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Diurnal, seasonal and sex variations in rectal temperature of African giant rats (*Cricetomys gambianus*, Waterhouse)

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ABSTRACT

(1) Rectal temperature (T_r) was measured in captive African giant rats (*Cricetomys gambianus*, Waterhouse), live-trapped in the Savannah during the harmattan, hot-dry and rainy seasons with the aim of determining diurnal, seasonal and sex patterns.
(2) Mean ($\pm$SEM) T_r in the morning (37.16 ± 0.04 °C) was lower ($P < 0.001$) than the afternoon (37.49 ± 0.03 °C) and evening (37.66 ± 0.03 °C). There was no significant difference ($P > 0.05$) between afternoon and evening T_r during the harmattan and rainy seasons, but the difference was significant ($P < 0.001$) during the hot-dry season. Overall T_r was higher ($P < 0.001$) during the hot-dry (38.03 ± 0.03 °C) than harmattan (37.17 ± 0.03 °C) and rainy (37.21 ± 0.03 °C) seasons. T_r of bucks was lower than that of does ($P < 0.0001$) during the harmattan and rainy seasons, but sex difference during the hot-dry season was not significant ($P > 0.05$).
(3) Base-line T_r values for the African giant rats are shown for the first time. Season, time of day and sex influence fluctuations in T_rs of African giant rats, and should be considered during diagnostic and clinical evaluations.

1. Introduction

Homeotherms (birds and mammals) employ physiologic mechanisms to maintain their body temperature (T_b) within a narrow range, despite constant exothermic metabolism and wide ambient temperature (T_a) fluctuations (Gordon, 2009). Homeostatic mechanisms are controlled by the hypothalamus via various neuro-endocrine pathways, leading to different endogenous and behavioral responses by the animals that are measurable and result in homeothermy (a constant narrow range of T_b) (Keim et al., 2002). Core T_b and its change from a base-line have traditionally been used to study thermal homeostasis (Ayo et al., 2008; Gordon, 2009). The rectal temperature (T_r) is a good indicator of core T_b that is widely used in animals because of its accuracy, convenience and safety (Keim et al., 2002; Gordon, 2009; Zhao et al., 2010).

According to the laws of thermodynamics, heat is transferred from a high temperature to a lower temperature. The body loses heat when environmental temperatures are lower and gains heat when environmental temperatures are higher (Keim et al., 2002). Therefore, it is important for the homeothermic process that the T_a is below the T_b, especially in the tropics where the animal often needs to lose heat to the environment (Vathana et al., 2002). Meteorological factors relating to heat transfer are a combination of T_a, wind speed, relative humidity (RH) and solar radiation (Bianca, 1976; Keim et al., 2002), but the overriding factor affecting T_b of animals is T_a (Bianca, 1976; Vathana et al., 2002). The most important climatological thermal conditions are heat stress during the hot season and the wind chill factor during the cold season of the year (Broucek et al., 2007). In tropical and subtropical countries an animal often may be under heat stress (Vathana et al., 2002). Heat stress results from the combined effects of high T_a and high RH. Therefore, the temperature–humidity index or heat index (HI) is commonly used as an indicator of thermal comfort (Kendall and Webster, 2009). Heat stress results in many physiologic responses including, increased T_b (Keim et al., 2002). Thus, physiologic responses of animals exposed to meteorological stress are determined by variations in T_b, often measured as T_r (Gordon, 2009). Changes in T_b are used as an index of meteorological stress, whereas the absence of any change serves as an index of tolerance (Ayo et al., 2008). Added to the meteorological factors that influence T_b variations are the animal factors of age, sex, body weight and metabolic rate (Keim et al., 2002).

Abbreviations: AGR, African giant rat; HI, Heat index; RH, Relative humidity; T_a, Ambient temperature; T_b, Body temperature; T_r, Rectal temperature

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The T_b of rodents, like other homeotherms, appears relatively stable with a predictable 24 h circadian rhythm (Gordon, 2009). Circadian rhythms are endogenously generated, although they can be modulated by external cues, primarily daylight (Johnsson, 2008) and synchronized with the rhythmic phases of environmental (exogenous) change (Ayo et al., 2008). T_b of rodents and other mammals may also be regulated by external yearly or seasonal variations or generated by internal mechanisms that have a period of about a year, circannual rhythms (Johnsson, 2008; Zhao et al., 2010). Changes in T_a have been reported to cause changes in core T_b of rodents (Malberg and Seiden, 1998; Zhao et al., 2010). Evidence for seasonal variations in metabolism and thermoregulation affecting T_b in rodents has been shown (Zhao et al., 2010). An elevation in core T_b induces changes in sympathetic nerve activity that result in a redistribution of blood flow from the viscera to the periphery to enable dissipation of heat from the body (Cham and Badoer, 2008).

In its native range of tropical Africa, the African giant rat (*Cricetomys gambianus* Waterhouse, 1840) (AGR) is harnessed as a source of nutritional protein (Ajayi, 1977) and an important laboratory animal for research purposes (Audu and Moveh, 2004). The AGR is also of importance to the United Nations and the World Health Organization because of its great potential in the detection of land mines in war-torn areas (Verhagen et al., 2003) and tuberculosis in human sputum samples (McKee, 2003). It is also a highly priced rodent in the thriving pet industry in Europe (Cooper, 2008). A thermoneutral zone of 21–34 °C and a mean T_r of 35.6 ± 1.1 °C below a T_a of 20 °C was reported for the AGR in Pretoria, South Africa (Knight, 1988), but corresponding T_b values for tropical Africa, which is its natural habitat (Peterson et al., 2006), have not been reported. Despite its growing number of uses, base-line data on T_b responses of the AGR to environmental challenges are lacking in the available literature. Temperature variations are important in AGRs housed in captivity, away from their burrow system. AGRs are sensitive to heat. Ajayi (1975) observed two captive AGRs that died from heat prostration in temperatures above 32 °C. In their natural habitat, the AGRs avoid heat by staying in their cooler burrows during the day (Ewer, 1967; Ajayi, 1975; Peterson et al. 2006). This kind of behavioral activity is altered when AGRs are housed in captivity; hence it is important to investigate their thermoregulatory responses under such conditions.

The aims of the present study were to establish base-line values and determine some basic factors of variation (time of day, season and sex) in the T_r of AGRs in the Northern Guinea Savannah zone of Nigeria, which may be useful in clinical and diagnostic evaluation. Some behavioral responses of the AGR to thermal environmental changes are also discussed.

2. Materials and methods

2.1. Animals

AGRs of both sexes (n = 103 bucks, 98 does), weighing between 0.8 and 2.0 kg, were live-trapped in Samaru (11°11′N, 07°38′E), Zaria, Nigeria, located at an altitude of 686 m above maximum sea level with an annual monthly mean (± standard error) photoperiod of 12.13 ± 0.13 h (Kowal and Knabe, 1972). Metal (steel) live box traps were baited with peanuts, maize and baked cake made from ground beans. Trapping occurred both in bushes and residential areas. Since the AGRs are nocturnal animals, traps were set before dusk and checked at dawn. The traps were retrieved during the day to prevent capture of diurnal, non-target taxa. The trap, capture and handling methods utilized in the study were in accordance with the American Society of Mammalogists guidelines (Gannon and Sikes, 2007). All the experimental protocols described were approved by the Ethics Review Committee for Animal Experimentation of Ahmadu Bello University, Zaria.

Each captured AGR was weighed (Dzenda et al., 2011), sexed and kept individually in a marked metal cage partition (40 cm × 20 cm × 24 cm). Pregnant does were removed. The study covered a period of three years but a fresh set of African giant rats was live-trapped and utilized during each individual season. A total of 90 (45 bucks, 45 does), 54 (29 bucks, 25 does) and 57 (29 bucks, 28 does) different sets of AGRs were live-trapped and studied during the harmattan, hot-dry and rainy seasons, respectively. The number of individual AGRs analyzed per year was 69, 66 and 66 for years 1, 2 and 3, respectively. The yearly distribution of the AGRs by season and sex was as shown in Table 1. The AGRs were housed in a well-ventilated animal room, pre-conditioned for at least two weeks, during which they were subjected to preliminary handling before the commencement of the experiments. They were fed dry food pellets, made from growers' mash (Rebson Agricultural Enterprises Ltd., Zaria) and groundnut cake flour in the ratio of 3:1. Proximate analysis of the feed showed that it contained 26.56% crude protein, 12.47% ether extract, 10.31% crude fiber and 8.78% ash. Tap water was given *ad libitum* using standard commercial rat drinkers.

Table 1
Yearly distribution of trapped African giant rats (*Cricetomys gambianus*, Waterhouse) by sex and season during the study period.

Season	Number of African giant rats (n)						
	Year 1		Year 2		Year 3		Total
	Male	Female	Male	Female	Male	Female	
Harmattan	15	15	15	15	15	15	90
Hot-dry	10	9	9	8	10	8	54
Rainy	10	10	10	9	9	9	57
Total	35	34	34	32	34	32	201

Table 2
Seasonal variations in maximum, minimum and range values of some thermal environmental parameters in the animal room during the study period.

Season	Ambient temperature (°C)			Relative humidity (%)			Heat index (°C)		
	Maximum	Minimum	Range	Maximum	Minimum	Range	Maximum	Minimum	Range
Harmattan	29.5	20	9.5	33	22	11	28	25	3
Hot-dry	33.5	27.5	6.0	65	19	46	37	29	8
Rainy	30	24.5	5.5	96	54	42	32	25	7
Overall	33.5	20	13.5	96	19	77	37	25	12
Mean ± SEM	31.00 ± 1.26[a]	24.00 ± 2.18[b]	7.00 ± 1.26	64.67 ± 18.19[a]	31.67 ± 11.20[a]	33.00 ± 11.06	32.33 ± 2.60[a]	26.33 ± 1.33[a]	6.00 ± 1.53

For each parameter, means (± SEM) of maximum and minimum values with different superscript letters.

[a,b] are significantly different (P < 0.05)