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Species, Age and Sex Effect on Thermoregulatory Parameters of Animals in Hot Season of Mubi

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ABSTRACT

The study was carried out to determine the effect of species, sex and age on thermoregulatory traits of three species of animals in the hot season of Mubi. The species were cattle, sheep and goat. A total of forty eight (48) animals were used, comprising of sixteen (16) each of cattle, sheep and goat that were sourced at international cattle market Mubi. Thermoregulatory parameters taken were, rectal temperature (RT), Respiration rate (RR) and Pulse rate (PR). Heat Tolerance Coefficient was calculated as an index. The thermoregulatory traits measured were subjected to analysis of variance using statistical analysis for sciences (SAS) and means were separated using Duncan Multiple Range Test. Species and sex significantly ($P<0.05$) affected rectal temperature and pulse rate. The highest recorded rectal temperature was in goat (39.74 ^{0}C). The highest pulse rate was in cattle (59.08 beats/minutes). The highest recorded rectal temperature was in male cattle (39.03 ^{0}C). The highest pulse rate was in female goat (36.97 beats/ minute), respectively. The highest recorded rectal temperature was in adult sheep (39.03 ^{0}C). The highest recoded respiratory rate was in young cattle (72.67 breaths/minute). The highest recorded pulse rate was in young sheep (39.33beats/minute). The highest recoded heat tolerance coefficient was in young cattle (4.48). Respiration rate perfectly correlated positively ($P<0.001$; $r=0.99$) with Heat Tolerant Coefficient. It was concluded that sheep had better thermoregulation ability than cattle and goat. This study recommend a provision of sheds at animal's stands to reduce the direct effect of radiation on the animals at Mubi livestock market.

INTRODUCTION

The livestock sector is an important sector because of its contribution in the Global food security. They are said to provide 17% of global kilocalories and 33% of global protein consumption (Athira *et al*., 2017; Nayak *et al*., 2018) and the demand for products from this sector is increasing rapidly particularly in the developing countries (Tapki and Sahin, 2006; Brscic *et al*., 2007; Athira *et al*., 2017). For instance, increasing demand for livestock product exist recently because of increase in population size, rising income, urbanization and insecurity in most of the developing countries (Delgado, 2005; Athira *et al*., 2017).

Heat stress which comes as a result of climate change have direct and indirect effect on animals' productivity and welfare. This concern is more pronounced because of increase rapid population growth and the more the population growth, the more the need of animal protein (Nardone *et al*., 2010; Baumgard *et al*., 2012; Nardone *et al*., 2010). Heat stress can be defined as situation or condition caused by an animal's inability to dissipate body heat efficiently to balance body temperature through a vital process that is known as thermoregulation (Rolf, 2015). Heat stress plays a significant negative role in animal performance and can be of greater impact in the future as climate change continuous (Raymond, 2017).

Among the environmental variables affecting animals, heat stress is one of the factors making animal production challenging in many part of the world (El – Tarabany *et al*., 2017). Although animal can adopt to climatic stressors, the response mechanisms that ensure survival are also detrimental to performance (Athira *et al*., 2017; Pragna *et al*., 2018). The vulnerability of livestock to heat stress varies based on species, breed, sex, age and genetic potential, life stage, management or production system and nutritional status (Das *et al*., 2016). Moreover, under the testing environmental conditions animal productivity is affected and this result in economic losses for livestock industries.

Heat stress affect the growth performance (Baumgard *et al*; 2012), milk production (Das *et al*., 2016), reproductive performance (Rhoads *et al*; 2009), milk production (Archana *et al*., 2018) and disease occurrences (Rojas – Dowing *et al*., 2017). Different breed and genotype have been reported to respond differently to varying environmental factors to be affected by adverse metrological conditions prevailing in the tropical Africa; predisposing them to hypathermia (that is heat stress) and hypothermia which is cold stress or shock (Dasilva *et al*., 2003). Some physiological traits such as sweating rate, rectal temperature and respiration rate have been reported to be related to the ability of the animals to cope with heat stress (Garner *et al*., 2016; Abbaya *et al*., 2020).

Rectal temperature, respiratory rate, pulse rate and heart rate have been used as a reliable indicators of short term physical stress in animals (Kubkomawa *et al*., 2015). Heat stress causes changes in phenotypic and genotypic traits in livestock and is quantified by the measurement of physiological responses such as respiration rate (RR), rectal temperature (RT), skin temperature (ST), pulse rate (PR) and sweating rate (SR) (Rashamol *et al*., 2018). Among the physiological traits RR, RT and ST are identified as the biomarkers for quantifying the heat stress impact on livestock (Shaji *et al*., 2016). To minimize problems related to heat stress, one way strategies is to select animals with superior genetic potential for adaptation to tropical climate (Baena *et al*., 2018). Mubi international livestock market is one of the biggest livestock markets in Nigeria where livestock are kept and sold every day. Information on thermoregulatory responses of the livestock kept and sold there will go a long way in knowing how these livestock should be properly handled for maximum profit. The objective of this paper therefore, is to evaluate species, age, and sex effect on the thermoregulatory parameters of cattle sheep and goat.

MATERIAL AND METHODS

Experimental site

The study was conducted in Mubi, which is located in the sub – Sudan Savanah vegetation belt with coordinate of 10˚ 16''N, 13˚ 16''E and an altitude of 1906 feet. The major occupation of the people is farming. However, because of the Yedseram River the people also engage in fishing activities but at a subsistence level. The climatic is tropical with average temperature of about 32.90˚C in dry season with relative rainfall. The major tribe of the town are; Gude, Nzanyi and Fali with Fulani, Margi, Higgi and Mundang as minority (Adeboye *et al*., 2020). The average annual temperature is 23.9˚C while the average rainfall is 1629mm (climate – data. Org, 2018). The least amount of rainfall occurs in July with an average of 77mm. Most precipitation falls in November with an average of 179mm. The temperature are highest on average in April, at around 24.4˚C. In July, the average temperature is 23.2˚C which is the lowest average temperature of the whole year (Adeboye *et al*., 2020).

Sources of Experimental Animals and Management

A total of Forty eight (48) animals was used, comprising of sixteen (16) each of cattle, sheep and goat. The animals used for the experiment were sourced at international cattle market Mubi. They were selected based on age and sex.

Age Estimation:

For cattle, the animals used for sampling were less than 2 years, and greater than 4 years. This gave rise to animals being categorized as young and adult for both males and females. For goats and sheep, animals were categorized into age groups as follows: less than 1 year, and more than 2 years. These for both males and females gave rise to young and adult animals, respectively. Dental formulae of the animals were used to estimate the ages for the animals. For cattle, sheep and goat, the formula used was (003/4033 and 0033/4033), for young and adult, respectively (Roderick, 1965; Akpa *et al*., 2017).

Thermoregulatory data collection

Rectal temperature (RT): This was taken using a digital thermometer. The sensory tip was disinfected and inserted into the rectum at the display of L˚C by the sound of alarm signal. It was recorded in ˚C.

Respiration rate (RR): This was determined by counting the number of flank movements per minute as recorded in breaths/minute

Pulse rate (PR): this was taken by using placing a stethoscope. It was measured by placing the device on the femoral arteries of the hind limb for 1 minute. It was recorded in beats/minute

Heat Tolerance Coefficient (HTC): HTC was calculated based on heat tolerance index developed by Benezra (1954). The formula is based on both respiration rate and rectal temperature.

HTC:RR/23+RT/38.33

Data Analysis

Statistical model

The statistical model for the experiment is as given below;

$Y_{ij} = \mu + S_i + e_{ij}$

Where, μ = general mean, S_i = i^{th} effect of Specie (S = 3) and e_{ij} = experimental error.

Statistical analysis

All data collected on thermoregulatory parameters were subjected to analysis of variance using the general linear model of SAS 9.0 (SAS, 2004). Means with significant differences were separated using Duncan Multiple Range Test (Duncan, 1955). Correlation coefficient was estimated using the correlation procedure of the same software.

RESULTS AND DISCUSSION

Table 1 shows the effect of species on thermoregulatory parameters of cattle, sheep and goat. Species significantly ($p<0.05$) affected rectal temperature and pulse rate. The highest recorded rectal temperature was in goat (39.74 ^{0}C). The highest pulse rate was in cattle (59.08 beats/minute).

Physiological adaptive mechanisms vary between species and within specie (Rashamol *et al*., 2018) and accurate measurement of heat stress in dairy cows is complicated since response to heat stress affects many processes (Atrian and Aghdam, 2012). Some physiological traits have been reported to be related to the ability of the animal to cope with heat stress (Garner *et al*., 2016; Ribeiro *et al*., 2018). These traits are sweating rate, rectal temperature and respiration rate. They increase when animals are exposed to warm environment (Dikmen *et al*., 2012; Perano *et al*., 2015; Garner *et al*., 2016; Rashamol *et al*., 2018). Even though the rectal temperature of goat recorded in this study fall within the normal range (38.3°C – 40.0°C) (Swenson and Reece, 2006; Ribeiro *et al*., 2018), the superiority of goat in rectal temperature against cattle and sheep in this study suggest that the goats in the study area react more to heat than cattle and sheep (Rashamol *et al*., 2018). Rectal temperature has been reported to be an ideal indicator for heat load in the animal's body and may be used to assess the adversity of the thermal environment which can affect the growth, lactation, and production of dairy cows (Johnson, 1980; Dikmen and Hansen, 2009; Koga *et al*., 2004; Thatcher *et al*., 2010; Rashamol *et al*., 2018). Increased rectal temperature in animals is a sign of discomfort (Singh *et al*., 2014). Rectal temperature is a product of balance between heat generated as a result of basal metabolism as well as the muscular activities and the heat lost from the body (Kubkomawa *et al*., 2015). The higher recorded rectal temperature in goat in this study may be due to the factors such as body size, excitement, stage of pregnancy, physical activity, time of the day the environment (ambient temperature and humidity), content and fullness of the digestive tract of the animal that has been reported to affect thermoregulation in animals (Prendiville *et al*., 2002; Kubkomawa *et al*., 2015; Pragna *et al*., 2016).

Pulse rate which is a rhythmic, periodic thrust felt over an artery in time and rhythm with the heartbeat (Babayemi *et al*., 2014; Kubkomawa *et al*., 2015) has been reported to be one of the major responses of animals to heat stress (Garner *et al*., 2016; Rashamol *et al*., 2018). The superiority of cattle in pulse rate over other species in this study suggests that cattle just like goat was more responsive to heat stress in the study area than sheep. This is because an increase in pulse rate will bring about an increase in the flow of blood to the body parts which will result in higher heat loss by sensitive and in sensitive ways (Marai *et al*., 2007; Ribeiro *et al*., 2018). The lowest values of thermoregulatory parameters in sheep in this studies could be due to the fact that sheep require small amount of energy to maintain normothermia with the thermoneutral zone (Moberg, 2000; Perez *et al*., 2020). This concur with the fact that the capacity of an animal to cope with the effect of increasingly environmental temperature without becoming heat stressed, differs within and between species (Aleena *et al*., 2020). Also in line with this study, it was reported that sheep and goats are more tolerant to heat stress, water and water scarcity than cattle (Aziz, 2010; Aleena *et al*., 2020).

Table 1: Effect of species (Mean ±S.E) on thermoregulatory traits

Parameters	Cattle	Goat	Sheep
Rectal Temperature (^{0}C)	38.85^b±0.1	39.74^a±0.18	38.68^b±0.16
Respiratory Rate (breaths/ minutes)	59.50±5.25	57.50±3.20	61.75±2.21
Pulse Rate (beats/minute)	59.08^a±2.44	33.98^b±1.17	36.17^b±1.08
Heat Tolerant Coefficient	3.600±0.23	3.54±0.14	3.69±0.10

^{ab} means with different superscripts along the rows are significantly different; S.E= Standard Error

Table 2 shows the effect of sex on the thermoregulatory parameters of cattle, sheep and goat. Sex had only significantly ($p<0.05$) affected the rectal temperature in cattle and pulse rate in goat. The highest recorded rectal temperature was in male cattle (39.03^{0}C). And the highest pulse rate was in female goat (36.97 beats/minute).

The significant effect of sex on the thermoregulatory parameters of goat in this study agreed with the report of Yakubu *et al*. (2016) reported a higher pulse rate (109.47) in female than male (97.01) in of Nigerian goats. Contrary to this findings also, Yakubu *et al*. (2016) reported a significant effect of sex on rectal temperature in Nigerian goats. Among other factors that can affect physiological response of animals to heat stress include; species, breed, sex, age and genetic potential, life stage, location, management or production system and nutritional status (Das *et al*., 2016; Yakubu *et al*., 2016). Sex had not significantly affected any of the thermoregulatory parameters in this study. Contrary to the findings of this experiment, authors (Fadare *et al*., 2012; Gemechu and Kibeb, 2017; Ibn Iddriss and Abdul Rahim, 2018; Suleiman *et al*., 2020) reported sexual dimorphism in rectal temperature, respiration rate and pulse rate with female having higher values than male sheep. Discrepancies observed with this study could be as a result of differences in breeds and location of experiment (Dasilva *et al*., 2003; Bello *et al*., 2016). In a separate study on goats in Democratic Republic of Congo, female goats subjected to prolonged solar radiation recorded higher physiological parameters than their male counterparts (Baenyi *et al*., 2020) while Suleiman *et al*. (2020) on the contrary, reported higher values of rectal temperature in male goats than in females. The high recorded value of pulse rate was in female goats than in males this may be due to vasodilation of skin capillaries bed which to increase blood flow to the body surface areas to facilitate heat loss (Wojtas *et al*., 2014; Baenyi *et al*., 2020) since female goats are affected by heat stress (Acharya *et al*., 1995).

Table 2: Effect of sex on thermoregulatory parameters of cattle, sheep and goat

Species	Sex	RT	RR	PR	HTC
Cattle	Male	39.03±0.18^a	59.00±2.53	56.00±2.53	3.58±0.38
	Female	38.67±0.02^b	60.00±6.61	62.17±3.98	3.62±0.29

Sheep	Male	38.70±0.27	65.50±2.63	35.67±1.56	3.86±012
	Female	38.65±0.21	58.00±3.00	36.67±1.61	3.53±1.34
Goat	Male	39.87±0.29	51.67±5.07	31.00±0.82[b]	3.29±0.22
	Female	29.62±0.21	63.33±2.40	36.97±1.33[a]	3.79±0.11

RT: rectal temperature, RR: respiratory rate, PR: pulse rate, HTC: heat tolerance coefficient

Table 3 shows the effect of age on thermoregulatory parameters of cattle, sheep and goat. Age significantly ($p<0.05$) affected rectal temperature, respiratory rate, pulse rate and heat tolerance coefficient. The highest recorded rectal temperature was in adult sheep (39.03°C). The highest recoded respiratory rate was in young cattle (72.67 breaths/minute). The highest recorded pulse rate was in young sheep (39.33 beats/minute). The highest recoded heat tolerance coefficient was in young cattle (4.48).

Heat tolerance coefficient measures the adaptability of an animal during heat stress. Hence lower HTC may indicate an improved thermo-tolerance which had been useful in genetic improvement in cattle (Kumar *et al*., 2017). From this study therefore, adult cattle were the most adaptable in the studied area. The high value of HTC recorded in young cattle species could be attributed to the fact that young cattle suffer most from heat stress absorbed from the environment due to their inheritability, (Blackshaw and Blackshaw, 1994; West, 1994; Dikmen and Hansen, 2009; Thatcher *et al*., 2010). Rectal temperature in this study was higher in adult sheep than in young sheep. Contrary to the findings of this experiment, Gemechu and Kibeb, (2017) reported a higher rectal temperature was significantly (39.21) higher in young sheep (1-3 years) than in adult (39.15) sheep (>3 years). In a separate experiment on goats, Bello *et al*. (2016) reported a lower body temperature in adult West African Dwarf goats than in the young suggesting that adults goats are better able to resist changes in body temperature than kids. Contrary to the result of this study also, rectal temperature, respiration rate and pulse rates for 3 years sheep were reported to be higher than 2. 5 years sheep (Suleiman *et al*., 2020).

Table 3: Effect of age on thermoregulatory parameters of cattle, sheep and goat

Species	Age	RT	RR	PR	HTC
Cattle	Young	39.00±0.16	72.67±5.97[a]	61.50±4.58	4.48±4.18[a]
	Adult	38.70±0.10	46.33±4.01[b]	56.67±1.91	3.02±0.17[b]
Sheep	Young	38.31±32[b]	58.83±2.65	39.33±0.99[a]	3.56±0.11
	Adult	39.03±0.08[a]	64.67±3.33	33.00±0.35[b]	3.83±0.14
Goat	Young	39.98±0.23	55.00±5.84	34.80±2.36[a]	3.43±0.25
	Adult	39.50±0.25	60.00±2.92	33.17±0.40[b]	3.64±0.13

RT: rectal temperature, RR: respiratory rate, PR: pulse rate, HTC: heat tolerance coefficient

Table 4 shows the correlation between thermoregulatory parameters of cattle, sheep and goat. Rectal temperature significantly ($P<0.05-0.01$, $r=-0.76-0.48$) correlated with RR (0.45); PR (-0.76) and HTC (0.48) in sheep. RR significantly ($P<0.05-0.01$; r-0.05-0.99) with HTC (0.99) in cattle, RR and HTC (-0.50 and 0.99). PR correlated positively ($P<0.05-0.01$) $r=-0.52-0.73$ with HTC in sheep and goat (-0.52 and 0.73) respectively.

The positive relationship among between thermoregulatory parameters in cattle, sheep and goats in this study concur with the report of Singh *et al*. (2014) who also reported a positive correlation between Rectal Temperature, respiration rate and other physiological responses in Murrah buffaloes, Karan Fries and cross bred cattle. Also, strong correlation was reported between rectal temperature and vaginal temperature in grazing *Bos Taurus* heifers (Lees *et al*., 2018). Heat Tolerant Coefficient has been reported to be the ideal measurement of heat stress in animals Nardone and Valenti, 2000; Heather and Chain, 2016) and rectal temperature, respiration rate and pulse rate are the major biomarkers of heat stress in animals (Shaji *et al*., 2016; Da Silver *et al*., 2017; Rashamol *et al*., 2018). This implies therefore, a significant increase in those thermoregulatory parameters that are positively correlated with each other will bring about a significant increase in the other, vice versa (Akpa *et al*., 2017; Abbaya *et al*., 2020).

Table 4: Correlation between thermoregulatory parameters in cattle, sheep and goat

		RT	RR	PR
Cattle	RT			
	RR	0.03		
	PR	- 0.23	- 0.08	
	HTC	0.15	0.99***	- 0.08
Sheep				
	RT			
	RR	0.45*		
	PR	-0.76**	-0.50*	
	HTC	0.48*	0.99***	-0.52*
Goat				
	RT			
	RR	0.13		
	PR	-0.01	0.73**	
	HTC	0.16	0.99***	0.73**

RT: rectal temperature, RR: respiratory rate, PR: pulse rate, HTC: heat tolerance coefficient, *significant, **high significant, ***very highly significant, RT: rectal temperature, RR: respiratory rate, PR: pulse rate, HTC: heat tolerance coefficient

CONCLUSION

It was concluded sheep had better thermo tolerance than cattle and goat. The highest rectal temperature recorded in male cattle while the highest recorded pulse rate was recorded in female goat. Rectal temperature was highest in adult sheep, highest respiration rate was in young cattle. Pulse rate was highest in young sheep while the highest recorded heat tolerance coefficient was in young cattle. We recommend that research be carried on the species, age and sex effect on thermoregulatory parameters in cold season of Mubi for a better comparison.

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