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Effect of temperature-humidity index (THI) on the performance of rabbits *(Oryctolagus cuniculus)* in the humid tropics

Asemota, O.D.[@]; Aduba, P.; Bello-Onaghise, G. and Orheruata, A.M.

Department of Animal Science. Faculty of Agriculture. University of Benin. Benin City. Nigeria.

ADDITIONAL KEYWORDS

Season.
Temperature-humidity index (THI) influence.
Physiological parameters.
Reproductive traits.
Rabbits.
Kits live body weight.

SUMMARY

This study was carried out to evaluate the effect of temperature-humidity index (THI) on rabbit husbandry performance in Benin City, Nigeria. The experiment was conducted using a total of 60 rabbits (50 does and 10 bucks) selected from a composite rabbit breed population. Data on ambient temperature and relative humidity were used to estimate temperature-humidity index (THI) for months and seasons. Data on rectal temperature (RT), respiratory rate (RR), pulse rate (PR), litter size at birth (LTSB), litter size at weaning (LTSW), gestation length (GLT); total number of kits born (TKB), pre-weaning mortality (PWM), percentage conception rate (PCR), post-weaning mortality (PPW), total number of kits that reached maturity (TNAM) were obtained. Inferential statistics was done by subjecting the data to analysis of variance (ANOVA) to determine the influence of temperature-humidity index (THI) on performance of rabbits. Results obtained showed that season THI had significant influence ($p<0.05$) on physiological indices with early rain having the highest values of 38.83 ± 0.04 °C rectal temperature and 115.23 ± 0.70 nmpm for respiratory rate, while late rain had the highest value of 124.50 ± 0.42bpm pulse rate. Even though, THI values showed significant difference ($p<0.05$) between the seasons, such effects were noticed only on total number of rabbits per season, conception rate and post weaning mortality. Mortality was higher in the dry season. THI have no significant effect on the Kits live body weight at 2 weeks of age, but had significant effects on body weight of rabbits at 4 to 22 weeks of age. The seasonal THI values obtained showed that the humid tropical environment is heat stressed hence efforts should be made to reduce such effect for a better performance of rabbits.

Efecto del índice temperatura-humedad (THI) sobre el rendimiento de conejos *(Oryctolagus cuniculus)* en los trópicos húmedos

PALABRAS CLAVE ADICIONALES

Estación.
Efecto del índice temperatura-humedad (THI).
Parámetros fisiológicos.
Caracteres reproductivos.
Conejos.
Peso corporal de las crías.

RESUMEN

Este estudio fue llevado a cabo para evaluar el efecto de del índice temperatura-humedad (THI) sobre la productividad de la cría de conejos en la ciudad de Benín, Nigeria. El experimento se realizó utilizando un total de 60 conejos (50 hembras y 10 machos) seleccionados de una población de conejos de raza compuesta. Se utilizaron datos de temperatura ambiental y humedad relativa para calcular el índice temperatura-humedad (THI) para cada mes y estación. Se obtuvieron datos sobre temperatura rectal (RT), tasa respiratoria (RR), número de pulsaciones (PR), tamaño de la camada al nacimiento (LTSB), tamaño de la camada al destete (LTSW), duración de la gestación (GLT), número total de gazapos nacidos (TKB), mortalidad pre destete (PWM), tasa de concepción porcentual (PCR), mortalidad pos destete (PPW) y número total de gazapos que alcanzaron la madurez (TNAM). Se realizó un análisis estadístico inferencial sometiendo a los datos al análisis de varianza (ANOVA) para determinar la influencia del índice temperatura-humedad (THI) sobre la productividad de los conejos. Los resultados obtenidos muestran que el índice temperatura-humedad estacional tiene influencia significativa ($p<0,05$) sobre los índices fisiológicos al comenzar las lluvias registrando los valores más altos (38,83 ± 0,04 ºC) la temperatura rectal y (115,23 ± 0,70) la tasa de respiraciones por minuto, mientras que con las lluvias tardías se registraron las cifras mas elevadas de pulsaciones (124,50 ± 0,42 pulsaciones por minuto). Aunque los índices de temperatura-humedad (THI) mostraron diferencias significativas entre estaciones, tales efectos fueron percibidos solamente sobre el número del total de conejos por estación, tasa de concepción y mortalidad post destete. La mortalidad fue mayor en la estación seca. El índice temperatura-humedad (THI) no tuvo efecto significativo sobre el peso corporal de los conejos a las dos semanas de edad, pero tuvo efectos significativos ($p<0,05$) sobre el peso corporal de los conejos de 4 a 22 semanas de edad. Los valores estacionales del índice temperatura-humedad (THI) obtenidos demostraron que el ambiente húmedo tropical, produce estrés térmico y, por ello, deben realizarse esfuerzos para reducir tal efecto y conseguir una mayor productividad de los conejos.

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aseadonis@yahoo.com

INTRODUCTION

High reproduction potentials in terms of young produced per female per year is influenced by climatic conditions such as temperature, and humidity which causes heat stress (Gacek, 2002). Gacek (2002) observed that high ambient temperature can impair the reproductive performance of rabbits, and 30 °C is considered as the threshold point beyond which infertility may result. In recent times there seems to be global climatic fluctuation in the tropics with already high ambient temperature. However, Nigeria is close to the equator and characterized by high ambient temperature between 27- 44 °C, which might be detrimental to the performance of animals (Iyeghe-Erakpotobor *et al*., 2012). McNitt *et al*. (1996) reported that in hot climate regions rabbit production has some problems such as heat stress, low quality food, diseases and parasites and among these, heat stress is the most important factor.

It had been suggested that the optimal temperature-humidity index for rabbit husbandry is 27.8 (Marai, 2002). It have been said that environmental temperature at low land in the humid tropics is 21.87–31.13 °C and relative humidity is 79-86% (BMKG, 2010). Ogunjimi *et al*. (2008) reported that the relationship of environmental temperature, relative humidity, energy intake and heat production in growing animal is fundamental factor that must be considered in designing and managing of an efficient livestock production. Meanwhile, Igono *et al*. (1992) proposed that temperature-humidity index (THI) could be used to evaluate the level of heat stress imposed by the environment. Temperature-humidity index (THI) is therefore the incorporation of both ambient temperature and relative humidity used to estimate the severity of heat stress imposed by the environment. This index is widely used in hot and humid areas worldwide to assess the impact of heat stress in rabbit (El-Raffa, 1996; Oseni and Lukefahr, 2014). This study therefore focuses on the comparative effect of temperature-humidity index (THI) on the performance of rabbit raised in Benin City, Nigeria.

MATERIALS AND METHODS

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 annual temperature range of between 24.5 °C and 32.7 °C, with a mean of 28.6 °C. Annual rainfall ranged from 1498 mm to 3574 mm with mean of 2430 mm. The relative humidity and daily sunshine are between 63.3 % and 81.71 % and 5.85 and 7.5 hours with means of 73.5 % and 6.68 hours respectively (Meteorological Section of the Nigeria Airports Authority-NAA, 2013, Benin City, Edo State, Nigeria).

EXPERIMENTAL ANIMALS, HOUSING AND MANAGEMENT PRACTICES

A total of 60 rabbits (50 does and 10 bucks) selected from the non- descript rabbit population in the farm were used for the study. However, only the composite rabbit does were monitored in this study. The experimental rabbits were housed in hutches made of wire mesh, frame with wood, measuring 60 cm x 90 cm x 60 cm. Located inside the rabbitry building. Each hutch has a feed and water trough made of weighted earthenware for concentrates and water respectively. The rabbits were fed commercial grower's mash of 17% CP and ME of 2800Kcal/kg and forage. The rabbitry surrounding and the hutches were cleaned daily of faeces, urine and left over feed. The drinkers and feeders were emptied, cleaned and replaced with clean water and fresh feed. Feed and water were supplied *ad libitum* throughout the experimental period. Doe were introduced to the buck in its cage for mating. Also, the kits were weaned at 4 weeks old, while this study lasted.

DATA COLLECTION

The data collected include micro-environment, physiological, reproduction and kit growth records.

Data on micro-environment of the experimental house, physiological parameters and reproductive traits of the composite does' rabbit were collected for a period of one year (January 2013 - December 2013, while the growth parameters of kits were collected from February 2013 - March 2014).

MICRO-ENVIRONMENT DATA

Daily ambient temperature and relative humidity were taken at 9.00 and 14.00 hours using a Mercury-in-glass thermometer and a wet and dry bulb thermometer respectively.

PHYSIOLOGICAL DATA

Rectal temperature (RT) was taken by using the Kris Alloy digital thermometer and a stop watch. It was done by inserting a digital thermometer into the rectum of the rabbits at approximately 4 cm for 1 minute after which reading was taken. Respiratory rate (RR) was determined by visual counting of nasal movement per 1 minute. In addition, pulse rate (PR) was determined by placing left arm between the radial and carotid artery and counting the contractions of the ventricle and

Table I. THI seasonal influence on the mean value of the physiological parameters of breeding does (Influencia estacional del índice temperatura-humedad (THI) sobre el valor medio de los parámetros fisiológicos de conejas en cría).

Season	Seasonal THI	RT (°C)	PR (bpm)	RR (nmpm)
Late dry	32.0±0.14^{a}	38.37±0.05^{c}	105.44±1.09^{c}	100.56±1.11^{c}
Early rainy	30.9±0.19^{bc}	38.83±0.04^{a}	122.70±0.61^{b}	115.23±0.70^{a}
Late rainy	29.0±0.19^{d}	38.45±0.02^{b}	124.50±0.42^{a}	111.39±0.49^{b}
Early dry	31.0±0.16^{b}	37.83±0.04^{d}	84.36±0.33^{d}	80.22±0.32^{d}

Values are least square means (± sem).
^{abcd}Means within the same column having different superscripts are significantly (p<0.05) different.
bpm: beats per minute; nmpm: nasal movements per minute.

corresponding number of times the heart beats per 1 minute.

Reproduction and growth data

Weight of doe before service, date of service, number of times served; kindling date, litter size at birth (LTSB), litter size at weaning (LTSW), pre-weaning mortality (PWMor), post-weaning mortality (PostWMor) and body weight of kits from 2 to 22 weeks of age were recorded. Thus, PostWMor are mortality that occurs at from 4 to 22 weeks age of kit rabbit in this study.

Statistical Analysis

Data obtained were subjected to statistical analysis using the GENSAT (2008) to obtain descriptive statistics. Inferential statistics were done by subjecting the data to ANOVA to determine the influence of THI on rabbit performance. Significant means were separated using Student Newman Keul's test.

Calculation of temperature relative humidity index (THI) and Determination of heat stress index (HSI):

THI was calculated using the same procedure of Marai *et al*. (2000) for rabbit. Equations of THI according to Ogunjimi *et al*. (2008) are;

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

Where:

t °C = dry bulb temperature in degrees Celsius, and RH = relative humidity percentage/100.

From the thermo comfort level of an animal environment according to LPHSI (1990), the 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;

> 30.0 = very severe heat stress.

The model adopted for the study is depicted as;

Yij = μ + Si + eij

Where:

Yij = the record of the kth rabbit in the ith month, of the jth season,

μ = the overall mean,

Si = effect of the jth season (Late dry, Early rainy, Late rainy, Early dry), and

eij = the vector of residuals, which was assumed; ~NID (0, σ_e^2).

RESULTS AND DISCUSSION

Table I shows the mean physiological parameters of the 50 breeding does as influenced by seasonal THI. The least squares means for the three physiological parameters (rectal temperature, RT; pulse rate, PR; respiratory rate, RR), showed that early rainy season with THI of 30.9 ± 0.19 had significantly different ($p<0.05$) highest values for RT (38.83 ± 0.04) and RR (115.23 ± 0.70). Late rain with the least THI (29.0 ± 0.19) had the highest value in PR (124.50 ± 0.42). However, the values obtained were in line with the standard parameters. The reason for the higher pulse rate, respiratory rate and rectal temperature in early and late rainy seasons could be attributed to the weather which is usually cold and to compensate for the heat loss to the environment, animal undergo homeostasis leading to the increased respiratory rate, pulse rate and thus higher rectal temperature observed in this experiment. Staw (2004) who estimated rabbit rectal temperature (RT) to be 38.6 °C to 40.1 °C, in agree with our results. Iyegbe-Erakpotobor *et al*. (2012) reported similar values for the effect of seasons on physiological performance of the local rabbits in the Northern Guinea Savanna. Marai *et al*. (1994) obtain RT, PR, and RR as 39.5 °C, 168 and 235 beats per minute respectively. This is at variance with the results obtained in this study. Several factors had however been found to influence some of these physiological parameters. A report from West Virgina University (2010) observed that respiratory rate was affected by the body size of the animal, environmental temperature, age, exercise and degree of fullness of the digestive tracts and all these varies from one animal to the other. The differences observed in the values obtained in this study and that of Marai *et al*. (1994) which are values for temperate purebreds could therefore be justified because the study environment was under stress as could be inferred from the THI values.

Table II. **THI seasonal influence on the reproductive traits of does** (Influencia estacional del índice temperatura-humedad (THI) sobre las características reproductivas de las conejas).

Season	Season THI	Number of does	Reproductive variables: GT (days)	TNKB	LTSB	LTSW	TNKW	CR (%)	PWMor (%)	Post-WMor (%)	TNKSM (%)
Late dry	32.00±0.14[a]	50	32.10±0.23	104[d]	5.20±0.39	4.13±0.40	66[c]	20(10/50)[c]	73.08[a]	78.78[a]	40[c]
Early rain	30.90±019[bc]	50	31.10±0.33	172[c]	4.10±0.23	3.74±0.18	142[b]	42(21/50)[b]	34.88[c]	28.18[c]	122[a]
Late rain	29.00±0.19[d]	50	29.60±0.30	236[b]	4.37±0.27	3.40±0.20	170[a]	54(27/50)[ab]	55.94[b]	51.76[b]	126[a]
Early dry	31.00±0.16[b]	50	30.30±0.40	256[a]	4.27±0.24	3.60±0.30	144[b]	60(30/50)[a]	87.5[a]	77.78[a]	88[b]

Values are least square means (± sem).
[abc]Means within the same row having different superscripts are significantly ($p<0.05$) different.
GT: Average gestation length; TNKB: Total number of kits born; LTSB: Litter size at birth; LTSW: Litter size at weaning; TNKW: Total number of kits at weaning; CR: Conception rate; PWMor: Pre-weaning mortality; PostWMor: Post-weaning mortality; TNKSM: Total number of kits at sexual maturity.

The mean values of the reproductive performance of does as influenced by seasonal THI are shown in **table II**. The mean gestation length recorded for each season fall within the normal average gestation length (28-31days) for rabbit. However, gestation length was longest in the first season and shortest in third season but was not influenced by seasonal THI. Also, this observation was recorded at variance with that of Gharib (2004), who reported that season had significant effect on gestation length of Bauscat rabbits. However, it is in agreement with the observation of Fayeye and Ayorinde (2008), who reported that there was no significant seasonal difference in rabbit gestation length. Afifi *et al*. (2000) also observed a non-significant effect of season on gestation length of New Zealand white and California rabbits.

Seasonal THI had influence on total number of kits born (TNKB), Total number of kits at weaning (TNKW), mortality and Total number of kits at sexual maturity (TNSM) with early dry season being most affected except for PWMor and TNSM **(table II)**. It can also be observed that the late dry season had the highest number of litter size at birth (5.20 ± 0.39) compare to other season. Oguike and Okocha (2008) and Fayeye and Ayorinde (2008) reported the same range of litter size (4.00-5.20) while Lukefahr and Cheeke (1990) reported a lower litter size. Bhatt *et al*. (2002) reported a non-significant effect of season of kindling on litter size and observed litter size of 5-7 for all the seasons (winter, summer and rainy) which was however higher than the values obtained in this study. It is important to note that litter size varies with breeds of rabbit and that the rabbits used in this experiment were composite rabbits. The litter size at weaning was not significantly (p<0.05) influenced by the seasonal THI. This could be due to the environment, that was already between severe heat stress (29.0-30.0) and very severe heat stress (>30.0) and therefore could not have been affected since they are exposed to the conditions. **Table II** also shows that late dry season with the highest THI (32.10±0.14) had the most deleterious effect on the TNKB (104), TNKW (66), CR (40%) and PWMor (78.78%). Abd El-Halim (2003) reported that seasonal differences in the doe's reproductive traits which he attributed to changes in weather conditions. Fayeye and Ayorinde (2008) reported a higher conception rate in dry season (78.5%) compare to rainy season (70.3%). They also observed higher number of kits in rainy season compare to dry season, as was the case in this study. The lowest number of kits born (TNKB) in the late dry season coincided with the hottest month (January, February and March) of the year. The reported THI in this research is similar to the reports of Somade (1982) who reported that in the tropical environment such as South Western Nigeria, season has deleterious effect on the reproduction of rabbits especially in the number of young born alive. Differences in litter traits in relation to THI was observed in this study and might be as a result of physiological changes that comes with season such as ovulation rate, embryo survival rate, embryonic mortality, mothering ability as well as the gross unstable changes of heat stress preventing easy heat balance of rabbits.

The mean body weights from 2 to 22 weeks of age are shown in **table III**. Rabbits in late dry season with THI value of 32.00±0.14 consistently had higher body weight at 12 weeks of age. These rabbits were those in early rain between the ages of 14 and 22 weeks. Generally, dry season with higher THI had higher body weight values. Fayeye and Ayorinde (2008) had similar findings with the results of the study. They reported that rabbits available in dry season were significantly heavier than those of wet season. Although, rabbits in the dry season had higher body weight but also a higher mortality. Similarly, Marai *et al*. (2001) reported that animals routinely kept under high ambient temperature develop metabolic mechanisms to adapt to heat stress. The environment where these rabbits were raised was under severe to very severe heat stress and

Table III. Effect of season and estimated THI on biweekly live body weight (g) of kits (Efecto estacional del índice temperatura-humedad (THI) sobre el peso vivo bisemanal de los gazapos).

			Live body weight (grams)						
Season (phase 1)	THI	Number of kits	2Wks	4Wks	6Wks	8Wks	10Wks	12Wks
Late dry	32.00±0.14^{a}	104	122.5	267.5^{a}	427.5^{a}	565.0^{a}	695.0^{a}	855.0^{a}
Early rain	30.90±019^{bc}	172	121.3	224.6^{c}	358.2^{c}	483.6^{c}	626.2^{c}	721.3^{d}
Late rain	29.00±0.19^{d}	236	126.3	222.2^{c}	355.6^{c}	489.2^{c}	619.5^{c}	734.1^{c}
Early dry	31.00±0.16^{b}	256	130.7	261.4^{ab}	390.9^{b}	539.8^{b}	684.1^{b}	831.8^{b}
Overall SEM			±10	±10	±10	±10	±10	±10
Season (phase 2)	THI	Number of kits	14Wks	16Wks	18Wks	20Wks	22Wks	
Early rain	30.90±019^{bc}	40	1015.0^{a}	1182.5^{a}	1212.5^{b}	1335.0^{a}	1397.5^{c}	
Late rain	29.00±0.19^{d}	122	859.8^{d}	1007.4^{d}	1135.4^{d}	1223.0^{d}	1352.5^{d}	
Early dry	31.00±0.16^{b}	126	882.5^{c}	1031.4^{c}	1154.0^{c}	1261.0^{c}	1409.2^{b}	
Late dry	32.00±0.14^{a}	88	977.3^{b}	1106.6^{b}	1222.7^{a}	1323.9^{b}	1452.3^{a}	
Overall SEM			±10	±10	±10	±10	±10	

Values are least square means (± sem).
[abcd] Means within the same column having different superscripts differ significantly (p<0.05).

therefore could have developed metabolic mechanisms to adapt to heat stress hence the productive traits were not significantly influenced by the THI. In addition, in the course of the study, the rabbits were observed to be stretching to expose higher surface area of their body to increase heat loss.

CONCLUSION

The results from this study had demonstrated that the season with the highest THI was the late dry, which has a marginal impulse on the physiological performance of the breeding does', due to optimal relative humidity and with highest temperature as component of this predicable season THI of the rabbitry unit. Reproductive traits of the does' at the different observable successive seasons in this study shown inconsistent trends, but was affected most during late dry season. The study also showed that the lowest pre-weaning mortality (PWMor) rate occurs at the early rain season. Live body weight of the kits kindled or available at the late dry season shows more growth by reaching sexual maturity faster with the upsurge live body weight observed, while study lasted. Therefore, the THI observed showed that animals kept under high ambient temperature may develop metabolic mechanisms to adapt to heat stress to a tolerable level.

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