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Effect of the Microclimatic Temperature-Humidity Index (THI) on the Productivity Performance of Rabbit

Dennis Osarenren Asemota and Arierhire Michael Orheruata

Abstract

Temperature-humidity index (THI) is a useful and easy way to assess the risk to heat stress. This index combines effects of environmental temperature and relative humidity. This study was conducted to determine the temperature-humidity index and to assess its effects on breeding does' productivity potential at the rabbit house of the University of Benin Teaching and Research Farm. Data on microclimatic factors of ambient temperature (TEMP) and relative humidity (RH) of the rabbit house were obtained on monthly bases for 1 year. The year was divided into four seasons: late dry (January to March), early rain (April to June), late rain (July to September), and early dry (October to December). Temperature-humidity index was calculated using the ambient temperature and relative humidity values obtained on monthly and seasonal bases. The estimated values for TEMP were 34.78 ± 0.17 , 33.41 ± 0.22 , 31.17 ± 0.22 , and $33.55 \pm 0.19^\circ\text{C}$ for late dry, early rain, late rain, and early dry seasons, respectively ($p < 0.05$), and the corresponding RH values were 56.89 ± 0.17 , 57.23 ± 0.16 , 59.03 ± 0.25 , and $57.17 \pm 0.20\%$ ($p < 0.05$). The highest and lowest THI values were reported in late dry (32.03 ± 0.14) and in late rain (29.03 ± 0.19) ($p < 0.05$), in agreement with the higher and lower thermal stress in these seasons. In relation to the productivity of does, percentage conception rate ranged from 0 to 20% in late dry vs. from 52 to 56% in late rain. In conclusion, the most favorable season was late rain with the lowest THI and the highest productivity potential parameters.

Keywords: temperature-humidity index (THI), ambient temperature, relative humidity, heat stress, reproductive traits

1. Introduction

Microenvironment is the immediate physical environment surrounding an animal; that is the environment in the primary enclosure such as the cage, pen, or stall [1]. In recent times there seems to be global increase temperature in the tropics even to the consciousness of the livestock farmer. Environmental temperature and relative humidity can affect livestock husbandry by imposing thermal stress on them. Heat stress may be defined as any combination of environmental variables that give rise to conditions that are higher than those of the temperature range of the animal's thermal neutral zone [2]. Igono et al. [3] proposed that the temperature-humidity index (THI)

could be used to evaluate the level of heat stress imposed by the environment. In order to estimate the severity of heat stress, the temperature-humidity index was proposed using both ambient temperature and relative humidity [4, 5].

Heat stress has been reported to evoke a series of drastic changes in the biological functions of rabbits which lead to impairment in production and reproduction [6–8] especially if the onset of heat is sudden [9]. Lebas et al. [10] reported that the body temperature of the domestic rabbit ranges from 18 to 26°C, with small variation of $\pm 5^\circ\text{C}$. The acceptable range of relative humidity is considered to be 30–70% for most mammalian species [10, 11]. Basically, the thermoneutral zone reflects the range of ambient temperature at which internal temperature regulation is solely achieved by control of dry heat loss, which means that the metabolic rate is relatively constant without regulatory changes in heat production [12]. Fayez et al. [13] had summary that temperature of 21°C is the comfort zone in rabbits. Choudhary et al. [14] described the highly influential effect of the season on gestation period, kindling interval, and litter weight at weaning. Oguike and Okocha [15] reported a decrease in conception rate in does with increase in the re-mating intervals they were subjected to.

Information on the microenvironment of our livestock especially those reared intensively will help to redirect our management to ensure they are conducive. This study was therefore undertaken to determine the average temperature, relative humidity, and estimate temperature-humidity index in each month and the four seasons of experimental year under tropical-humid condition and to analyze the effects of the THI on productivity performance of does.

2. Material and methods

2.1 Location

The experiment was conducted at the Teaching and Research Farm of the University of Benin, Edo State, Nigeria. The University of Benin is located on latitude 6.02° N and longitude 5.06° E in the Humid Rain Forest Zone of Southern Nigeria, with an annual temperature range between 24.5 and 32.7°C, with a mean of 28.6°C. Annual rainfall ranges from 1498 to 3574 mm with a mean of 2430 mm. The relative humidity and daily sunshine are between 63.3 and 81.7% and 5.85 and 7.50 hours with means of 73.5% and 6.68 hours, respectively [16].

2.2 Housing

The orientation of the rabbit house was in east-west direction, with rabbits individually housed in a four-compartment hutches with dimensions of 60 cm high, 90 cm long, and 60 cm wide [17]. The hutches were made of wood with the floor and sides covered with wire netting. The hutches were about 90 cm above the ground.

2.3 Experimental animals, housing, and management practices

A total of 60 rabbits (50 does and 10 bucks) were used for the study. The experimental rabbits were housed individually in hutches made of wood and wire mesh, as described in the previous section. The hutches were located inside the rabbit unit. Each hutch has a feed and water trough made of weighted earthenware for concentrates and water, respectively. The rabbits were fed with commercial grower's mash of 17% CP and ME of 2800 kcal/kg and forage [18]. Feed and water were supplied *ad libitum* throughout the experimental period. They have a body weight of 1.7–1.8 kg at first

mating. Semireproductive rate system of 10–14 days interval immediately after kindling date from one complete gestation to another [10] was adopted while the project lasted.

Nesting boxes were introduced at 25 days after successful mating. After kindling, the nest box was checked. Weaning was done at 4 weeks of age. At weaning, the does were taken away to another hutch. Cage identification method was used throughout the project.

2.4 Data collection

2.4.1 Microenvironment data

The ambient daily temperature and relative humidity were taken twice daily at 9.00 am and 2.00 pm using a mercury-in-glass thermometer and a wet and dry bulb thermometer, respectively. The data were grouped into months and seasons. The seasons were late dry (January to March), early rain (April to June), late rain (July to September), and early dry (October to December).

The rabbit house daily ambient temperature was measured in degree Celsius (°C), and the standard relative humidity in percentage (%) was obtained from a wet and dry thermometer humidity table. The temperature-humidity Index was computed using the procedure of Marai et al. [19] depicted as:

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

where t is the dry bulb temperature in degrees Celsius (°C) and RH is the relative humidity in percentage/100. THI values were classified as <27.8, the 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.

2.4.2 Productivity data

The following traits were recorded:

- a. Conception rate (CR, %), estimated as $\frac{\text{number of parities}}{\text{number of mating}} \times 100$.
- b. Kindling interval (KI, days), estimated as days between two consecutive parities
- c. Successive mated doe (SMD)
- d. Group of kits that reached sexual maturity at 22 weeks (GK)

Other doe productivity indices under a small holder system were calculated using the method of Odubote et al. [20]

- e. Weaned/doe/year, estimated as $LTSW \times (365/KI)$
- f. Slaughtered/doe/year, estimated as $\text{weaned/doe/year} \times 0.85$
- g. Live weight/doe/year, estimated as $\text{slaughtered/doe/year} \times 1.85 \text{ kg}$
- h. Dressed weight/doe/year, estimated as $\text{live weight/doe/year} \times 0.56$

where LTSW = litter size at weaning; 0.85 = post-weaning survival rate; 0.56 = dressing out percentage for rabbit.

2.5 Statistical analysis

Temperature, relative humidity, and THI were analyzed with a model that included seasons as fixed effect (late dry, early rain, late rain, and early dry). Also, a polynomial line was fitted for temperature, relative humidity, and THI with months.

3. Results and discussion

The temperature (TEMP, °C), standard relative humidity (RH, %), and temperature-humidity index per month at the rabbit house of the University of Benin Teaching and Research Farm are presented in **Figures 1–3**, respectively. The prediction equation (polynomial) that gave the simplest and best fits was also indicated in the charts. The ambient temperature for the year ranged between 31 and 36°C. This study revealed that the least values in the seasons throughout the experimental were beyond the rabbit thermo-comfort zone of 20–21°C [21]. The microenvironment relative humidity was below 60%, ranging approximately from +1 to +5 up the sensitive limit of 55% for rabbit as reported by Lebas et al. [10], although the values of this study within HR range would be considered as appropriate (30–70%) for most mammalian species [11]. The months where the ambient temperature values were higher than the best-fit (polynomial) line (March, April, May, November

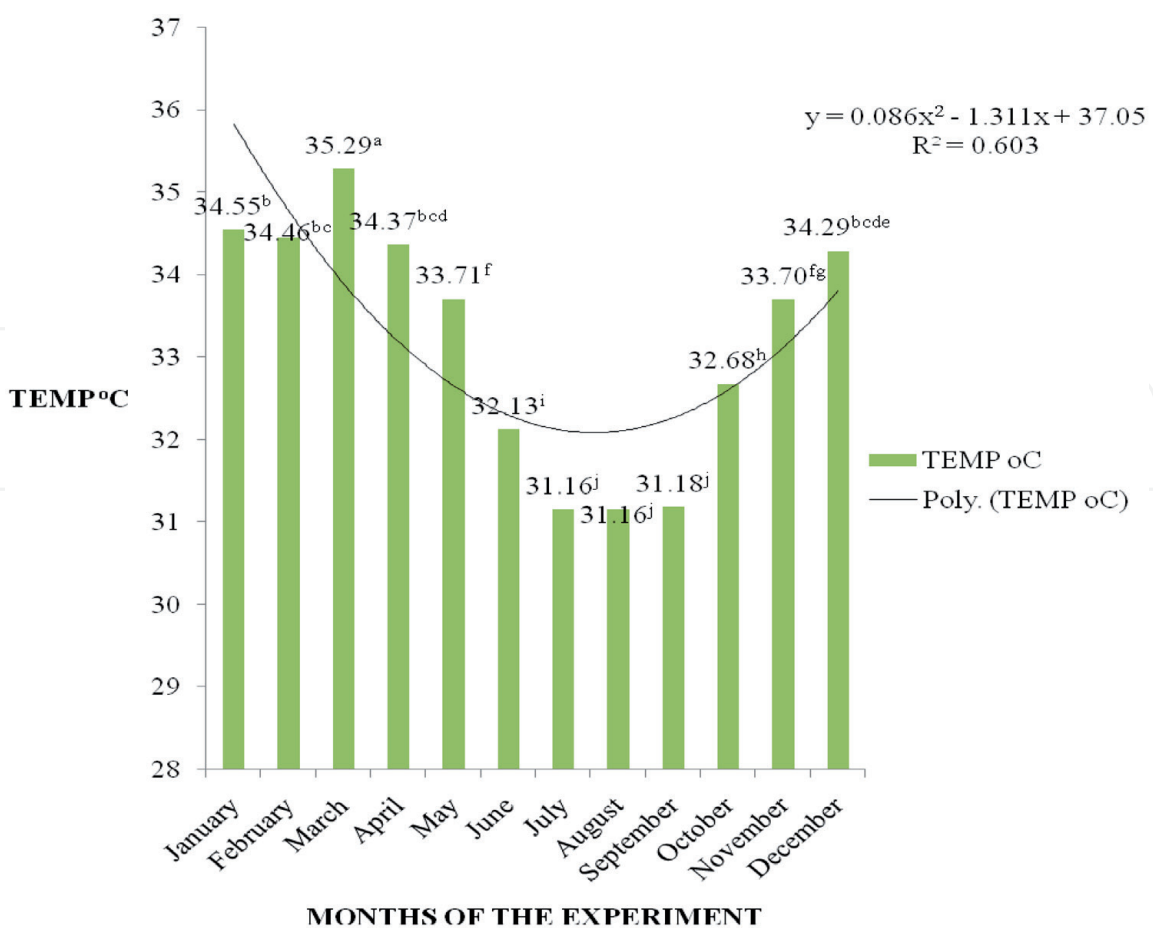


Figure 1. Temperature (TEMP, °C) during the months of the experimental periods. Mean label values are least square means, $n = 12$, $SEM = \pm 0.33$. ^{abcde}_{ghij} Means with different superscripts within the chart differ significantly.

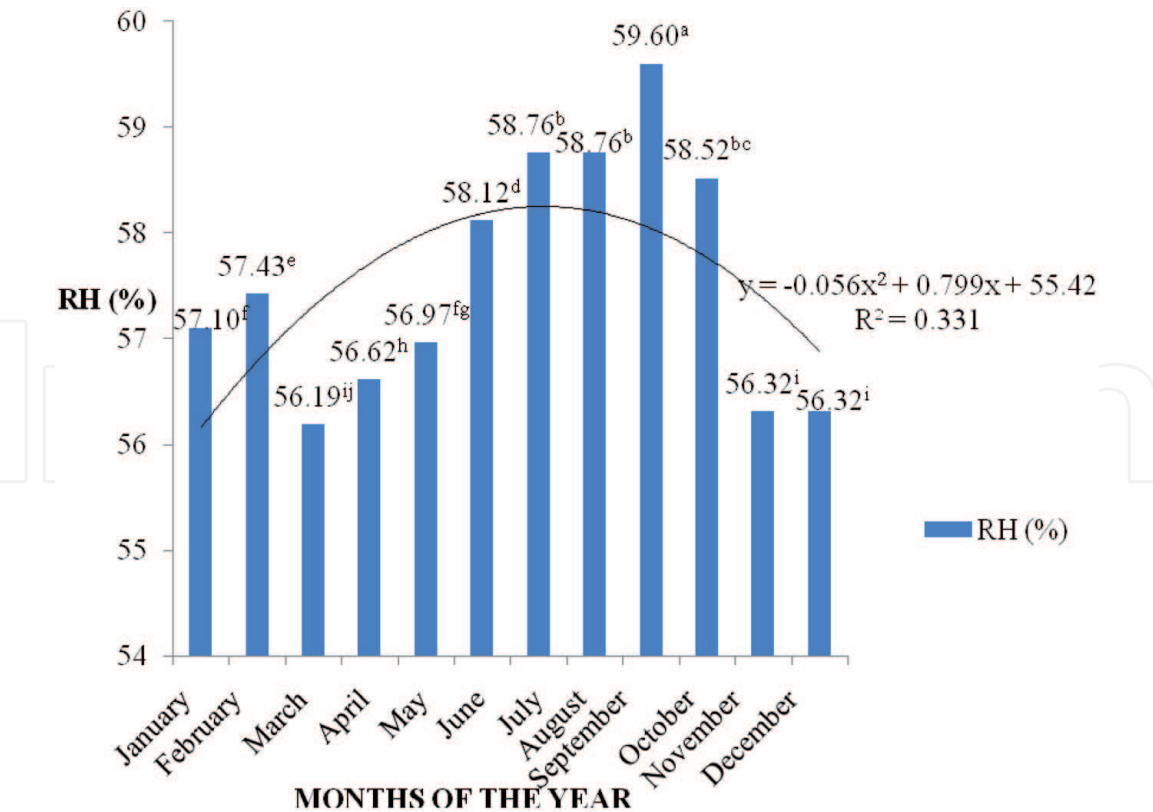


Figure 2. Relative humidity (RH, %) during the months of the experimental periods. Mean label values are least square means, $n = 12$, $SEM = \pm 0.29$. ^{abcde fghij} Means with different superscripts within the chart differ significantly.

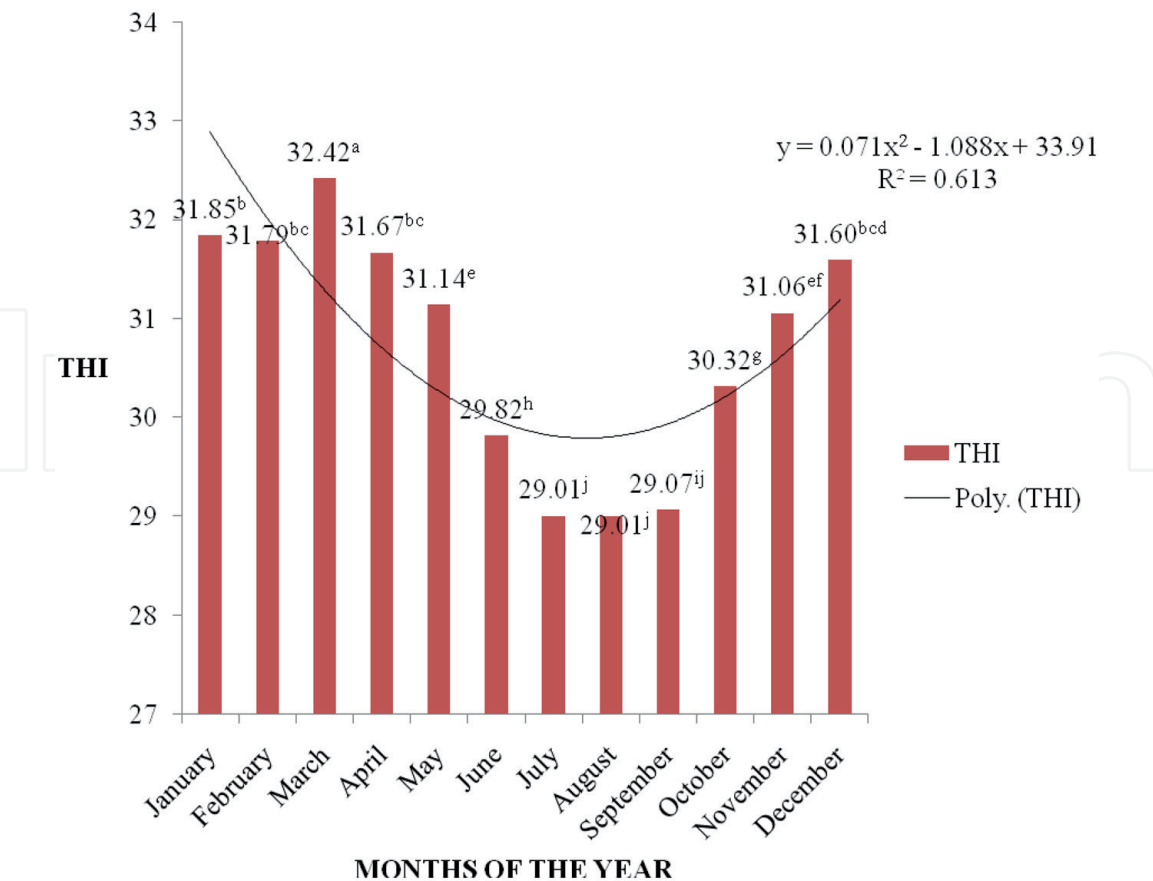


Figure 3. Temperature-humidity index (THI) during the months of the experimental periods. Mean label values are least square means, $n = 12$, $SEM = \pm 0.28$. ^{abcde fghij} Means with different superscripts within the chart differ significantly.

and December) incidentally had lower relative humidity values. Such situation can no doubt lead to heat stress. Heat stress has been reported to cause negative balance between the net amount of energy flow from an animal to its surrounding environment and the amount of heat energy produced by the animal. Therefore, such month will affect the performance of animals. Similar observation was made by Farooq et al. [22]. The animal under such condition has less water intake, which results in poor growth [23]. There are not enough literature to debunk this variability or established how true this variable as influenced by season, but this may be due to reflects changes in the average state of the micro-climatic atmosphere in relative with the air speed velocity, and photoperiodic of the rabbit house [24].

The average values for TEMP, RH, and THI per season are shown in **Table 1**. The estimated values for TEMP were 34.78 ± 0.17 , 33.41 ± 0.22 , 31.17 ± 0.22 , and $33.55 \pm 0.19^\circ\text{C}$ for late dry, early rain, late rain, and early dry season, respectively ($p < 0.05$), and the corresponding RH values were 56.89 ± 0.17 , 57.23 ± 0.16 , 59.03 ± 0.25 , and $57.17 \pm 0.20\%$ ($p < 0.05$). For THI, the reported values were 32.03 ± 0.14 in late dry, 30.88 ± 0.19 in early rain, 29.03 ± 0.19 in late rain, and 30.99 ± 0.16 in early dry ($p < 0.05$). According to Marai et al. [19], late rain season is considered as severe heat stress season (29.0–30.0), and late dry, early, and early dry seasons are considered very severe heat stress seasons (>30.0).

Table 2 shows the descriptive statistics for doe productivity performance by season THI. The late dry season and the first part of early rain season displayed the worse values for conception rate (CR), from 0 to 20 and 16%, respectively. Therefore, between 100 and 80% of the matings did not lead to a delivery. Kindling interval (KI) was very high at the first part of early rain season (98 days). The reason for this large mating failure rate and high KI could be attributed to heavier

	Late dry	Early rain	Late rain	Early dry
RH (%)	56.89 ± 0.17^d	57.23 ± 0.16^b	59.03 ± 0.25^a	57.17 ± 0.20^{bc}
TEMP (°C)	34.78 ± 0.17^a	33.41 ± 0.22^{bc}	31.17 ± 0.22^d	33.55 ± 0.19^b
THI	32.03 ± 0.14^a	30.88 ± 0.19^{bc}	29.03 ± 0.19^d	30.99 ± 0.16^b

Values are least square means (\pm SEM).
^{abcd}Means within the same row having different superscripts are significantly ($p < 0.05$) different.

Table 1.
Relative humidity (%), temperature (°C), and temperature-humidity of the experimental season.

Season	Parity	N	SMD	CR (%)	KI (days)	GK
Late dry	1st	50	10	20	—	20
	2nd	50	4	0	—	0
Early rain	3rd	50	4	16	98	1
	4th	50	17	68	49	49
Late rain	5th	50	13	52	49	29
	6th	50	14	56	49	34
Early dry	7th	50	13	52	49	26
	8th	50	17	68	49	18

SMD, successive mated doe; CR, conception rate; KI, kindling interval; GK, group of kits that reached sexual maturity at 22 weeks.

Table 2.
Productivity performance of does within the expected parities as influenced by season THI.

Parameter	Index
Weaned/doe/year	27.69
Slaughtered/doe/year	23.54
Live weight/doe/year	43.54
Dressed weight/doe/year	24.38

Table 3.
Doe productivity indices during the period of experiment.

precipitation and higher temperature (38–42°C) during this period. These findings agree with those of Isaac et al. [25], who reported that onset of rain will superimpose deleterious reductive effect on productive potential of breeding does. The remaining seasons showed similar range of values for CR (68% for the last part of early rain, from 52 to 56% for late rain, and from 52 to 68% for early dry), and the KI exhibited a value of 49 days in all them. Akpo et al. [26] reported higher values for KI in the first three parities (51–65 days) and similar values to ours from fourth parity (44 days). The highest value of 49 groups of kits that reached the maturity of 22 weeks was kindled in the last month (June) of the early rain with 29.82 THI (**Figure 3**), proceeding with most favorable 3 months of the late rain season with the severe heat stress on the rabbit body metabolic mechanism. This rabbit's grouped offspring was raised under severe heat stress and therefore could have developed favorable metabolic mechanisms to adapt to heat stress.

Table 3 shows the productivity indices under tropical conditions. Rabbit females could reach to 27.69 weaned/year, 23.57 slaughtered/year, 43.54 kg of live weight/year, and 24.38 kg of dressed weight/year. These results agree to Lebas et al. [10] who recorded at least 30 weaned/doe/year in the tropics under identical production conditions of semi-intensive reproductive rate system.

4. Conclusion

Tropical rabbit farming was subjected to severe heat stress in the late dry, early rain, and early dry seasons. The most favorable season was late rain with the lowest THI and the highest productivity potential parameters.

Author details

Dennis Osarenren Asemota* and Arierhire Michael Orheruata
Department of Animal Science, University of Benin, Benin City, Nigeria

*Address all correspondence to: aseadonis@yahoo.com

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