THERMAL COMFORT EFFECTS ON PHYSIOLOGICAL ADAPTATIONS AND GROWTH PERFORMANCE OF WEST AFRICAN DWARF GOATS RAISED IN NIGERIA.

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Abstract

Physiological traits and growth performance of West African dwarf (WAD) goats raised under hot-humid conditions were assessed, 12 growing WAD goats managed intensively were used for the study. Temperature and relative humidity of the farm were monitored across seasons (rain and dry) using thermo-hygrometer, the study was conducted during rainy and dry seasons to compare parameters in normal and heat stress conditions. Months of December, 2012 to February, 2013 were considered as the dry season, while the months of March, 2013 to May, 2013 were considered as the rainy season. Data obtained for temperature and relative humidity were used to develop an index for measuring thermal comfort level for the goats. Data were collected on growth performance and physiological characteristics of the goats. Rectal temperature and respiration rate were significantly affected ($P<0.001$) by temperature humidity index (THI). However, pulse rate was the only physiological trait of the goats that was not significantly affected ($P>0.001$) by THI. Also, the body weight and average daily gain of the goats significantly differed with increase in the THI. Rising ambient temperature and relative humidity as expressed in form of THI are associated with poor growth performance as well as adverse effects on physiological characteristics of the animals.

Keywords: Growth performance, physiological traits, temperature humidity index, WAD goats

Introduction

Domestic animals are homeotherms that tend to maintain a constant body temperature through a balance of heat gain or loss. Homeotherms have optimal temperature zones for production within which no additional energy above maintenance is expended to warm or cool the body, West (2003). The environment surrounding an animal at any particular instant influences the amount of heat exchange between it and the environment. Under humid tropical climatic conditions, high temperature and relative humidity are major environmental factors that result in heat stress which influences the productivity and physiological development of animals. Among the climatic components that may impose influence on the animals are ambient temperature, humidity, air movement, radiation and photoperiod of which temperature is the most important, Rashwan et al., (2004).

West African dwarf (WAD) goats are found in large number in Southern parts of Nigeria, they possess the widest margin of adaptation amongst the ruminants (Oni, 2003).

They are multi-functional animals that play significant roles in the economy and nutrition of rural and urban dwellers. However, the major constraint to its productivity in tropical and sub-tropical areas is high temperature. This effect is aggravated when it is accompanied by high ambient humidity (Marai et al., 2000; Abdel-Hafez, 2002). Climate all over the world has been changing during the last decade, temperature and humidity are also changing in all areas of the world, (Suksuwan, 2001). Temperature humidity index (THI) is commonly used as an environmental factor to predict production losses of an animal exposed to hot and humid climatic conditions, (Karaman et al., 2007). The THI is an indicator of thermal climatic condition which is estimated from measurement of temperature and humidity (LPHSI, 1990; Marai et al., 2001). Thus this study sought to assess the thermal comfort effects on growth performance and physiological traits of WAD goats raised in South-western Nigeria.

Materials and Methods

The study was conducted at the Teaching and Research Farm of the Federal College of Animal Health and Production Technology, Ibadan, Nigeria (7.3907^{0}N, 3.8923^{0}E) between December, 2012 to May, 2013. Temperature and relative humidity in the goat unit were monitored across seasons (rain and dry) and across day periods (minimum temperature in the morning and maximum temperature in the afternoon) two to three days using a DeltaTrak thermo-hygrometer . As far as possible, this instrument was hung on the wall inside the pen to provide a record of the temperature and relative humidity experienced by the goats.

Based on the recordings of farm ambient temperature and relative humidity, the study was conducted during rainy and dry seasons to compare parameters in normal and heat stress conditions. Months of December, 2012 to February, 2013 were considered as the dry season, while the months of March, 2013 to May, 2013 were considered as the rainy season periods.

Data obtained for temperature and relative humidity were used to develop an index for measuring thermal comfort level for the goats. It was measured according the following equation as developed by Marai et al., (2001): $THI = db\ ^0C - \{(0.31 - 0.31\ RH)(db\ ^0C - 14.4)\}$ where db ^{0}C is the dry bulb temperature (^{0}C) and RH is the relative humidity (RH%)/100. 12 WAD goats of the same age (9 months) were used for this study. Initial weight of the animals was taken at the first day of the study, subsequently this was repeated once in a week .Feed consumption was also recorded twice a week to monitor animal growth from which average daily gain was estimated.

Physiological parameters to obtain categorical heat stress indices were taken on each animal and these include rectal temperature, respiration rate and pulse rate. These physiological parameters were measured two times a week to avoid undue stress on the animals .The rectal temperature was measured using a digital rectal thermometer inserted into the rectum and left in position, thereafter the reading was taken. Respiration rate was recorded as the number of frequency of flank movement per 20 seconds and later calculated as breaths /min (Thwaites et al.,1990). Pulse rates was also recorded as beats per seconds by placing the stethoscope on the chest of the goats to determine the rhythmic beats of the heart which was later calculated as beats /min (Thwaites et al.,1990).

Data Analysis

Data collected on growth performance (body weight and average daily gain) and physiological characteristics (rectal temperature, respiration rate and pulse rate) of the animals were statistically analysed using statistical analysis system (SAS, 2004). One-way analysis of variance (ANOVA) was performed to compare variations in growth performance and physiological characteristics of the animals as influenced by ambient temperature and relative humidity. Duncan's Multiple Range test was used to separate the means where significance was indicated. The summary statistics for climatic variations were also calculated within each season.

Results and Discussion

Average climatic data during dry and rainy seasons

The average temperature, relative humidity and THI of two seasons were shown in Table 1. The mean temperature, relative humidity and THI during dry season were 32.89 ± 0.57^{o}C, 47.25 ± 1.54% and 29.50 ± 0.99 respectively. The mean temperature, relative humidity and THI during rainy season were 24.59 ± 0.44, 54.00 ± 0.99 and 25.27 ± 0.15 respectively.

Table 1.Mean temperature, relative humidity and THI during dry and rainy seasons

Variables	Seasons	
	Dry	Rain
Temperature (^{o}C)	32.89 ± 0.57	24.59 ± 0.44
Relative humidity (%)	47.25 ± 1.54	54.00 ± 0.99
THI	29.50 ± 0.99	25.27 ± 0.15

Effects of THI on some physiological traits of WAD goats

Effects on Rectal Temperature

Table 2 shows ANOVA of the effects of THI on heat tolerance of WAD goats as measured by rectal temperature. The rectal temperature of the goats was significantly affected (P<0.001) by THI . Highest rectal temperature (39.61 ± 0.09 ^{o}C) was obtained when THI was greater than 27.50, followed by 39.52 ± 0.08 ^{o}C when THI was between 25.50 – 27.50; 38.99 ± 0.15 ^{o}C when THI ranged between 23.50 – 25.50 and the least rectal temperature (38.95 ± 0.10 ^{o}C) was obtained when THI was less than 23.50 (Table 3). Rectal temperature of the goats increases with corresponding increase in THI values. The animal's body temperature expressed in rectal temperature increases, when the body fails to maintain its heat balance. Significant variation in rectal temperature observed in the animals was as a result of their exposure to heat stress as registered by THI (Marai et al., 2001). Similar result was obtained in rams as reported by (Abdel- Hafez, 2002).

Table 2. Analysis of Variance (ANOVA) of the effects of THI on rectal temperature of WAD goats

Source of Variation	df	Sum of Squares	Mean Square	F-ratio	Sig. level
RT	3	40.74	13.59	10.22	<0.0001
Error	524	696.90	1.33		
Corr. Total.	527	737.67			

Significant (P<0.001). RT – rectal temperature

Table 3. Multiple range analysis for rectal temperature of WAD goats

Factors (THI)	n	Mean	Standard Error	Duncan grouping
<23.50	132	38.95	0.10	B
23.50 - 25.50	132	38.99	0.15	B
25.50 – 27.50	132	39.52	0.08	A
>27.50	132	39.61	0.09	A

Effect on Pulse rate

Table 4 shows the ANOVA of the effects of THI on heat tolerance of WAD goats as measured by pulse rate. The pulse rate of the goats was not significantly affected (P<0.001) by THI. However, the pulse rate increased with change in values of THI. Ismail et al., (1995) reported significant difference in pulse rate of Barki sheep between winter and summer. However, Alexiev et al. (2004) reported the pulse rate to accelerate during the peak hour of the heat load in ewes that had ad libitum access to water due to the increased cutaneous blood flow; the same authors also reported breed differences in the rate of cutaneous cooling. Thus, at very high temperatures, the pulse rate may decrease due to a decrease in the metabolic rate.

Table 4. Analysis of Variance (ANOVA) of the effects of THI on pulse rate of WAD goats

Source of variation	Df	Sum of squares	Mean square	F-ratio	Pr>F
PR	3	6036.13	2012.04	1.21	0.3053^{ns}
Error	524	871156.19	1662.51		
Corr. Total	527	877192.32			

^{ns}-not Significant (P>0.001), PR- Pulse rate.

Table 5. Multiple range analysis for pulse rate of WAD goats

Factors (THI)	n	Mean	Standard Error	Duncan grouping
<23.50	132	117.64	3.69	A
23.50 - 25.50	132	117.63	5.08	A
25.50 – 27.50	132	122.63	2.61	A
>27.50	132	126.84	3.98	A

Effects on respiration rate

The result of ANOVA of the effects of THI on heat tolerance of WAD goats as measured by respiration rate is shown in Table 6. THI had significant effects (P<0.001) on respiration rate of WAD goats. The respiration rate differ significantly when THI was greater than 27.50 and was between 25.50 - 27.50; but did not differ significantly when THI was less than 23.50 and ranged between 23.50-25.50. Highest respiration rate (70.40± 2.45 breaths/min) was obtained when THI ranged between 25.50-27.50 while the least (49.27± 2.86breaths/min) was obtained when THI was less than 23.50 (Table 7).This is an indication that respiration rate of WAD goats increases under hot ambient temperature with high relative humidity. Thus, WAD goats are stressed thermally when respiration rates increase with corresponding increase in THI since respiration rate can be an indicator of heat stress as elucidated by Habeeb et al., (1992). This result agreed with report of Marai et al., (2002b) that there was an increase in respiratory frequency in sheep with regard to the effect of humidity, when a load of high relative humidity was superimposed upon an already high ambient temperature. The increase in respiration rate of the goats was related to an increase in the perception of warmth which is the most obvious reaction.

Table 6. Analysis of Variance (ANOVA) of the effects of THI on respiration rate of WAD goats

Source of variation	df	Sum of square	Mean square	F-ratio	Sig. level
RR	3	47533.40	15844.47	15.91	<0.0001
Error	524	521711.23	995.63		
Corr. Total	527	589244.64			

**- Significant (P<0.001); RR- Respiration rate

Table 7. Multiple range analysis for respiration rate of WAD goats

Factors (THI)	n	Mean	Standard Error	Duncan grouping
<23.50	132	49.27	2.02	B
23.50 - 25.50	132	50.90	2.86	B
25.50 – 27.50	132	70.40	2.45	A
>27.50	132	64.24	3.42	A

Effects of THI on growth performance of WAD goats
Effect on Body weight of WAD goats.

Table 8 Shows the result of ANOVA of the effects of THI on body weight of the goats. Body weight of the animals was significantly affected (P<0.001) by THI. The body weight differ significantly when THI was greater than 27.5, ranged between 25.50-27.50 and when it was greater than 27.50. However, the body weight decreases with corresponding increase in THI values such that highest body weight (7.16 ± 0.17kg) was obtained in the goats when the THI was less than 23.50 and the lowest (6.07 ± 0.12kg) was obtained when the THI was greater than 27.50. The effects of interaction between elevated ambient temperature and high humidity on body weight are the products of a decline in feed intake. Similar results were reported in earlier studies; the daily feed intake and feed conversion also significantly decreased in Suffolk lambs under hot conditions in a climatic chamber (30.5 ◦C), compared to a group under shelter (19.3 ◦C), during spring (Padua et al., 1997). Marai et al., (2007) also reported that exposure of sheep to heat stress is accompanied by changes in the biological functions. It includes the depression in feed intake and utilization.

Table 8. Analysis of Variance the Effects of THI on Body Weight of WAD goats

Source of variation	df	Sum of square	Mean square	F-ratio	Sig. level
BW	3	95.94	31.98	13.63	<0.0001
Error	524	1229.44	2.35		
Corr. Total	527	1325.39			

Significant (P<0.001); BW-Body Weight.

Table 9. Multiple range analysis for body weight of WAD goats

Factors (THI)	n	Mean	Standard Error	Duncan grouping
<23.50	132	7.16	0.17	A
23.50 - 25.50	132	6.99	0.11	AB
25.50 – 27.50	132	6.72	0.19	B
>27.50	132	6.07	0.12	C

Effect on Average Daily Gain (ADG) of WAD goats.

The result of ANOVA of the effects of THI on ADG of WAD goats is shown in Table 10. ADG of the goats was significantly affected (P<0.05) by THI. ADG of the goats reduce with increase in THI such that the goats had highest ADG (4.50±0.03g) at the lowest THI (Table 11). Increase in ADG at lower THI can be attributed to higher feed intake when the temperature and relative humidity of the environment are favourable for the goats; the lower the THI of an environment, the more is the comfort level for the goats. Similar results were reported in earlier studies on sheep; Habeeb et al., (1992) reported that elevated ambient temperatures are considered as some of the environmental factors that can influence ADG. Lamb ADG values were recorded to be lower in summer than in winter in lambs, as well as in a psychrometric chamber (30–40 ◦C) compared to a shelter (20–30 ◦C), for Suffolk sheep (Marai et al., 1997a; Padua et al., 1997). Similarly, body weight, growth rate, total body solids and body solids daily gain were impaired following exposure to elevated temperatures (Marai et al., 1997a; Ismail et al., 1995). Marai et al., (2007) elucidated that the effects of elevated ambient temperature on growth performance are the product of a decrease in anabolic activity and the increase in tissue catabolism. This decrease in anabolism is essentially caused by a decrease in voluntary feed intake of essential nutrients.

Table 10. Analysis of variance of the effects of THI on average daily gain

Source of variation	df	Sum of square	Mean square	F-ratio	Sig. level
ADG	3	0.126	0.059	1.06	<0.021
Error	79	4.379	0.055		
Corr. Total	82	4.554			

Significant (P<0.05)', ADG - average daily gai

Table 11. Multiple range analysis for average daily gain of WAD goats

Factors (THI)	n	Mean	Standard Error	Duncan grouping
<23.50	132	4.50	0.03	A
23.50 - 25.50	132	3.90	0.07	B
25.50 – 27.50	132	1.90	0.25	C
>27.50	132	1.07	0.09	C

Conclusion

The effect of heat increases when heat stress is accompanied with high relative humidity. Physiological traits and growth performance of the goats varied at different thermal comfort level as determined by THI. High THI (rising ambient temperature and relative humidity) values are associated with poor growth performance as well as adverse effects on physiological characteristics of the animals. However, WAD goats tolerate higher levels of THI more than values proposed by Marai et al., (2001) as comfort level for sheep and goats. Management strategies are needed to improve goat production by minimizing thermal stress on the goats in order to attain optimal animal comfort. However, further studies are needed to elucidate the tolerance level exhibited by WAD goats.

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