DIURNAL, SEASONAL AND SEX INFLUENCES ON HEART RATES OF AFRICAN GIANT RATS (*Cricetomys gambianus*, WATERHOUSE) IN THE NORTHERN GUINEA SAVANNAH ZONE OF NIGERIA

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Abstract
Heart rate (HR) was measured over a 3-year period in captive African Giant rats (AGRs), live-trapped in Zaria, Nigeria during the harmattan (cold-dry), hot-dry and rainy seasons, as influenced by diurnal, seasonal and sex patterns. The HR showed no significant diurnal changes ($P > 0.05$) during the hot-dry and rainy seasons, but the morning and afternoon effects differed ($P < 0.01$) during the cold-dry season. Overall seasonal HR differed ($P < 0.001$) among the seasons, with the highest (165.8 ± 0.51 bpm) and lowest (153.1 ± 0.74 bpm) values recorded during the cold-dry and hot-dry seasons, respectively. HR of males (bucks) was lower than that of females (does) during the cold-dry ($P < 0.0001$) and hot-dry ($P < 0.01$) seasons, but sex difference during the rainy season was not significant ($P > 0.05$). It is concluded that season, time of day and sex influenced fluctuations in HRs of AGRs, and should be considered during clinical evaluations.

INTRODUCTION

The relationship between the animal and its environment is best studied based on the knowledge of the physiological constants, maintained by self-regulating processes of the animal, such as body temperature, respiratory rate and heart rate (HR) (Pagot, 1992; Carnevali and Sgoifo, 2014). HR is the rate of heart beat, expressed in beats per minute (bpm). A modest diurnal rhythm in HR has been demonstrated in some rodents, including the rat (Sei *et al.*, 1997) and mouse (Sei *et al.*, 2008; Sheward *et al.*, 2010). The HR of rats (Chambers *et al.*, 2000; William *et al.*, 2002) and mice (Sun *et al.*, 2002; Swoap *et al.*, 2004) has an inverse relationship with ambient temperature. Season has also been shown to influence the HR (Abdelatif and Saeed, 2009), with significant correlations between HR and feed consumption (Mesteig *et al.*, 2000). Stupfel and Costagliola (1979) demonstrated that HR in Sprague-Dawley rats during most part of their lives always had higher values in females than males, with significant correlations between HR and live weight. The influences of daytime, season and/or sex on the body temperature, live weight, and feed and water consumptions of Africa's largest muroid rodent, the African Giant rat (AGR), *Cricetomys gambianus*, Waterhouse – 1840, were previously reported (Dzenda *et al.*, 2013). The present report examines how such factors may affect the HR in the rodent.

MATERIALS AND METHODS

The study was conducted in Samaru-Zaria (11°10′N, 07°38′E), located in the Northern Guinea Savannah zone of Nigeria. AGRs were live-trapped in the area as previously described (Dzenda *et al.*, 2013). The sex of each AGR was determined and the rat kept individually in a marked metal cage partition (40 × 20 × 24 cm). Pregnant does were removed and not included in the study. The AGRs were housed in a well-ventilated animal room and quarantined for two weeks before the commencement of the experiment. They were fed dry feed pellets (26.56 % crude protein, 12.47 % ether extract, 10.31 % crude fibre and 8.78 % ash). Fresh water was given *ad libitum* using standard commercial rat drinkers. The study covered a period of three years, but a fresh set of AGRs was live-trapped and utilised during each 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. AGRs weighing up to 0.8 kg were considered adult (Ajayi, 1977) and used for the study. The number of individual AGRs analysed per year was 69, 66 and 66 for the 1st, 2nd and 3rd year, respectively. The HR of each restrained (Gannon and Sikes, 2007) AGR was recorded as the number of heart beats per minute (bpm) by auscultation with the aid of a stethoscope (3M™ Littman® Classic II S.E; U.S.A), placed on the left ventro-lateral side of the thorax (Pagot,

1992). Measurements of HR of all the AGRs were taken in the morning (7-9 h), afternoon (12-14 h) and evening (16-18 h) for 3 days (a week apart) during each of the 3-year experimental seasons. Indicated times are West-Central African time (GMT +1). The 3 experimental days were spread across 3 weeks; that is, 1 day per week, at the peak of each season. The peaks of the harmattan, hot-dry and rainy seasons in the study area are late December/early January, late March/early April and late July/August, respectively (Kowal and Knabe, 1972). Data were analysed using GraphPad Prism, version 4.03 for Windows (GraphPad Software, San Diego, California, USA, www.graphpad.com.). The data obtained were expressed as mean ± standard error of the mean (mean ± SEM). Diurnal and seasonal variations in HR of the AGRs were analysed using repeated-measures analysis of variance (ANOVA), followed by Tukey's multiple comparison *post-hoc* test. Two-tailed, paired Student's *t*-test was used to determine sex differences in the HR values.

RESULTS AND DISCUSSION

The HR fluctuated between 90 and 210 bpm throughout the study period; with the nadir and peak values recorded during the hot-dry and harmattan seasons, respectively (Tables 1 and 2). The mean HR value differed across the seasons ($P < 0.001$); with peak (165.8 ± 0.51 bpm) and nadir (153.1 ± 0.74 bpm) values recorded during the harmattan and hot-dry seasons, respectively. The results showed that the HR of the AGRs fluctuated seasonally, with the highest and lowest values recorded during harmattan and hot-dry seasons, respectively. The seasonal decrease in HR of AGRs during the hot-dry season may be the combined effect of increased ambient temperature (William *et al.*, 2002; Swoap *et al.*, 2004) and decreased feed consumption (Dzenda *et al.*, 2013); presumably reflecting changes in cardiac output and/or the rate of flow of blood to the gastro-intestinal tract, which are influenced by meal size (Barnes *et al.*, 1983; Mesteig *et al.*, 2000). The present study also showed significant ($P < 0.05$) diurnal changes in HR between the morning (nadir) and afternoon (peak) during the harmattan season, but diurnal changes during the hot-dry and rainy seasons were not significant. The diurnal variation was more evident during the harmattan season; probably because the season provided more classical differences in extremes of ambient temperature between night and day (Igono *et al.*, 1982), with greater influence on the diurnal rhythm. Diurnal rhythm in HR has been reported in other rodents including the rat (Sei *et al.*, 1997) and mouse (Sei *et al.*, 2008). The modest diurnal rhythm of resting HR obtained on AGRs is in agreement with the findings of Sheward *et al.* (2010), who made similar observations in the mouse. Results of sex variations in HR (Table 2) showed that the HR value of female AGRs was higher than that of the males during the harmattan ($P < 0.0001$), hot-dry ($P < 0.01$) and rainy ($P > 0.05$) seasons. The present finding is in agreement with that of Stupfel and Costagliola (1979), who reported that HR in Sprague-Dawley rats during most part of their lives always had higher values in females than males, with significant correlations between HR and live weight. Thus, the smaller size of the female AGRs (Dzenda *et al.*, 2011) may be at least partly responsible for their higher HR values.

Conclusion

This study established base-line HR information on the AGR in the study area. Season, time of day and sex had influence on HRs of AGRs, and should be considered during clinical evaluations in these animals.

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Table 1: Diurnal and seasonal effects on heart rate of the African Giant rat in the Northern Guinea Savannah zone of Nigeria

Time of day (GMT +1)	Heart rate (beats/min) (Mean ± SEM)			
	Harmattan (n = 90)	Hot-dry (n = 54)	Rainy (n = 57)	Overall (n = 201)
Morning (07-09 h)	$164.6 \pm 0.85^{a,1}$ (114-194)	153.9 ± 1.11^{b} (105-192)	162.8 ± 1.10^{c} (114-198)	161.2 ± 0.60 (105-198)
Afternoon (12-14 h)	$167.0 \pm 0.83^{a,2}$ (125-207)	153.3 ± 1.16^{b} (105-186)	164.4 ± 1.25^{c} (108-195)	162.6 ± 0.64 (105-207)
Evening (16-18 h)	$165.7 \pm 0.96^{a,1,2}$ (111-210)	152.3 ± 1.52^{b} (90-192)	163.1 ± 1.30^{c} (96-195)	161.4 ± 0.73 (90-210)
Overall	165.8 ± 0.51 (111-210)	153.1 ± 0.74 (90-192)	163.4 ± 0.70 (96-198)	161.7 ± 0.38 (90-210)

Mean values in the same row with different superscript letters (^{a,b,c}) are significantly different ($P < 0.001$); Mean values in the same column with different or not sharing superscript numbers are significantly different (^{1,2} = $P < 0.01$). Minimum-maximum values are indicated in parentheses below the means.

Table 2: Seasonal and sex effects on heart rate of the African Giant rat in the Northern Guinea Savannah zone of Nigeria

Season	Heart rate (beats/min) (Mean ± SEM)		
	Male (n = 103)	Female (n = 98)	Overall (n = 201)
Harmattan	$160.0 \pm 0.73^{a,1}$ (111-207)	$170.3 \pm 0.61^{b,1}$ (129-210)	165.8 ± 0.51 (111-210)
Hot-dry	$150.5 \pm 1.06^{a,2}$ (90-189)	$156.1 \pm 0.98^{c,2}$ (108-192)	153.1 ± 0.74 (90-192)
Rainy	163.0 ± 0.88^{3} (105-195)	163.8 ± 1.10^{3} (96-198)	163.4 ± 0.70 (98-198)
Overall	158.8 ± 0.53 (90-207)	164.8 ± 0.53 (96-210)	161.7 ± 0.38 (90-210)

Mean values between sexes in each season with different superscript letters (^{a,b}) are significantly different (^{a,b} = $P < 0.0001$; ^{a,c} = $P < 0.01$); Mean values of each sex between seasons with different superscript numbers (^{1,2,3}) are significantly different ($P < 0.001$). Minimum-maximum values are indicated in parentheses below the means.