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Comparative study of some biochemical and physiological profile among Nigerian sheep

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Target Audience: *Animal scientists, sheep breeders and livestock farmers*

Abstract

Physiological and biochemical data of the four breeds of sheep were collected from Bauchi, Kastina, Nasarawa and Anambra States for Balami, Uda, Yankasa and West Africa Dwarf sheep, respectively using a multi-stage sampling method. A total of 46 Balami (18 males and 28 females), 30 Uda (5males and 25 females), 36 Yankasa (9 males and 27 females) and 37 WAD (7 males and 30 females) were sampled. Sampling was done from the selected States based on distance from one another and an abundance of sheep. Data were collected during the hottest season of November to March. Blood samples were collected from 60 adult sheep out of the entire population for the study. Blood samples were collected from jugular vein puncture using a 5ml syringe, and the samples were then transferred into well-labelled ethylene diamine tetra acetate (EDTA) bottles. Data collected for the study were analyzed using the General Linear Model Procedure of SAS using the fixed-effect model that incorporated breed, sex and age of the sheep. The pulse rate of adult Balami sheep was higher than what was obtained from the other three breeds (P<0.01). The pulse rate for Balami sheep was 94.33±6.50 beats per minute as against those of WAD, Uda and Yakasa (77.42±8.38, 76.85±8.38 and 72.80±7.84 beats per minute, respectively). Adult WAD, Yankasa and Balami had similar (p>0.05) respiratory rate (73.92±8.73, 71.20±7.73, 69.33±6.40 breath per minute, respectively). The values for the three breeds were higher than 67.76±8.16 breath per minute obtained for Uda sheep. The rectal temperature of adult Balami (39.29±0.21^oC) and Yankasa (39.21±0.25^oC) were similar but differed from the values obtained for adult WAD sheep (38.40±0.29^oC). Malondialdehyde (MDA) is not a good marker for monitoring heat stress among breeds of sheep in Nigeria because breeds did affect (p>0.05) the activity level of MDA. Metabolic markers like thyroid, cortisol hormones level and glucose could also be used in the future. Pulse rate had a high and positive correlation (0.452; P<0.01) with an atmospheric temperature of Balami sheep. Moderate and positive correlations (0.265, 0.221; P<0.05) were obtained between pulse rate and temperature of Uda sheep and WAD, respectively. Molecular markers of biochemical and heat stress such as like heat shock protein (HSP) should be used to study the diversity of sheep breeds in Nigeria.

Keywords*: Biochemical, Nigeria, physiological profile, sheep, heat stress.*

Description of the Problem

The first step towards an efficient conservation strategy for sheep is the proper characterization of different breeds and their wild relatives (1). Sheep biodiversity has been described using morphological measurements (2, 3) or characterized using molecular data (4, 5). The phenotypic variation in a population arises due to genotypic and environmental effects, and the magnitude of phenotypic variability differs under different environmental conditions. Food and Agriculture Organization of the United Nations (6) estimated that more than half of our common livestock breeds are now endangered through genetic diversity. Such loss of diversity in domestic species including sheep, has far-reaching economic, ecological, scientific and social implications. Four major breeds of sheep in Nigeria are Balami, Uda, Yankasa and West African Dwarf (WAD). The ability of Balami, Uda and Yankasa sheep to thrive in the hot region of northern Nigeria is due to genetic diversity (7). The physiological response of sheep to environmental stress during the dry and wet season with their energy balance showed that seasonal heat and cold stress have profound effects on some thermoregulatory and physiological parameters. Several researchers like (8, 9 and 10) have indicated that the best thermo-physiological parameters to monitor animal welfare in harsh environment objectively are rectal temperature (RT), respiratory rate (RR), pulse rate (PR) and blood indices. Stockman (11) submitted that high RR is a good indicator of the onset of thermal stress in ewes. Hence, the ability of sheep to maintain heat adaptation capacity to the harsh environment need to be investigated. Animal blood profiles are particularly sensitive to changes in the environmental temperature, being an important indicator of physiological responses to stressing agent in sheep. Hair sheep were generally found to be better adapted to heat stress than wooled sheep (12) with Morada Nova showing superiority within the hair sheep breeds (13). This study was purposed to compare the biochemical and physiological profiles of the four breeds of sheep in Nigeria while evaluating the effect of heat as a stress factor to the stocks.

Materials and Methods

Physiological and biochemical data of the four breeds of sheep were collected from Bauchi, Kastina, Nasarawa and Anambra States for Balami, Uda, Yankasa and West Africa Dwarf sheep, respectively using a multi-stage sampling method. A total of 46 Balami (18 males and 28 females), 30 Uda (5males and 25 females), 36 Yankasa (9 males and 27 females) and 37 WAD (7 males and 30 females) were sampled. Sampling was done from the selected States based on distance from one another and an abundance of sheep.

Physiological variables

Physiological variables that were measured on each animal were:

Pulse rate (PR): This was obtained by counting the number of contractions of the heart in a minute using a stethoscope on the chest of the animal. The unit of measurement was beats per minute.

Respiratory rate (RR): This was obtained by counting the flank movement of breaths from a distance per minute before examining the rectal temperature in order not to disturb the animal. The unit of measurement was breaths per minute.

Rectal temperature (RT): This was taken on each animal using a digital thermometer. The sensory tip was disinfected using a methylated spirit and cotton bud which was inserted into the rectum of the sheep in close contact with the rectal mucosa at the display of 0°C by the thermometer (indicating that the thermometer was set for temperature reading). This was removed after the indicator sound. The displayed body temperature was then recorded. The unit of measurement was degree centigrade (^oC).

Atmospheric temperature and relative humidity

The atmospheric temperature was taken according to International Organization for Standardization (ISO1) that specifies the standard reference temperature for geometrical product specification and verification. This type of measurement has been used by Rebecca (14). This was measured by using a temperature and humidity gauge meter at each representative location of the region. The unit of measurement was degree centigrade (^oC). Meanwhile, relative humidity was measured (in percentages) using a temperature/humidity gauge meter at each representative location of the region.

Sample Collection and Analysis of Blood Biochemicals

Blood samples were collected from 60 adult sheep out of the entire population for the study. Blood samples were collected from jugular vein puncture using a 5ml syringe, and the samples were then transferred into well-labelled ethylene diamine tetraacetate (EDTA) bottles. The samples were stored in an ice park and transported immediately to the laboratory for analysis. The analysis was carried at the Histopathology Laboratory, Chem-Histopathology Department of Ahmadu Bello University Teaching Hospital Zaria.

The following precautions were taken during the blood collection:

- All blood samples were collected between 10 am and noon in order to standardize time-related variables which are known to influence specific blood components.
- Care was taken to avoid coagulation of the collected blood samples.

Procedure for blood analysis

At the laboratory, serum separator tubes were used to centrifuge the samples for 10-15 minutes at the speed of 2000-3000g, which aided easy separation of plasma portioned into four separate tubes for determination of malondialdehyde (MDA) using MDA ELISA kits for sheep. Total protein, albumin and Fe^{3+}were analyzed using automated haematocrit analyzer. Determination of serum iron F^{3+} concentrate was done by pipetting 20nl of serum, added to ml of biuret reagent and was incubated for 37^0C for 10 minutes and result read on a spectrometer at 610mm.

Procedure for determination of malondialdehyde

Blood sample of 10µl was pipetted into microwell and 40µl of sample diluents (serum) was added. This was incubated for 30 minutes at 37^oC. The solution was washed with sulphate buffer. About 50µl of peroxidase reagent was added and incubated for 30 minutes at 37^oC. The solution was washed with a buffer solution. Substrate A (hydrogen peroxide) 50µl was added, and another 50µl of substrate B (tetramethyl-benzendine) was added and incubated for 15minutes. Stop solution (hydro-chloric acid) of 50µl was added and MDA was read at 450nanometer (nm) on a microplate reader.

Procedure for determination of total protein

About 10µl of serum was pipette, and added to 1ml of biuret reagent. This was incubated for 25^oC for 15minutes and read on a spectrometer at 540nm.

Procedure for determination of serum albumin

Albumin was determined by pipetting 10µl of the serum which was added to 1ml of biuret regent and Bromocresol green which was later incubated for 25^oC for 15minutes and read on a spectrometer at 630nm.

Procedure for determination of iron (F^{3+})

Determination of F^{3+} was done by pipetting 20µl of the serum, added to 4ml of biuret regent and was incubated for 37^oC for 10minutes and read on a spectrometer at 610nm.

Data Analysis

The effect of age, breed and sex on body weight and linear body measurement were analyzed using the General Linear Model (GLM) procedure of SAS JMP (15) using the model as shown below. Means were separated within age, breed and sex groups using Duncan Multiple Range Test.

$Y_{ijkl} = \mu + B_j + S_k + \varepsilon_{ijkl}$
Where:
Y_{ijkl}= trait of interest in Nigerian Sheep
μ= population mean
B_j = effect of j^{th} breed (j=1, 2, 3,4)
S_k = effect of k^{th} sex (k=1, 2)
ε_{ijkl} = random error within experimental units, independently and identically normally distributed with zero means and constant variance $(0,\sigma^2)$.

The measure of relationships among all pair of biometric variables was computed for all the animals within each breed, age groups and sex using CORR procedure of SAS JMP (15).

Results and Discussion

Effect of Breeds on Physiological Parameters of Adult, Yearling and Weaner Sheep

The effect of breeds on physiological parameters of adult, yearling and weaner sheep are presented in Table 1. Breeds affected physiological parameters of adult sheep. Pulse rate (94.33±6.50^{o}C) recorded for Balami was higher than the values obtained for the other breeds. However, the pulse rates for adult Uda, WAD and Yankasa sheep were similar. Adult WAD, Yankasa and Balami sheep had similar values for respiratory rate (73.92±8.73, 71.20±7.73 and 69.33±6.40 breaths per minute) respectively. However, the respiratory rate of adult Uda sheep (67.76±8.16 breaths per minute) had the least. The rectal temperature of adult Balami (39.29±0.21^{o}C) and Yankasa (39.21±0.25^{o}C) were similar but together differed from the values obtained for adult WAD sheep (38.40±0.29^{o}C). WAD sheep breed are mainly adapted to the southern Nigerian areas due to its small compact hardy breed. Their characteristic feature of tolerant/resistant to trypanosomiasis makes the breed to be adapted to humid zone.

Adult Uda sheep also had similar rectal temperature with Yankasa sheep. Uda breed appears to be adapted mainly Sahel and Sudan vegetation zone. The breed thrives/ adapts well in hot, dry environment but suffer poor survival outside their ecological zone. They are particularly adapted to extensive grazing and are renowned for its trekking ability due to massive grazing land. Adult Balami sheep consistently had higher values for pulse rate, respiratory rate and rectal temperature than most of the other breeds of sheep. The effect of breeds of sheep obtained in this study is in line with previous studies on Nigerian sheep (16, 17). Generally, all body weight and linear body measurements of Balami, Uda, WAD and Yankasa significantly increased with age with the highest was in adult sheep (3years and above) and least in weaner (6 months to less than 1year), with the yearling (1-2years) being intermediate. Yankasa sheep breeds are more adapted in the Northern part of Nigeria because they are easily reared on free-ranged which is less costly and it’s a common characteristics of Northern livestock farmers that keep sheep. This area is also a suitable ecological environment for its adaptability.

Effect of breed on physiological parameters of yearling sheep

Breeds affected ($P<0.01$) physiological traits of yearling sheep except for rectal temperature ($P>0.05$). Pulse rate (100.70±4.80beats/minute) recorded for Balami was higher than the values obtained for the other breeds. However, pulse rate 66.96±5.47beats/minute recorded for yearling Uda was the lowest. Yearling WAD and Balami sheep had higher respiratory rates (77.79±4.33 and 73.44±4.26 breaths/minute) respectively compared to yearling Uda and Yankasa sheep (66.96±5.47 and 63.83±3.94 breaths per minute, respectively). Yearling Balami sheep consistently had higher values for pulse rate and respiratory rate than most of the other breeds of sheep. The rectal temperature was not affected by breed (p>0.05). The impact of breeds of sheep obtained in this study is in line with previous studies on Nigerian sheep (16, 17).

Effect of breeds on physiological parameters of weaner sheep

Breed affected (P<0.01) physiological traits of weaners sheep. Pulse rate (97.36±4.90beats/minute) for weaner Balami was higher than the values obtained for the other breeds. However, the pulse rate for weaner Uda and WAD were similar. Lowest pulse rate (54.48±19.12beats/minute) was obtained for weaner Yankasa (54.48±19.12beats/minute). Weaners of Balami and Yankasa sheep had similar respiratory rate (93.06±4.93, 89.28±19.23breaths/minute) respectively and were higher than the values obtained for weaner WAD. Lowest respiratory rate (64.47±7.16breaths/minute) was obtained from weaner Uda (64.47±7.16breaths/minute). Weaner Balami sheep consistently had higher values for pulse rate, respiratory rate and rectal temperature than most of the other breeds of sheep. The effect of breeds of sheep obtained is in line with previous studies on Nigerian sheep (16, 17).

Table 1: Effect of Breeds on Physiological Parameters of Adult, Yearling and Weaner Sheep

	Breeds					
Age groups/ Variables	**Balami**	**Uda**	**WAD**	**Yankasa**	**SEM**	**LOS**
ADULT						
PR(beats/min.)	94.33±6.50 [a]	76.85±8.38[b]	77.42±8.85[b]	72.80±7.84[b]	2.71	**
RR(breaths/min.)	69.33±6.40 [a]	67.76±8.16[b]	73.92±8.73[a]	71.20±7.73[a]	2.34	**
RT(°C)	39.28±0.21 [a]	39.08±0.27[b]	38.40±0.29[c]	39.21±0.25[ab]	0.09	**
YEARLING						
Pul.RT (beats/min.)	100.70±4.80 [a]	66.63±6.16[d]	72.72±4.88[c]	82.07±4.43[b]	2.71	**
Res.RT(breaths/min)	73.44±4.26 [a]	63.96±5.47[b]	77.79±4.33 [a]	63.83±3.94[b]	2.18	**
Rec.TP(°C)	39.59±0.15 [a]	39.06±0.20 [a]	38.69±0.16 [a]	39.56±0.14 [a]	0.86	NS
WEANER						
Pul.RT (beats/min.)	97.36±4.90 [a]	73.21±7.12[b]	72.12±6.70[b]	54.48±19.12[c]	4.01	**
Res.RT(breaths/min.)	93.06±4.93 [a]	64.47±7.16[c]	78.31±6.74[b]	89.28±19.23 [a]	3.80	**
Rec.TP(°C)	42.54±1.99 [a]	39.17±2.90[b]	37.25±2.73[b]	39.08±7.78[b]	1.36	**

Pul.RT = pulse rate, Res.RT = respiratory rate, Rec.TP = rectal temperature, WAD = West African Dwarf, SEM = standard error of mean, LOS = level of significance, **[abc] means with different superscript along the rows are significantly different (P<0.01), °C=degree centigrade

Effect of Sex on Physiological Parameters of Sheep

The effect of sex on physiological traits of adult, yearling and weaner sheep are shown in Table 2. Sex affected (P<0.01) rectal temperature of adult sheep but not pulse rate and respiratory rate. Rectal temperature (39.13±0.08°C) recorded by adult females was higher than the values obtained for adult males (38.86±0.42) the effect of sex on physiological traits of yearling sheep. The non-significant effect was recorded in all the physiological traits irrespective of sex (P>0.05). A similar trend was also observed in weaner sheep for all the physiological traits of recorded irrespective of sex (P>0.05). Effect of sex on physiological parameters of sheep obtained is in line with the previous studies (18, 19, 20, 21). Female sheep had a rectal temperature of 39.13±0.08°C, which was similar to the rectal temperature recorded by Butswat *et al.* (18). The rectal temperature obtained for females was higher than what was obtained by Oladimeji *et al*. (8). This could probably be as a result of hormonal action. Hormones in females are responsible for increasing the physiological process which makes them come on estrus, when the physiological mechanisms of the animal fail to negate the excessive heat load in this way the rectal temperature is increased.

Table 2: Effect of Sex on Physiological Parameters of Adult, Yearling and Sheep

	Sex			
Variables	**Female**	**Male**	**SEM**	**LOS**
ADULT				
Pul.RT(beats/min.)	77.68±2.57 [a]	83.02±12.78 [a]	2.71	NS
Res.RT(breaths/min.)	71.89±2.54 [a]	69.22±12.60 [a]	2.34	NS
Rec.TP(°C)	39.13±0.08 [a]	38.86±0.42 [b]	0.09	**
YEARLING				
Pul.RT(beats/min.)	81.18±2.80 [a]	79.89±4.96 [a]	2.71	NS
Res.RT(breaths/min.)	70.35±2.49 [a]	68.66±4.41 [a]	2.18	NS
Rec.TP(°C)	39.27±0.09 [a]	39.17±0.16 [a]	0.86	NS
WEANER				
Pul.RT(beats/min.)	76.78±7.31 [a]	71.81±5.82 [a]	4.01	NS
Res.RT(breaths/min.)	80.56±7.36 [a]	82.00±5.86 [a]	3.80	NS
Rec.TP(°C)	38.49±40.53 [a]	40.53±2.67 [a]	1.16	NS

Pul. RT= pulse rate, Res. RT = respiratory rate, Rec.TP= rectal temperature, SEM = standard error of mean, LOS= level of significance, min.= minute, **[ab] means with different superscript along the rows are significantly different (P<0.01), °C=degree centigrade

Mean Atmospheric Temperature, Relative Humidity and Elevation of the Sampled Location

Mean atmospheric temperature, relative humidity and elevation of the sampled location are shown in Table 4.15. Mean temperature, relative humidity and elevation affected (P<0.01) physiological traits in all the sampled site. Mean temperature (35.96±0.66°C) recorded at Bauchi, Katsina state (34.47±0.62°C) and Nasarawa (34.52±0.65°C) were similar but higher than the values obtained for the Anambra state (28.87±0.65°C). Relative Humidity (40.57±0.95%) recorded at Bauchi state was higher than the values obtained for the other sampled locations. The relative humidity obtained at Nasarawa state had the lowest (22.68±0.93%). Elevation obtained at Katsina and Bauchi states (481.65±9.65, 471.06±9.65meter above sea level) respectively were higher from the value obtained for Nasarawa state (370.84±10.33meter above sea level). The lowest elevation (311.84±10.33meter above sea level) was recorded at Anambra state.

Table 4. 15: Mean Atmospheric Temperature, Relative Humidity and Elevation

Location (States)	Atmospheric temperature (°C)	Relative humidity (%)	Elevation (metre above sea level)	N
Anambra	28.87±0.65[b]	34.49±0.93[b]	311.84±10.33[c]	37
Bauchi	35.96±0.66[a]	40.57±0.95[a]	471.06±9.65[a]	46
Kastina	34.47±0.62[a]	28.05±0.93[c]	481.65±9.65a	30
Nasarawa	34.52±0.65[a]	22.68±0.93[d]	370.84±10.03[b]	36
SEM	0.39	0.71	7.65	
LOS	**	**	**	

SEM = standard error of mean, ** = highly significance, LOS= level of significance, °C=degree centigrade, **[abc] means with different superscript along the rows are significantly different (P<0.01), N=number of animal

Effect of Breed on Biochemical Parameters of Sheep

The effect of breed on biochemical parameters of sheep are presented on table 4. Breed of sheep does not have an effect (P>0.05) on malondialdehyde but breed affected (P<0.01) protein, albumin and Fe^{3+}profiles of the sheep. WAD sheep had the highest value (70.21±1.06; P<0.01) for total protein. Values for total protein obtained for Uda (68.39±0.98) was however, similar to those of Yankasa (67.22±0.93) and Balami sheep (67.14±0.96). Also, highest Albumin was obtained in Uda (39.94±0.85). The Yankasa (38.39±0.81) and Balami (37.93±0.83) had similar values. Uda had the highest Fe^{3+} (128.17±4.75) while WAD sheep recorded (118.81±5.14), which was similar to the values obtained for Yankasa (112.74±4.49) and Balami (112.34±4.65). The effect of breed on MDA of sheep obtained in this study is similar to the previous studies (22, 23). The activity level of MDA (1.09-1.17) was similar with what was obtained for the sheep breeds by Simsek *et al*., (22). However, values of the MDA obtained were higher than the values obtained by Nazifi *et al.* (23) in Iranian Fat-tailed sheep. The possible reason for higher concentration of MDA could be due to chance and decreased activity of defense system protecting tissue from free radical damage. The presence of lipid peroxidation could contribute to hepatic injury and to the reduced capacity for handling of drugs and xenobiotics. This is also possible based on the choice of biochemical procedure used and different factors (nutrition and age). Nazifi *et al*. (23) who recorded lower MDA values carried out his experiment in Pakistan where the climate was characterized by variations of temperature between (38-47°C) for both daily and seasonal.

Table 4: Effect of Breed on Biochemical Parameters of Sheep

Breeds/ Parameters	Balami	Uda	WAD	Yankasa	SEM	LOS
MDA	1.16±0.60[a]	1.17±0.06[a]	1.20±0.06[a]	1.09±0.06[a]	1.07	NS
Protein	67.14±0.96[b]	68.39±0.98[b]	70.21±1.06[a]	67.22±0.93[b]	0.73	**
Albumin	37.93±0.83[b]	39.94±0.85[a]	39.01±0.92[ab]	38.39±0.81[b]	0.58	**
Fe^{3+}	112.34±4.45[b]	128.17±4.75[a]	118.81±5.14[b]	112.74±4.49[b]	3.65	**

MDA= maliondialdehyde, Fe^{3+}=iron, WAD = West African Dwarf, SEM= standard error of mean, LOS= level of significance, **[abc] means with different superscript along the rows are significantly different (P<0.01), NS = non-significant, **= highly significance

Correlation Coefficients Between Environmental Parameters and Physiological Traits of Indigenous Breeds of sheep in Nigeria

Correlation coefficients between pulse rate and environmental temperature of overall and indigenous breeds of sheep in Nigeria irrespective of sex, age and location are shown in table 5. Pulse rate had high and positive correlation (0.452; P<0.01) with an atmospheric temperature of Balami sheep. A moderate and positive correlation (0.265, 0.221; P<0.01) was obtained between pulse rate and temperature of Uda sheep and WAD, respectively. Also, pulse rate had a low and negative relationship (-0.072; P>0.05) with a temperature of Yankasa sheep. Correlation between pulse rate and temperature of Uda, WAD and Yankasa sheep were non-significant (P>0.05). However, pulse rate had low and positive correlation (0.243; P<0.01) with a temperature of overall sheep. Pulse rate and temperature of Balami and overall sheep had positive correlation while the correlation between pulse rate and atmospheric temperature were non-significant for Uda, WAD and Yankasa sheep. The respiratory rate had high and positive correlation (0.472; P<0.01) with the temperature of Balami sheep. The respiratory rate had moderate, positive and non- significant correlation (0.042; P>0.05) with the temperature of overall sheep. Also, the respiratory rate had low and non-significant correlation (0.113, 0.058; P>0.05) with the temperature of the Yankasa and Uda sheep, respectively. Low and negative correlation (-0.161; P>0.05) was obtained between respiratory rate and temperature of WAD sheep. The respiratory rate had a high and positive correlation (0.638; P<0.01) with relative humidity of Balami sheep. A moderate and positive correlation (0.422; P<0.01, 0.388; P<0.01) was obtained for overall sheep and Yankasa sheep, respectively. Also, WAD and Uda sheep had negative and non-significant correlation (-0.601; P>0.05, 0.111; P>0.05). The rectal temperature had moderate and positive correlation (0.397; P<0.01) with relative humidity of WAD. Correlation (0.151; P>0.05, 0.076; P>0.05) between rectal temperature and elevation of overall sheep and Yankasa was moderate and non-significant, while negative and non-significant relationship was recorded for Balami and Uda sheep. Correlation coefficients between rectal temperature and elevation had a significant correlation for WAD sheep.

Table 5: Correlation Coefficients Between Environmental Parameters and Physiological Traits of Sheep and Indigenous Breeds of Sheep in Nigeria

	Atmospheric temperature (°C)	Relative humidity (%)	Elevation (metre above sea level)
Pulse rate(beats/minute)			
Balami	0.452**	0.346*	0.436**
Uda	0.265^{NS}	0.070^{NS}	-0.274^{NS}
WAD	0.221^{NS}	-0.370*	-0.237^{NS}
Yankasa	-0.072^{NS}	-0.163^{NS}	-0.403*
Respiratory rate(breaths/minutes)			
Balami	0.472**	0.638**	0.197^{NS}
Uda	0.058^{NS}	-0.111^{NS}	0.003^{NS}
WAD	-0.161^{NS}	-0.601^{NS}	0.061^{NS}
Yankasa	0.113^{NS}	0.388*	0.095^{NS}
Rectal temperature (°C)			
Balami	0.166^{NS}	0.134^{NS}	-0.039^{NS}
Uda	0.050^{NS}	0.310*	-0.228^{NS}
WAD	-0.24^{NS}	-0.247^{NS}	0.397*
Yankasa	-0.265^{NS}	0.198^{NS}	0.076^{NS}

°C = degree centigrade, NS = non-significance, * = significance, ** = highly significance

Conclusions and Applications

1. Breed of sheep affected ($p<0.05$) some biochemical and physiological indices in relation to locations (environments) and age of the stocks.
2. Malondialdehyde (MDA) is possibly not a good marker for monitoring heat stress among breeds of sheep in Nigeria because breeds did affect the activity level of MDA. Other Metabolic markers like thyroid, cortisol hormones level and glucose could also be used in the future.
3. Effort should be made to use molecular markers of heat stress such as malondioldehyde and heat shock protein to study diversity of sheep breeds in Nigeria.

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