ISSN 0189-0514
*J. Anim. Prod. Res. (2019) 31(1):88-100*

National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journals.napri.gov.ng

# THERMOREGULATORY RESPONSE OF HYLA RABBIT DOE GROUPS TO SUPPLEMENTATION WITH ASCORBIC ACID UNDER SUB-HUMID TROPICAL ENVIRONMENT

**[1]Ibiwoye, K. O., [2]Iyeghe-Erakpotobor, G. T., [3]Obadire, F. O. and [1]Omage, J. J.**
*[1]Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria*
*[2]National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zara, Nigeria*
*[3]Department of Animal Science, Faculty of Agriculture, Federal University, Dutse, Nigeria.*

## ABSTRACT

A study was carried out to evaluate the effect of feed grade ascorbic acid dietary supplementation on thermoregulatory response of Hyla rabbit does under sub-humid tropical environment. A total of 81, matured rabbit of eighteen to thirty-six old does of average weight 2.75 kg comprising 35 multiparous pure New Zealand White (Parents), 31 primiparous pure New Zealand White (pure F1) and 15 cross Californian (cross F1) were used for the study. Heart rate, rectal temperature and respiratory rate were determined weekly for 14 weeks with a 2-week feeding adjustment period. Temperature-humidity index (THI) was calculated using temperature and humidity records taken inside and outside the Rabbitry in the morning and afternoon. Results indicated that ambient temperature ranged from 22.01 to 39.48°C while THI ranged from 20.87 to 33.86 from January to April. Heart and respiratory rates significantly ($P<0.05$) increased while rectal temperature significantly ($P<0.05$) decreased as the levels of ascorbic acid supplementation increased in the diet. Heart rate increased by 10.12 bpm in does fed 400 mg AA/kg diet while rectal temperature decreased by 0.80°C in does fed 300 and by 0.81°C in does 400 mg AA/kg diets compared to rabbit does fed the control diet. Doe group had significant ($P<0.05$) effect on heart rate, rectal temperature and respiratory rate while month of the year had significant ($P<0.05$) effect on heart and respiratory rates of the does. Interaction between ascorbic acid levels and doe group had significant ($P<0.05$) effect on heart rate and rectal temperature of the does. However, only respiratory rate was significantly ($P<0.05$) affected by interaction between ascorbic acid and month of the year. It could be concluded that the rabbit does were exposed to a high ambient temperature of 39.48°C and a THI of 33.86 which led to their higher respiratory but lower heart rates. Ascorbic acid supplementation might start at 200 mg/kg level in order to reduce the adverse effect of high ambient temperature on rabbits in the tropics.

**Keywords:** Ascorbic acid, Thermoregulatory response, Ambient temperature, Rabbits.

## INTRODUCTION

The low animal protein intake of the populace in Nigeria has aroused an increasing interest in the production of micro-livestock such as rabbit (FAO, 1993). This is mainly because rabbits utilize less competitive feeds, produce high quality and nutritious meat and useful by-products. They have rapid growth and small body size, short generation interval and potentials for genetic improvement (Herbert, 2011). However, adverse effects of heat stress caused by high ambient temperature accompanied by oxidative stress caused by pro-oxidants or reactive oxygen species (ROS) Heise *et al.* (2006) results in productive inefficiency Ghaly (1988) and poor reproductive performance Abo El-Ezz *et al.* (1985) of rabbits in the tropics. It also exerts adverse effects on animal health, growth,

production and overall performance (Smith *et al.,* 1995; Ayo *et al.,* 2011). High ambient temperature and relative humidity increase heat stress and are responsible for increase in rectal/body temperature observed in animals (Altan *et al.,* 2003; Marai *et al.,* 2007). High ambient temperature according to Yassein *et al.* (2008) is one of the major constraints in rabbit production in tropical and subtropical climates. Nigeria being close to the equator is characterized by high ambient temperatures between 27$^{o}$C and 44$^{o}$C, which can be detrimental to the performance of exotic animals newly introduced due to heat stress (Iyeghe-Erakpotobor *et al.,* 2013). Deleterious effects of elevated temperature are increased production of reactive oxygen species Loven (1988). Although, cells generate small amounts of free radicals during their normal metabolism; their low levels are essential in many biochemical processes, but their accumulation may damage biological macromolecules such as carbohydrates, lipids and proteins (Mates *et al.,* 1999). The aim of this study was to evaluate the relationship between heat stress, antioxidant vitamin (ascorbic acid) and the performance of Hyla doe rabbit groups.

## MATERIALS AND METHODS

### Location of Experimental Site

The study was conducted in the Rabbit Unit of the National Animal Production Research Institute (NAPRI), Shika, Zaria. Shika is geographically situated on latitude 11° 12′42′′N of the equator and longitude 7°33'14" E with an altitude of 691m above sea level (Ovimaps, 2012). The area falls within the Northern Guinea Savannah zone of Nigeria having an average annual rainfall of 1100 mm, which starts from April to September. Over the experimental period from January to April, the minimum and maximum ambient temperature and relative humidity in the morning ranged from 17.0 to 36.1°C and 15 to 41% while in the afternoon, the minimum and maximum ambient temperature and relative humidity ranged from 23.4 to 46.6°C and 15 to 39 respectively.

### Measurement of Environmental Factors

The environmental factors determined were inside and outside temperature and relative humidity of the rabbit house. This was done twice daily, morning and afternoon (8.00a.m and 2.00p.m) and was determined with the aid of a digital temperature-humidity clock. These factors were monitored weekly in January and February to estimate environmental conditions during mating and gestation periods of the rabbits.

Temperature-Humidity Index (THI) was estimated using the equation below as modified by Marai *et al.* (2001):

$$THI=t–[(0.31–0.31(RH/100))\ (t–14.4)]$$

Where t=dry bulb temperature in degree Celsius, and RH=Relative Humidity in percentage.

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.

### Experimental Animals and Management

A total of 81 rabbit does comprising of 35 multiparous pure New Zealand White (NZW: Parents), 31 primiparous purebred New Zealand White (NZW: pure F1) and 15 primiparous crossbred (Californian X NZW: cross F1) does with average initial weight of 4.0kg and age ranging from 5-6 years old was randomly picked from the flock of rabbits in the Rabbit Breeding Project, NAPRI. The animals were weighed and randomly allotted to four dietary groups in a completely randomized design. Each group constituted a treatment and each rabbit within a group was a replicate. The levels were 0, 200, 300 and 400 mg/kg ascorbic acid for treatments 1, 2, 3 and 4 with 11, 23, 23 and 24 does respectively in each treatment. The parameters studied were productive,

physiological, haematological and biochemical parameters and reproductive performance.

**Measurement of physiological parameters**

Physiological parameters measured weekly include rectal temperature, respiratory rate and heart rate in a 4x3x4 factorial arrangement. Effects of ascorbic acid levels (0, 200, 300 and 400) mg/kg, doe group (Parents, pure F1 and cross F1) and month of the year (January, February, March and April) as well as their interactions were considered. Six does were used per treatment.

Rectal temperature (RT) was measured using a digital clinical thermometer (Hartmann-United Kingdom) with the tip of the thermometer inserted into the rectum in close contact with the rectal mucosa at a depth of approximately 4cm. It was measured with an accuracy of ±0.1°C.

Respiratory rate (RR) was measured by visual counting of the flank movements of the rabbit for one minute using a stopwatch with the animal sitting quietly and breathing normally.

Heart rate (HR) was obtained by monitoring the number of contractions of the heart in one minute using a stethoscope.

**Statistical Analysis**

Data for environmental factors and thermoregulatory parameters were subjected to analysis of variance using General Linear Method (GLM) while the significant differences between means were separated using pairwise-difference method (P-diff: SAS, 2002).

## RESULTS

The result of the monthly temperature and relative humidity during experimental period inside and outside the Rabbitry is presented in Table 1. In the morning, the temperature and relative humidity inside and outside the Rabbitry significantly ($P<0.0001$) increased from January to April. In the morning, the temperature was 2ºC higher outside than inside the Rabbitry in March and April. However, in the afternoon, the temperature was 2ºC higher outside than inside the Rabbitry in February and March while in April, temperature was 5ºC higher outside than inside the Rabbitry in April.

The monthly THI inside and outside the Rabbitry during the experimental period is presented in Figure 1. The morning THI was consistently higher in the afternoon than in the morning from January to April.

The effect of ascorbic acid (AA) levels on thermoregulatory response of rabbit does is presented in Table 2. The results indicated that heart and respiratory rates significantly ($P<0.05$) increased while rectal temperature significantly ($P<0.05$) decreased as the levels of ascorbic acid increased in the diet. Does fed 400 mg AA diet had significantly higher heart rate than their counterparts fed 0 mg AA diet; does fed 200 and 300 mg AA diet had similar ($P>0.05$) heart rate as does fed 0 and 400 mg AA diets. However, does fed 0 and 200 mg AA diets had similar but significantly ($P<0.05$) higher rectal temperature than does fed 300 and 400 mg AA diets which were similar. Does fed 300 and 400 mg AA diets had similar but significantly ($P<0.05$) higher respiratory rate than does fed 0 mg AA diet; does fed 200 mg AA diet had similar respiratory rates as does fed other levels of ascorbic acid.

The effect of doe group and month of year on thermoregulatory response of rabbit does is presented in Table 3. The results indicated that doe group had significant ($P<0.05$) effect on heart rate, rectal temperature and respiratory rate while month of the year had significant ($P<0.05$) effect on heart and respiratory rates. Cross F1 does had significantly ($P<0.05$) higher heart rate than parent and pure F1 does which were similar ($P>0.05$). Parent does had significantly ($P<0.05$) higher rectal temperature than cross F1 does; being similar as pure F1 does. Parent and pure F1 does had similar but significantly ($P<0.05$) respiratory rate than cross F1 does. However, all the does had

significantly (P<0.05) higher heart rates in April than in January, February and March; being similar (P>0.05) but lower in January and February than in March. In March and April, the does had similar but significantly (P<0.05) higher respiratory rate than in January and February.

The interaction between ascorbic acid levels and doe group on thermoregulatory response of rabbit does is presented in Table 4. The results indicated that there was significant (P<0.05) interaction on heart rate and rectal temperature monitored for the does. Cross F1 does had significantly (P<0.05) higher heart rate than parent does while parent does had significantly (P<0.05) higher rectal temperature than cross F1 does.

**Table 1: Monthly temperature and relative humidity during study period inside and outside the Rabbitry**

| | **Temperature (ºC)** | | | |
|---|---|---|---|---|
| **Month** | **(Morning inside)** | **(Morning outside)** | **(Afternoon inside)** | **(Afternoon outside)** |
| January | 22.01±0.55$^{c}$ | 22.69±0.63$^{c}$ | 27.96±0.56$^{c}$ | 28.23±0.73$^{d}$ |
| February | 23.27±0.40$^{b}$ | 24.02±0.55$^{b}$ | 29.55±0.49$^{b}$ | 31.21±0.64$^{c}$ |
| March | 28.20±0.37$^{a}$ | 29.75±0.52$^{a}$ | 34.28±0.46a | 36.77±0.60$^{b}$ |
| April | 27.58±0.92$^{a}$ | 29.64±1.28$^{a}$ | 34.40±1.14$^{a}$ | 39.48±1.49$^{a}$ |
| P value | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | **Relative humidity (%)** | | | |
| **Month** | **(Morning inside)** | **(Morning outside)** | **(Afternoon inside)** | **(Afternoon outside)** |
| January | 28.86±1.09$^{b}$ | 28.81±1.26$^{b}$ | 28.67±1.07$^{b}$ | 27.48±1.09$^{b}$ |
| February | 19.63±0.96$^{d}$ | 19.33±1.11$^{d}$ | 21.19±0.94$^{c}$ | 20.74±0.96$^{d}$ |
| March | 23.29±0.89$^{c}$ | 26.27±1.04$^{c}$ | 22.78±0.88$^{c}$ | 22.71±0.90$^{c}$ |
| April | 37.80±2.22$^{a}$ | 39.00±2.58$^{a}$ | 32.90±2.19$^{a}$ | 31.00±2.24$^{a}$ |
| P value | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

$^{abcde}$: Means with different superscripts in the same column are significantly (P<0.05) different

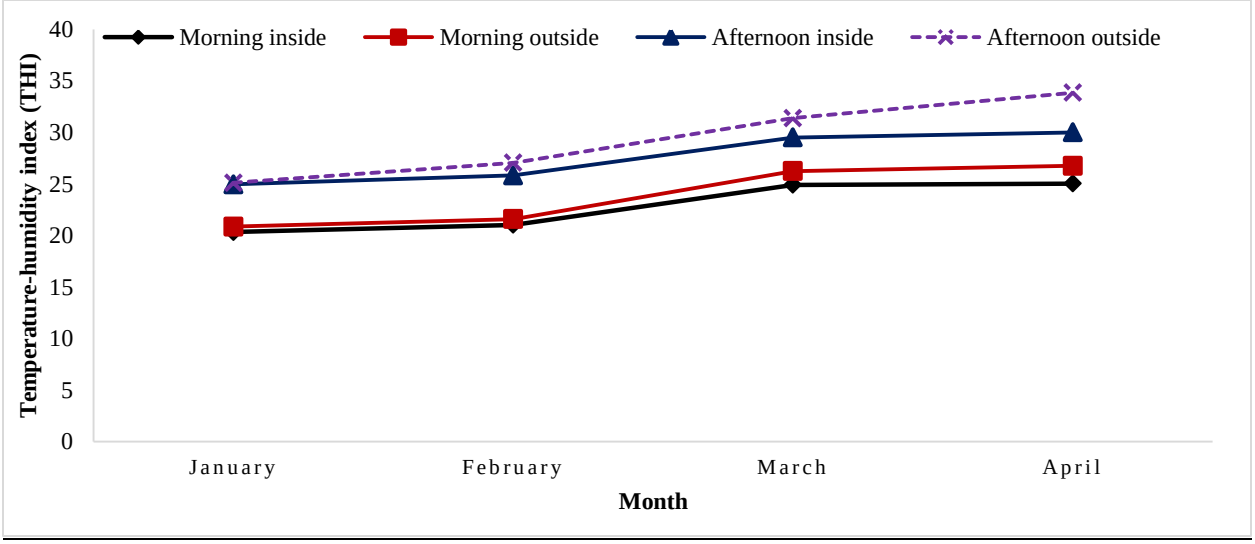



**Figure 1:** Monthly temperature-humidity index (THI) inside and outside the Rabbitry in the morning and afternoon during the study period

The interaction between ascorbic acid (AA) levels and month of the year on heart rate, rectal temperature and respiratory rate of rabbit does is presented in Figures 2. The results indicated that heart rate, rectal temperature and respiratory rate increased from January to April; only respiratory rate was significant ($P<0.05$) affected by the interaction. Heart rate was slightly higher in does fed 400 mg AA diet in March and April (Figure 2i). Rectal temperature was slightly higher in does fed 0 mg AA diet in February and March and in does fed 200 mg AA diets in February (Figure 4.8ii). Respiratory rate was significantly ($P<0.05$) higher in does fed 200 and 400 mg AA diets in January and March and in does fed 300 and 400 mg AA diets in April (Figure 4.8iii).

**Table 2: Effect of ascorbic acid level on thermoregulatory response of rabbit does**

| | Ascorbic acid level (mg/kg feed) | | | | |
|---|---|---|---|---|---|
| **Parameters** | **0** | **200** | **300** | **400** | **P value** |
| Heart Rate (bpm) | $126.25\pm4.37^{b}$ | $129.72\pm3.57^{ab}$ | $130.44\pm4.37^{ab}$ | $136.37\pm4.13^{a}$ | 0.024 |
| Rectal Temperature (°C) | $38.10\pm0.33^{a}$ | $37.96\pm0.26^{a}$ | $37.30\pm0.33^{b}$ | $37.29\pm0.31^{b}$ | 0.016 |
| Respiratory Rate (cpm) | $110.58\pm3.34^{b}$ | $112.97\pm2.72^{ab}$ | $117.83\pm3.34^{a}$ | $117.92\pm3.15^{a}$ | 0.001 |

$^{ab}$: Means with different superscripts in the same row are significantly ($P<0.05$) different, bpm=beats per minute, cpm=counts per minute

**Table 3: Effect of doe group and month of the year on thermoregulatory response of rabbit does**

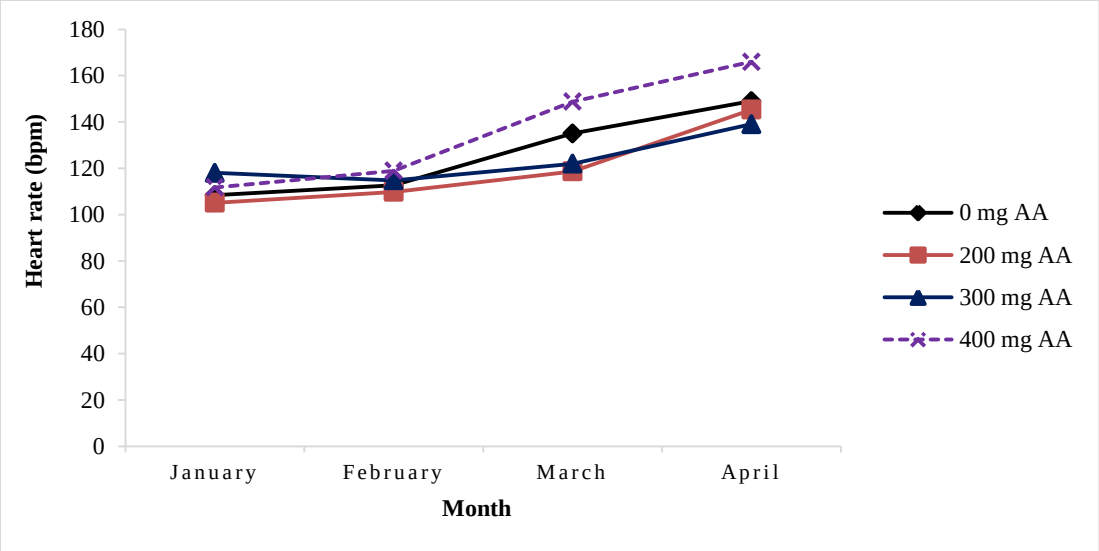
| Parameters | Group | | | P value | Month | | | | P value |
|---|---|---|---|---|---|---|---|---|---|
| | Parent | F1(pure) | F1(cross) | | January | February | March | April | |
| Heart Rate (bpm) | 120.83±2.72$^{b}$ | 123.56±4.57$^{b}$ | 135.04±4.62$^{a}$ | <0.0001 | 110.79±3.19$^{c}$ | 114.03±3.19$^{c}$ | 131.12±3.91$^{b}$ | 149.83±5.68$^{a}$ | <0.0001 |
| RT (°C) | 38.00±0.17$^{a}$ | 37.93±0.29$^{ab}$ | 37.39±0.36$^{b}$ | 0.042 | 37.48±0.24 | 37.84±0.24 | 38.08±0.39 | 38.01±0.42 | 0.444 |
| RR (cpm) | 116.02±2.58$^{a}$ | 115.67±4.34$^{a}$ | 85.67±5.31$^{b}$ | <0.0001 | 102.12±2.44$^{b}$ | 106.43±2.44$^{b}$ | 112.37±2.98$^{a}$ | 116.58±4.34$^{a}$ | <0.0001 |

$^{abc}$: Means with different superscripts in the same row are significantly (P<0.05) different, RT=Rectal temperature, RR=Respiratory rate, bpm=beat per minute, cpm=counts per minute, F1=First filial generation (pure and cross)

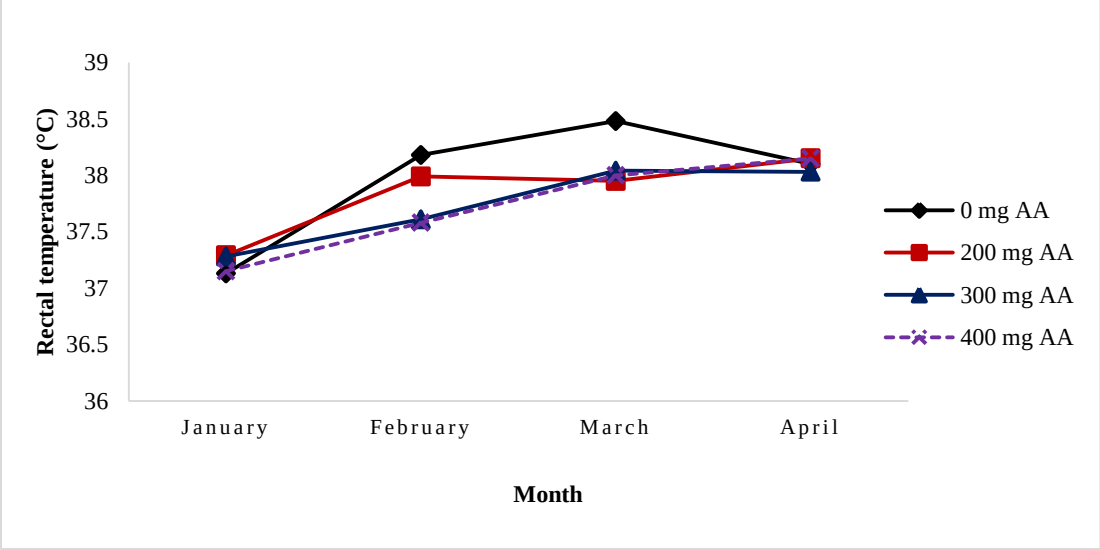
**Table 4: Interaction between ascorbic acid level and doe group on thermoregulatory response of rabbit does**

| Group | Ascorbic acid (mg/kg feed) | | | | | | | | | | | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | 200 | | | 300 | | | 400 | | | |
| | Parent | F1 (Pure) | Parent | F1 (Pure) | F1 (Cross) | Parent | F1 (Pure) | F1 (Cross) | Parent | F1 (Pure) | F1 (Cross) | |
| HR (bpm) | 120.59 ±9.28$^{b}$ | 126.11 ±9.14$^{ab}$ | 121.78 ±9.57$^{ab}$ | 124.89 ±9.14$^{ab}$ | 121.89 ±9.14$^{ab}$ | 121.17 ±9.47$^{ab}$ | 121.78 ±9.14$^{ab}$ | 129.45 ±9.14$^{ab}$ | 137.11 ±9.14$^{ab}$ | 138.44 ±9.14$^{ab}$ | 139.78 ±9.28$^{a}$ | <0.0001 |
| RT (°C) | 38.48 ±0.58$^{a}$ | 37.76 ±0.34$^{ab}$ | 37.61 ±0.29$^{ab}$ | 38.23 ±0.58$^{ab}$ | 37.92 ±0.58$^{ab}$ | 37.61 ±0.41$^{ab}$ | 37.79 ±0.58$^{ab}$ | 37.60 ±0.58$^{ab}$ | 37.81 ±0.34$^{ab}$ | 37.45 ±0.58$^{ab}$ | 37.21 ±0.58$^{b}$ | <0.0001 |
| RR (cpm) | 108.15 ±5.01 | 112.89 ±8.67 | 115.94 ±4.34 | 116.50 ±8.67 | 105.78 ±8.67 | 116.22 ±6.13 | 108.44 ±8.67 | 102.22 ±8.67 | 113.78 ±5.01 | 115.33 ±8.67 | 110.67 ±8.67 | 0.279 |

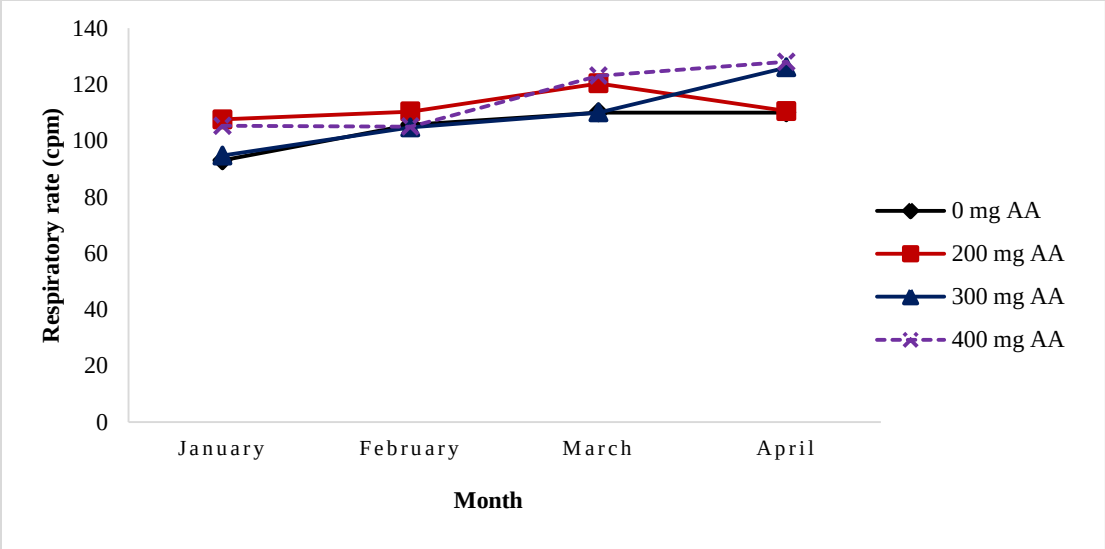
$^{abc}$: Means with different superscripts in the same row are significantly (P<0.05) different, RT=Rectal temperature, RR=Respiratory rate, bpm=beat per minute, cpm=counts per minute, F1=First filial generation (pure and cross)




i) Heart rate




ii) Rectal temperature




iii) Respiratory rate

**Figure 2:** Interaction between ascorbic acid level and month of the year on heart rate (SEM=0.60, P=0.52), rectal temperature (SEM=0.20, P=0.87) and respiratory rate (SEM=0.58, P=0.027) of rabbit does, SEM=Standard error of mean

## DISCUSSION

In this study, the ambient temperature both inside and outside the rabbit house during the study period was above thermo-comfort zone of 18-21$^{o}$C established for rabbits (Marai *et al.*, 2001). This is a clear indication that the rabbits were subjected to heat stress. The values agreed with Marai *et al.* (2002) who reported that rabbits in the tropics are raised at temperatures between 22 to 44$^{o}$C. In addition, Majekodunmi *et al.* (2013) recorded relative humidity of 58.48 to 89.24% and ambient temperature of 30.90 to 36.73°C well above the thermo neutral zone (18 to 22°C) for broiler birds indicating exposure to perpetual heat stress. Ozkan *et al.* (2003) reported that environmental fluctuations resulting from variation in ambient temperature below or above the thermal comfort zone is an important element in the evaluation of the negative effects of stress factors that affects the organism.

Marai *et al*. (2002) suggested that the limiting factor for rabbit performance in warm countries is the influence of hot ambient temperature on body temperature since high temperature combined with high relative humidity can compound the effect of high ambient temperatures. The values of both relative humidity and ambient temperature observed in this study were slightly higher than the findings of Iyeghe-Erakpotobor (2001) who reported relative humidity of 20.48, 16.09, 20.99, and 37.06%; minimum temperature of 12.17, 15.00, 18.94 and 21.93°C and maximum temperature of 28.10, 31.06, 35.07 and 36.19°C for January, February, March and April respectively. The increase might be due to variables in the climatic factors, global warming, increased frequency and intensity of heat waves (King and Karoly, 2017).

In addition, Okab *et al.* (2008) in Egypt reported the maximum and minimum ambient temperatures of 27.1°C and 18.9°C in spring and 32.2°C and 26.5°C in summer, and average relative humidity of 86.1% in spring and 89.5% in summer. Also, Adenkola *et al.* (2011) reported significantly higher maximum atmospheric temperature and relative humidity

during the hot-dry season as 38.06±0.39°C and 61.00±3.05% than 34.53±0.35°C and 46.00±0.32°C obtained during the harmattan season respectively as well as significantly higher minimum atmospheric temperature and relative humidity during the hot-dry season as 26.20±0.15°C and 35.00±4.58 than 16.32±0.43°C and 22.5±3.50°C in the North-eastern part of Nigeria.

Temperature-humidity index during heat stress is an invaluable tool in the presumptive diagnosis of the animal state of health, and it is relevant in evaluating the adaptability of the animal (Karaman *et al.,* 2007). The values of THI recorded in the morning (20.87) and afternoon (25.11) in January and in the morning (21.60) and afternoon (25.83) in February inside the Rabbitry were averagely less than 27.8 reported by Marai *et al.* (2001). These values indicate no heat stress and the rabbits were apparently considered to be comfortable. However, results from this study revealed that the rabbits were heat stressed as noticed in their heart rate in January (110.79 beats per minutes) and February (114.03 beats per minutes) which was lower than 150-300 beats per minutes and respiratory rate in January (102.12 counts per minutes) and February (106.43 counts per minutes) which was higher than the established normal range of 30-60 counts per minute for domestic rabbits as reported by Robertshaw (2004). Marai *et al.* (1991) reported that animals kept under high ambient temperatures develop adaptive metabolic mechanisms to heat stress such as increased water intake, increased panting, increased urination, lowered activity during the day especially in the afternoon and body stretching to expose a higher surface area for heat loss; these were noticed mechanisms used by rabbits in this study.

Lower THI in the morning than in the afternoon agrees with the findings of Akinsola (2012) who reported higher average THI in the evening than in the morning (24.2 vs. 27.8). Higher THI in March and April than in January and February recorded in this study suggests that the rabbits experienced more heat stress in the former than in the later months. Adenkola *et al.* (2009) reported that the period preceding rainy season is thermally stressful to livestock. THI inside the Rabbitry obtained in this study ranges from 20.87-30.01, being higher in April was similar to the findings of Marai *et al.* (2004) who recorded THI of 33.9 during hot season in Egypt but was lower than the report of Marykutty and Nandakumar (2000) who recorded a THI of 76.06-81.26 from January to April in the humid tropic of India. Reports on the maintenance of homeostasis in heat stressed rabbits regarding some functional parameters such as thermoregulatory parameters have been documented (Paci *et al.,* 1993).

Increasing ambient temperatures will probably elevate the incidence of heat stress in livestock and rabbits in particular which are known to be susceptible (Maya-Soriano *et al.,* 2015). Higher heart rate was observed in does fed ascorbic acid supplemented diet at 400 mg/kg compared to does fed the control diet in this study. These observations suggest that ascorbic acid enhanced more warm blood to be pumped from the heart to the lungs and the peripheral for effective cooling. Lower rectal temperature but higher respiratory rate observed in does fed 300 and 400 mg/kg diets compared to does fed the control diet suggest that ascorbic acid enhanced evaporative heat loss via the lungs thus causing a reduction in the core body temperature of the does. However, lower rectal temperature was reported in rabbit fed ascorbic acid supplementation at 100 mg/5 ml of sterile water by Ayo *et al.* (2011) and at 250 mg/kg diet by Anoh *et al.* (2016). Kassim and Norziha (1995) reported lower respiratory rate in broiler birds fed ascorbic acid supplemented diet at 400 and 600 mg/kg and Sivakumar *et al.* (2010) in goats fed 1-2mg/animal/day ascorbic acid supplemented diet. The heart rate was below the normal range of 150-300 beats per minutes, the rectal temperature was within the normal range of 37.0-40.0°C while the respiratory rate was above the normal range of 30-60 counts per

minute established for rabbit (Robertshaw, 2004).

Higher heart rate observed in cross F1 does in this study may be due to vasodilatation of heart vessels which consequently increased blood flow to facilitate heat dissipation in rabbits (Wojtas *et al.,* 2014). Higher rectal temperature and respiratory rate observed in parent rabbit does compared to cross F1 does in this study suggest that the parent does were more vulnerable to the adverse effect of heat stress under increased ambient temperature than the cross F1 does. Fadila and Amal (2015) also suggested that similar to other farm animals, when rabbits are exposed to heat stress, a heat loss mechanism becomes activated resulting in increased respiration as to decrease the elevated core body temperature reflected by rectal temperature. Higher respiratory rate could lead to reduced cell oxygenation (Liem *et al.,* 1995) in rabbits.

Higher heart and respiratory rates observed in March and April than in January than February in all the does could be attributed to increased heat production, high metabolic rate due to high ambient temperature or diurnal fluctuations during the study period. Higher heat production and metabolic rate due to higher ambient temperature or diurnal fluctuations were reported to increase thermoregulatory parameters in chickens (Ayo *et al.,* 2011). Also, these observations could be justified by higher temperature-humidity index recorded in March and April than in January and February (29.51, 30.01 vs. 25.11, 27.05). Increase in thermoregulatory parameters due to increase in THI has been documented (Ogunjimi *et al.,* 2008). Zeferino *et al.* (2011) reported that intense and moderate heat stress under high ambient temperature caused elevations in heart and respiratory rates in Botucatu and crossbred rabbits. Quiniou *et al.* (2000) reported that increased respiration rate is a sign of high ambient temperature in pig.

Respiratory rate was reported to be affected by increased environmental temperature (West Virgina University, 2010). Higher respiratory rate was observed in does fed 200 and 400 mg AA diets in January and March and in does fed 300 and 400 mg AA diets in April. These observations suggest that irrespective in monthly variation of ambient temperature, ascorbic acid could enhance heat loss via respiration thereby reducing the thermal/heat load in rabbits.

## CONCLUSIONS

The study showed that the ambient temperature obtained both inside and outside the rabbit house during the study period was above thermo-comfort zone of 18-21$^{o}$C established for rabbits. Hence, the animals experienced more heat stress in March and April than in January and February as evidenced in their higher heart rate and respiratory rate in the former than in the later months. The cross F1 does seemed to adapt and tolerate heat better than the parent and pure F1 does as evidenced in their lower rectal temperature and respiratory rate. Hence, they will be suitable to be kept on the farm as micro livestock for meat production. Ascorbic acid increased respiratory rate at 400 mg/kg.

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