

Full-Length Research Article

Body Temperatures, Respiration, Heart Rate and Haematological Parameters of Four Species of Captive Monkeys in Nigeria during the Rainy Season

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Summary: Monkeys are phylogenetically close to humans and are therefore used in a lot of research models. This study aimed to determine the basic physiological and haematological parameters in four different species of captive monkeys during the rainy season. Fourteen adult monkeys at the University of Ibadan Zoological Garden were used for this study (3 - *Cercocebus sebaeus*, 3 - *Cercopithecus mona*, 3- *Erythrocebus patas* and 5- *Papio Anubis*). Dry-bulb temperature and relative humidity were recorded concurrently with the measurement of rectal temperature (RT), body surface temperatures (BST), respiratory (RR) and heart rates (HR). Blood sample were collected for the evaluation of haematological parameters. The dry-bulb temperature and relative humidity were 25.9°C and 75%, respectively. The *Erythrocebus patas* monkey had mean RT value of 38.23 ± 0.2°C, while the *Cercocebus sebaeus* monkey had 38.87 ± 0.7°C when compared to that of *Papio Anubis* and *Cercopithecus mona* monkey (38.4 ± 0.3°C and 38.53 ± 0.6°C, respectively). The mean RR value of 40.0 ± 2.3 cycle/min in *Erythrocebus patas* monkey was significantly ($p < 0.05$) higher than 27.33 ± 1.3 cycles/min and 21.60 ± 1.9 cycles/min in *Papio Anubis* and *Cercocebus sebaeus* monkey, respectively. The mean bias difference of rectal temperature versus eye temperature (0.8643 ± 0.749) was significantly ($p < 0.05$) lower than the mean bias differences of the rectal temperature versus forehead (2.19 ± 0.75), but was not statistically ($p > 0.05$) different from the value of 1.471 ± 0.9 obtained in the comparison of rectal temperature versus base of the tail temperature. The haematological parameters were not significantly different among the species. In conclusion, the basic thermoregulatory apparatus and haematological parameters of the different species of monkeys were not significantly different and the values recorded were within the established range for the monkey.

Keywords: Monkey; Rectal temperature; Body surface temperature, Haematology.

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INTRODUCTION

At high temperatures, monkeys increased evaporative heat loss through increased respiration and sweating rate (Mahiney, 1980; Walters *et al.*, 2004). The interaction between ambient temperature and relative humidity has been linked to alterations in thermal balance in animals (Adair, 1985; Habeeb *et al.*, 2018, 2023). Thermoregulation in animals under varying weather conditions varies in depth depending on the innate ability of the animal to regulate its thermal balance. The effectiveness of individual animals to regulate body temperature in extreme thermal conditions is important for their survival (Mota-Roja *et al.*, 2021).

The ability of the monkeys in captivity for thermoregulation may be significantly influenced by their adaptation to captivity. In order to ensure the thermal comfort of captive monkeys, understanding of their physiological responses in the different seasons, with varied climate parameters, is very important. Primates in captivity are challenged with the great demand of maintaining an optimal body temperature within a physiologically acceptable range in a thermally changing environment (Thompson *et al.*, 2014).

Thermal challenges may be more prevalent in primates than previously thought, especially with the advent of increasing global warming. Prolonged birth interval in free-

ranging baboons has been linked to changes in climate conditions in different seasons of the year (Thompson *et al.*, 2014). It has been reported that vevet monkeys cope well in the heat conditions by the use of behavioural changes to aid their thermoregulation capability (Mcfarland *et al.*, 2020). Basic clinical and haematological variables are conveniently used as index of health status in different animals (Koo *et al.*, 2019; Yu *et al.*, 2019; Ayo *et al.*, 2023; Bakker *et al.*, 2023). It is imperative for clinicians in the zoo and the wild to be cautious in the interpretations of basic physiological and haematological variables; alterations in these variables have been linked to diurnal and circadian fluctuations and also seasonal effects (Ake *et al.*, 2023a; Coskun *et al.*, 2023; Iconaru *et al.*, 2024). According to Park *et al.* (2016) there is no established link between changing environmental parameters and the values of haematological parameters recorded, suggesting that haematological values obtained in particular region can be used in another region. There is the need to review the long-established values of haematological parameters, due to evolving laboratory methods and the different methods of restraint applied. Age, sex and living conditions have been reported to affect haematological values (Rosenblum and Coulston, 1981; Koga *et al.*, 2005; Nakayama *et al.*, 2017). Species difference may also be a factor that influences the values (Ogunro *et al.*, 2019). Therefore, the aim of the study was to determine the physiological and haematological parameters of four different species of captive monkeys during the rainy season.

MATERIALS AND METHODS

Animals and management: Fourteen adults' caged monkeys were used for this study (3 - *Cercocebus sebaeus*, 3 - *Cercopithecus mona*, 3- *Erythrocebus patas* and 5- *Papio Anubis*). The monkeys were kept at the University of Ibadan Zoo, Oyo state, Nigeria. This work is part of the Humboldt Research Hub project and Ethical approval was obtained from the Nigerian Veterinary Research Institute (AEC/03/116/22). Additionally, approval for the method and personnel to bleed the monkeys was granted by the Board of the Zoological Garden, University of Ibadan. The study was conducted during the rainy season. All the animals were apparently healthy at time of sampling.

Environmental parameters: The recording of environmental parameters was done concurrently with the physiological measurements. Dry-bulb temperature was recorded using a wet- and dry-bulb thermometer (Haryana, India), and relative humidity was calculated using Osmond's hygrometric table (Narindra Scientific industries, Haryana, India).

Evaluation of rectal and body surface temperatures: The measurement of rectal temperature (RT) from each monkey was recorded after the effect of the administered anesthetic agents has been established, using a standard digital clinical thermometer (Krusser Thermometer® Amazon, Berlin, Germany) inserted at 5 cm deep into the rectum via the anus. The recording of the body surface temperature (BST) (eye, forehead and base of the tail temperatures) was done using infrared thermometer (Model: JXB-181, Nanjing, Jiangsu, China). The distance of the animal from the infra-red

thermometer camera was < 0.5 m for each temperature measurement.

Measurement of heart and respiratory rates: Evaluation of heart rate (HR) and respiratory rate (RR) was measured in all the monkeys, using stethoscope to count the number of beats per minute. The RR was measured by observing and counting the number of respiratory flank movements for one minute for each monkey.

Blood sample collection: The monkeys were darted at close range (1-5m) with a blow pipe delivering anaesthetic (ketamine hydrochloride, Ketanil®, Wildlife Pharmaceuticals, Windsor, USA) at 10mg/kg body weight of the monkey. Phlebotomy was via cephalic or tibial venipuncture using 21-gauge needle and a 5-mL syringe in each sedated animal. The volume of blood collected was 4mLs, placed in tubes with potassium ethylenediaminetetraacetic acid (EDTA) was used for the evaluation of haematological parameters.

Determination of packed cell volume (PCV): The PCV of each blood sample was determined using the microhaematocrit method described by Schalm (2010).

Determination of haemoglobin concentration: Haemoglobin concentration was determined by cyanmethaemoglobin method described by Schalm (2010). The absorbance of cyanmethaemoglobin was then determined spectrophotometrically.

Determination of red blood cell (RBC) count: The RBC count was determined by the haemocytometer method.

Determination of white blood cell count: The total white blood cell (leucocytes) count was determined using the haemocytometer method.

Determination of differential leucocyte count: A drop of blood from the EDTA blood sample was placed on a clean glass slide; it was fixed with methanol and then stained with Giemsa. One hundred cells were identified morphologically and counted and the number of each leukocyte type was expressed as a percentage of the total WBC from which the absolute leukocyte values were calculated.

Haematological indices: The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated from the PCV, RBC and HB values obtained earlier using the following formulas:

$$\text{MCV (fl)} = \frac{\text{PCV (\%)} \times 10}{\text{RBC (X } 10^{12}/\mu\text{L)}}$$

$$\text{MCH (pg)} = \frac{\text{Hb (g/dl)} \times 10}{\text{RBC (X } 10^{12}/\mu\text{L)}}$$

$$\text{MCHC (g/dl)} = \frac{\text{Hb (g/dl)} \times 100}{\text{PCV (\%)}}$$

Statistical analysis

The data were expressed as standard error of the mean (Mean \pm SEM) and were subjected to normality test (Kolmogorov-Smirnov test). One-way ANOVA was used to compare the mean differences among the groups and subjected to Tukey's post-hoc test to determine the means differences. Values of $p < 0.05$ were considered significant.

RESULTS

The prevailing environmental temperature and relative humidity recorded during the study period are shown in Figure 1. The dry-bulb temperature measured was 25.9°C, while relative humidity recorded was 75%. Table 1 shows the basic physiological parameters of four species of monkeys during the rainy season. The rectal temperature of the four different species of monkey ranged from 37.4 – 39.6°C. The *Cercocebus sebaeus* monkey had highest mean RT ETs values of $38.87 \pm 0.7^\circ\text{C}$ and $37.87 \pm 0.3^\circ\text{C}$ when compared to others, though not significantly different. The mean FTs of the four monkeys were within the range of 36.2 – 37.9°C.

The mean RR value of 40.0 ± 2.3 cycle/min in *Erythrocebus patas* monkey was significantly ($p < 0.05$) higher than 27.33 ± 1.3 cycles/min and 21.60 ± 1.9 cycles/min in *Papio Anubis* and *Cercocebus sebaeus* monkey, respectively. The mean RR value of 27.33 ± 1.3 cycles/min in *Papio Anubis* monkey was significantly ($p < 0.05$) higher than the values recorded in *Cercopithecus mona* and *Cercocebus sebaeus* monkey. The HR values in the four monkeys range from 66 – 130 beats/min.

The Bland-Altman comparisons of rectal temperature with body surface temperatures in the four species of monkey during the rainy season are shown in Figure 2. The upper limit and lower limit of agreement for the rectal temperature versus eye temperature measurement were -0.6037 and 2.332, respectively. The rectal temperature versus forehead temperature level of agreement, the value for the upper limit of agreement was 3.669 while the value

for the lower limit of agreement was 0.7172. The limits of agreement for the rectal temperature versus base of the tail temperature were 3.264 and -0.3207 for the upper and lower points, respectively.

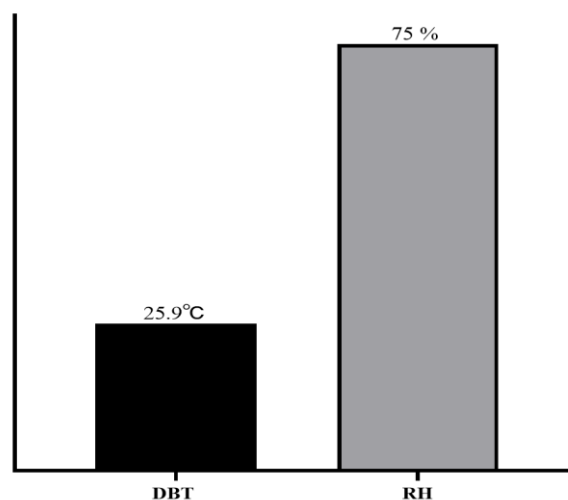


Figure 1: Dry-bulb temperature and relative humidity recorded during data collection in the rainy season

Figure 3 shows the statistical comparisons between the mean bias differences of rectal temperature with the body surface temperatures in the four species of monkey. The mean bias difference of rectal temperature versus eye temperature (0.8643 ± 0.749) was significantly ($p < 0.05$) lower than the mean bias differences of the rectal temperature versus forehead (2.19 ± 0.75), but was not statistically ($p > 0.05$) different from the value of 1.471 ± 0.9 obtained in the comparison of rectal temperature versus base of the tail temperature. There was no significant ($p > 0.05$) difference between the mean bias differences of the rectal temperature versus forehead and rectal temperature versus base of the tail temperature.

Table 1:

Basic clinical parameters of four species of Monkeys during the rainy season (mean \pm SEM)

Parameters	<i>Cercocebus sebaeus</i>	<i>Cercopithecus mona</i>	<i>Erythrocebus patas</i>	<i>Papio Anubis</i>
RT (°C)	38.40 ± 0.3 (39.1 – 37.8)	38.87 ± 0.7 (39.6 – 37.5)	38.23 ± 0.2 (38.6 – 37.5)	38.53 ± 0.6 (39.6 – 37.4)
ET (°C)	37.76 ± 0.2 (38.3 – 37.2)	37.87 ± 0.3 (38.4 – 37.6)	37.17 ± 0.5 (38.2 – 36.6)	37.63 ± 0.1 (37.7 – 37.5)
FT(°C)	36.36 ± 0.1 (36.7 – 36.2)	36.30 ± 0.1 (36.4 – 36.2)	36.30 ± 0.1 (36.5 – 36.2)	36.20 ± 0.0 (36.2 – 36.2)
BT (°C)	37.20 ± 0.3 (37.9 – 36.4)	37.03 ± 0.1 (37.2 – 36.9)	37.00 ± 0.5 (37.9 – 36.4)	36.73 ± 0.4 (37.4 – 36.2)
RR (cycles/min)	21.60 ± 1.9^a (26.0 – 15.0)	21.33 ± 3.5^a (28.0 – 16.0)	40.0 ± 2.3^b (44.0 – 36.0)	$27.33 \pm 1.3^{a,c}$ (30.0 – 26.0)
HR (beats/min)	106.0 ± 7.6 (128.0 – 88.0)	90.33 ± 16.8 (124.0 – 73.0)	90.33 ± 4.3 (96.0 – 82.0)	91.33 ± 19.6 (130.0 – 66.0)

Maximum – minimum in parenthesis

RT = rectal temperature, ET = eye temperature, FT = forehead temperature, BT = base of the tail temperature, RR = respiratory rate, HR = heart rate

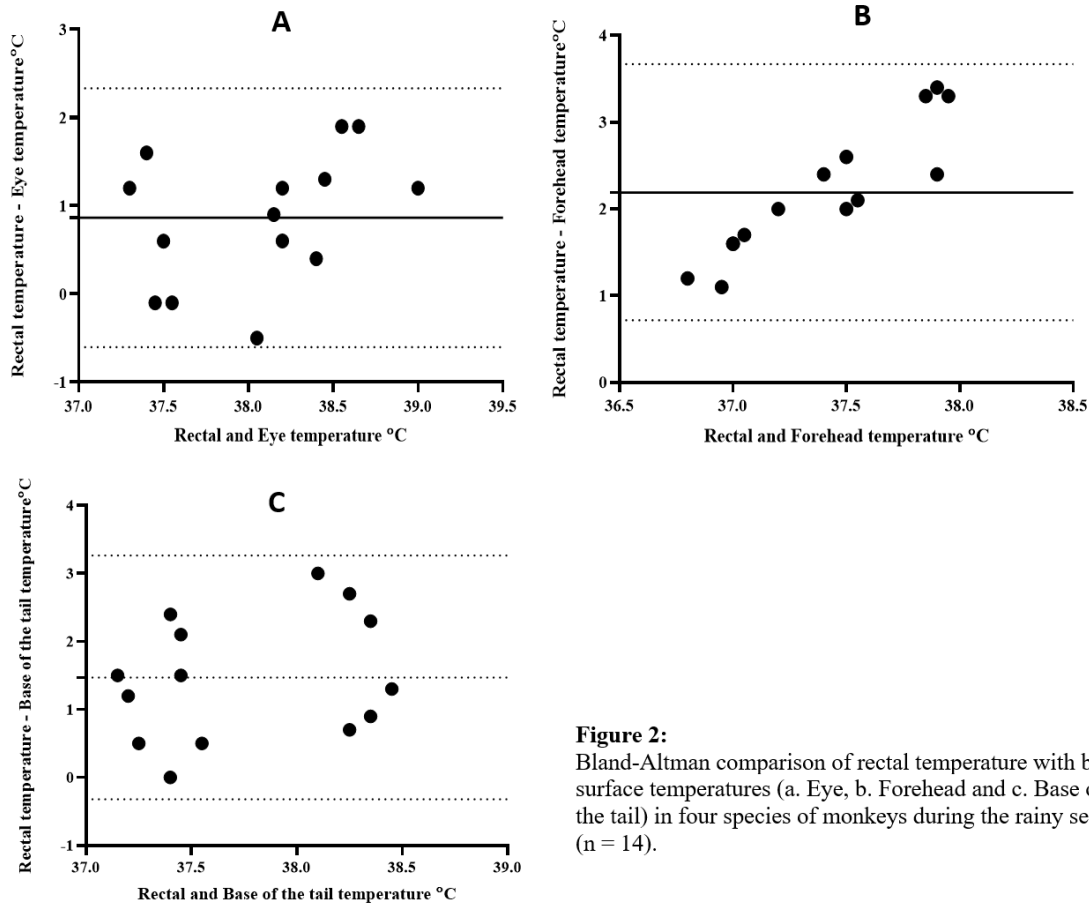


Figure 2: Bland-Altman comparison of rectal temperature with body surface temperatures (a. Eye, b. Forehead and c. Base of the tail) in four species of monkeys during the rainy season (n = 14).

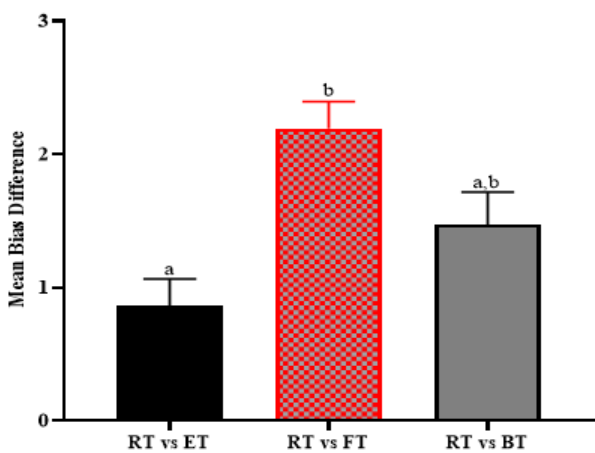


Figure 3: Mean bias differences in rectal temperature versus body surface temperatures in of four species of monkeys during the rainy season. (Mean \pm SEM, n = 14). Different superscripts alphabets indicate significant (p < 0.05) difference. Note: RT = rectal temperature, ET = eye temperature, FT = forehead temperature, BT = Base of the tail

The comparisons of the rectal and body surface temperatures using receiver operating characteristic curve analyses are presented in Figure 4. The comparison between rectal temperature and eye temperature had area under curve of 0.8138 ± 0.08 while that of rectal temperature versus forehead temperature and rectal temperature versus base of the tail temperature had area under curve of 1.0 ± 0.0 each. Table 2 shows the relationships of rectal temperature versus respiratory rate and versus heart rate in the monkeys. The

correlation coefficient values obtained in rectal temperature versus respiratory rate and versus heart rate were not significantly (p > 0.05) different.

The erythrocytic parameters of four species of Monkeys during the rainy season are shown in Table 3. The mean PCV and Hb values in the *Cercocebus sebaeus* ($46.33 \pm 8.7\%$ and $15.43 \pm 2.9\text{g/dL}$, respectively) were the highest, it was not significantly (p > 0.05) different to the values recorded in the other species.

The value of RBC ranged from 2.2 to $7.0 \times 10^6/\mu\text{L}$ in the Monkeys. The highest mean RBC value of $5.26 \pm 0.4 \times 10^6/\mu\text{L}$ was recorded in *Cercocebus sebaeus*. The mean RBC values were not significantly (p > 0.05) different. The MCV, MCH, MCHC and RDW values ranges in the four species of monkeys are $80 - 100$ fl, $26 - 32.3$ pg, $33.3 - 33.5$ g/dL and $13.6 - 15.2$ fl, respectively. The leukocytes values in four different species of monkeys are shown in Table 4. The highest mean TWBC ($8.77 \pm 2.4 \times 10^3/\mu\text{L}$) was recorded in the *Cercopithecus mona* species. The values of the TWBC obtained in the monkeys were not significantly different.

The Neutrophil values ranges are $1.1 - 3.4 \times 10^3/\mu\text{L}$, $2.0 - 9.3 \times 10^3/\mu\text{L}$, $0.8 - 1.4 \times 10^3/\mu\text{L}$ and $2.2 - 6.9$ in the four species of monkeys. *Cercopithecus mona* monkey had the widest Neutrophil value range of $2.0 - 9.3 \times 10^3/\mu\text{L}$ while *Erythrocebus patas* had the highest Lymphocyte value of $2.1 \pm 0.2 \times 10^3/\mu\text{L}$. The highest mean platelet count was recorded in *Cercopithecus mona* (291.70 ± 39.8 g/dL). The platelets values recorded in the monkeys were not significantly (p > 0.05) different.

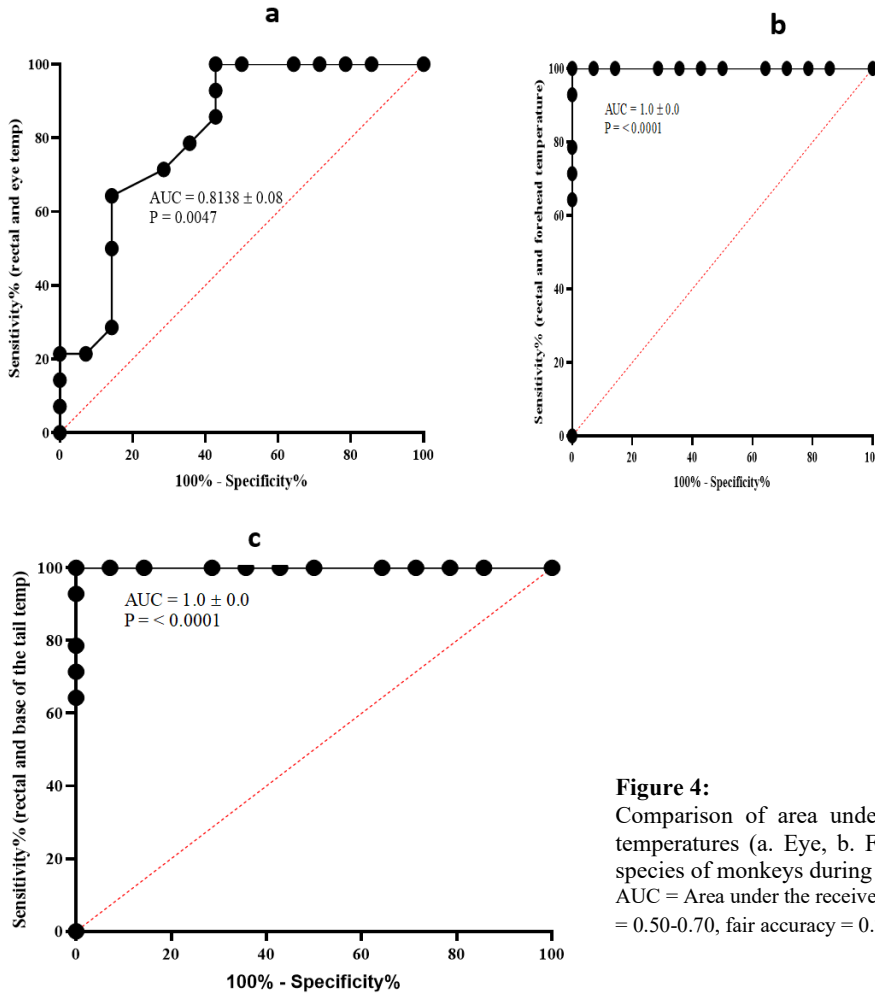


Figure 4: Comparison of area under the curve of rectal and body surface temperatures (a. Eye, b. Forehead and c. Base of the tail) of four species of monkeys during the rainy season (n = 14). AUC = Area under the receiver operating characteristic curve. Low accuracy = 0.50-0.70, fair accuracy = 0.70-0.90, and high accuracy = > 0.90

Table 2: Correlation coefficient of rectal temperature with respiratory and heart rates in in of four species of monkeys during the rainy season

Parameters	Correlation coefficient (r)			
	<i>Cercocebus sebaeus</i> (n = 3)	<i>Cercopithecus mona</i> (n = 3)	<i>Erythrocebus patas</i> (n = 3)	<i>Papio Anubis</i> (n = 5)
RT vs RR	0.1474 ^{ns}	0.8386 ^{ns}	0.9966 ^{ns}	0.5424 ^{ns}
RT vs HR	0.5216 ^{ns}	0.9216 ^{ns}	0.2833 ^{ns}	-0.5280 ^{ns}
RR vs HR	-0.7670 ^{ns}	0.9843 ^{ns}	0.2035 ^{ns}	0.0774 ^{ns}

ns = p>0.05

Table 3: Erythrocytic parameters of four species of monkeys during the rainy season (mean ± SEM) during the rainy season (mean ± SEM)

Parameters	<i>Cercocebus sebaeus</i>	<i>Cercopithecus mona</i>	<i>Erythrocebus patas</i>	<i>Papio Anubis</i>
PCV (%)	46.33 ± 8.7 (61.0 – 31.0)	38.33 ± 7.8 (54.0 – 30.0)	40.00 ± 1.0 (42.0 – 39.0)	36.80 ± 6.5 (57.0 – 17.0)
Hb (g/dL)	15.43 ± 2.9 (20.3 – 10.3)	12.77 ± 2.6 (18.0 – 10.0)	13.33 ± 0.3 (14.0 – 13.0)	12.28 ± 2.1 (19.0 – 5.7)
RBC (x 10 ⁶ /μL)	5.26 ± 1.0 (7.0 – 3.4)	4.37 ± 0.9 (6.2 – 3.4)	4.56 ± 0.1 (4.7 – 4.5)	4.156 ± 0.6 (5.9 – 2.2)
MCV (fl)	86.0 ± 1.2 (88.0 – 84.0)	85.33 ± 1.5 (88.0 – 83.0)	87.33 ± 1.5 (90.0 – 85.0)	88.40 ± 3.3 (100.0 – 80.0)
MCH(pg)	29.53 ± 0.4 (30.3 – 29.0)	29.27 ± 0.1 (29.4 – 29.1)	29.20 ± 0.4 (29.9 – 28.6)	29.0 ± 1.0 (32.3 – 26.0)
MCHC (g/dL)	33.30 ± 0.0 (33.4 – 33.3)	33.30 ± 0.0 (33.3 – 33.3)	33.3 ± 0.0 (33.3 – 33.3)	33.36 ± 0.04 (33.5 – 33.3)
RDW (fl)	14.40 ± 0.1 (14.6 – 14.2)	14.27 ± 0.2 (14.6 – 13.9)	14.07 ± 0.1 (14.2 – 13.8)	14.18 ± 0.3 (15.2 – 13.6)

Maximum – minimum in parenthesis

PCV = Packed cell volume, Hb = Haemoglobin concentration, RBC = Red blood cell count, MCV = Mean corpuscular volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration.

Table 4:Leukocytes parameters of four species of monkeys during the rainy season (mean \pm SEM) during the rainy season (mean \pm SEM)

Parameters	<i>Cercocebus sebaeus</i>	<i>Cercopithecus mona</i>	<i>Erythrocebus patas</i>	<i>Papio Anubis</i>
TWBC (x 10 ³ /μL)	4.97 \pm 1.9 (8.7 – 2.4)	8.77 \pm 2.4 (13.5 – 5.6)	3.88 \pm 0.3 (4.2 – 3.2)	7.80 \pm 1.9 (15.1 – 4.3)
NEU (x 10 ³ /μL)	1.9 \pm 0.6 (3.4 – 1.1)	4.8 \pm 2.3 (9.3 – 2.0)	1.2 \pm 0.2 (1.4 – 0.8)	3.5 \pm 0.9 (6.9 – 2.2)
LYM (x 10 ³ /μL)	1.8 \pm 0.1 (1.9 – 1.6)	1.5 \pm 0.4 (2.2 – 0.9)	2.1 \pm 0.2 (2.5 – 1.7)	1.6 \pm 0.1 (1.9 – 1.4)
MON (x 10 ³ /μL)	0.1 \pm 0.04 (0.2 – 0.1)	0.2 \pm 0.10 (0.3 – 0.1)	0.1 \pm 0.01 (0.1 – 0.1)	0.2 \pm 0.04 (0.3 – 0.1)
EOS (x 10 ³ /μL)	0.01 \pm 0.00 (0.01 – 0.01)	0.01 \pm 0.00 (0.01 – 0.01)	0.01 \pm 0.00 (0.01 – 0.01)	0.01 \pm 0.00 (0.01 – 0.01)
BAS (x 10 ³ /μL)	0.0 \pm 0.0 (0.0 – 0.0)	0.0 \pm 0.0 (0.0 – 0.0)	0.0 \pm 0.0 (0.0 – 0.0)	0.0 \pm 0.0 (0.0 – 0.0)
Platelets (x 10 ³ /μL)	237.67 \pm 79.0 (384.0 – 113.0)	291.70 \pm 39.8 (369.0 – 237.4)	173.67 \pm 9.9 (185.0 – 154.0)	212.6 \pm 40.2 (332.0 – 82.0)
MPV (fl)	8.00 \pm 0.1 (8.1 – 7.9)	8.27 \pm 0.7 (9.6 – 7.3)	8.53 \pm 0.4 (9.2 – 7.8)	7.6 \pm 0.1 (8.0 – 7.3)

Maximum – minimum in parenthesis

TWBC = Total white blood cell count, NEU = Neutrophil count, LYM = Lymphocyte count, MON = Monocyte count, EOS = Eosinophil count, BAS = Basophil count, MPV = Mean platelet volume.

DISCUSSION

The prevailing environmental parameters, dry-bulb temperature and relative humidity obtained in the current study during the rainy season are characteristic of the season. Low air temperature and high relative humidity have little impact on thermoregulatory mechanisms of animals because at low air temperature the body homeostatic apparatus does little to keep the body temperature within the normal range. Stitt and Hardy (1971) reported the thermoneutral zone of monkey to be within the range of 25 - 35°C. The value of ambient temperature recorded in this study was largely within the established thermoneutral zone. Basic clinical parameters of monkeys in the captive are very important basis for the evaluation of the wellbeing and health status of the animals (Pasciu *et al.*, 2023). Seasons of the year, hours of the day have been reported to exact significant influence on these parameters and therefore their interpretation in drawing inference on the state of the health and wellbeing of the monkeys must be carried out with the cognizance of the impacts of these factors. The results of the environmental parameters indicated high relative humidity and low ambient temperature which are characteristic of the rainy season (Oke *et al.*, 2021). As the ambient temperature increases, the body temperatures tend to also increase, but rectal temperature is maintained within a limited range for homeostatic purposes. The values of rectal temperature obtained in the four species of monkey in the captive are a reflection of the thermoregulatory capacities of the animals. Normal rectal temperature range of 38.0 – 39.5°C has been reported in *Macaca fascicularis* hand caught and restrained for examination. The results of the current study show that the rectal temperature ranges of *Cercocebus sebaeus* (37.8 – 39.1°C), *Cercopithecus mona* (37.5 – 39.6°C), *Erythrocebus patas* (37.5 – 38.6°C) and *Papio Anubis* (37.4 – 39.6°C) were all close to the range of normal rectal temperature reported in cynomolgus macaques (Laffins *et al.*, 2017). The findings indicate that the rectal temperature of the four species of monkey recorded in this study were normal and could serve as basis for further studies. The results of the body surface temperature recorded in the eye, forehead and base of the tail regions of the body varied

significantly across the different regions of the body. The values of the body surface temperatures recorded in the monkeys were within the range of 34 to 37°C reported by Baker *et al.* (1976) in undisturbed animals. Body surface temperatures are largely influenced by the prevailing environmental parameters, but some regions of the body are much influenced than others (Thompson *et al.*, 2017; Ake *et al.*, 2023b). The eye temperature in particular has been considered reliable, stable and with reduced influence from environmental parameters when compared to other parts of the body (da Costa *et al.*, 2024). The findings of the study indicate that the eye temperature in the different species of monkeys was the closest to the rectal temperature. The result is in agreement with the previous studies that the eye temperature was stable and could be a reliable alternative to the rectal temperature (Ake *et al.*, 2023b). The base of the tail temperature was also not too far from the rectal temperature; apparently the anatomical structures around the tail and the root of the tail close to the rectal orifice of the monkey are much more exposed to the direct effect of air temperature when compared with other non-primate animals. Finding reliable and accurate alternative to rectal temperature measurement requires further studies and applications of mathematical models in establishing the validity of the method.

The relationships between the rectal temperature and body surface temperature were not significant in this study. Respiratory and heart rates have been reported in previous studies to have some degree of association with increase in body temperature (Jensen and Brabrand, 2015; Heal *et al.*, 2022). The meteorological conditions prevailing during the data collection were within the thermoneutral comfort for the monkeys, therefore does not require additional responses from the respiratory or cardiovascular system to maintain adequate thermoregulatory responses. The cardiorespiratory values recorded might have been influenced by the chemical use for restraint. The combination of ketamine and xylazine has been previously reported to reduce respiratory rate and the heart rate in monkeys (Hernández-Godínez *et al.*, 2019; Archer *et al.*, 2025). This must be taken into perspective, especially when

recording the basic physiological parameters of monkeys requires the use of anesthetic agents.

Established haematological values are of great importance for clinical diagnosis, determination of treatment outcomes, diseases prevention and for biomedical research purposes (Haile *et al.*, 2023). The findings in the haematological parameters evaluated in the study apparently showed no species significant difference. The results are consistent with the reports from several studies (Nakayama *et al.*, 2017; Koo *et al.*, 2019; Ogunro *et al.*, 2019; Perez-Brigido *et al.*, 2021; Bakker *et al.*, 2023). Several other studies in monkeys have indicated the influence of age, sex and especially living conditions on haematological parameters (Sugimoto *et al.*, 1986; Xie *et al.*, 2014; Yu *et al.*, 2019). Sugimoto *et al.* (1986) reported larger percentage of Lymphocyte compared to the percentage of Neutrophil in Monkeys from birth to about 4 years of age but the relationship is inverted as the monkeys become adults. The reverse is true in the adult monkeys used in this study especially in *Cercocebus sebaeus*, *Erythrocebus patas* and *Papio Anubis*. The higher percentage of Neutrophil compared to percentage of Lymphocytes was only recorded in *Cercopithecus mona*. Some other studies have also reported varied values in the percentage of Neutrophil to that of Lymphocytes in different species of Monkeys (Schoorman *et al.*, 2004; Capitanio *et al.*, 2023). The values of haematological parameters obtained in this study will add to the existing clinical measurement in different species of monkeys in the captive, which will aid practicing clinicians and researchers to draw inference which could help in arriving at a sound clinical judgment and interpretation, respectively. In conclusion, the basic thermoregulatory apparatus of the different species of monkeys were not significantly different and the values recorded were within the established range for the monkey in the tropical region. The eye temperature was the closest to the rectal temperature and can serve as a reliable and valid alternative. Haematological parameters were not significantly different across the species studied.

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