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Physiological Response, Haematology and Triiodothyronine Profile in West African Dwarf and *KalaWad* does as Affected by the Cold-dry Season

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Abstract

Although animals can adapt to climatic stressors, the response mechanisms that ensure survival are also detrimental to performance (Pragna et al., 2018). An experiment to investigate the physiological response, haematological changes and triiodothyronine profile in non-gravid West African Dwarf (n=9) and KalaWad (n=9) does aged between 2-3 years with live weight between 15-35 kg in the cold dry season (November-January) was carried out. Animals were raised semi-intensively and allowed to graze in a paddock planted with Pennisetum purpureum and Pannicum maximum grass. Physiological parameters were recorded weekly and blood samples were collected twice a month for three months via the jugular vein puncture for haematological and hormonal assay analysis. Data were analysed using a general linear model appropriate for 2 x 2 x 3 factorial format. West African Dwarf goats had significantly higher ($p<0.001$) rectal temperature (36.73 vs. 36.52°C), and heart rate (80.07 vs. 78.09beats/min) than KALAWAD goats while respiratory rates and pulse rates were not significant ($p>0.05$) in the two breeds. The interaction between breed and month of sampling on haematological variables showed that RBC counts ($10.01 \pm 0.54\times10^{12}$/L) and MCH (9.22 ± 0.11pg) were higher in the month of November in KALAWAD while RDW (27.08 ± 0.43fl) and B (0.58 ± 0.08%) on the other hand werehigherin the WAD goats in the same month. The month of November had the highest T_3 level followed by December and January in that order (3.46±0.36 vs 2.78±0.22 vs 2.3±0.2 ng/mL) respectively. It can be concluded from the study that the West African Dwarf was able to withstand the hot afternoons in the humid tropics as well as cope with high humid conditions due to their faster metabolic activities so as to maintain homeostasis.

Keywords: Physiological response; Blood profile; Triiodothyronine profile; Cold-dry season

Réponse physiologique, hématologie et profil de triiodothyronine chez les chèvres West African Dwarf et *KalaWad* en fonction de la saison froide et sèche

Résumé

Bien que les animaux puissent s'adapter aux stress climatiques, les mécanismes de réponse qui assurent leur survie sont également préjudiciables à leurs performances (Pragna et al., 2018). Une expérience a été menée pour étudier la réponse physiologique, les modifications hématologiques et le profil de triiodothyronine chez des chèvres non gravides de race West African Dwarf (n=9) et KalaWad (n=9), âgées de 2 à 3 ans et pesant entre 15 et 35 kg, pendant la saison froide et sèche (novembre-janvier). Les animaux étaient élevés de manière semi-intensive et autorisés à paître dans un enclos planté d'herbes Pennisetum purpureum et Panicum maximum. Les paramètres physiologiques ont été enregistrés chaque semaine, et des échantillons sanguins ont été prélevés deux fois par mois pendant trois mois par ponction de la veine jugulaire pour des analyses hématologiques et hormonales. Les données ont été analysées à l'aide d'un modèle linéaire général adapté à un format factoriel 2 x 2 x 3. Les chèvres West African Dwarf présentaient une température rectale (36,73 vs. 36,52 °C) et une fréquence cardiaque (80,07 vs. 78,09 battements/min) significativement plus élevées ($p < 0,001$) que les chèvres KALAWAD, tandis que les fréquences respiratoires et les pouls n'étaient pas significativement différents ($p > 0,05$) entre les deux races. L'interaction entre la race et le mois d'échantillonnage sur les variables hématologiques a montré que les taux de globules rouges (10,01 ± 0,54

× 10¹²/L) et la TCMH (9,22 ± 0,11 pg) étaient plus élevés en novembre chez les KALAWAD, tandis que le RDW (27,08 ± 0,43 fL) et les lymphocytes B (0,58 ± 0,08 %) étaient plus élevés chez les chèvres West African Dwarf le même mois. Le mois de novembre a enregistré le taux de T3 le plus élevé, suivi de décembre et janvier respectivement (3,46 ± 0,36 vs. 2,78 ± 0,22 vs. 2,3 ± 0,2 ng/mL). Il peut être conclu de cette étude que la chèvre naine ouest-africaine a mieux résisté aux après-midis chauds des tropiques humides et s'est adaptée aux conditions de forte humidité grâce à son métabolisme plus rapide, lui permettant ainsi de maintenir l'homéostasie.

Mots-clés : Réponse physiologique ; Profil sanguin ; Profil de triiodothyronine ; Saison froide et sèche

Introduction

Worldwide, approximately 80% of goat production is restricted to low-income countries, particularly in tropical Africa and Asia (Morand-Fehr *et al*., 2004). In developing countries, small ruminants are described as 'village banks', while goats are known as the cow of the poor (Ikwuebu *et al*., 1994; Haldar and Ghosh 2014). The promotion of small-scale livestock production would be one way to reduce poverty and improve human nutrition in rural Africa (Azzarri *et al*., 2014).

The four (4) distinct seasons of the Guinea savannah area of South-Western Nigeria are: cold-dry season (CDS; harmattan i.e November-January), hot-dry season (HDS i.e. February-April) and Early rainy season (ERS i.e. May-July) and Late rainy season (LRS i.e. August-October). These seasons have different combinations of meteorological parameters, and domesticated animals must adjust to periodic changes in these parameters so that they can adapt and maintain productivity. Likewise, these seasonal differences also affect the availability of feed since plants growth occurs, primarily during the rainy season. High (Gaughan *et al*., 2013) or low (Zhao *et al*. 2013) ambient temperatures due to seasonal changes are well known to induce stress and have a negative impact on physiology and livestock productivity. Among the environmental variables affecting animals, heat stress is one of the factors making animal production challenging in many parts of the world (El-Tarabany *et al*., 2017). The vulnerability of livestock to heat stress varies according to species, genetic potential, life stage, management or production system and nutritional status (Das *et al*. 2016). It has also been observed, that the ability of the animals to adjust to these climatic extremes is related to their level of adaptation and this is inversely correlated with their production potential (Maurya *et al*., 2015).

Haematological parameters differ in animals due to differences in species of animals, environmental factors (most importantly season which also determines how well they will perform), nutritional factors, and management. However, the search for feed during the dry season when there is reduction in quantity and quality of forage given to the animal, has proven to be a major disadvantages to small ruminant production. Afolabi *et al*. (2010) emphasized that most tropical forage species have low dry matter digestibility and intake which causes changes in haematological parameters. Thyroid hormone concentration was found out to be dependent on several factors such as genetic, environmental and nutritional status of the animals as reported by Todini (2007). The environmental temperature, being the most important external factor in modulating the activity of the thyroid gland (Dickson 1993), is inversely proportional to the blood thyroid hormone concentration in goats (Colavita *et al*., 1983; Todini *et al.*, 1992) and sheep (Valtorta *et al*., 1982; Webster *et al*., 1991; Starling *et al*., 2005).

Over the years, scientists have put intense efforts into understanding how domestic animals respond to climate stressors. However, most of these studies were conducted in developed countries with a significant amount of data generated on adaptation and the impact of environmental stress on the production, reproduction and health of animals (Scholtz *et al*., 2013). Physiological changes in blood cellular components, free radical biology, as well as endocrine, respiratory and cardiovascular systems have been used as important parameters to evaluate the adaptation of animals to a given geographical location (Sejian *et al*., 2013; Ribeiro *et al*., 2015). This may help in the selection of animals that are capable of producing satisfactorily in harsh environments and outside the zone of thermal comfort (Ribeiro *et al*., 2015).

However, little is known about the adaptation of animals to the rapidly changing environmental conditions in developing countries especially the Guinea savannah in the humid tropics of South-Western Nigeria, where the stressors are different and the intensity of expected changes from one season to the other is greater.

This study was therefore; carried out to evaluate the adaptation of West African Dwarf and KALAWAD does to the cold-dry season of the guinea savannah zone of Nigeria by evaluating the changes in physiological variables, haematology, and serum thyroid hormone (T_3) concentration.

Materials and methods

Experimental Site

The study was carried out at the Institute of Food Security Environmental Resources and Agricultural Research (IFSERAR) Farm, Federal University of Agriculture, Abeokuta. The region lies between latitudes 7º18′2′N and 7º18′30′N; and longitude3º22′10′E and 3º22′41′E. The site is within the Guinea savannah 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 (May–July) and late rainy season (August–October) and 30–34°C during the cold-dry season (November–January) and hot-dry season (February–April) 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 [source: FUNAAB, (2012)].

Origin of experimental animals and management

Eighteen apparently healthy non-pregnant does consisting of nine West African Dwarf (WAD) and nine *KALAWAD* females aged between 2-3 years with live weight between 15-35 kg were used. The animals were sourced from the Experimental Unit of the Small Ruminant section of the Livestock Production Research Programme, Institute of Food Security, Environmental Resource and Agricultural Research (IFSERAR), Federal University of Agriculture Abeokuta, Ogun state, Nigeria. The WAD goats are one of the commonest breed found within the South-Western region of Nigeria while the *KALAWAD* goats originated from two lines consisting of a line of Kalahari Red goats and West African Dwarf goats. The crosses were bred at the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The animals were managed intensively throughout the experimental period in a well-ventilated pen with slatted floor. The roof of the pen was made of asbestos sheets. The animals were separated into different pens while maintaining proper hygiene and strict bio-security measure. The animals were fed *Pennisetum purpureum* and *Pannicum maximum* grasses daily at 2% body weight dry matter basis supplemented with concentrate ration of rice bran (24%); cotton seed cake (30%); Wheat offal-(40%); bone meal (3%); salt (3%) at 0.3-0.7kg/head/day (2% body weight dry matter basis). Water was provided ad-libitum.

Determination of physiological variables

Once a week throughout the cold-dry season (between 1st November 2021 to 31st January, 2022), the rectal temperature (RT), respiratory rate (RR), pulse rate (PR) and heart rate (HR) were taken at 8:00 a.m. and 2:00 p.m respectively according to the methods described by Oladimeji (1994): RR was obtained by counting the movement of the flank at the paralumbar fossa per unit time using a stop watch and presented as breaths/minute. PR was obtained by counting the pulsations felt in the femoral artery per unit of time using a stop watch and presented as beats/minute. RT was obtained by inserting a digital thermometer about 5cm into the rectum of the animal and presented as °C. HR was obtained by placing a stethoscope around the first rib of the right chest and counting the number of beats per minute using a stop watch and presented as beats/min.

Meteorological 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 using a digital thermo-hygrometer throughout the study. The temperature-humidity index (THI) which evaluates the level of heat stress induced by the environment and was calculated using the equation reported by Ravagnolo *et al*. (2000):

$THI = (1.8 \times T + 32) - \{(0.55 - 0.0055RH)(1.8 \times T - 26)\}$

Where;

T= Ambient temperature (°C)

RH= Relative humidity (%)

Blood collection and determination of haematological variables

Five (5) mL of blood was drawn via the jugular vein of the goats twice a month using a vacutainer needle. Blood samples were collected into a vacutainer tube containing ethylene diamine-tetra- acetate (EDTA) as anti-coagulant for haematological studies. Haematological variables were determined by the aid of an auto–haemo analyser (Model VH30, Genvet, Genmi Biotech Inc., China).

The haematological variables determined includes: Packed cell volume (PCV), Haemoglobin concentration (Hb); Red blood cell (RBC) count, White Blood cell (WBC) count. The white blood cell differentials; Neutrophils, Eosinophils, Basophils, Lymphocytes and Monocytes were also determined.

Determination of serum triiodothyronine (T_3) concentration

On the other hand, five (5) ml of blood was drawn into an anti-coagulant free tube. Blood samples were then centrifuged; serum obtained and stored for 2 weeks in the freezer at -20°C for triiodothyronine (T_3) concentration analysis using the enzyme linked immunosorbent assay (Bio-Inteco, Inteco Diagnostics UK Ltd, Beechwood Road, E8 3DY England). (Triiodothyronine (T_3) which is a metabolic hormone was read using an absorbance immunoassay system (ELx800™ Biotek Instruments, Inc., Vermont, USA).

Experimental design

The experimental design for this experiment is a general linear model appropriate for a 2×2×3 factorial arrangement with the breed; time of the day and month of sampling as independent variable while the physiological responses, haematological and hormonal variables are the dependent variables.

Statistical Analysis

Data obtained were analysed by method of least squares analysis of variance (SAS, 2003) (SAS institute Inc. NC27153, New York, USA) and significant means were separated using the Duncan multiple range test.

Results

Effects of breed, month of sampling and time of the day on physiological responses in West African Dwarf and KALAWAD goats

The results of the analysis of variance of the effects of breed, week of sampling, time of day and treatment interaction on physiological response showed that breed had a significant effect (P< 0.01) on rectal temperature and heart rate while it had no significant effect (P>0.05) on pulse rate and respiratory rate. Time of day had a highly (P<0.001) significant effect on all the physiological parameters monitored i.e rectal temperature, pulse rate, respiratory rate and heart rate. Month of sampling on the other hand, had a highly (P<0.001) significant effect on all the physiological parameters monitored except for pulse rate which was not significant (P>0.05). The interactions showed that breed and time of the day interaction had a highly significant (P<0.001) effect on all the physiological parameters i.e rectal temperature, pulse rate, respiratory rate and heart rate. Breed and month of sampling interaction also had a high significant effect (P<0.001) on all the physiological parameters monitored except pulse rate which was not significant (P>0.05).

The Least square means of the effect of breed on physiological parameters as shown in table 1 revealed that rectal temperature and heart rate was higher in the West African Dwarf than the *KALAWAD* goats. The least square means of the effect of time of the day on physiological parameters as shown in Table 2 revealed that, rectal temperature, respiratory rate, pulse rate and heart rate were higher all in the afternoon than the morning.

Table 1: Least square means of the effect of breed on physiological parameters

Physiological Response	WAD	KALAWAD	SEM	P-VALUE
Rectal temperature, (°C)	36.73[a]	36.52[b]	0.13	<.0001
Respiratory rate, (breaths/min)	43.37	43.41	0.77	0.9748
Pulse rate, (pulses/min)	62.92	62.10	0.81	0.4757

Heart rate, (beats/min)	80.07^a	78.09^b	0.72	0.0403

^{a,b}means in the same row having different superscripts differ significantly (P< 0.05)

Table 2: Least square means of the effect of time of the day on physiological parameters

	Time of the day			
Physiological parameters	**Morning**	**Afternoon**	**SEM**	**P-VALUE**
Rectal temperature, (ºC)	35.89^b	37.35^a	0.13	<.0001
Pulse rate, (pulse/min)	58.46^b	66.56^a	0.77	<.0001
Respiratory rate, (breaths/min)	36.88^b	46.90^a	0.73	<.0001
Heart rate, (beats/min)	75.59 ^{b}	82.57^a	0.68	<.0001

^{a,b}means in the same row having different superscripts differ significantly (P< 0.001)

The least square means of physiological response as affected by month of sampling as shown in table 3 revealed that rectal temperature, respiratory rate and heart rate all increased as the month of sampling progressed from November to December and thereafter decreased in the month of January. The highest rectal temperature, pulse rate and heart values (36.94±0.16 and 36.98±0.16ºC; 44.06±0.87 and 46.37±0.87breaths/min; 79.62±0.86 and 80.19±0.86 beats/min) were all recorded in the months of January and February respectively.

The breed and time of the day interaction effect on physiological response as shown in table 4 revealed that rectal temperature, pulse rate, respiratory rate and heart rate were all higher in the afternoon in both breeds (i.e West African Dwarf and KALAWAD). The least square means of physiological response as affected by breed and month of sampling interaction in table 5 showed rectal temperature, respiratory rate and heart rate were highest in both breeds in the month of November and December. All the physiological parameters increased as the month of sampling progressed from November to December and thereafter decreased in the month of January.

Table 3: Least square means of physiological response as affected by month of sampling

Month of sampling	**Rectal temperature, (ºC)**	**Pulse rate, (pulse/min)**	**Respiratory rate, (breaths/min)**	**Heart rate, (beats/min)**
November	36.94^a	61.77	44.06^a	79.62^a
December	36.98^a	61.51	46.37^a	80.19^a
January	35.87^b	64.5	39.00^b	77.15^b
SEM	0.16	0.94	0.87	0.86
P-VALUE	<.0001	0.0685	<.0001	0.0352

^{a,b}means in the same column having different superscripts differ significantly (P< 0.001)

Table 4: Least square means of physiological response as affected by breed and time of the day interaction

Breed	**Time of the day**	**Rectal temperature, (ºC)**	**Pulse rate, (pulse/min)**	**Respiratory rate, (breaths/min)**	**Heart rate, (beats/min)**
West African Dwarf	Morning	35.97^b	58.92^b	39.93^b	76.88^b

	Afternoon	37.47[a]	66.97[a]	46.88[a]	83.35[a]
KALAWAD	Morning	35.82[b]	58.00[b]	39.83[b]	74.27[b]
	Afternoon	37.24[a]	66.15[a]	46.92[a]	81.79[a]
	SEM	0.17	1.09	1.78	0.96
	P-VALUE	<.0001	<.0001	<.0001	<.0001

[a,b]means in the same column having different superscripts differ significantly (P< 0.001)

Table 5: Least square means of physiological response as affected by breed and month of sampling interaction

Breed	Month of sampling	Rectal temperature, (ºC)	Pulse rate, (pulse/min)	Respiratory rate, (breaths/min)	Heart rate, (beats/min)
West African Dwarf	November	37.02[a]	63.17	43.15[ab]	81.61[a]
	December	37.09[a]	61.56	46.47[a]	80.42[ab]
	January	35.97[b]	64.39	39.72[bc]	78.08[abc]
KALAWAD	November	36.86[a]	63.17	44.96[a]	77.63[bc]
	December	36.87[a]	61.56	46.47[a]	79.96[ab]
	January	35.76[b]	64.39	38.28[c]	76.21[c]
	SEM	0.22	1.32	1.23	1.22
	P-VALUE	<.0001	0.2084	<.0001	0.0269

[a,b,c]means in the same column having different superscripts differ significantly (P< 0.001)

The climatic variables and temperature-humidity index (THI) throughout the experimental period are shown in table 3. It was revealed that temperature in the morning during the cold dry season had no significant effect (p>0.05) while relative humidity had a significant effect (p<0.05) on weather changes with relative humidity highest throughout the three (3) months experimental period. THI was highest in the month of November decreased sharply in the month of December and slightly in the month of January. In the afternoon however; temperature and humidity had a significant impact on weather condition with December and January having the highest temperature and November with the lowest temperature. Relative humidity was however highest in the month of January and lowest in the months' of November and December. THI increased as the month advanced from November to December and decreased sharply as the month advanced from December to January which had the lowest value.

Table 3: Climatic variables and temperature-humidity index (THI) throughout the experimental period

	November	December	January
Morning			
Temperature ºC	28.14 ± 0.22	27.66 ± 0.46	28.11 ± 0.20
Relative Humidity (%)	83.68 ± 0.29[ab]	82.80 ± 1.23[b]	86.36 ± 0.84[a]
THI	82.3	79.5	80.7
Afternoon			

Temperature ^{o}C	30.85 ± 0.29^{b}	32.92 ± 0.64^{a}	32.91 ± 0.94^{a}
Relative Humidity (%)	75.13 ± 1.09^{b}	77.27 ± 1.37^{b}	81.06 ± 1.39^{a}
THI	83.5	87.8	81.7

^{a,b}means in the same row with different superscript differ significantly (P<0.05)

Effect of breed, month of sampling and breed*month of sampling interaction on haematological variables in West African Dwarf and KALAWAD goats

The results of the analysis of variance of the effects of breed, month of sampling and breed by month of sampling interaction on haematological variables revealed that breed had a significant effect (P< 0.05) on the haemoglobin (Hb) concentration, Lymphocytes (L) and Neutrophils (N) while there was no significant effect (P>0.05) on packed cell volume (PCV), Red blood cell (RBC), white blood cell (WBC) count, mean corpuscular volume (MCV), Mean Corpuscular haemoglobin (MCH), Mean Corpuscular haemoglobin concentration (MCHC), Red cell distribution width (RDW), Monocytes (M), Eosinophils (E) and Basophils (B). Month of sampling had a highly significant effect (P<0.001) on all the haematological variables determined except PCV. The breed by month of sampling interaction on) the other hand, was also significant (P<0.05) for all the haematological variables determined except PCV and MCH.

The least square means of haematological variables as affected by breed as shown in Table 4 revealed that Hb and L was higher in *KALAWAD* than WAD (98.742 ± 2.20 vs 92.43 ± 2.15 g/L and 34.47 ± 1.68 vs 28.42 ± 1.30%) while N was higher in WAD than *KALAWAD* (61.67 ± 1.77 vs 55.38 ± 1.94%). Also, the least square means of haematological variables as affected by month of sampling on Table 5 showed that the Hb concentration (102.31 ± 1.43g/L), MCV (27.80 ± 0.89fL) and N (66.75± 2.44%) were highest in January. RBC (9.49 X10^{12}/L), MCH (9.20 ± 0.08pg), RDW (26.78 ±0.31fL), E (3.29± 0.24%) and B (0.57± 0.06%) were highest in November while MCHC (503.08 ± 4.85g/L); WBC (11.12 ± 0.51×10^{9}/L); L (35.60 ± 1.33%) and Monocyte (11.41 ± 0.30%) were all highest in the month of December respectively.

Furthermore, the least square means of the interaction between breed and month of sampling on haematological variables on Table 6 revealed that RBC counts (10.01 ± 0.54×10^{12}/L) and MCH (9.22 ± 0.11pg) were higher in the month of November in *KALAWAD* while RDW (27.08 ± 0.43fL) and B (0.58 ± 0.08%) on the other hand were higher in the WAD goats in the same month. MCHC (504.33 ± 16.3g/L), WBC counts (11.93 ± 0.82×10^{9}/L) and L (38.37 ± 1.55%) were higher in *KALAWAD* while M (11.69 ± 0.47%) was higher in the WAD goats all in the month of December respectively. Hb concentration (104.83 ± 1.65g/L) and MCV (28.31 ± 0.94fL) were higher in the *KALAWAD* while N (70.56 ± 2.55%) was higher in the WAD goats in the month of January.

Table 4: Least square means of the effect of breed on haematological variables

Breed	**Haemoglobin (Hb) (g/L)**	**Lymphocytes (L) (%)**	**Neutrophils (N) (%)**
West African Dwarf	92.43 ± 2.15^{b}	28.42 ± 1.30^{b}	61.67 ± 1.77^{a}
KALAWAD	98.742 ± 2.20^{a}	34.47 ± 1.68^{a}	55.38 ± 1.94^{b}

^{ab}Means in the same column having different superscript differ significantly (P<0.05)
n=108
±SEM

Table 5: Means of the effect of month of sampling on haematological variables

Haematolological Variables	**November**	**December**	**January**
Hb (g/L)	87.39 ± 3.19^{b}	97.11 ± 2.62^{a}	102.31 ± 1.43^{a}
RBC (×10^{12}/L)	9.49 ± 0.36^{a}	8.61 ± 0.36^{b}	7.06 ± 0.15^{c}

MCV (*fl*)	21.41 ± 0.09^{b}	26.76 ± 1.06^{a}	27.80 ± 0.89^{a}
MCH (*Pg*)	9.20 ± 0.08^{a}	8.89 ± 0.09^{b}	8.76 ± 0.09^{b}
MCHC (g/L)	429.92 ± 5.40^{b}	503.08 ± 4.85^{a}	438.28 ± 5.70^{b}
RDW (*fl*)	26.78 ±0.31^{a}	20.79 ± 1.17^{b}	20.01 ± 1.07^{b}
WBC (×10^{9}/ L)	9.69 ± 0.26^{b}	11.12 ± 0.51^{a}	8.53 ± 0.67^{b}
L (%)	28.17 ± 1.57^{b}	35.60 ± 1.33^{a}	30.56 ± 2.45^{ab}
N (%)	58.50 ± 2.12^{b}	50.33 ± 1.50^{c}	66.75 ± 2.44^{a}
M (%)	9.46 ± 0.44^{b}	11.41 ± 0.30^{a}	1.94 ± 0.35^{c}
E (%)	3.29 ± 0.24^{a}	2.39 ± 0.27^{b}	0.69 ± 0.03^{c}
B (%)	0.57 ± 0.06^{a}	0.27 ± 0.04^{b}	0.06 ± 0.03^{c}

^{ab}Means in the same row having different superscript differ significantly (P<0.05)
n=108; number of observation
LSM±SEM; least square means ± standard error means

Table 6: Effects of breed and month of sampling interaction on haematological variables

Haematological variables	WAD			*KALAWAD*		
	NOV	DEC	JAN	NOV	DEC	JAN
HB (g/L)	82.44±3.88^{b}	95.17±3.72^{ab}	99.78±2.22^{ab}	92.33±4.88^{ab}	99.06±3.73^{ab}	104.83±1.65^{a}
RBC (×10^{12}/L)	8.99±0.42^{ab}	8.68±0.50^{b}	6.99±0.28^{c}	10.01±0.54^{a}	8.53±0.53^{b}	7.12±0.16^{c}
MCV (*fl*)	21.48±0.14^{b}	25.94±1.34^{a}	28.31±0.94^{a}	21.34±0.12^{b}	27.57±1.66^{a}	27.29±1.54^{a}
MCHC (g/L)	427.67±8.44^{b}	501.83±25.32^{a}	441.33±9.2^{b}	432.17±6.9^{b}	504.33±16.3^{a}	435.22±6.87^{b}
RDW (*fl*)	26.48±0.44^{a}	21.46±1.55^{b}	19.64±1.43^{b}	27.08±0.43^{a}	20.12±1.79^{b}	20.37±1.62^{b}
WBC(×10^{9}/L)	9.61±0.40^{bc}	10.31±0.57^{ab}	8.01±0.77^{c}	9.77±0.35^{bc}	11.93±0.82^{a}	9.04±1.10^{bc}
L (%)	25.74±20.08^{c}	32.84±1.99^{abc}	26.67±2.41^{c}	30.61±2.26^{bc}	38.37±1.55^{a}	34.44±4.14^{b}
N (%)	61.88±20.86^{b}	52.59±2.29^{c}	70.56±2.55^{a}	55.13±2.99^{bc}	48.06±1.87^{c}	62.94±4.04^{ab}
M (%)	8.69±0.57^{b}	11.69±0.47^{a}	1.94±0.51^{c}	10.23±0.63^{a}	11.13±0.39^{a}	1.94±0.50^{c}
E (%)	3.12±0.37^{ab}	2.62±0.46^{ab}	0.72±0.25^{c}	3.49±0.32^{a}	2.17±0.28^{b}	0.67±0.31^{c}
B (%)	0.58±0.08^{a}	0.26±0.05^{b}	0.11±0.08^{bc}	0.55±0.09^{a}	0.28±0.07^{b}	0.05±0.00^{c}

^{abc}Means in the same row with different superscript differ significantly (P<0.05)
LSM±SEM
N=108

Effects of breed, month of sampling and breed*month of sampling interaction on triiodothyronine (T_3) levels in West African Dwarf and KALAWAD goats

The results of the analysis of variance of the effects of breed, month of sampling and breed* month of sampling interaction on triiodothyronine level showed that Breed and breed * month of sampling interaction had a high significant effect (P<0.001) on triiodothyronine level while month of sampling had a significant effect (P<0.05). The least square means of the effect of breed on triiodothyronine level as shown in table 6 revealed that triiodothyronine level was higher in West African Dwarf than *KALAWAD* goats (3.35±0.26 vs 2.29±0.16 ng/ml). The least square means of triiodothyronine as affected by month of sampling also shown in table 7 revealed that triiodothyronine level decreases across the month of sampling with November having the highest mean value followed by December and January with the lowest mean value respectively (3.46±0.36 vs 2.78 ± 0.22 vs 2.33 ±0.22 ng/ml). Statistically, triiodothyronine level was highest in the month of November and December.

Table 7: Summary of the least square means of triiodothyronine levels as affected by breed and month of sampling

Source of variation	no of observations	Least square ± standard error means
		Triiodothyronine (T_3) ng/mL

MONTH		
November	36	3.46±0.35[a]
December	36	2.78±0.22[ab]
January	36	2.33± 0.22[b]
BREED		
WAD	54	3.50 ±0.26[a]
KALAWAD	54	2.29±0.16[b]

[ab]means in the same column having different superscript differ significantly (P<0.05)

The least square means of the effect of breed * month of sampling interaction as shown in figure 6, revealed that Triiodothyronine levels decreases across the month of sampling in the two breeds. The highest value was recorded in the month of November followed by December, and January having the lowest value. Triiodothyronine level decreased sharply throughout the month of sampling in the West African dwarf goat while the decrease was gradual across the month of sampling in the *KALAWAD*.

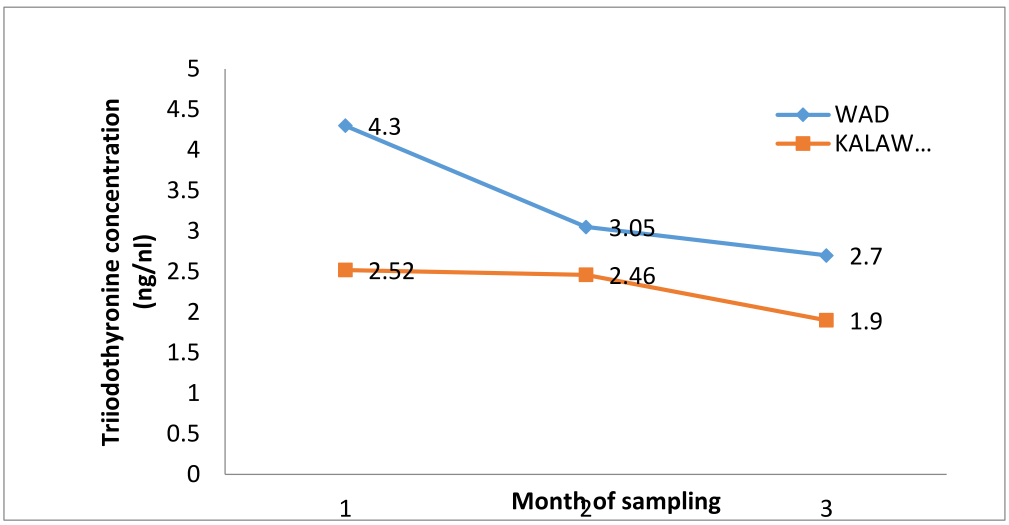

Figure 1. Triiodothyronine levels as affected by breed*month of sampling interaction

Discussion

Effects of breed, week of sampling and time of the day on physiological responses in West African Dwarf and KALAWAD goats

The higher rectal temperature recorded in the West African Dwarf goats in this experiment suggested that West African Dwarf goats dissipated more heat thereby the animals tried to reduce metabolic heat production to minimize heat load and maintain normal body temperature. This could also imply a strong association between morphological variables and environmental temperature, such that the relatively larger body surface area of the smaller breeds helps to enhance the efficiency of heat dissipation in hot climates, while small body surface areas in larger breeds helps to conserve heat in cold climates (Mayr 1970; Daramola and Adeloye 2009). The lower rectal temperature and heart rate in the KALAWAD could be attributed to the fact that they are cross breed of West African Dwarf and Kalahari red goat.

The high rectal temperature, respiratory rate, pulse rate and heart rate recorded in the afternoon suggested that there was high atmospheric heat in the afternoon in the hot humid tropics of South Western Nigeria.

The high rectal temperature, pulse rate, respiratory rate and heart rate recorded in both the WAD and *KALAWAD* goats in the afternoon suggest that there was a high atmospheric heat especially in the afternoon thereby the animals tried 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).

Such factors associated with increase in solar radiation may justify the high values recorded in the afternoon.

The rectal temperature in this study was highest in the month of November and December in both breeds. This could be due to the fact that goats are homeotherms and hence tend to maintain a constant body temperature between the environment through a balance of heat gain and loss. It could also be due to the high relative humidity prevalent during the period when the experiment was conducted.

The high respiratory rate recorded in the West African Dwarf and KALAWAD goats in the month of November and December could be attributed to an attempt by the goats to increase respiratory evaporation heat loss which is an adaptive mechanism for heat regulation. Similar findings were 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 both breeds responded to heat stress by making rapid physiological adjustment to maintain homeostasis. The higher respiratory rate in the West African Dwarf goats could be genetically related to their miniature body size as compared with the other breeds (Ngere *et al*. 1984). The heart rate in this study was also highest in the month of November and December in both breeds. This could be attributed to a high metabolic rate which increases blood flow from the core to the surface to make room for more heat to be lost.

Effect of breed, month of sampling and breed*month of sampling interaction on haematological variables in West African Dwarf and KALAWAD goats

The higher haemoglobin concentration (Hb) in the *KALAWAD* goat in the month of January in this study suggest that the *KALAWAD* goats seems to possess relatively high haemoglobin values which is an advantage in terms of the oxygen carrying capacity of the blood. It could also be due to elevated loss of body fluid through heat stress induced evaporative heat loss. The haemoglobin concentration in both breeds was higher than that obtained by Tambuwal *et al*. (2002), in the Red Sokoto goats. The higher RBC counts in the *KALAWAD* in the month of November in this study is in agreement with the findings of Benerjee *et al*. (2014), who reported that RBC was higher in the cold dry season. The higher MCV value in the *KALAWAD* in this study could be as a result of the availability in the quantity and nutritional quality of pasture during this period as the month of November is a transient between the end of the rainy season and onset of the dry season in the tropics. Most plant species at this time are richer in nutrients such as nitrogen and potassium which enables a high digestibility due to low amounts of secondary metabolites. The high MCV could also be due to natural heat stress which causes an increase in the number of erythrocytes membrane vesicles formed and shed from the erythrocytes (Moore *et al*. 2013). The higher MCHC in December in the *KALAWAD* could be as a result of the physiological activeness of the *KALAWAD* which is a hybrid of the cross between the WAD and Kalahari Red goats. The MCHC value of (504.33±16.3 g/dl) was within the range recorded by Daramola *et al*. (2003). The highest WBC recorded in the KALAWAD goats in the month of November in this study could suggest that the KALAWAD goats could be fighting an infection which indicates that they possess a protective system, providing a rapid and potent defense against infectious agents. This Result corroborates the findings of Tambuwal *et al*. (2002) and Daramola *et al*. (2005) in WAD goats who recorded mean values of 10.6×10^9/L and 13.5×10^9/L respectively.

Effects of breed, month of sampling and breed*month of sampling interaction on triiodothyronine (T_3) levels in West African Dwarf and KALAWAD goats

The significant breed effect in this study with respect to WAD goats could be due to their smaller body size compared to the larger body size in KALAWAD which enables a faster metabolic rate. This suggests that the WAD goats are more suited to the hot humid tropics unlike the *KALAWAD* which combines the gene of Kalahari × WAD. This corroborates the findings of Afshin Raoofi *et al*. *(*2017) who reported that breed and physiological state of the animal influenced thyroid activity in Beetal-cross goats. It is also reported that Endogenous factors (breed, age, gender, body weight, and physiological state), environmental factors (climate, season, photoperiod) and nutrition are able to affect thyroid activity and hormone concentrations in blood (Anderson and Harness 1975; Riis and

Madsen 1985; Blaszczyk *et al*. 2004; Todini *et al*. 2006; Todini *et al*. 2007). Similarly, the study of Indu *et al*. (2014) and Ribeiro *et al*. (2015) in goats showed a high T4 and T3 during the cold compared to the hot seasons. The highest triiodothyronine level in the month of November could be due to the high relative humidity during that period as this period marks the onset of the dry season after a high humid period of the late rainy season.

The higher triiodothyronine level in the month of November in the WAD goats which decreased sharply as the month increases could be due the ability of the WAD goats to increase metabolic rate faster than the KALAWAD due to their smaller body size which is a biochemical basis for the adaptation of this species to this ecological zone (humid tropics). The continued reduction in the level of triiodothyronine as the dry season progresses could be due to the decreased relative humidity. Thus, suggesting that as seasons change, breeds that can effectively regulate thyroid hormone secretion may survive better, particularly in the situation where animals are not been provided with special housing according to the prevailing seasons of the year.

Conclusion

It was concluded from this study that:

1. Rectal temperature and heart rate was lower in the *KALAWAD* than the West African Dwarf goats.
2. The differential responses of rectal temperature, respiratory rate, pulse rate and heart rate to diurnal variations were higher in the afternoon than the morning.
3. Rectal temperature, respiratory rate and heart rate were all highest in the two breeds in the month of November and December.
4. Rectal rate, respiratory rate, pulse rate and heart rate were all higher in the afternoon in both breeds during the cold-dry season.
5. Hb and L were higher in *KALAWAD* than WAD while N was vice-versa.
6. RBC count and MCH were higher in the month of November in *KALAWAD* while RDW and B on the other hand were higher in the WAD goats also in November.
7. WBC count was higher in the *KALAWAD* while M was higher in the WAD goats all in the month of December.
8. Hb concentration and MCV were higher in the *KALAWAD* while N was higher in the WAD goats in the month of January.
9. Triiodothyronine level was higher in the WAD than the *KALAWAD* goats.
10. Triiodothyronine level was highest in the month of November and December.
11. Triiodothyronine level was highest in the WAD goats in the month of November.

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