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Effect of Some Qualitative Traits and Non-Genetic Factors on Heat Tolerance Attributes of Extensively Reared West African Dwarf (WAD) Goats

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Abstract

Heat tolerance attributes of extensively reared West African Dwarf goats as influenced by some qualitative traits and non-genetic factors was studied on-farm. The qualitative traits of interest were the coat colour and wattle types while the sex and season were the non-genetic factors. The coat colours and wattle types were first identified in the population of WAD goats. The heat tolerance traits include, rectal temperature (RT), pulse rate (PR), respiratory rate (RR) and heat stress index (HSI). The study identified ten coat colours and three wattle types in the goat population studied. Coat colour and season significantly affected (P < 0.05, 0.001) all the heat tolerance traits under study while PR and RT were significantly influenced (P < 0.05) by wattle type. Only RR was significantly affected (P < 0.05) by sex. The lowest values of RR, RT, PR and HSI were obtained in the White (A^{wt}) goats during the late wet season. Bilateral wattled goats (WW) had the lowest RT and beats/minute while the highest RR was recorded in the male goats. This therefore suggest that coat colour and wattle types of WAD goats could be used as an indirect and affordable selection criteria in the tropical environment.

Key words: Extensive, Goats, Heat, Non-genetic, Qualitative traits, WAD,

Introduction

West African dwarf goat breed are found in large number in the southern part of Nigeria and most especially in the rural areas. They possess the widest margin of adaptation amongst the ruminants (Oni, 2003). They are small, hardy, early maturing, prolific, non-seasonal breeder (Osuagwuh and Akpokodje, 1982) and plump, measuring less than 50cm in height and weighs between 20 – 25 kg (Ozoje, 2002) and they are trypanosome tolerant. Their coat colour varies, ranging from black, brown, to white and combinations of these colours in various proportion. There are also some variations in the wattle occurrences, beard, horn and this had been attributed to selection by the natural environment in the traditional production systems (Ozoje and Mgbere, 2002).

Heat is a major constraint on animal productivity in the tropical belt and arid areas (Silanikove, 1992). Solar radiation in the tropics considerably increases thermal load on the animal grazing during the day. The amount of radiant heat absorbed by the animals coat is partly determined by coat colour, length and condition of its hair (Acharya *et al*., 1995). Domestic animals are homeotherms, therefore, excess heat must be eliminated for the animals to be in a thermal balance state. The general homeostatic response to thermal stress in mammals include raised respiration rates (Yousef, 1985), panting, drooling, reduced heart rates, positive sweating (Blazquez *et al*., 1994), decreased feed intake (Silanikove, 1992) as well as reduced milk production (Albright and Alliston, 1972; Liu, 1989).

The most common index of heat tolerance in mammal is core body temperature as measured by rectal temperature (moderately heritable) (Liu, 1989; Silanikove, 1992), respiratory rate and moisture vaporization rate (Silanikove, 1992). In addition, changes in rectal temperature, pulse rate and respiratory rate have been frequently used as indices of physiological adaptability to tropical environments (Oladimeji *et al*., 1996).

Bahga *et al*. (1984) and Umaru (1988) had noted that the normal pulse pate in goats ranged between 60 – 150 beats per minute while the basal respiratory rates in cattle and sheep are 20 and 25 – 30 breaths per minute respectively (Thomas and Pearson, 1986., Robertshaw and Daniel, 1983). Thomas and Pearson (1986) and Hales and Brown (1974) opined that the Respiratory rate in severely stressed cattle and sheep could reach as high as 200 and 300 breaths per minute respectively. Jean Pagot (1990) gave the normal body temperature of goats to range from 37 – 40^{0}C. All these authors concluded that size, age and external factors, such as, intense sunlight and activity of the animal could rapidly alter these aforementioned physiological parameters. High ambient temperature depresses body activities and such overheating creates physiological stress that could invariably affect production by promoting an unfavourable endocrine balance, metabolism or by reducing feed intake. Heat stress affects livestock productivity vis-à-vis milk production, body growth prenatal growth, postnatal growth, wool growth and reproduction.

Coat colour is a highly repeatable character with a heritability estimate of 53% (Peters *et al*., 1982) and could adapt animals to different climatic zones as well as influencing the performance of various animals (Odubote, 1994a; Ebozoje and Ikeobi, 1998). Peters *et al.* (1982) and Odubote (1994b) had opined that the absorption of heat is directly related to the degree of coat pigmentation and therefore concluded that coat pigmentation could be of importance in humid and sub-humid with high ambient temperatures and intense solar radiation.

Evidence of the relationship between coat colour and absorption of solar radiation was reported by early study of Bonsma as cited by Peters *et al.* (1982). They showed that absorption rate increases from white, brown to black coat. The reports of Osinowo *et al.* (1988) though inconclusive revealed that coat colour influenced radiant heat loss in Nigerian Yankassa sheep.

Wattle is inherited in a simple Mendelian autosomal dominant trait with complete or incomplete penetrance and variable expressivity (Osinowo *et al*., 1990; Odubote, 1994a). Wattle occurrence in WAD goats varies from bilateral, unilateral to non-wattled. The colour always follows the predominant coat colour of the animal. No available literatures had linked possession of wattle in WAD goats to heat tolerance however; Odubote (1994b) only suggested that wattle possession in WAD goats could be for thermoregulatory role adapting animals to the environment.

The ability to regulate temperature is an evolutionary adaptation that allows homeotherms to function in spite of variation in ambient temperature (Baker, 1989). The excess heat load must therefore be eliminated for animals to be in a thermal balance state and this will involve energy, which could have been channeled towards production.

Therefore, there is the need to study the effect of coat colour and wattle type in relation to heat tolerance as possible selection criteria and indicators of adaptive superiority of West African Dwarf goats in the traditional production system.

Materials and Methods

Description of the Study Area

The study was carried out in Ogbomoso agro-ecological zone of Oyo State, Nigeria.. The zone covers a total land mass of 14.82 square kilometers and it is located approximately at the intersection of latitude 8^0 15^1 North of the Equator and longitude 4^0 15^1 East of the Greenwich Meridian. It is situated between 300 and 600 meters above the sea level. The annual temperature ranges between 25.5^0C to 40.0^0C and while the mean annual rainfall is 1247mm (Oguntoyinbo, 1988). The relative humidity is high in the early mornings (89%) throughout the year with marked decrease in the afternoons (62%). The area is a derived savannah woodland, secondary forests and anthropic vegetation communities, as well as mixed cropping arable farmland (Adejuwon, 1983). The zone covers five local government areas, Ogbomoso North, Ogbomoso South, Oriire, Surulere and Ajaawa. The study lasted for twelve months to account for seasonal variation. The season was then categorized as late dry (January – March), early wet (April – June), late wet (July – September) and early dry (October – December)

Table 1: Least square means of physiological parameters as influenced by coat colour gene, wattle gene, season and sex of West African dwarf goats in Ogbomoso

Variable	No of observation	RR (breath/min)	RT (T°C/min)	PR (Beats/min)	HSI
Overall	3828	61.64±0.12	40.25±0.01	76.77±0.16	1.75±0.013
Coat colour:					
Black (aaB-S-)	970	65.58±0.23^{a}	40.96±0.53^{a}	83.57±0.30^{a}	1.83±0.040^{a}
White (A^{wt})	385	60.40±0.37^{e}	40.63±0.02^{cd}	74.97±0.45^{e}	1.74±0.006^{c}
Brown (aabbS-)	246	61.51±0.51^{cd}	40.63±0.29^{cd}	75.11±0.70^{de}	1.75±0.090^{d}
Bagerface (A^{b})	126	61.16±0.71^{de}	40.61±0.04^{d}	74.35±0.94^{ef}	1.75±0.012^{d}
Benzoar (A^{bz})	217	61.11±0.47^{de}	40.64±0.03^{cd}	74.06±0.67^{f}	1.75±0.009^{d}
Swiss marking (A^{sm})	222	61.10±0.48^{de}	40.70±0.02^{bc}	74.53±1.03^{e}	1.74±0.224^{c}
Mahogany (A^{mh})	658	62.46±0.29^{b}	40.77±0.02^{bc}	79.91±0.37^{c}	1.77±0.004^{b}
Black with white markings (aaBBss)	572	61.43±0.30^{cd}	40.77±0.04^{bc}	76.88±0.40^{cd}	1.76±0.005^{c}
Brown with white markings (aabbss)	174	61.82±0.58^{c}	40.57±0.02^{e}	75.76±0.68^{d}	1.76±0.011^{c}
Grey (A^{g})	186	61.85±0.43^{c}	40.89±0.03^{b}	80.71±0.53^{b}	1.78±0.006^{b}
Wattle type:					
Absent (ww)	416	65.44±0.35	40.85±0.02^{a}	80.15±0.43^{a}	1.80±0.007
Unilateral (Ww)	69	61.64±0.98	40.77±0.04^{b}	75.43±1.11^{b}	1.75±0.019
Bilateral (WW)	3343	60.71+0.13	40.72±0.27^{c}	73.73±0.18^{c}	1.74±0.015
Season:					
Late dry	878	65.96±0.26^{a}	40.90±0.01^{a}	73.18±0.35^{a}	1.74±0.050^{a}
Early wet	1262	61.96±0.19^{c}	40.70±0.69^{b}	70.58±0.29^{b}	1.73±0.040^{b}
Late wet	886	59.07±0.24^{d}	40.57±0.13^{c}	68.49±0.29^{d}	1.69±0.030^{d}
Early dry	802	62.40±0.26^{c}	40.66±0.02^{b}	70.27±0.34^{c}	1.70±0.004^{c}
Sex:					
female	2706	61.42±0.21^{b}	40.85±0.08	75.17±0.28	1.75±0.003
male	1122	62.77±0.14^{a}	40.96±0.33	76.70±0.19	1.76±0.019

^{abcdefg} means within the same variable in a column with different superscripts are significantly different ($P < 0.05$; 0.001)

Note: RR: Respiratory rate; RT: Rectal temperature; PR: Pulse rate; HSI: Heat stress index

Management of West African Dwarf Goats

A total of one thousand three hundred and twenty apparently healthy West African dwarf goats of both sexes and different ages (not less than 4 months) were surveyed on-farm within the agro-ecological zone using purposive sampling technique. Less than 4 months old goats were not considered because the real coat colour was still evolving and the femoral artery is not fully palpable. West African dwarf goats in the studied agro-ecological zone were predominantly on free range. The animals were generally left to scavenge with their kids on grasses, and on kitchen and food processing wastes and might return to the homestead at dusk where minimum or no shelter was provided. This system of rearing was adopted by the people in this community so as to reduce the competition between humans and goats for food. The goat owners cared little about the health status of their animals. Efforts were made as much as possible to exclude pregnant does in the study so as to minimize errors as a result of pregnancy status. The age of each animal was determined by dentition as described by Sastry and Thomas (1980).

The coat colour types were classified and genetically grouped according to the pigmentation types and colour patterns (Adalsteinsson *et al.,* 1994 and Ozoje, 1998) while the wattle types were classified into absence, unilateral and bilateral according to the findings of Odubote (1994b). Animals were also classified based on sex into male and female.

Before measurements on the physiological parameters was done, each goat was caught and adequately restrained by the owners (WAD goats are generally uncomfortable with strangers, and if handled they become more agitated and they show this with increase body temperature, respiratory rate and pulse rate which could interfere with the measurements) using a rope with minimal pressure on the neck and the rope was tied to a pole under the sun where there was no shade for at least twenty minute in order to elevate animal's body temperature. Afterwards, measurements of pulse rate, respiratory rate and rectal temperature were taken and recorded under the sun. These measurements were done twice (separate days) in each season under intense sunlight (13.00 – 16.00hrs). However, no animal was allowed to stay more than twenty minutes under the sun.

Pulse rate was observed directly by counting the beats of the pulse when felt with the index finger the pulse at the femoral arteries on the medial aspect of the hind limb for one minute and recorded as beats per minute.

Respiratory rate was recorded by counting the number of flank movements per minute from non-obstructive distance and recorded as breaths per minute.

Rectal temperature was recorded by gently inserting a properly disinfected (methylated spirit) clinical thermometer into the rectum (about 3 cm deep) for a minute and it was read of in centigrade.

Table 2: Least squares means of the interaction effect of coat colour X wattle type on the physiological parameters of West African dwarf goats in Ogbomoso

Coat colour	Wattle type	No of obs	RR	RT	PR	HSI
Black (aaB-S-)	Absent (ww)	105	70.79±0.60	40.96±0.03	83.57±0.84	1.83±0.01
	Unilateral(Ww)	18	65.00±1.34	40.77±0.07	80.33±2.27	1.78±0.03
	Bilateral (WW)	784	60.23±0.28	40.74±0.01	73.77±0.32	1.74±0.01
White (A^{wt})	Absent (ww)	30	64.40±1.05	40.77±0.04	74.97±0.97	1.74±0.02
	Unilateral(Ww)	12	59.50±0.69	40.68±0.03	71.30±1.29	1.72±0.01
	Bilateral (WW)	343	56.35±0.39	40.64±0.03	70.21±0.49	1.71±0.01
Brown (aabbS-)	Absent (ww)	39	69.00±1.11	40.73±0.08	75.21±0.49	1.75±0.02
	Unilateral(Ww)	6	61.00±1.34	40.71±3.55	73.57±1.42	1.73±0.01
	Bilateral (WW)	198	59.77±0.56	40.68±0.02	70.00±0.89	1.71±0.01
Badgerface (A^{b})	Absent (ww)	6	65.50±3.80	40.71±0.07	74.35±0.80	1.76±3.21
	Unilateral(Ww)	3	63.00±3.56	40.68±3.62	73.50±5.59	1.75±0.01
	Bilateral (WW)	117	59.72±0.73	40.66±0.04	72.00±3.45	1.74±0.01
Benzoar (A^{bz})	Absent (ww)	6	67.00±3.66	40.74±3.70	74.06±0.96	1.75±0.08
	Unilateral(Ww)	211	61.38±0.48	40.71±0.09	72.00±1.78	1.73±0.02
	Bilateral (WW)	18	60.67±1.21	40.69±0.05	71.22+0.68	1.69±0.26
Swissmarkings (A^{sm})	Absent (ww)	18	67.40±1.21	40.70±0.05	74.53±0.68	1.74±0.01
	Unilateral(Ww)	192	63.00±1.21	40.69±2.07	69.33±2.18	1.73±0.03
	Bilateral (WW)	192	59.73±0.43	40.68±0.02	65.00±0.60	1.65±0.04
Mahogany (A^{mh})	Absent (ww)	111	65.65±0.68	40.77±0.05	79.92±0.81	1.77±0.01
	Unilateral(Ww)	15	61.60±2.49	40.69 ±0.13	73.40±2.99	1.75±0.03
	Bilateral (WW)	532	60.75±0.32	40.69±0.02	71.08±0.41	1.72±0.05
Black with white markings (aaBBss)	Absent (ww)	48	62.81±1.02	40.87±0.04	76.88±1.19	1.76±0.02
	Unilateral(Ww)	3	60.00±3.82	40.78±3.91	74.00±3.80	1.73±3.45
	Bilateral (WW)	522	59.61±0.32	40.74±0.02	72.41±0.43	1.71±0.01
Brown with white markings (aabbss)	Absent (ww)	12	59.28±2.17	40.78±0.07	75.76±1.57	1.76±0.04
	Unilateral(Ww)	162	58.22±0.60	40.72±0.04	74.43±0.72	1.74±0.01
	Bilateral (WW)	21	58.43±1.23	40.69±0.03	68.00±1.35	1.69±0.02
Grey (A^{g})	Absent (ww)	5	66.40±0.97	40.79±0.15	80.44±0.24	1.78±0.04
	Bilateral (WW)	181	65.00±0.44	40.73±0.03	78.18±0.54	1.77±0.05

Note: obs - observation

Statistical Analysis

Preliminary analyses revealed that age and size of the animals had significant effects ($P < 0.05$) on the parameters understudy. Therefore, the data was corrected for the age and size effects by using them as covariates. The data was analysed for the fixed effect of coat colour, wattle type, season and sex using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS, 2003). Regarding the second order interaction effects, only coat colour X wattle and coat colour X sex significantly ($P > 0.05$) influenced the parameters under consideration therefore; they were included in the model. The significant means were separated with the use of Duncan Multiple Range test procedure of the same statistical package.

The linear model is as shown below:

Model

$Y_{ijklm} = \mu + A_i + B_j + C_k + S_l + (AB)_{ij} + (AS)_{il} + e_{ijklm}$

Y_{ijklm} = the parameter of interest

μ = the overall mean for the parameter of interest

A_i = effect of the i^{th} coat colour (i = 1 to 10)

B_j = effect of the j^{th} wattle type (j = 1,2,3)

C_k = effect of k^{th} season (k = 1, 2,3,4)

S_l = effect of l^{th} sex (l = 1, 2)

$(AB)_{ij}$ = interaction effect of the i^{th} coat colour and j^{th} wattle type

$(AS)_{il}$ = interaction effect of the i^{th} coat colour and l^{th} sex

e_{ijklm} = random error associated with each record the relationships between pulse and respiratory rates (from the study) together with their normal average values were used to derive the heat stress index as described by Oladimeji *et al*. (1996).

Results

Ten predominant coat pigmentations were observed in the goat population as shown in Table 1. Coat pigmentation had a very highly significant ($P < 0.001$) effects on rectal temperature, respiratory rate (breaths/min) and heat stress index while it affected pulse rate (beats/min) significantly ($P < 0.05$) (Table 1). The least square means (Table 1) revealed that goats with black pigmentation had the highest respiratory rate (RR) followed by mahogany (A^{mh}) goats while the lowest respiratory rate was obtained in goats with white (A^{wt}) pigmentation. Black (aaB-S-) goats had the highest mean values of rectal temperature, pulse rate and heat stress index and were significantly different ($P < 0.05$) from the values obtained in other coat pigmentations. Incidentally, White (A^{wt}) goats had the lowest rectal temperature, pulse rate and heat stress index.

Wattle type had significant effects on pulse rate (PR) ($P < 0.01$) and rectal temperature ($P < 0.05$). Goats with no wattle (ww) had the highest rectal temperature and pulse rate and were significantly different ($P < 0.05$) from those of unilateral (Ww) and bilateral wattled (WW) goats. However, the lowest values of rectal temperature and pulse rate were observed in the bilateral wattled (WW) goats (Table 1). Respiratory rate, rectal temperature, pulse rate and heat stress index were significantly affected ($P < 0.001$) by seasonal variation. The highest values of respiratory rate, rectal temperature, pulse rate and heat stress index were obtained in the late dry season while the lowest mean values were recorded during the late wet season (Table 1).

There was a significant ($P < 0.05$) sex difference only in the respiratory rate. The least square means showed that male goats had more breaths/min than their female counterpart (Table 1).

The significant interaction effect of coat colour x wattle genes (Table 2) revealed that bilateral wattled (WW) white (A^{wt}) goats had the lowest rectal temperature while the lowest value of heat stress index was obtained in the bilateral wattled (WW) swiss marked (A^{sm}) goats. Tables 3 revealed the significant interaction effect of coat colour X sex on all the physiological traits under study. Black female goats had the highest mean values in all the physiological parameters. However, male goats exhibiting bezoar (A^{bz}), brown with white markings (aabbss) and swiss marking pigmentations had the lowest respiratory rate, rectal temperature and pulse rate respectively while the males of badgerface (A^{b}) and bezoar (A^{bz}) had the lowest values of heat stress index.

Discussion

Heat is a major constraint on animal productivity in the tropical and arid areas (Silanikove, 1992). The significant effect of coat pigmentation genes on rectal temperature, respiratory rate, pulse rate and heat stress index in the present study agrees with previous findings of Acharya *et al.* (1995), Okeleji (2006) and Sanusi (2008). The variations in all the physiological parameters suggest differential absorption of solar radiation by coat pigmentation genes. The apparent high mean values of rectal temperature, respiratory rate and pulse rate observed in black goats could be an indication of higher heat load occasioned by intense solar radiation. However, for the animals to be in a thermal balance state, efforts would be made to dissipate the accumulated body heat thereby resulting in increased respiration rate, body temperature, consumption of water and a decline in feed intake (Marai *et al*., 2007). Silanikove (2000) opined that the amount of heat absorbed by an object from direct (solar) radiated heat depends not only on the temperature of the object, but on its colour and texture with dark surfaces radiating and or absorbing more heat than light coloured surfaces at the same temperature.

Table 3: Least square means of the interaction effect of coat colour X sex on physiological parameters of West African dwarf goats in Ogbomoso

Coat colour	Sex	No of obs	RR	RT	PR	HSI
Black (aaB-S-)	Male	198	63.83±0.52	40.82±0.02	80.74±0.72	1.79±0.01
	Female	700	65.67±0.25	40.96±0.01	83.44±0.33	1.83±0.00
White (A^{wt})	Male	114	60.34±0.65	40.71±0.05	73.42±0.76	1.72±0.00
	Female	271	61.06±0.44	40.77±0.03	74.36±0.56	1.74±0.01
Brown (aabbS-)	Male	54	60.51±1.01	40.69±0.03	74.39±1.37	1.74±0.02
	Female	192	61.47±0.58	40.73±0.02	75.34±0.81	1.75±0.07
Badgerface (A^{b})	Male	33	60.64±1.35	40.77±0.07	73.45±1.61	1.71±0.01
	Female	93	61.55±0.84	40.81±0.04	74.74±1.31	1.75±0.03
Benzoar (A^{bz})	Male	96	60.19±0.73	40.65±0.03	74.06±1.11	1.71±0.05
	Female	121	61.60±0.61	40.72±0.04	76.06±0.82	1.75±0.02
Swiss markings(A^{sm})	Male	48	61.81±0.68	40.77±0.03	71.38±1.23	1.72±0.04
	Female	174	61.68±0.58	40.79±0.02	74.21±1.27	1.74±0.08
Mahogany (A^{mh})	Male	249	61.19±0.45	40.72±0.03	77.69±0.59	1.75±0.06
	Female	409	62.48±0.37	40.87±0.03	79.60±0.47	1.77±0.09
Black with white markings (aaBBss)	Male	180	60.78±0.46	40.80±0.03	75.93±0.67	1.75±0.01
	Female	393	61.95±0.38	40.87±0.02	76.02±0.49	1.76±0.02
Brown with white markings (aabbss)	Male	51	61.05±0.87	40.68±0.03	74.65±1.15	1.77±0.03
	Female	123	62.02±0.81	40.77±0.04	75.46±0.81	1.76±0.04
Grey (A^{g})	Male	99	60.97±0.63	40.80±0.05	79.33±0.66	1.76±0.06
	Female	87	61.02±0.57	40.89±0.02	80.04±0.83	1.78±0.01

The highest mean value of heat stress index obtained in black goats could be as a result of the absorption of solar radiation by the dark pigmentation thereby making the animal to be thermally stressed. This result is in agreement with the reports of Seigfried and Hofmeyr (1979) that the net solar energy impinging on the skin of black cattle was higher than white marked cattle. Also, this result agrees with the findings of Sanusi (2008) in West African dwarf sheep of Nigeria in the humid zone. However, Schleger as cited by Peters *et al.* (1982) found no indication of higher heat load in the darker animals as evidenced by their body temperature. While Kumar and

Khaliefa (1971) also reported that birds with light coloured plumage suffered greater heat stress than birds with darker plumage.

The highest respiratory rate also observed in black goats could have resulted from attempts to dissipate body heat by panting in order to increase body cooling by respiratory evaporation since the major evaporative heat loss mechanism is panting in ruminant or poultry. Increased respiration (tachypnea) following heat stress has been previously reported in goats (Katamoto *et al*., 1998), cattle (Gaughan *et al*., 1999) and sheep (Gadberry *et al*., 2003). Increased respiratory rate is an immediate response of goats to environmental stress (Hales and Brown, 1974). The increase pulse rate in Black goats could have resulted from increase in blood flow from the core to the surface for more heat to be lost by sensible (loss by conduction, convention and radiation) and insensible (loss by diffusion of water form the skin) means. This is in line with the report of Alexiev *et al*. (2004) that acceleration of heart rate occurred during the peak hour of the heat load in ewes. In the present study, black goats were more thermally stressed than goats with lighter pigmentation; however, goats in the study area were predominantly black which could be a feature of adaptation. There is a possibility that black goats would absorb more solar radiation during the day which invariably could be of immense benefit during the cold nights or winter months (Dmi'el *et al*., 1980).

The significant effect of wattle gene on rectal temperature and pulse rate demonstrated the impact of wattle on heat tolerance among West Africam dwarf goats in the study area. The highest rectal temperature and pulse rate obtained in non-wattled West African dwarf goats under the intense sun could be an indication that this category of animals were thermally stressed and invariably justified the assumption (Odubote, 1994b) that wattle possession in goats could have thermoregulatory functions and this could be translated to one of the adaptive features of wattled goats in the humid environment. This could have equally accounted for the preponderance of bilateral wattled goats in the area of study.

The significant seasonal differences in the physiological parameters indicated that rectal temperature, respiratory rate, pulse rate and heat stress index amongst West African dwarf goats varied with the season. This is in agreement with the findings of Sleiman and Abi Saab (1995), Butswat *et al*. (2000), Marai *et al*. (2007) and Sanusi (2008). They all reported higher rectal temperature, respiratory rate and pulse rate during the late dry season among different breeds of sheep. Also, Oladimeji *et al*. (1996) reported appreciable differences in rectal temperature, respiratory rate and pulse rate during the hot dry season over cold dry season among Yankasa sheep. Increased physiological parameters during the late dry season is not surprising because, this period is characterized by high ambient temperature and relative humidity which could go beyond the comfort zone of the animals thereby resulting in variation in the heat energy produced and heat energy dissipated. The lowest rectal temperature, respiratory rate, pulse rate and heat stress index in the late wet season might be as a result of lower ambient temperatures and better nutrition status because of increased availability of pasture during the wet season (Butswat *et al*., 2000).

The significant effect of sex on only respiratory rate in the present findings is in line with the reports of Oladimeji *et al*. (1996), Butswat *et al*. (2000) and Sanusi (2008) among sheep of different breeds. The higher respiratory rate observed in male goats is in agreement with the report of Oladimeji *et al.* (1996). They reported that male sheep had higher values over females in all the physiological indices measured including respiratory rate. Even though, male goats had higher respiratory values than the females, this could not be unconnected with the fact that male goats exhibit fears and aggressiveness when they see strangers and this could be noticed in the way they pant. Invariably, this could have contributed to the values recorded. However, many literatures (Osinowo *et al., 1988*; Butswat *et al*. 2000; Sanusi, 2008) have indicated that healthy female goats always exhibit more breath/minute even under normal condition because of some physiological processes (oestrus, gestation etc) going on within the animal.

Bilaterally wattled white and swiss marked goats had the lowest rectal temperature and heat stress index respectively indicating that these lighter coloured goats were more tolerant to the prevailing environmental conditions of the study area. This is not surprising because the lighter coat pigmentation absorbs less solar radiation coupled with heat regulation ability of wattle. The lowest physiological parameters observed in favour of male goats with lighter pigmentation could be as a result of less absoption of solar radiation and possession of heat regulation mechanism. However, female goats were expected to have higher physiological values due to onset of oestrus and possibly gestation (Butswat *et al*., 2000).

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