Comparative study of physiological adaptation in West African dwarf and Kalahari red goats in the humid tropics

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Abstract

Animal production output has suffered significantly due to climate change, necessitating thorough research on breed-specific adaptive mechanism, particularly for goats, in order to better understand these animals' tolerance level. The comparative physiological adaptation of the West African Dwarf (WAD) goat indigenous to the humid climate of West Africa and the Kalahari Red (KR) goat introduced to the humid zone of Southwestern Nigeria from the semi-arid sub-tropical zone of South Africa was investigated. Fourteen goats consisting of seven WAD and seven KR aged between 2 and 4 years were housed in a well ventilated concrete-floored pen. The animals were zero-grazed and fed concentrate and Bracharia decumbens hay for six months consisting of two seasons; cold-dry season (November – January) and hot-dry season (February – April). Rectal temperature, respiratory rate, heart rate and pulse rate were monitored twice daily once a week. Kalahari Red goats had significantly higher ($p<0.001$) rectal temperature (38.97 vs. 38.39^o C), respiratory rate (51.20 vs. 47.98 breaths / min) and pulse rate (61.56 vs. 60.22 pulses / min) than WAD goats while heart rate was similar ($p<0.05$) in the two breeds. Rectal temperature, respiratory rate and pulse rate were lower in both breeds in the cold dry season than in the hot dry season. All the physiological parameters measured in this experiment were significantly ($p<0.001$) affected by time of day and week of sampling. Rectal temperature, respiratory rate, heart rate and pulse rate were all higher in the afternoon than in the morning while the highest values were recorded in the 20th, 22nd, 23rd and 3rd week of sampling, respectively. Rectal temperature, respiratory rate and pulse rate were lower in both breeds in the cold dry season than in the hot dry season. The study concluded that rectal temperature, respiratory rate and pulse rate were all higher in the Kalahari Red than the West African Dwarf goats. Though the adaptive physiological responses of both breeds to the humid tropical climate appeared to be adequate, however, the West African Dwarf goat appeared to cope better in the hot-dry season while the Kalahari Red goat appeared to cope better in the cold-dry season.

Keywords: Physiological adaptation; Kalahari Red; West African Dwarf; humid tropics

Etude comparative de l'adaptation physiologique chez la chèvre West African Dwarf et la chèvre du Kalahari red dans les tropiques humides

Résumé

La production animale a considérablement souffert du changement climatique, ce qui a nécessité des recherches approfondies sur les mécanismes d'adaptation spécifiques aux races, en particulier pour les chèvres, afin de mieux comprendre le niveau de tolérance de ces animaux. L'adaptation physiologique comparative de la chèvre West African Dwarf (WAD) indigène au climat humide de l'Afrique de l'Ouest et de la chèvre du Kalahari Red (KR) introduite dans la zone humide du sud-ouest du Nigéria à partir de la zone subtropicale semi-aride d'Afrique du Sud a été enquêté. Quatorze chèvres, dont sept WAD et sept KR âgées de 2 à 4 ans, ont été hébergées dans un enclos *au sol en béton bien ventilé. Les animaux ont été nourris au pâturage zéro et nourris avec du concentré et du foin de Bracharia decumbens pendant six mois répartis sur deux saisons ; saison froide et sèche (novembre – janvier) et saison chaude et sèche (février – avril). La température rectale, la fréquence respiratoire, la fréquence cardiaque et le pouls ont été surveillés deux fois par jour une fois par semaine. Les chèvres rouges du Kalahari avaient une température rectale (38,97 contre 38,39 °C), une fréquence respiratoire (51,20 contre 47,98 respirations/min) et un pouls (61,56 contre 60,22 impulsions/min) significativement plus élevés (p<0,001) que les chèvres WAD tandis que le cœur le taux était similaire (p <0,05) dans les deux races. La température rectale, la fréquence respiratoire et le pouls étaient plus faibles chez les deux races pendant la saison sèche froide que pendant la saison sèche chaude. Tous les paramètres physiologiques mesurés dans cette expérience étaient significativement (p <0,001) affectés par l'heure de la journée et la semaine d'échantillonnage. La température rectale, la fréquence respiratoire, la fréquence cardiaque et la fréquence du pouls étaient toutes plus élevées l'après-midi que le matin, tandis que les valeurs les plus élevées ont été enregistrées respectivement au cours des 20e, 22e, 23e et 3e semaines d'échantillonnage. La température rectale, la fréquence respiratoire et le pouls étaient plus faibles chez les deux races pendant la saison sèche froide que pendant la saison sèche chaude. L'étude a conclu que la température rectale, la fréquence respiratoire et le pouls étaient tous plus élevés chez la chèvre rouge du Kalahari que chez la chèvre naine d'Afrique de l'Ouest. Bien que les réponses physiologiques adaptatives des deux races au climat tropical humide semblent être adéquates, la chèvre naine d'Afrique de l'Ouest semble mieux s'en sortir pendant la saison chaude et sèche, tandis que la chèvre rouge du Kalahari semble mieux s'en sortir pendant la saison froide et sèche.*

Mots-clés : Adaptation physiologique ; Kalahari Red; West African Dwarf; tropiques humides

Introduction

Goats play a major role in the food and nutritional security of the rural poor. Goat farming also enhances the socio-economic status of the rural population in terms of income generation, payment of dowry and cultural inclinations (Mahendra and Dilip, 2021). However, climate change emerged as one of the main threats to the growth of the livestock sector (Nardone *et al.*, 2010). Further, the climate change induced heat stress has been established as one of the crucial factors affecting livestock production. Physiological adaptability is the modifications in the behavioural or metabolic response in animals to cope with the extreme environmental conditions. Adaptability of an animal has been defined as the ability to survive and reproduce within a defined environment, or the degree to which an animal can become adapted to a wide range of environments by physiological or genetic means (Barker, 2009). The environment surrounding an animal at any particular time influences the amount of heat exchange between it and the environment. Consequently, it influences the physiological adjustment of the animal which is necessary in order to maintain a body heat balance (Donald *et al.*, 1988). The ability to regulate body temperature depends on complex interactions among anatomical and physiological factors. Factors such as properties of the skin and hair, sweating and respiration capacity, tissue insulation, the relationship between surface area per unit body weight or relative lung size, hormonal profiles and metabolic heat production are known to influence heat loads (McManus *et al.*, 2008). Heat stress is one of the several interruption factors that make animal production and reproduction difficult in many areas of the world (El-Tarabany *et al*., 2017). Its consequences are impaired production, reproduction, growth, milk quantity and quality, as well as natural immunity and making the animals more susceptible to different diseases (Yasha *et al*., 2017). Adaptation to prolonged heat stress may lead to production losses (Sejian *et al.,* 2013). In order to maintain the body temperature during heat, animals initiate compensatory and adaptive mechanisms like behavioural and physiological changes to re-establish homeothermy and homeostasis which promote welfare and favours survival in a specific environment (Indu *et al*., 2015).

Air temperature and relative humidity have mainly direct influences potentials of ruminant animal production (Seixas *et al*., 2017). The changes in biological functions of goats due to exposure to heat stress include the depression in feed intake and utilization, disturbance in the metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites (Habeeb *et al.*, 1992; Marai *et al.*, 2000; 2003). At very high temperatures, the pulse rate may decrease due to a decrease in the metabolic rate. Taniguchi *et al.* (2004), reported that as ambient temperature increases pulse rate also increases as well the circulation of blood to transfer heat from the core to the periphery. Rectal temperatures vary between 38.3 and 39.9ºC under thermo-neutral conditions. An increase in the ambient air temperature from 18 to 35ºC is accompanied by significant increases in rectal temperature in sheep (Abdel–Samee, 1991; Marai *et al.,* 2000). The tropics is characterized by high ambient temperature (22-32ºC or higher). The prevailing high relative humidity aggravates the heat load as it reduces the ability of the animals to loose heat through evaporative cooling (sweating) (Oladimeji, 1994). This notwithstanding, the West African Dwarf goat is hardy and thrives well in the humid tropics which is possible because of the innate adaptogenic power of the animal to react to a particular stressor (Adeloye, 1998; Adeloye and Daramola, 2004). The Kalahari Red goats on the other hand, were imported from Elpasso farms, located in the semi-arid subtropical zone of Sterkfontein South Africa to the humid zone of Southwestern Nigeria. This study was therefore aimed at comparing the physiological adaptation trends exhibited by the Kalahari Red goats in the humid tropics relative to the West African Dwarf goats.

Materials and Methods

Experimental Site

The study was carried out at the Directorate of University Farms (DUFARMS), Federal University of Agriculture Abeokuta. The region lies between 7º18′2′N - 7º18′30′N; latitude and 3º22′10′E - 3º22′41′E longitude. The site is within the rain forest vegetation zone of South-Western Nigeria and the climate is humid. The mean annual rainfall of the area is 1,330 mm with a mean annual temperature of 29.3ºC and relative humidity of 80%, respectively. Temperatures are fairly uniform with daytime values of 28–30°C during the early rainy season of the year (April–June) and late rainy season (July–September) and 30–34°C during the early dry season (October–December) and late dry season (January–March) with the lowest night temperature of around 24 °C during the harmattan period between December and February. Relative humidity is high during the rainy season with values between 63% and 96% as compared to the dry season (55–84%). The temperature of the soil ranges from 24.5 to 31.0°C FUNAAB, (2012).

Origin of experimental animals

Seven bucks with ages ranging between 2-3 years were imported from Elpasso farms, located in Sterkfontein South Africa on the 10th of September, 2011 by the management of the Federal University of Agriculture, Abeokuta essentially for teaching, research and learning. Elpasso farms is located in the sub-tropical region of Southern Africa with average summer temperature of 27º C and average winter temperature of 18º C. Extreme temperature ranges from 3º C in winter to 36º C in height of summer. The Kalahari Red goats were quarantined for two months (between 10th of September and 10th November, 2011) by the Nigeria Veterinary Quarantine Services, Ikeja for the following diseases: Brucellosis, Pestis des petit ruminat (PPR) and tuberculosis following which a clean bill of health was then issued. On the other hand, the Seven West African Dwarf bucks with ages ranging between 3-4 years used for this study were experimental animals already adapted to the environment.

Experimental Animals, management and design

Physiological trends exhibited by the Kalahari Red goat following their introduction into the sub-humid tropics in Nigeria alongside the West African Dwarf already adapted to the prevalent weather conditions in the sub-humid tropics were monitored. Fourteen bucks consisting of 7 each of West African Dwarf and Kalahari Red breeds between 2-4 years of age (15-20kg for West African Dwarf) and (60-68kg for Kalahari Red) were used for the study. They were both managed intensively on a slatted floor in a well ventilated house with corrugated asbestos roof. Humidity was low, atmospheric air dry and environment moist dry during the cold dry season while the hot-dry season was characterised by high ambient temperature and intense solar radiation. They were fed *Bracharia decumbens* hay *ad libitum* and supplemented with concentrate feed at 4% body weight dry matter basis daily. Water was supplied *ad libitum*. Once a week the rectal temperature, respiratory rate, pulse rate and heart rate were taken from each animal at 8:00 a.m. and 2:00 p.m for six months. The experimental design for this experiment is a factorial format with the physiological parameters as the dependent variables and breed, time of the day, season and week series as independent variables. The daily minimum and maximum ambient temperature, relative humidity and wet-and dry-bulb temperatures readings throughout the experimental period at 8:00 am and 2:00 pm were obtained from the meteorological unit of the university. The temperature-humidity index was then determined from the data of temperature and relative humidity collected.

Measurement of Physiological parameters

Rectal temperature was determined using a digital clinical thermometer inserted 5cm into the rectum of the animal and allowed to stay for 1 min. before taking the reading.

Heart rate was determined by auscultation with the aid of a stethoscope on the first rib of the right chest and counting the number of beat per minute using a stop-watch.

Respiratory rate was determined by counting the number of flank movements per minute using a stop-watch.

Pulse rate was determined by placing a finger on the femoral artery on the medial area of the hind limb for one minute using a stop-watch. All the physiological parameters were determined according to the methods described by Oladimeji (1994).

The daily minimum and maximum ambient temperature, relative humidity and wet-and dry-bulb temperatures readings throughout the experimental period at 8:00 am and 2:00 pm were obtained from the Agrometeorology Department of the University of Agriculture Abeokuta. The temperature-humidity index was then determined from the data of temperature and relative humidity collected using the heat index formula reported by Marai *et al*. (2001):

$$THI = db^{o}C - \{(0.31 - 0.31\,RH)(db^{o}C - 14.4)\}$$

Where:

THI = Temperature – humidity index

$db^{o}C$ = Dry bulb temperature ^{o}C

RH = Relative humidity (RH %) / 100

Data Analysis

Data obtained were analyzed by method of least squares analysis of variance (Systat, 1993) using a general linear model appropriate for a (2x2:24 and 2x2x2) factorial format. The two models are stated below:

Model 1:

$$Y_{ijkl} = \mu + B_i + W_j + T_k + BW_{ij} + BT_{ik} + WT_{jk} + BWT_{ijk} + \sum_{ijkl}$$

Where;

Y_{ijkl}= the value of parameters of interest

U = overall mean

B_i = effect of i[th] breed (i= 1, 2)

W_j = effect of j[th] week of sampling (i= 1-24)

T_k = effect of k[th] time of the day (k= 1, 2)

BW_{ij} = effect of ij[th] interaction between breed and week of sampling

BT_{ik} = effect of ik[th] interaction between breed and time of the day

WT_{jk} = effect of jk[th] interaction between week of sampling and time of the day

BWT_{ijk} = effect of ijk[th] interaction between breed, week of sampling and time of the day

$\sum_{ijkl}$= random residual error associated with each record

Model 2:

$$Y_{ijkl} = \mu + B_i + S_j + T_k + BS_{ij} + BT_{ik} + ST_{jk} + BST_{ijk} + \sum_{ijkl}$$

Where;

Y_{ijkl}= the value of parameters of interest

U = overall mean

B_i = effect of i[th] breed (i= 1, 2)

S_j = effect of j[th] season (i= 1, 2)

T_k = effect of k[th] time of the day (k= 1, 2)

BS_{ij} = effect of ij[th] interaction between breed and season

BT_{ik} = effect of ik[th] interaction between breed and time of the day

ST_{jk} = effect of jk[th] interaction between season and time of the day

BST_{ijk} = effect of ijk[th] interaction between breed, season and time of the day

$\sum_{ijkl}$= random residual error associated with each record

Results and Discussion

Effects of diurnal variations in temperature and humidity on rectal temperature, respiratory rate, heart rate and pulse rate in West African Dwarf and Kalahari Red goats

The results of the analysis of variance for the effects of breed, week of sampling and time of day on physiological parameters are summarized in Table 1. Breed had a highly significant effect ($P< 0.001$) on rectal temperature, respiratory rate and pulse rate while it had no significant effect ($P> 0.05$) on heart rate. Week of sampling and time of day on the other hand had a highly ($P< 0.001$) significant effect on all the physiological parameters monitored. The interactions showed that breed by week of sampling interaction had a highly significant ($P< 0.001$) effect on all the physiological parameters while breed by time of the day had a significant ($P< 0.01$) effect on rectal temperature and pulse rate but had no significant ($P> 0.05$) effect on respiratory and heart rate respectively. Week of sampling by time of day interaction on the other hand had a highly significant effect ($P< 0.001$) on rectal temperature and respiratory rate but had no significant ($P> 0.05$) effect on heart rate and pulse rate. The breed by week of sampling by time of day interaction had a highly significant ($P< 0.001$) effect on rectal temperature, respiratory rate and pulse rate while it had no significant ($P> 0.05$) effect on heart rate.

Rectal temperature, heart rate and pulse rate were all higher in the Kalahari Red than the West African Dwarf goats (38.97 vs. 38.39^o C; 51.20 vs. 47.98 breaths / min; 61.56 vs. 60.22 pulses / min respectively) as shown in the least square means on table 2. Percentage breed differentials revealed that rectal temperature, respiratory rate and pulse rate were higher in the Kalahari Red than the West African Dwarf goats by 1.5 %, 6.9 % and 2.23 % respectively. The high rectal temperature, heart rate and pulse rate in the Kalahari Red could be due to their introduction into the humid zone of West Africa since they are ideally suited for the semi-arid sub-tropical zone of Southern Africa which confers a high temperature on them. This is an indication that the Kalahari red goats have a lower adaptive mechanism for heat regulation.

The least square means of the interaction between breed and time of day shown on table 3, revealed that rectal temperature was higher in the Kalahari Red goats (39.25 ± 0.04 ^{o} C) while pulse rate was higher the West African Dwarf goats (61.78 ± 0.35 pulses/min) all in the afternoon. Percentage breed differential responses to diurnal variations revealed that rectal temperature, in the West African Dwarf goats increased by 2.03 % as against 1.45 % in the Kalahari Red goats while pulse rate increased by 5.34 % in the West African Dwarf goats as against 0.08 % in the Kalahari Red goats from morning to afternoon.

The high rectal temperature recorded in the Kalahari Red goats in the afternoon suggest that there was a high atmospheric heat especially in the afternoon thereby animals try to reduce metabolic heat production to minimize heat load and maintain normal body temperature. It could also be due to the fact that there was a protective mechanism of homeostasis against stress due to exercise and heat increment of digestive process (Abegaz and Gemeda, 2002). The high pulse rate values in the afternoon in the West African Dwarf goats corroborates the findings of Egbowon (1993), who recorded a higher variation in the values obtained for diurnal changes of pulse rate, respiratory rate and rectal temperature in the afternoon. This also corroborates the findings of Otoikhan *et al*. (2009) who observed higher values for rectal temperature, heart rate and respiratory rate in the afternoon while monitoring the physiological response of West African Dwarf and White Bornu goat breeds to varied climatic condition in South-South, Nigeria.

Table 1: Summary of the analysis of variance of effects of breed, week of sampling and time of day on physiological parameters

		Mean Squares			
Source of variation	df	Rectal temperature	Respiratory rate	Heart rate	Pulse rate
Breed (B)	1	55.75***	1708.15***	8.91^{ns}	297.68***
Week of sampling (W)	23	2.37***	1151.40 ***	826.02 ***	163.40 ***
Time of day (T)	1	71.47***	13258.75***	2033.16***	414.27***
B x W	23	1.07***	577.83***	304.46***	89.79***
B x T	1	1.88**	8.32^{ns}	43.82^{ns}	389.82***
W x T	23	1.31***	142.86**	83.43^{ns}	23.16^{ns}
B x W x T	23	0.47***	225.75***	108.74^{ns}	55.40***
Error	562	0.21	70.75	71.74	20.65

**P< 0.01, ***P< 0.001, ns- non-significant (P> 0.05); df-degree of freedom

Table 2: Least square means of physiological parameters as affected by breed

	Least square means ± standard error of means Breed	
Physiological parameters	West African Dwarf	Kalahari Red
Rectal temperature (^{o}C)	38.39 ± 0.03^b	38.97 ± 0.03^a
Respiratory rate (breaths/min)	47.98 ± 0.46^b	51.20 ± 0.47^a
Pulse rate (pulses/min)	60.22 ± 0.25^b	61.56 ± 0.25^a

$^{a-b}$ Means in the same row having different superscripts differ significantly (P< 0.001)

Table 3: Least square means of rectal temperature and pulse rate showing interaction between goat breed and time of day

		Least square means ± standard error of means Breed	
Time of day	Physiological parameters	West African Dwarf	Kalahari Red
Morning (8am)	Rectal temperature, ºC	38.00 ± 0.04^a	38.69 ± 0.04^b
Afternoon (2pm)	Rectal temperature, ºC	38.77 ± 0.04^b	39.25 ± 0.04^c
Morning (8am)	Pulse rate, pulses/min	58.65 ± 0.35^a	61.54 ± 0.36^b
Afternoon (2pm)	Pulse rate, pulses/min	61.78 ± 0.35^b	61.59 ± 0.36^b

$^{a-c}$ Means for the same parameter having different superscripts differ significantly ($P<0.001$)

Furthermore, the least square means of physiological parameters arising from the interaction between breed and week of sampling revealed that rectal temperature was lower in both breeds in the first 12 weeks of sampling which fell within the cold dry season than in the final twelve weeks which fell within the hot dry season. The difference in rectal temperature between the breeds was wider and more consistent in the last 12 weeks of sampling. Rectal temperature was highest in the West African Dwarf goats in the 1st week of sampling in the cold dry season; while in the Kalahari Red goat the 19th week of sampling was the highest which fell within the hot dry season as shown in figure 1. Respiratory rate trends showed that the West African Dwarf goats had a higher respiratory rate values in the first 12 weeks of sampling with the 7th week of sampling being the highest. Respiratory rate was however higher in the Kalahari Red goats in the last 12 weeks of sampling which fell within the hot-dry season with the 20th week of sampling being the highest respiratory rate value. The difference in rectal temperature between the breeds was wider and more consistent in the last 12 weeks of sampling as shown in figure 2.

Pulse rate trends showed that pulse rate was higher in the West African Dwarf goats in the first 12 weeks of sampling which fell within the cold-dry season with the highest value in the 7th week of sampling while it was higher in the Kalahari Red goats in the last 12 weeks of sampling which fell within the hot-dry season with the highest pulse rate value being the 19th week of sampling as shown in figure 3. On the other hand, Heart rate trends took a different mode with heart rate values closer in both breeds in the last 12 weeks of sampling which fell within the hot-dry season. Heart rate values was higher in the West African Dwarf goats in the first 12 weeks of sampling with the 10th week of sampling being the highest while it was higher in the Kalahari Red goats in the last 12 weeks of sampling with the 21st week sampling being the highest as shown in figure 4.

The increased rectal temperature and pulse rate in this study in the 19th week of sampling (March) in the Kalahari Red goats shows that the Kalahari Red goats experienced a moderate heat stress during the hot dry season in the humid tropics. The increased rectal temperature could be due to the fact that goats are homeotherms and hence tends to maintain a constant body temperature between the environment through a balance of heat gain and loss. It could also be due to the season the experiment was conducted i.e the hot dry season which is thermally stressful and hence, a higher rectal temperature and pulse rate. The high rectal temperature and pulse rate in the 19th week of sampling which falls in the month of March may also be due to the prevalent environmental changes which confer heat load on the animals which suggest that this period exerted more heat on the animal since it was the peak of the dry season in South Western Nigeria when there is high temperature. This claim could be backed by the increased temperature in month of March as shown by the temperature-humidity index calculation on table 7.

The high rectal temperature, respiratory rate, heart rate and pulse rate in 1st, 7th, 10th, week of sampling respectively in the West African Dwarf goats all in the cold dry season could also be due to the high relative humidity prevalent during the cold dry season. This fact is corroborated by Singh *et al.* (2003) who stated that heart rate and respiratory rate is positively correlated with ambient temperature and humidity. This goes a long way to show that the West African Dwarf goats are well adapted to the humid tropics of Nigeria. The high heart rate recorded in the 10th week (January) in the West African Dwarf goats could be due to the small body size which increases the rate of metabolism thereby leading to a high heart rate values. This is in line with (Fukuhura *et al*., 1983 and Barkai *et al*., 2002) who reported a correlation between heart rate and metabolic heat production. This suggests that the West African Dwarf goats are better adapted to the hot dry season of the sub-humid tropics by decreasing the heat load to increase the respiratory rate. The high respiratory rate recorded in the West African Dwarf goats in the 7th week sampling which falls in the month of December could be attributed to an attempt by the goats to increase respiratory evaporization which is an adaptive mechanism for heat regulation. A similar finding was obtained by (Egbowon, 1993) in the West African Dwarf goats while monitoring the heat stress index in the West African Dwarf, Red Sokoto and Sahel goats. This suggests that the West African Dwarf goats respond to heat stress by making rapid physiological adjustment to maintain homeostasis.

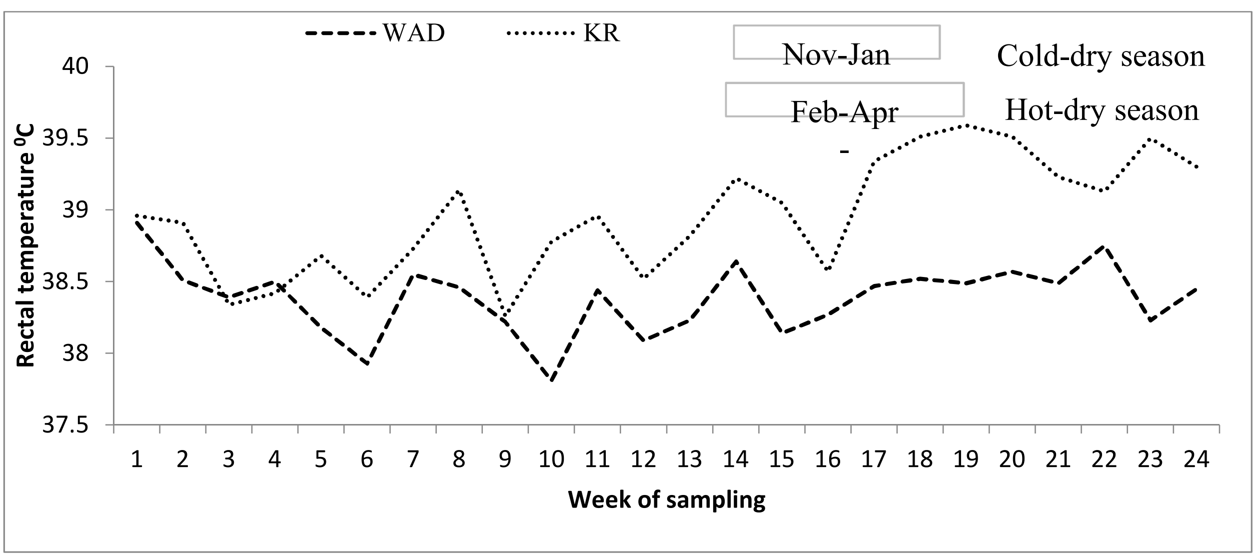

Figure 1: Rectal temperature trends arising from the interaction between breed and sampling week throughout the experimental period

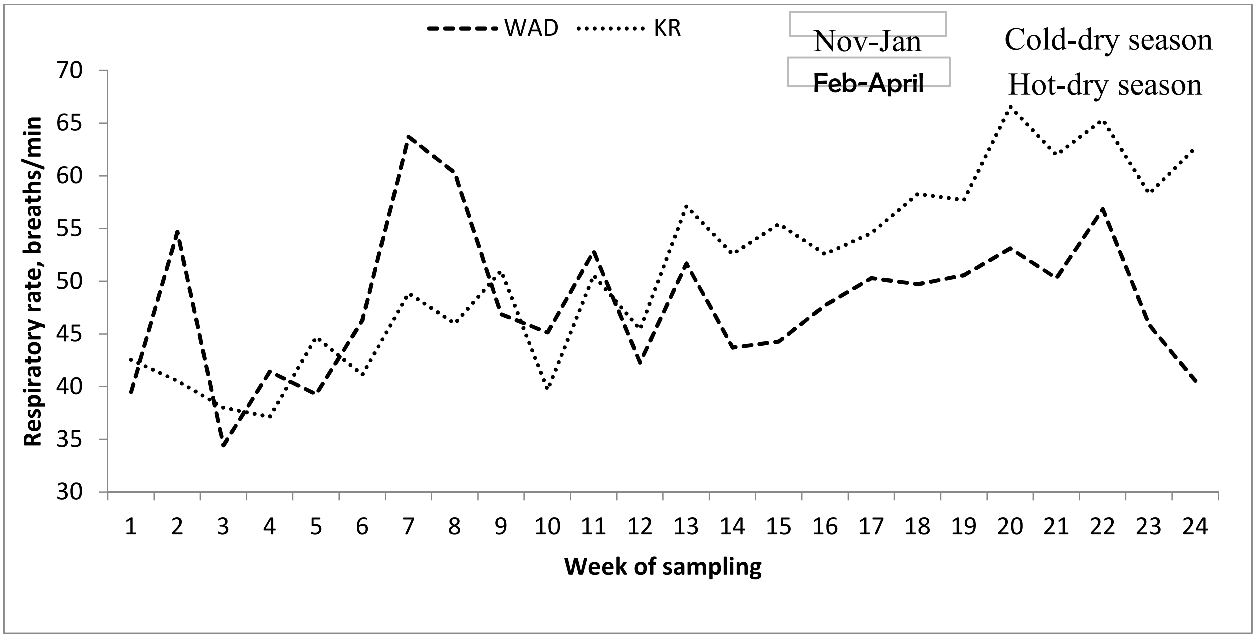

Figure 2: Respiratory rate trends arising from the interaction between breed and sampling week throughout the experimental period

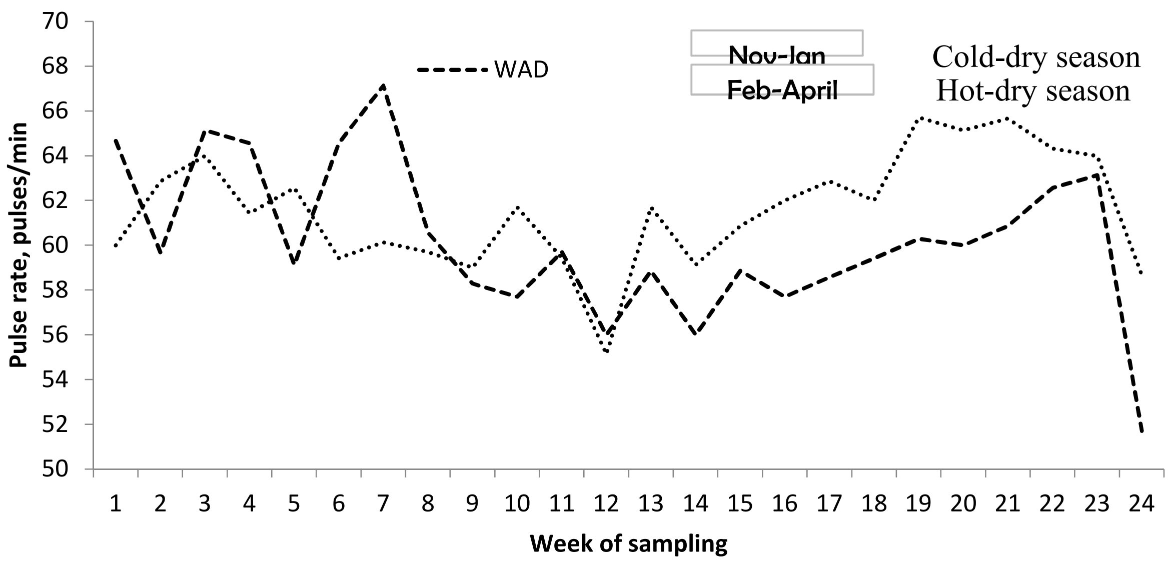

Figure 3: Pulse rate trends arising from the interaction between breed and sampling week throughout the experimental period

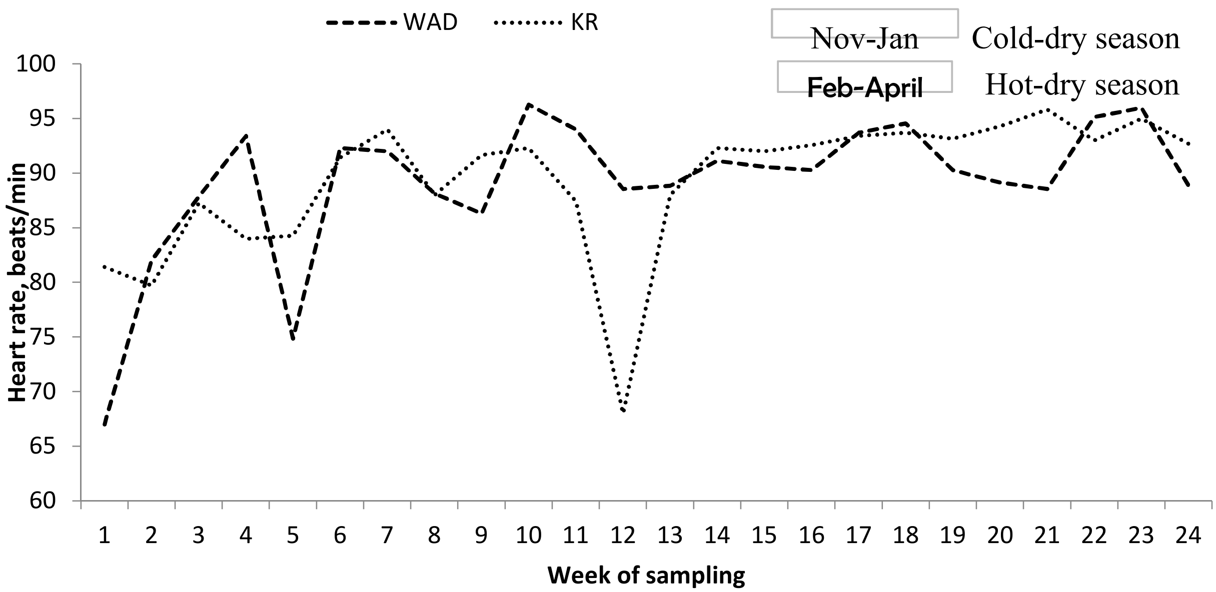

Figure 4: Heart rate trends arising from the interaction between breed and sampling week throughout the experimental

Effects of seasonal variations in temperature and humidity on rectal temperature, respiratory rate, heart rate and pulse rate in West African Dwarf and Kalahari Red goats

The results of the analysis of variance of effects of breed, season and time of day on physiological parameters are summarized in Table 4. Breed had a highly significant effect (P< 0.001) on rectal temperature, respiratory rate and pulse rate while it had no significant effect (P> 0.05) on heart rate. Season also had a highly significant effect (P< 0.001) on rectal temperature, respiratory rate and heart rate while it had no significant effect (P> 0.05) on pulse rate. Time of day on the other hand, had a highly significant effect (P< 0.001) on all the physiological parameters monitored. Breed by season interaction had a highly significant effect (P< 0.001) on rectal temperature, respiratory rate and pulse rate while it had no significant effect (P> 0.05) on heart rate. Breed by time of day interaction had a highly significant effect (P< 0.001) on pulse rate and was also significantly different (P<0.01) for rectal temperature. Respiratory rate and heart rate on the other hand was not significant (P>0.05). Season by time of day interaction had a highly significant (P< 0.001) effect on rectal temperature while it had no significant effect (P> 0.05) on respiratory rate, heart rate and pulse rate. The breed by season by time of day interaction had a highly significant (P< 0.001) effect on respiratory rate and pulse rate while it had no significant effect (P> 0.05) on rectal temperature and heart rate.

Rectal temperature, heart rate and respiratory rate were all higher in the hot-dry season than the cold-dry season as shown in the least square means on table 5. Rectal temperature, respiratory rate and heart rate were all higher by 0.91%, 17.8% and 3.04% in the hot-dry season over the cold-dry season. The high rectal temperature, respiratory and heart rate in the hot-dry season in this experiment could be attributed to increased temperature and humidity in the humid zone within this period which confers a high temperature (heat load) on the animal thereby increasing the rectal temperature, which made the animal to breath faster and increased heart beat.

Due to the high heat load, the animal tried to reduce metabolic heat production to minimize heat load and maintain normal body temperature.

From the least square means of the physiological parameters as affected by breed and season as shown on Table 6, rectal temperature was higher ($P<0.05$) in the cold-dry and hot-dry season in the Kalahari Red goats. The percentage seasonal deviation in the two breeds was 0.94% in the cold-dry and 2.13% in the hot–dry season. Respiratory rate and pulse rate were higher in West African Dwarf goats in the cold-dry season while it was higher in the Kalahari Red goats in the hot-dry. The percentage seasonal deviation in the two breeds was 8.03% in the cold-dry and 19.91% in the hot–dry season; 1.54% in the cold-dry and 6.19% in the hot-dry season for respiratory rate and pulse rate respectively. The increased rectal temperature, respiratory rate and heart rate in the hot-dry season in the Kalahari Red goat could be due to thermogenesis following the prevalent increased temperature and relative humidity in the humid tropics.

Table 4: Summary of the analysis of variance of effects of breed, season and time of day on physiological parameters

		Mean Squares			
Source of variation	df	Rectal temperature	Respiratory rate	Heart rate	Pulse rate
Breed (B)	1	57.15***	1575.23***	0.06^{ns}	300.87***
Season (S)	1	20.19***	10784.79 ***	5388.01 ***	2.26^{ns}
Time of day (T)	1	72.13***	13533.85***	2078.22***	423.65***
B x S	1	8.89***	7171.56***	365.37ns	867.94***
B x T	1	1.97*	0.99^{ns}	44.09^{ns}	391.83***
S x T	1	5.35***	173.73^{ns}	186.96^{ns}	23.16^{ns}
B x S x T	1	0.07ns	934.29**	170.59^{ns}	294.77***
Error	650	0.31	105.73	98.95	27.87

**P< 0.01, ***P< 0.001, ns- non-significant (P>0.05)
df-degree of freedom

Table 5: Least square means of physiological parameters as affected by season

	Least square means ± standard error of means Season	
Physiological parameters	Cold dry season	Hot dry season
Rectal temperature, ºC	38.50 ± 0.03^{b}	38.85 ± 0.03^{a}
Respiratory rate, breaths/min	45.48 ± 0.57^{b}	53.58 ± 0.57^{a}
Heart rate, beats/min	89.46 ± 0.55^{b}	92.18 ± 0.55^{a}

$^{a\text{-}b}$ Means in the same row having different superscripts differ significantly (P< 0.001)

Table 6: Least square means of physiological parameters showing interaction between goat breed and season

	Rectal temperature		Respiratory rate		Pulse rate	
Season	West African Dwarf	Kalahari Red	West African Dwarf	Kalahari Red	West African Dwarf	Kalahari Red
Cold dry season	38.32 ± 0.04[b]	38.68 ± 0.04[a]	47.23 ± 0.80[a]	43.72 ± 0.79[b]	61.40 ± 0.41[a]	60.47 ± 0.41[b]
Hot dry season	38.44 ± 0.04[b]	39.26 ± 0.04[a]	48.73 ± 0.80[b]	58.43 ± 0.81[a]	59.00 ± 0.41[b]	62.65 ± 0.41[a]

[a-b] Means in the same row having different superscripts differ significantly (P<0.001)

Temperature – Humidity index (THI)

The temperature – humidity index as shown in table 7 revealed that the temperature – humidity index was highest in the morning and afternoon in the month of March which fell within the hot-dry season in the humid tropics. THI values as calculated in this study showed that there was extreme heat stress in the morning and afternoon except for the month of December in the morning which had severe heat stress.

Table 7: Temperature-Humidity index (THI) for the experimental period

Month	Morning (8am)	Afternoon (2pm)
November	26.4(ehs)	29.9(ehs)
December	24.7(shs)	28.7(ehs)
January	27.5(ehs)	29.3(ehs)
February	26.4(ehs)	29.9(ehs)
March	27.8(ehs)	31.3(ehs)
April	26.8(ehs)	29.7(ehs)

ahs- absence of heat stress (values < 22.2), mhs- moderate heat stress (values between 22.2 to < 23.3), shs- severe heat stress (values between 23.3 to < 25.6), ehs-extreme heat stress (values from 25.6 and more)

Conclusion and recommendations

The results obtained from the present work showed that rectal temperature, respiratory rate and pulse rate were all higher in the Kalahari Red than the West African Dwarf goats. The differential response of rectal temperature and pulse rate to diurnal variations was lower in the Kalahari Red than the West African Dwarf goats. Rectal temperature, respiratory rate and pulse rate values were closer in both breeds in the cold-dry but more divergent in the hot-dry season with higher values in the Kalahari Red than the West African Dwarf goats. It can therefore be concluded that the adaptive physiological responses of both breeds to the humid tropical climate appeared to be adequate. However, the West African Dwarf goat appeared to cope better in the hot-dry season while the Kalahari Red goat appeared to cope better in the cold-dry season.

References

Abdel Samee, A. M. 1991. Detection of heat adaptability of growing lambs in the sub-tropics. *Zagazig Veterinary Journal* 19(3), 719 – 731.

Abegaz, S. and Gemeda, D. 2002. Genetic and phenotypic parameters of Growth, Reproductive and survival performances of

Harrow sheep at Balco Agricultural Research Center. Research Fellowship Report, Animal Genetic Resources group, International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia, February, 2002. Pp. 132.

Adeloye, A. A. 1998. The Nigerian small ruminant species. Corporate Office Max: Ilorin, Nigeria. 7-8.

Adeloye, A. A. and Daramola, J. O. 2004. Improving living conditions of domestic animals in Nigeria: a review. In: Amalu, U.C and Gottswald, F.T (eds.). Studies of sustainable agriculture and animal science in sub-Saharan Africa (Studies in sub-Saharan Africa Volume 1). Peter Lang Publishing Group: Berlin, Germany. Pp 99 - 115.

Barkai, S. A., Landau, A. and Brosh, P. 2002. Estimation of energy intake from heart rate and energy expenditure in sheep under confinement or grazing condition. *Livestock Production Science*. 78: 99-105.

Barker, J. S. F. 2009. Defining fitness in natural and domesticated populations In: Vander Werf J.,Graser H. U. and Frankham R. (Eds.) Adaptation and Fitness in Animal Populations: evolutionary and breeding perspectives on genetic resource management, Springer, 3 – 14.

Donald, E., Collin, R. P., Thomas, S., and Nicholas, W. R. 1988. Textbook of Physiology. English Language Book Society, 11th edition. Pp 16 – 22, 510-530.

Egbowon, B. 1993. Determination of heat stress index in three breeds of goat. Tool to a good management practice to tropical goat breeds in Nigeria. Published by VDM Verlag Dr. Muller Aktiengesellschaft and Co. KG, Germany. Pg1.

El-Tarabany, M. S., El-Tarabany, A. A. and Atta, M. A 2017. Physiological and lactation responses of Egyptian dairy Baladi goats to natural thermal stress under sub-tropical environmental conditions. International Journal of Biometeorology 61,61–68.

Fukuhura, K., Sawai, T. and Yamamoto, S. 1983. The relationship between the heart rate and heat production of dairy cows in prepartum and postpartum. *Japan Journal of Zootech Science*, 9: 497-501.

FUNAAB (Federal University of Agriculture Abeokuta). 2013. Annual weather and climate report of the University Environment by the Agrometeorology Department.

Habeeb, A. A., Marai, I. F. M. and Kamal, T. H. 1992. Heat stress. In: Philips, C., Piggens, D. (Eds), Farm Animals and the Environment, C. A. B. International. Pp. 27 – 47.

Indu S, Sejian, V., Kumar, D., Pareek, A. and Naqvi, S. M. K. 2015. Ideal proportion of roughage and concentrate required for Malpura ewes to adapt and reproduce under semi-arid tropical environment. *Tropical Animal Health and Production* 47, 1487–1495.

Mahendra, L. and Dilip, B. 2021. The importance of goats in the world. *Professional Agricultural Workers Journal.* Vol. 6(2).

Marai, I. F. M., Bahgat, L. B., Shalaby, T. H. and Abdel-Hafez, M. A. 2000. Fattening performance, some behavioural traits and physiological reactions of male lambs fed concentrates mixture alone with or without natural clay, under hot summer of Egypt. *Ann arid zone* 39(4), 449 – 460.

Marai, I. F. M., Ayyat, M. S., Abdel Monem, U. M. 2001. Growth performance and reprod uctive traits at first party of New Zealand white female rabbits as affected by heat stress and its alleviation, under Egyptian conditions. *Tropical Animal Health Production*. 33, 457 – 462.

Marai, I. F. M., El-Darawany, A. A., Abou-Fandoud, E. I., and Abdel–Hafez, M. A. 2003. Alleviation of heat stressed Egyptian Suffolk rams by treatment with selenium, melatonin or prostaglandin F2X during hot summer of Egypt. *Journal of Animal Veterinary Adv*ances 2 (4), 215 – 220.

McManus, C. Prescott, E., Paludo, G. R., Bianchini, E., Louvandini, H. and Mariante, A. S. 2008. Heat tolerance in naturalized Brazilian Cattle breeds. *Livestock science* 120 (3), 256 – 264.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M.S. and Bernabucci, U. 2010. Effects of climate change on animal production and sustainability of livestock systems. *Livestock Science* 130, 57–69.

Oladimeji, A. 1994. Estimation of average values for pulse rate, respiratory rate, rectal temperature and development of heat stress index for adult Yankasa sheep. *Bulletin of Animal Health and Production in Africa*, 45, 105 – 107.

Otoikhan, C. S. O., Orheruata, J. A., Imasuen, J. A. and Akporhuarho, O. P. 2009. Physiological response of local (White Bornu) goat breed to varied climatic conditions in South-South Nigeria. *African Journal of General Agriculture*, Pg 101-106.

Seixas, L., De Melo, C.B., Tanure, C.B. and Peripolli, V. 2017. Heat tolerance in Brazilian hair sheep. *Asian-Australias Journal of Animal Science*. 2017, 30, 593–601.

Sejian, V., Maurya, V. P., Kumar, K. and Naqvi, S. M. K. 2013. Effect of multiple stresses (thermal and walking stress) on growth, physiological response, blood biochemical and endocrine response in Malpura ewes under semi-arid tropical environment. *Tropical Animal Health and Production* 45, 107–116.

Singh, V. P., Singh, W. I. and Singh, N. P. 2003. Comparative physiological responses and heat tolerance of lactating Murrah buffalos under different seasons. Cheiron, 32: 129-131.

Systat, T. 1993. Systat computer package version 5.02. Systat Inc. 1800 Sherman Avenue Evanston, Illinois, USA 6021, 708.864.5670.

Taniguchi, K., Nakamura, K., Yoneyema, I., Ito, T., Sugino, T. and Obitsu, T. 2004. Effects of Short-term exposure to heat stress in splanchnic metabolism in sheep. *Journal of Animal and Feed Scence.* 13(Suppl.1), 359 – 362.

Yasha, A., De La, F., Luanna, S., Batista, F., Af, S. and Elb, S. 2017. Growth and reproduction hormones of ruminants subjected to heat Stress. *Journal Animal Behaviour and Biometeorology*. 2017, 5, 7–12.