Rabbit Weight Gain, Feed Efficiency, Rectal Temperature and Respiration Rate as affected by Building Thermal Environment in the Humid Tropical Climate of Southwestern Nigeria

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ABSTRACT

The effect of tropical climate of Southwestern Nigeria and building conditions on the weight gain, feed efficiency and some physiological traits of weaner rabbits have been studied. The study was carried out at the Animal Science section of the Teaching and Research Farm, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria, (Latitude 07^0 28'N and Longitude 04^0 33'E) during the dry season. The amount of opening (30% and 50%) and building orientations of 45 and 90 degrees (to the direction of prevailing wind) were the parameters considered in determining the effect of environment on the studied traits. The rabbits were fed and watered *ad libitum* throughout the period of experiment. The amount of feed consumed and weight gain by each rabbit was measured weekly while the rectal temperature and respiration rate were measured twice a week to avoid undue stress on the animals. It was observed that buildings in the tropical climate of the Southwestern Nigeria produce a relatively higher temperature-humidity index (THI) values than those of the temperate and subtropical areas and hence a more stressful production environment for rabbits. However, both building ventilation opening level and orientation were observed to have significant effects on the level of thermal comfort as measured by THI. The 90 degrees orientation building provided lower values of THI for both the 30% and 50% opening pens. Rabbits in the 90 degrees building pens for the two openings gained more weight, had higher feed efficiency, lower rectal temperatures and respired less frequently than those rabbits in the 45 degrees orientation pens. The rabbits in the 50% opening pens had better weight gain, feed efficiency, and lower rectal temperature and respiration rates than those in the 30% opening pens for both the 90^o and 45^o building orientations.

Keywords: Heat stress, physiological factors, rabbits, thermal comfort, tropical climate, weight gain, Nigeria.

1. INTRODUCTION

Under humid tropical climatic conditions, high temperature and relative humidity are major environmental factors that result in heat stress which in turn determine the productivity and physiological development of animals. In such an environment, rabbits are susceptible to heat stress since they have few functional sweat glands and difficulty in eliminating body heat (Marai *et al*., 1991, 2001, 2002; Marai and Habeeb, 1994; Finzi *et al*., 2000). The alleviation of heat load can be attained in tropical areas by the provision of suitable feeding, housing and management system that could help heat-stressed animals to express their full production capacity and physiological characteristics (Marai *et al*., 1995). Heat stress in rabbits evokes a series of drastic changes in their biological functions and leads to the impairment of both production and reproduction (Marai *et al*., 1991, 1999; Fernandez *et al*., 1994).

A micro-climate for rabbit production in a tropical area should be such as to provide an environment with a thermal comfort level that will relatively be conducive to the animals' effective productivity. Thermal comfort level of an animal environment according to LPHSI (1990) which was modified by Marai *et al*., (2000) for rabbit is a function of temperature and relative humidity of the enclosure; it is referred to as temperature-humidity index, THI. It was measured according to the following equation (Marai *et al*., 2000):

$$THI = t - \left[\left(0.31 - 0.31\left(\frac{RH}{100}\right)\right)\left(t - 14.4\right)\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

where t^0C = dry bulb temperature in degrees Celsius, and RH = RH percentage/100. THI values were classified as follows:

<27.8 = absence of heat stress;
27.8 – 28.9 = moderate heat stress;
29.0 – 30.0 = severe heat stress; and
> 30.0 = very severe heat stress.

In the establishment of a favourable micro-environment, Boulard and Baille (1995); Koerkamp, (1998) observed that ventilation affects the control of the internal thermal environment of a building. On the one hand, Boutet, (1987) stated that both configuration and orientation of a building provide a range of effects on the air movement pattern and velocity on the other hand. These affect or alter the interior and exterior environment of a structure; so also, the energy consumption by the occupants of the building is greatly impaired. Environmental modification inside an animal building is then a function of airflow pattern, which depends on the ventilation apparatus and various airflow influencing factors available.
The present study was conducted to investigate the growth performance characteristics of weight gain, feed efficiency and some physiological traits such as rectal temperature, pulse rate and respiration rate of rabbits as affected by the tropical climate of Southwestern Nigeria and building condition under which the animals were raised.

2. MATERIALS AND METHODS

The study was conducted at the of the Animal Science section of the Teaching and Research Farm, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria, (Latitude 07^0 28'N and Longitude 04^0 33'E) during the dry season: from November 2005 to April 2006. Sixteen (16) six weeks old New Zealand White rabbits were used in this experiment. Two rabbits were randomly allotted to a 1200 x 1200 x 1200 mm pen partitioned into a 600 x 1200 x 1200mm pens for each animal to prevent physical contact while providing the same environment for the animals. All the animals were kept under similar management and hygienic conditions throughout the experimental period. Two buildings each with two different inlet openings of 50 and 30% of the sides, while the outlet opening was 20% of the side were used; one was oriented perpendicular (90^O) and the other skewed (45^O) to the direction of the north-east prevailing wind, which was assumed to be constant during the period of study, Figures 1 and 2.

The rabbits were acclimatized in their individual environment for two weeks before the experiment commenced. All animals were fed with the same commercial pelleted feed and fresh water *ad libitum* throughout the period of the experiment that lasted 13 weeks (91 days). The initial weight of the animals was taken at the first day of the experiment, while

Figure1 Experimental building set-up showing both the (i) Perpendicular [90^0] and Skewed [45^0] orientations to the direction of the prevailing wind

subsequently this was repeated every week throughout the period. The measurements were taken using a Triple Beam Balance, MB – 2610 with a capacity of 2610 ± 0.10 gm. Weekly feed intakes and body weight gain of each rabbit were measured while physiological parameters of rectal temperature and respiration rate were measured two times a week to avoid stressing the animals. The buildings' Internal Environmental Temperature ($T_{i,}$); Relative Humidity (RH) and External Temperature (T_e) were measured using a Taylor 1442 Type Digital multimeter gauge two times daily to obtain the direct effect of orientation, percent opening on the rabbits' performance.

Data concerning body weight, feed efficiency and physiological characteristics (reactal temperature and respiration rate) of the animals were statistically analysed using statistical analysis system procedure (SAS, 2000). Two-way analysis of variance (ANOVA) was performed to compare variations in performance characteristics of rabbits' production and physiological behaviours with building condition of THI as influenced by building ventilation opening and orientation. Where significance was indicated Duncan's Multiple Range test was used to separate the means.

Figure 2 Picture showing a typical placement of individual rabbit to disallow physical interaction but giving the animals same pen condition.

3. RESULTS AND DISCUSSION

3.1 Effect of Building Conditions on some Rabbit Performance Characteristics

The effect of building conditions on the rabbit production characteristics was evaluated by using the interaction between temperature and relative humidity of the enclosure, (temperature-humidity index, THI) in accordance with Marai *et al*., (2002). From the analysis of data obtained for the THIs of the building conditions considered (Table 1), the 50% opening pens in both orientations provide lower THI values of 33.82 and 32.49^{o}C, respectively, for 45 and 90^o orientations, hence less stressful environments for the rabbits occupying then. On the other hand, each pen in the 90 degrees orientation pens provides a more comfortable environment for the rabbits than those of the corresponding 45 degrees orientation pens

Table 1. Mean values of THI of building, Rabbit Weight Gain, Feed Efficiency, Rectal Temperature and Respiration Rate as affected by Building Orientation and Ventilation Opening

Orientation	Opening	THI (°C)	Weight gain (g)	Feed efficiency	Rectal temperature (^{o}C)	Respiration rate (rpm*)
45^0	30%	35.40**	62.88	0.55	39.46	54.42
		(1.05)	(5.94)	(0.04)	(0.10)	(0.94)
	50%	33.82	75.82	0.67	39.50	46.79
		(0.99)	(2.00)	(0.01)	(0.07)	(0.34)
90^0	30%	34.21	74.17	0.61	38.97	47.04
		(0.80)	(4.13)	(0.02)	(0.07)	(1.02)
	50%	32.49	76.88	0.68	38.85	41.08
		(0.81)	(5.40)	(0.01)	(0.13)	(0.87)

* "rpm" means "respiration rate per minute"; ** Figures in bracket are Standard deviations

3.1.1 Effect of Factors on Weight Gain

Figure 3 shows the effect of both climate and building conditions of ventilation opening and orientation (as indicated by THI values of the buildings) on rabbit's weight gain while from Table 1 the mean values of rabbit weight gain can be observed against the corresponding THI value.

From Figure 3 it could be observed that the weight gain of rabbits reduced as the thermal comfort level (as indicated by the THI value) of building increased. The result of analysis of variance (ANOVA) for rabbit showed that the weight gain was significantly ($P<0.001$) affected by both the building opening and orientation, (Table 2). It was while considering the Duncan's Multiple Range test for rabbit weight gain (Table 3) observed that rabbits in the pens with 50% opening gained 3.71 and 2.94gm more weight than those in the 30% opening in both the 90 and 45 degrees orientation, respectively. On the other hand rabbits in pens of the 90 degrees orientation gained more weight than those in the 45 degrees orientation at all the ventilating opening levels, Table 1. The regression equation between rabbit weight gain (WG) and temperature-humidity index under the various factors considered showed a strong relationship [$WG = -2.6256(THI)^2 + 173.46(THI) - 2787.2$] for which $R^2 = 1$. This relationship showed that there is a high correlation between rabbit weight gain and thermal comfort level of the habitat.

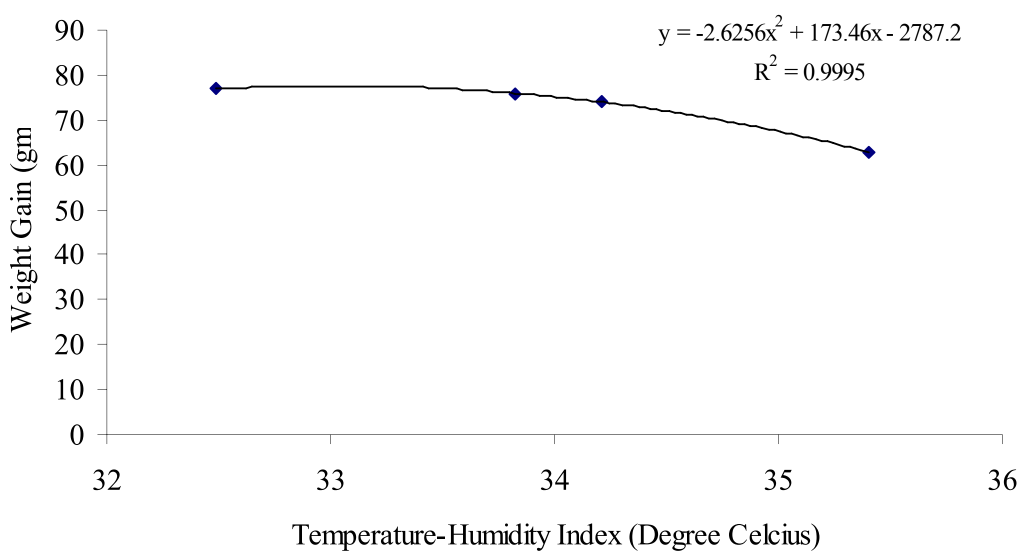

Figure 3. Daily Mean Weight Gain of Rabbit as affected by Temperature-Humidity Index (THI) underdifferent Building Environments

Table 2. Analysis of variance (ANOVA) of Weight Gain for rabbit with building orientation and ventilation opening level.

Source of variation	Sum of squares	Degree of freedom	Mean square	F - ratio	Sig. level
Model	14185.54	21	675.512	125.94	<0.0001
Treatment	4167.858	9	463.095	86.34	<0.0001
Replicates	10017.896	12	834.825	155.64	<0.001
Error	579.296	108	5.364		
Total (Corr.)	14765.050	129			

0 missing values have been excluded.

Table 3. Multiple range analysis for Weight Gain for rabbit (Alpha = 0.05)

Duncan grouping	Mean	Number of treatment	Treatment
A	75.82	13	45/50
A	76.88	13	90/50
B	74.17	13	90/30
C	62.88	13	45/30

Means with the same letter are not significantly different; 45/30- 45^0 building orientation, 30% ventilation opening level; 45/50- 45^0 building orientation, 50% ventilation opening level; 90/30- 90^0 building orientation, 30% ventilation opening level; 90/50- 90^0 building orientation, 50% ventilation opening level.

3.1.2 Effect of Factors on Feed Efficiency

Figure 4 shows the effect of both climate and building conditions of ventilation opening and orientation on feed efficiency while from Table 1 the mean values of rabbit feed efficiency can be observed against the corresponding THI value.

It was observed from the result of analysis that feed efficiency level of rabbits in the 50% opening pens like the weight gain are higher than those of rabbits in the 30% opening pens. Considering the orientations, the animals in the 90 degrees orientation pens whose THI showed a more comfortable value also have the animals feed efficiency higher significantly ($P<0.01$) than those in the 45 degrees orientation pens when comparing the corresponding pen opening. The result of analysis of variance (ANOVA) for rabbit showed that the feed efficiency was significantly ($P<0.001$) affected by both the building opening and orientation, Tables 4 and 5. From Table 1 it could be observed that rabbits in the 50% opening pens had feed efficiency values of 0.12 and 0.07 higher than the 30% opening pens, respectively for the 45 and 90^o orientations while for the orientations it could be observed that the 90^o orientation building pens had 0.06 and 0.01 higher than those of the 45^o orientation building pens, respectively, for the 30% and 50% opening. The regression between rabbit feed efficiency (FE) and temperature-humidity index under the various factors considered showed a strong relationship [$FE = -0.019(THI)^2 + 0.8961(THI) - 13.775$] for which $R^2 = 0.92$. This relationship showed that there is a high correlation between rabbit feed efficiency and thermal comfort level of the habitat.

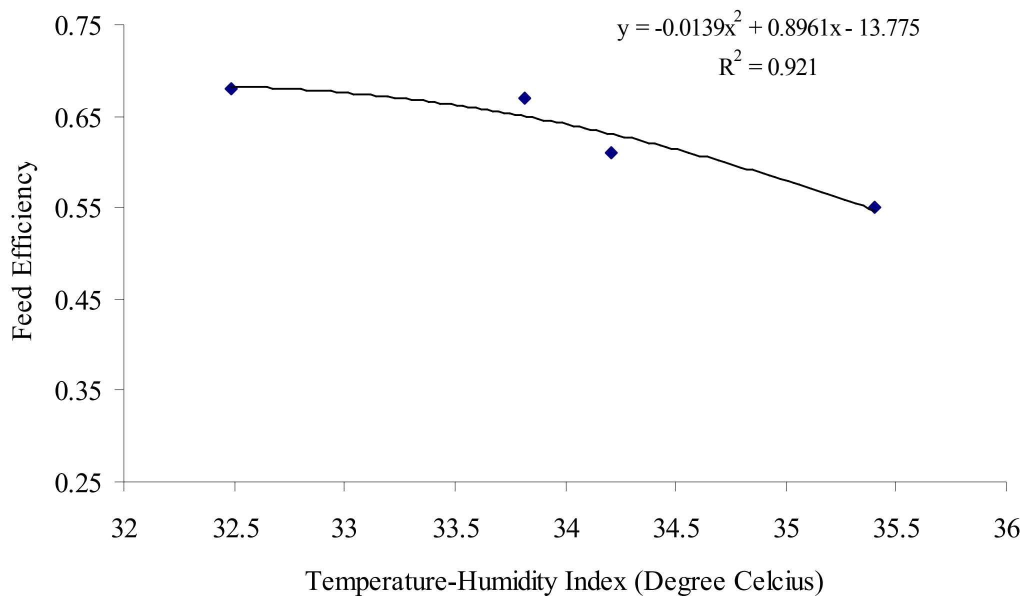

Figure 4 Daily Mean Feed Efficiency of Rabbit as affected by Temperature-Humidity Index (THI) underdifferent Building Environments

Table 4. Analysis of variance (ANOVA) of Feed Efficiency for rabbit with building orientation and ventilation opening level.

Source of variation	Sum of squares	Degree of freedom	Mean square	F - ratio	Sig. level
Model	0.314	21	0.0149	19.18	<0.0001
Treatment	0.298	9	0.0330	42.46	<0.0001
Replicates	0.016	12	0.0013	1.71	0.0739
Error	0.084	108	0.0008		
Total (Corr.)	0.398	129			

0 missing values have been excluded.

Table 5. Multiple range analysis for Feed Efficiency for rabbit (Alpha = 0.05)

Duncan grouping	Mean	Number of treatment	Treatment
A	0.674	13	45/50
A	0.682	13	90/50
B	0.612	13	90/30
C	0.550	13	45/30

Means with the same letter are not significantly different; 45/30- 45^0 building orientation, 30% ventilation opening level; 45/50- 45^0 building orientation, 50% ventilation opening level; 90/30- 90^0 building orientation, 30% ventilation opening level; 90/50- 90^0 building orientation, 50% ventilation opening level.

3.2 Effect of Factors on some Physiological Characteristics

Figures 5 and 6 show the effect of both climate and building conditions of ventilation opening and orientation on rectal temperature and respiration rate of rabbits during the experimental period. The mean values of the rectal temperature and respiration rate of rabbits against the corresponding THI are shown in Table 1.

3.2.1 Effect on Rabbits' Rectal Temperature

From Figure 5 it was observed that as the THI increased, the rectal temperature of rabbits increased at a diminishing rate. The result of analysis of variance (ANOVA) for rabbit showed that the rectal temperature was not significantly affected by both the building opening and orientation (Table 6). However, from Table 1 and the Duncan multiple range test (Table 7) there were observed such differences as 0.09 and 0.09°C between rabbits in the 30% and 50% opening pens of the 90° and 45° orientation buildings, respectively while differences of 0.52 (30% opening) and 0.26°C (50%) were observed for the rabbits when the corresponding openings of the two orientation were considered. It was observed that the rectal temperatures of rabbits in the 50% opening pens were generally lower than those of rabbits in the 30% opening pens in both orientations. Considering the orientations, the rectal temperature of animals in the 90 degrees orientation pens are lower than those in the 45 degrees orientation pens when comparing the corresponding pen opening. The regression between rabbit rectal temperature (RT) and THI under the various factors considered showed a relatively low relationship [$RT = -0.0362(THI)^2 + 2.6417(THI) - 8.6967$] for which $R^2 = 0.45$. This relationship showed that there is a low correlation between rabbit rectal temperature and thermal comfort level of the habitat.

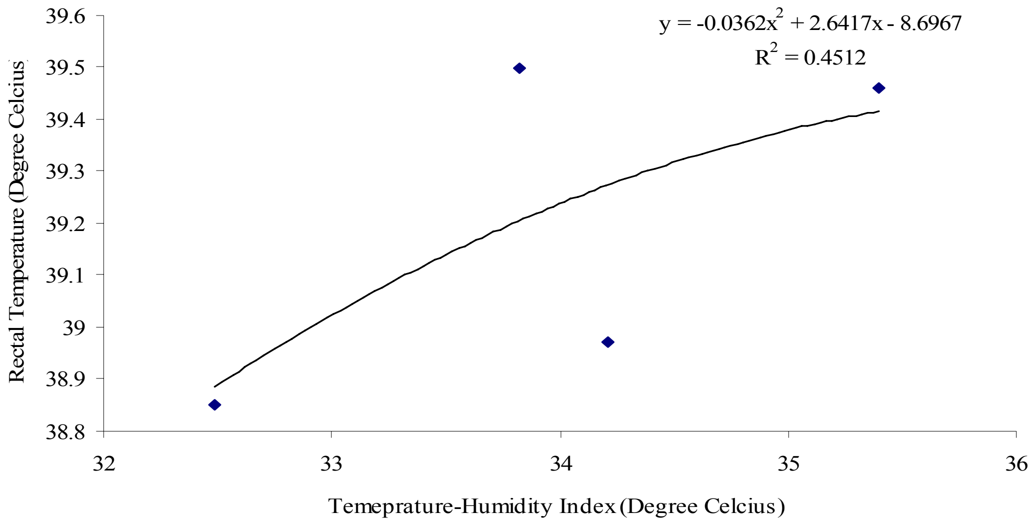

Figure 5 Daily mean Rectal Temperature of Rabbit as affected by Temperature-Humidity Index (THI) underdifferent Building Environments

Table 6. Analysis of variance (ANOVA) of Rectal Temperature for rabbit with building orientation and ventilation opening level.

Source of variation	Sum of squares	Degree of freedom	Mean square	F - ratio	Sig. level
Model	64.449	21	3.069	1.09	0.3746
Treatment	27.198	9	3.022	1.07	0.3918
Replicates	37.251	12	3.104	1.10	0.3695
Error	305.405	108	2.828		
Total (Corr.)	369.854	129			

0 missing values have been excluded.

Table 7. Multiple range analysis for Rectal Temperature for Rabbit (Alpha = 0.05)

Duncan grouping	Mean	Number of treatment	Treatment
A	39.458	13	45/30
B	38.737	13	90/30
AB	39.107	13	45/50
AB	38.848	13	90/30

Means with the same letter are not significantly different; 45/30- 45^0 building orientation, 30% ventilation opening level; 45/50- 45^0 building orientation, 50% ventilation opening level; 90/30- 90^0 building orientation, 30% ventilation opening level; 90/50- 90^0 building orientation, 50% ventilation opening level.

3.2.2 Effect on Rabbits' Respiration

Figure 6 shows the relationship between rabbit respiration rate and the THI level under the different building conditions of opening level and building orientation. It was observed that the respiration rate of rabbit increased as the thermal comfort level of the habitat reduced. The result of the analysis of variance (ANOVA) for rabbit's respiration rate (Table 8) for the 30% and 50% openings of both orientations showed significant effects ($P \leq 0.01$) in this experiment. When considering Table 1 and the Duncan Multiple Range test on the average (Table 9) for respiration, the respiration rate for all animals due to opening reduced by 6.80 rpm when the opening increased from 30% to 50%. On the other hand, for orientation it reduced by 6.55 rpm as the orientation increased from 45^0 to 90^0. The regression between rabbit respiration rate (RR) and THI under the various factors considered showed a strong relationship [$RR = 0.5451(THI)^2 - 32.495(THI) + 521.52$] for which $R^2 = 0.99$. This relationship showed that there is a high correlation between rabbit feed efficiency and thermal comfort level of the habitat. These results are expected since under stressed condition animals will breath more rapidly than when the enclosure is less stressful, which is in accordance to the findings of Gebremedhin *et al*., (1981).

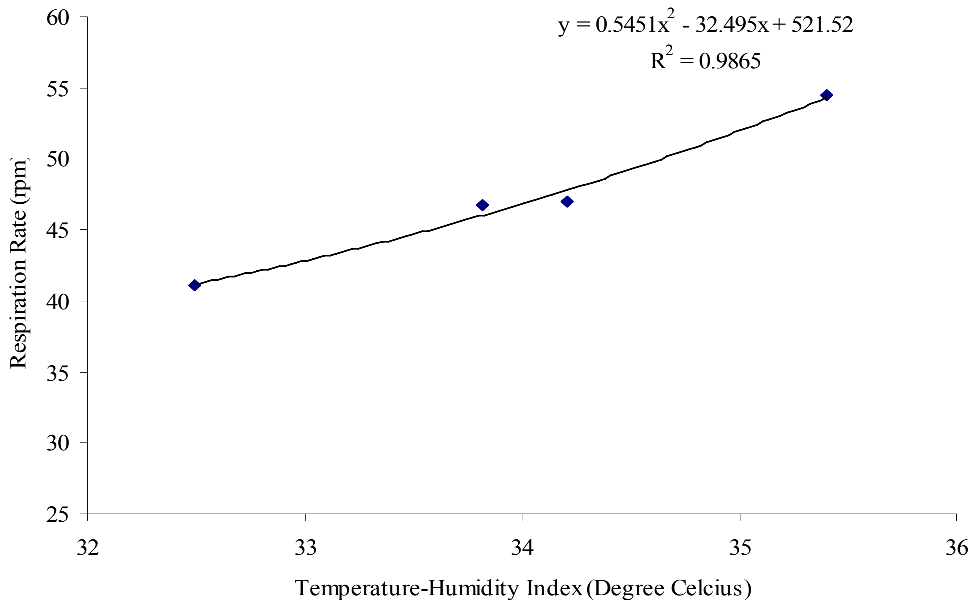

Figure 6 Daily mean Respiration Rate of Rabbit as affected by Temperature-Humidity Index (THI) underdifferent Building Environments

Table 8. Analysis of variance (ANOVA) of Respiration Rate for rabbit with building orientation and ventilation opening level.

Source of variation	Sum of squares	Degree of freedom	Mean square	F - ratio	Sig. level
Model	2624.860	21	124.993	141.99	<0.0001
Treatment	2567.202	9	285.245	324.03	<0.0001
Replicates	57.658	12	4.805	5.46	
Error	95.073	108	0.880		
Total (Corr.)	2719.933	129			

0 missing values have been excluded.

Table 9. Multiple range analysis for Respiration Rate for Rabbit (Alpha = 0.05)

Duncan grouping	Mean	Number of treatment	Treatment
A	54.423	13	45/30
B	47.038	13	90/30
C	46.788	13	45/50
E	41.077	13	90/30

Means with the same letter are not significantly different; 45/30- 45^0 building orientation, 30% ventilation opening level; 45/50- 45^0 building orientation, 50% ventilation opening level; 90/30- 90^0 building orientation, 30% ventilation opening level; 90/50- 90^0 building orientation, 50% ventilation opening level.

4. CONCLUSION

Results from this work showed that the humid tropical climate of the Southwestern Nigeria produced a higher temperature-humidity index that gave a high level of heat stress for the rabbits. However since the rabbits were acclimatized they preformed favourably well in weight gain; feed efficiency; and in their physiological characteristics of rectal temperature and respiration rate. These parameters' values were higher for rabbits in those pens with high THI values as reported by other researchers in related works. The thermal comfort level of the environment in the pens of the 90 degrees orientation building is more favourable to the animals; hence there is a better feed utilization and weight gain. The physiological reactions of the animals in terms of level of rectal temperature and respiration rate are both in accordance with the results of past works in similar studies for the heat stress and the acclimatization level reached. Under the humid tropical climate for efficient rabbit production, a large ventilation opening perpendicular to the direction of the prevailing wind that will provide a full impact of the wind and a good balance of heat and moisture within the pens will be required.

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