AGE-DEPENDENT CHANGES IN DIURNAL THERMOREGULATORY RESPONSES OF RABBITS DURING THE EARLY-RAINY SEASON

Yaqub L.S.[1]*, Ezekiel A.E.[1], Umar A.[1], Habibu B.[1], Shittu M.[2] and Kawu M.U.[1]

[1]Department of Veterinary Physiology, Ahmadu Bello University, Zaria
[2]Department of Veterinary Pharmacology and Toxicology, Ahmadu Bello University, Zaria
***Corresponding author**: yaqvet@gmail.com; +2348033875044

ABSTRACT
The study investigated the effect of age on diurnal thermoregulatory responses in rectal (RT) and ear surface temperatures (ET) of rabbits during the early-rainy season. Seventeen apparently healthy rabbits were divided into three groups of 5 weaners, 6 growers and 6 adults. Physiologic parameters of RT and ET of the rabbits were recorded concurrently with thermal environmental parameters of dry-bulb (DBT) and wet-bulb readings every three hours, at 07:00, 10:00, 13:00, 16:00 and 19:00 h, once per week for three weeks using standard procedures. Result revealed that RT and ET were higher in adult compared to weaner or grower rabbits. The RT was higher in adult than weaner rabbits at 13:00, 16:00 and 19:00 h. While, the ET was higher in adult than the weaner rabbits at 07:00 h (33.53 ± 0.39 ˚C vs 31.91 ± 0.39 ˚C). However, there was no significant ($P > 0.05$) difference in physiological parameters between the weaner and grower rabbits. Thermal environmental parameters of DBT positively correlated with ET in all age groups of rabbits (Weaners r = 0656, $P < 0.01$; Growers r = 0.584, $P < 0.01$; Adults r = 0.642, $P < 0.01$). It was concluded that there was age-dependent effect on diurnal thermoregulatory responses of rabbits and prevailing relative humidity negatively impacted on the heat dissipation. It is therefore recommended that adequate ventilation should be provided in rabbit house to reduce the negative impact of high relative humidity on heat dissipation ability of rabbits during the early-rainy season.
Keywords: Diurnal changes, Early-rainy season, Ear temperature, Rabbits and Rectal temperature.

INTRODUCTION
Rabbit is an economic livestock that could be used to bridge gap in dietary protein intake, especially in most developing countries of the tropics (Marai *et al*., 2002). However, constraint to efficient and rapid multiplication of rabbit in these countries is the prevailing meteorological parameters of high ambient temperature during the dry season and high relative humidity and ambient temperature during the early-rainy season (Ferraz *et al*., 2019). Early-rainy season is a transition period from hot-dry period to rainy season. The prevailing ambient temperature and relative humidity are often above the thermoneutral zone for rabbit. In addition, they are highly sensitive to very low relative humidity (< 55%), especially when the ambient temperature is in the range of rabbit core body temperature. Hence, the latent heat of dissipation becomes inefficient, because it is dependent on the relative humidity (Ferraz *et al*., 2019). Unfortunately, this is a common situation in tropical climate during the early-rainy season. In addition to the meteorological factors that influence body temperature variations are the animal factors of age and body weight (Keim *et al*., 2002).

There is a paucity of information in the available literature on the effect of age of rabbit on diurnal variations in rectal and ear surface temperatures during the early-rainy season in the tropics. Such information, if generated, may provide insight into thermoregulatory mechanisms of rabbits of different age groups during high ambient temperature and relative humidity that characterises the early-rainy season in the tropics.

MATERIALS AND METHODS
Experimental design
Seventeen (17) apparently healthy rabbit does, weighing between 0.7 kg - 2.9 kg were used in the present study. The rabbits were preconditioned for two weeks to the experimental procedure. They were individually housed in a locally fabricated house measuring 50 x 25 cm. The rabbits were provided with feed and water *ad-libitum.*

The rabbits were allotted to three groups of 5 growers (6-12 months), 6 weaners (4-6 months) and 6 adults (12 months and above). Rectal and ear surface temperatures were determined using digital clinical (DT-01A) and infrared thermometers, respectively. These parameters were determined once a week for three consecutive weeks, three-hourly, starting at 07:00 h - 19:00 h. Wet and dry bulb temperatures of the experimental room were recorded three-hourly during the determination of physiological parameters using wet and dry-bulb hygrometer (Brannan®, San Diego, California, U.S.A). Relative humidity values were deduced from the dry and wet-bulb temperature values using conversion tables condensed from the Bulletin of the U.S weather Bureau No. 1071. Temperature humidity index was calculated.

Data analysis

All values were expressed as mean (± SEM). Repeated Measures Analysis of Variance followed by Turkey's post-hoc test to determine difference between and within groups. Relationships between meteorological and physiological parameters were determined using Pearson's correlation. The statistical package used was graph pad software, San Diego, California, U.S.A. values of $P < 0.05$ were considered significant.

RESULTS AND DISCUSSION

The maximum ambient temperature and relative humidity index recorded in the early-rainy season in the present study fell above the thermo neutral zone established for rabbits (21-25 ºC) (Marai *et al*., 2002), suggesting that the rabbits were subjected to heat stress during the early-rainy season. Results of the present study revealed diurnal fluctuations in mean rectal and ear surface temperatures, irrespective of the age of the rabbit. In the present study, the highest mean rectal temperature was obtained in the morning relative to other hours of the day in all the groups of rabbits. This implies in part that the prevailing ambient temperature did not have a marked effect on the rectal temperature of the rabbits during the afternoon, presumably because the thermoregulatory mechanisms of the rabbits were able to maintain thermal homeostasis during the afternoon and early evening hours. This finding is in consonant with report of Zeferino *et al*. (2011), that reported a non-significant effect of different ambient temperatures in two breeds of rabbits in controlled chambers. Furthermore and most important, the highest rectal temperature recorded during the morning hour may be due to highest prevailing relative humidity recorded during the morning hour in the present study, that affected the rabbits from dissipating body heat through the skin and ear surfaces as exemplified by the lowest skin and ear surface temperatures in all the groups of rabbits during the morning hours. The significantly higher RT in adult rabbits relative to the weaner and adult rabbits may suggest that the rabbits were more sensitive to the prevailing meteorological parameters with age (Zeferino *et al.*, 2011).

The statistically significant diurnal fluctuation in mean ear temperature obviously indicates that the rabbits employed these organs in offsetting the body heat load during the hot afternoon hours. This point is supported in part by a stronger statistically significant positive correlation between the prevailing ambient temperature and ear temperatures. This suggests that as the prevailing ambient temperature increased with hours of the day, it induces changes in sympathetic activity that resulted in redistribution of blood flow from the viscera to the periphery to enable dissipation of heat from the body (Cham and Badoer, 2008). However, the RH negatively correlated with ear temperatures, which implies an hinderance to efficient heat dissipation as the prevailing RH increases. Hence, increased heat accumulation in body was probably responsible for the highest RT recorded at 07:00 h in this study.

CONCLUSION

There was age-dependent effect on diurnal thermoregulatory responses of rabbits during the early-rainy season. The prevailing meteorological parameters, most especially the RH negatively impacted on heat dissipation ability of the rabbits during the early-rainy season. It is therefore recommended that adequate ventilation should be provided in rabbit house to reduce the negative impact of high relative humidity on heat dissipation ability of rabbits during the early-rainy season. Also, rabbit

farmers should take into cognizance of age-dependent thermoregulatory mechanisms of heat dissipation in order to achieve optimal productivity.

Table 1: mean (± SEM) meteorological parameters during the study period

Time of the day (hour)	Dry-bulb temperature (˚C)	Relative humidity (%)	Temperature-humidity index
07:00	28.83 ± 0.73[a]	75.00 ± 4.36	27.69 ±.0.48
10:00	29.83 ± 1.01[b]	69.00 ± 6.61	27.53 ± 1.42
13:00	31.33 ± 1.09	69.00 ± 10.12	29.64 ± 0.49
16:00	32.17 ± 0.93[c]	66.33 ± 9.33	29.87 ± 0.59
19:00	30.73 ± 1.19	66.33 ± 4.63	28.45 ± 0.94

[a] $P < 0.05$ = 07:00 vs 13:00,16:00 or 19:00 ; [b] $P < 0.05$ = 10:00 vs 13:00 or 16:00; [c] $P < 0.05$ = 16:00 vs 19:00.

Table 2: Effect of age on diurnal variation in rectal temperature (˚C) of rabbits during the early rainy season

Hour of the day	Weaners	Growers	Adults
07:00	37.98 ± 0.17[x]	38.08 ± 0.12[x]	38.53 ± 0.22
10:00	37.61 ± 0.19	37.67 ± 0.15	38.08 ± 0.27
13:00	37.28 ± 0.15[a, y]	37.19 ± 0.17[a, y]	38.03 ± 0.13[b]
16:00	37.76 ± 0.15[a]	37.38 ± 0.15[b, y]	38.04 ± 0.15[c]
19:00	37.43 ± 0.20[a]	36.85 ± 0.16[b, y]	37.99 ± 0.19[c]

[a,b,c] = row with different superscript letters are significantly different ($P < 0.05$)

[x,y] = column with different superscript letters are significantly different ($P < 0.05$)

Table 3: Effect of age on diurnal variation in ear surface temperature (˚C) of rabbits during the early-rainy season

Hour of the day	Weaners	Growers	Adults
07:00	31.91 ± 0.39[a, x]	32.14 ± 0.35[a, x]	33.54 ± 0.39[b, x]
10:00	33.35 ± 0.36[y]	33.41 ± 0.27[y]	34.19 ± 0.44
13:00	34.18 ± 0.30[y]	34.29 ± 0.25[y]	35.06 ± 0.27[y]
16:00	34.56 ± 0.34[y]	35.24 ± 0.34[y]	34.96 ± 0.29[y]
19:00	33.39 ± 0.53[y]	33.50 ± 0.39[y]	34.31 ± 0.46

[a,b] = row with different superscript letters are significantly different ($P < 0.05$)

[x,y] = column with different superscript letters are significantly different ($P < 0.05$)

Table 4: Relationships between thermoregulatory responses and meteorological parameters

Correlated parameters	Weaners	Growers	Adults
Dry-bulb temperature and rectal temperature	- 0.071[ns]	- 0.335**	- 0.160[ns]
Dry-bulb temperature and ear temperature	0.656***	0.584***	0.642***
Relative humidity and rectal temperature	0.024[ns]	0.151[ns]	0.138[ns]
Relative humidity and ear temperature	0.591***	0.504***	0.520***

ns = non-significant; ** = $P < 0.01$; *** = $P < 0.001$

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