory parameters of with hot seasons having the highest values. Breed influenced ($p<0.05$) all the parameters measured. Red Bororo had the highest rectal temperature, while Sokoto has the least rectal temperature. Higher respiratory rate was recorded in SokotoGudali. Respiratory Rate of White Fulani are statistically similar with both Red Bororo and SokotoGudali, but Respiratory Rate of Red Bororo cattle has significantly difference ($P<0.05$) with SokotoGudali breeds of cattle. Pulse rate differs significantly ($P<0.05$), SokotoGudali recorded the highest rate and the least rate was observed in White Fulani cattle. It was concluded that Season affect all the thermoregulatory parameters and all the tested parameters were higher during hot season and SokotoGudali react more to thermal stress than Red Bororo and White Fulani

Keywords: thermoregulatory parameters, Red Bororo, SokotoGudali, season

INTRODUCTION

Climate change enforces adverse effects on animal physiology of livestock, leading to complete decrease in efficiency of production and reproduction (Li *et al.,* 2020). Heat stress is one of the main climatic effects faced by livestock, especially in tropical and sub-tropical countries. It has been reported that any change in the environmental conditions threatens the normal metabolic balance and regularly produces a positive feedback once the temperature is above the upper critical temperature (UCT: 025-26 C) (Hayes *et al.,* 2009; Atrian and Aghdam, 2012). Heat stress in the tropics is generally related with animal welfare issues and momentous economic losses resulting from reduced performance but increased morbidity and mortality of animal (Marai and Haeeb, 2010). The influence of heat stress is projected to become worse in the recent climate change scenario as it will increase the potential intensity of hot and humid conditions in the future, leading to an increased incidence of heat stress episodes (Gauly *et al.,* 2013). At higher ambient temperatures above 30°C, excessive heat load baskets the ability of animals to dissipate their body heat (Li, 2020). Heat stress occurs usually when animals are unable to maintain the balance between heat produced/stored and heat dissipated (Wankar *et al.,* 2014; Alhussien and Dang, 2018). To manage this excessive heat load, livestock animals attempt to reduce metabolic heat production while increasing heat dissipation to maintain euthermia. This is accompanied by a series of physiological, metabolic, and behavioral manifestations to thrive and mitigate adverse effects of heat stress. The first line of response to excessive heat load largely includes accelerated respiratory rate (RR), increased water intake but reduced feed intake (Bernabucci *et al.,* 2010). Physiological parameters such as body surface temperature (BST), rectal temperature (RT), respiratory rate, and pulse rate (PR) are the quick, ultimate responses of animals to climatic stress and eventually the level of discomfort or comfort of animals in a given environment (Silanikove, 2000).

Tropical cattle are known for their ability to tolerate heat while maintaining the efficiency in milk yield, reproduction, and disease resistance (Atrian and Aghdam, 2012). Thermo-tolerance in cattle is one of the desired adaptive ability of tropical cattle (Abbaya *et al.,* 2020). Cattle demonstrate certain physiological responses when under heat stress. Many indices have been proposed to measure the level of heat stress, however, their application is restricted to Temperature Humidity Index (THI) which had been used to integrate environmental temperature and relative humidity (Thatcher *et al.*, 2010). It has also been considered to be a reliable indicator of heat stress in cattle (Dikmen and Hansen, 2009). Animals can often endure higher temperatures if humidity is low, and the risk for heat stress increases dramatically as humidity increases, even at lower ambient temperatures (Dikmen and Hansen, 2009). Rectal temperature, respiratory rate, pulse rate and heart rate have been used as a reliable indicators of short time physical stress in animals (Ayo *et al.,* 1998; Kubkomawa *et al.,* 2015). Respiration rate which is the intake of oxygen and elimination of carbon dioxide under thermo-neutral condition that leads to evaporation and dissipation of moisture from the respiratory tract to maintain thermal balance (da Silva et al., 2017; Rashamol *et al.,* 2018) has been considered as one of the critical biomarkers for determining heat stress in farm animals. Rashamol *et al.* (2018) also opined that RR may act as an early signal of heat stress condition in livestock. High producing cattle have been reported to suffer more from heat stress than low producing cattle (West, 2002; Nayak *et al.,* 2018). Consequently, there is an urgent need to better understand the mechanisms by which thermal stress compromises efficient production of high-quality animal protein for human consumption. This study was designed to determine the season and breed variation in thermo-tolerance of three selected Nigerian indigenous cattle using thermoregulatory biomarkers.

MATERIALS AND METHODS

Experimental Site

This study was conducted at the Large Ruminant unit of the Livestock Teaching and Research Farm, Department of Animal Science, Federal University Dutsin-Ma. The farm is situated in the Sudan Savanna Zone within Latitude 12^{o}27, 10"N and 12^{o}27, 16"N and Longitude 07^{o}29, 56"E and 07^{o}30,04"E. The climate of the area is Semi-Arid classified as Tropical wet and dry climate (AW), as classified by W. Koppens. Maximum day temperature reaches about 38^{o}C in the month of March, April and May and minimum temperature is about 22^{o}C in December and January. (Tukur *et al.,* 2013).

Experimental Animal

A total of 9 cattle (3 Red Bororo, 3 Sokoto Gudali, and 3 White Fualni) of averagely the same age were used for the experiment. The animals were managed under semi-intensive system; where they were allowed to go for grazing early morning and come back later in the evening. Feed and water were supplemented to the animal *ad-libitum*. Prior the experiment, the animals were dewormed against parasitic infestation.

Thermoregulatory Data Collection

Thermoregulatory Parameters such as Rectal Temperature, Respiratory rate and Pulse rate were recorded daily. The rectal temperature was determined by inserting the sensory tip of digital thermometer into 1cm depth inside rectum of the cattle at the display of L^{O}C by a thermometer (which indicated that the thermometer is set for temperature reading). Each cattle was restrained gently and calmly and the reading lasted until thermometer beeped. The respiratory rate was determined when cattle are at resting period by visual counting the flank movements for one minute, while the Pulse rate was determined by using a stethoscope and stop watch. The stethoscope was placed on the left region of the thoracic vertebrae to count a number of heart rhythmite (contraction) in one minute.

Metrological Observation

The ambient temperature and relative humidity of the cattle pen and within the farm were recorded in the morning and evening daily using digital of thermo-hygrometer (Kadio RGMr 765) throughout the experimental period.

The mean ambient temperature (Ta) and relative humidity (RH) were recorded during the experimental period. The temperature humidity index (THI) was calculated using equation described by Mader *et al.* (2006).

THI= (0.8*Tdb) + [(RH/100)*(Tdb-14.4)] + 46.4

Where:

THI= Temperature humidity index

Tdb= Dry bulb air temperature. ^{O}C

RH=Relative air humidity, %

THI values were graded as; 27.8= absence of heat stress, 27.8-28.9=moderate stress, 29.0-30= severe heat stress and 30and above = very severe heat stress levels (Marai *et al.*, 2001).

Statistical Analysis

All data obtained during experiment were subjected to analysis of variance using SAS (2002) and means were separated using Duncan Multiple Range Test (DMRT). The relationships among thermoregulatory parameters were determined using the Pearson product moment correlation of the same software.

RESULT AND DISCUSSION

Table 1 shows the metrological variables recorded throughout the experimental period. The variables recorded are ambient temperature and relative humidity. The temperature humidity index (THI) was calculated. The result clearly indicated that, there were significant ($P < 0.05$) difference in ambient temperature, relative humidity and THI with hot season having the highest values in all the parameters. THI values are used to evaluate the heat stress on cattle. THI value ≤ 74 is a thermoneutral zone for the cattle (Du Preez, 2000). The THI value of 77.67 during hot season indicates that the animals are living in under heat stress, while value of 55.41 during cold season indicate the animal are under thermoneutral zone.

Table 1: Means of Daily Metrological Variables Recorded During Experimental Period

	Seasons		
Parameters	Hot	Cold	SEM
Atmospheric Temperature (ºC)	35.23^{a}	25.85^{b}	0.82
Relative Humidity (%)	31.06^{a}	10.15^{b}	0.54
Temperature Humidity Index	77.67^{a}	55.41^{b}	1.48

^{ab} means within the same row with different super script are significantly ($P < 0.05$) different

SEM – Standard Error of Mean

Tables 2 showed the effect of season on thermoregulatory parameters of Cattle Raised in Sudan Savanna Zone of Nigeria. Seasons significantly ($P < 0.05$) affected all the thermoregulatory parameters of rectal temperature, respiratory rate and pulse rate with hot seasons having the highest These results agree with the findings of Abbaya *et al.*, (2020), who reported higher rectal temperature, respiratory rate and pulse rate during late dry season (December to February), compared to early rainy season (April to June). The findings also agree with report of Kumar *et al*. (2017) who also reported that season has influence on thermoregulatory parameters of rectal temperature, respiratory rate and pulse rate in Hariana and Sahiwal breeds of cattle with summer season recording the highest values for all the parameters measured (Kumar *et al*., 2017).

The rectal temperature reported from the present experiment were 38.20 and 37.76 for hot and cold seasons respectively. This is in agreement to the findings of Abbaya *et al.*, (2020) and Habibu *et al*., (2019). Rectal temperature serves as the direct indicator of the thermal state of an animal, skin temperature, respiratory rate, pulse rate and heart rate reflect the thermolytic state of the animal (Kabuga, 1992; Jian *et al*., 2015; Habibu *et al*., 2017; Habibu *et al*., 2019). Rectal temperature is the optimal parameter for measuring body temperature due to better reflect the core body heat balance rather than the temperature of the surface of the skin (Aritonang *et al.*, 2017). This increase during hot season is as a result of increase in ambient temperature as reported by Daramola *et.al.* (2012) who reported that when the temperature raises, both the surface skin temperature and rectal temperature increased due to vasodilatory. The vasodilation will increased blood flow to peripheral blood vessels which aims to release heat from the body to the environment (Daramola *et. al.*, 2012).

The result from our studies reported that respiratory rate is higher in hot season (30.07 breath/min) than in cold season (25.33 breath/min) and this agree with the findings of Raymond (2017) who reported a rise in respiratory rate during hot dry season in exotic dairy animals. So also, Tuner *et al.* (1992) recorded 16 breath/min. less in a cold season than in hot season of dairy cows. Habeeb *et al*. (1997) and Marai *et al*. (2001) also reported an increase in thermoregulatory parameters in the hot dry season. Sailo *et al* (2017) also reported an increase in respiratory rate of 15.74, 18.16 and 29.82 in Sahiwal and 15.78, 22.98 and 47.30 breaths/minute in Karan Fries cattle during the winter, spring and summer seasons, respectively. Respiratory rate was reported to be the most sensitive cardinal and most useful animal based thermoregulatory indicator of heat stress in livestock (Gaughan *et al*., 2000; Yaqub *et al*., 2017). This is because changes in respiratory rate always precede changes in the other cardinal thermoregulatory variables such as rectal temperature, sweating and pulse rate (Jian *et al*., 2015; Dalcin *et al*., 2016; Singh *et al*., 2018). The changes in the respiratory rate are indicators of adaptive response of the animal to maintain homoeo-thermic balance (Kumar *et al*., 2017).

The pulse rate recorded from the experiment were 55.85 beat/min and 51.61 beat/min for cold and hot seasons respectively. This agreed with finding of Abbaya *et al.,* (2020) who reported 31.30 beat/min and 16.80 beat/min during late dry and late rainy season. Increase in pulse rate causes an increases in the blood flow to the surface and thereby facilitating heat loss (*Marai et al*., 2001). Shaji *et al* (2016) also reported an increase in pulse rate in Osmanabadi goats exposed to heat stress indicating its role in assessing heat loads in animals.

Significant higher thermoregulatory parameters of pulse rate and respiratory rate in the present study during the hot season may be due to the high ambient temperature and which must have exceeded the comfort zone of the animals as see in THI of Table 1, resulting in the imbalance in the heat energy production and dissipation (Singh *et al*., 2014; Kumar *et al*., 2017). Deviation from the normal rectal temperature has been considered as an index of discomfort, and it has been considered as an index of body temperature even though considerable variations in various body parts in core body temperature exist at different times of the day (Singh *et al*., 2014).

Table 2: Effect of Season on Thermoregulatory Parameters

	Seasons		
Parameters	Hot	Cold	SEM
Rectal Temperature (^{o}C)	38.20^{a}	37.76^{b}	0.45
Respiratory Rate (Breath/Minute)	30.07^{a}	25.33^{b}	1.59
Pulse Rate (Beat/Minute)	55.85^{a}	51.61^{b}	3.74

^{ab} means within the same row with different super script are significantly ($P < 0.05$) different

SEM – Standard Error of Mean

Breed influenced all the thermoregulatory parameters (*P*<0.05, Table 3). Red Bororo had the highest rectal temperature, while Sokoto has the least rectal temperature. Higher respiratory rate was recorded in Sokoto Gudali. Respiratory Rate of White Fulani are statistically similar with both Red Bororo and Sokoto Gudali, but Respiratory Rate of Red Bororo cattle has significantly difference (*P*<0.05) with Red Bororo breeds of cattle. Pulse rate differs significantly (*P*<0.05), Sokoto Gudali recorded the highest rate and the lease rate was observed in White Fulani cattle. This result agreed with the findings of Ewuola *et. al.* (2015) who reported that breed has effect on thermoregulatory parameters of four breeds of cattle. Breed variation in respiratory rate was also reported by Sailo *et al.* (2017), the respiratory rate was reported to be 15.74 in Sahiwal and 15.78 breaths/ minute in Karan Fries cattle during winter. In another study, Valente *et al* (2015) reported a higher respiratory rate in Angus cattle (104 breaths/ minute at 370C) during a heat stressed condition. Correa-Calderon *et al.* (2004) observed a higher respiratory ratein heat stressed Brown Swiss and Holstein cows under a cooling system than other breeds.

Indu and Pareek (2015) is of the opinion that higher respiratory rate above 80breath/minute ia great indicator of higher quantum of heat stress in farm animals. A significant breed variation within different seasons is reported by Sailo *et al*. (2017). The increase in pulse rate causes an increase in the blood flow to the surface and thereby facilitates heat loss (Marai *et al.*, 2007).

Gaughan *et al*. (1999) also reported breed variations in thermoregulatory parameters of cattle. He reported that Zebu cattle (*B. indicus*) had better body temperature regulation than the Taurine cattle *(B. taurus*) in tropical climatic conditions in

India. Rectal temperature and respiratory rate are the major indicators of heat stress in animals (Gaughan *et al*., 2012; Aritonang *et al*., 2017).

In this present studies, Sokoto Gudali appears to be more thermally stable than its other indigenous counterparts. The differences in thermoregulatory parameters could be as a result of differences in genes that can affect colour characteristics and structure of the cattle's body (Aritonang *et al*., 2017).

Table 3: Breed Effect on Thermoregulatory Parameters

	Breeds			
Parameters	RB	SG	WF	SEM
Rectal Temperature (ºC)	38.11[a]	37.91[b]	37.93[b]	0.38
Respiratory Rate (Breath/Minute)	27.31[b]	27.99[a]	27.83[ab]	1.88
Pulse Rate (Beat/Minute)	53.79[ab]	54.24[a]	53.17[b]	3.28

[ab] means within the same row with different super script are significantly ($P < 0.05$) different

RB - Red Bororo, SG – Sokoto Gudali, WF – White Fulani.

SEM – Standard Error of Mean

CONCLUSION

Season affect all the thermoregulatory parameters and all the tested parameters were higher during hot season. Therefore, hot season is the most likely season the cattle will lived in uncomforted thermal zone in Sudan Savanna Zone of Nigeria. It was also established that breeds have effect on all the thermoregulatory parameters. Sokoto Gudali react more to thermal stress than Red Bororo and White Fulani, this may be due to the court color differences between the breeds.

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