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THE EFFECT OF HIGH TEMPERATURE ON SOME BIOCHEMICAL PARAMETERS OF THE NILE RATE *ARVICANTHUS NILOTICUS*

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ABSTRACT

This study was designed to determine the lethal temperature of the Nile rat *Arvicanthus niloticus* and the suitable biochemical indicators of heat stress. All experimental rats completely collapsed after one hour exposure to 42°C, and this was considered as the lethal temperature. Male and female rats loose 3.4% and 4.3% of their body weights, respectively. Plasma osmolality significantly increased (P<0.01) from (334.2 ± 5.8 to 335.5 ± 8.7 m.osm/L) in the males and from (334.2 ± 8.0 to 340.7 ± 8.8 m.osm/L) in the females. The number of red blood cells increased significantly (P<0.05) in females only from (5.5 ± 0.3 to 6.4 ± 0.4 cell/ml), while the packed cell volume (PCV) decreased from (38.3 ± 3.1 to 32.5 ± 3.9%) in males and from (38.2 ± 1.9 to 32.3 ± 3.1%) in females. Hypervolumia and failure of the circulatory system were considered as the main causes of death. *Arvicanthus niloticus* is recommended as a good model for the study of heat stress syndromes. Osmolality, packed cell volume (hematocit) and red blood cells (erythrocyte number) are also recommended for measuring the general condition check.

Keywords: *Arvicanthus niloticus*, Erythrocytes, Lethal Temperature, Nile Rat, Osmolality, PCV

INTRODUCTION

Mammals are most active homeotherms that can tolerate a wide range of thermal environment. They can efficiently maintain a constant body temperature irrespective of the fluctuation in environmental temperature **[1]**. Many of the body structures and

physiological processes contribute toward the maintenance of a steady core temperature within a range of 36°C to 40°C, the optimum range for enzymes activity **[2]**. At 40°C the enzymes denatured and their activities ceased, and at 42°C death may occur. Mammals tolerate change in surface and body temperature by vasodilatation, panting and sweating which speed evaporation and cool the body. However, when the body temperature exceeded the core temperature, the animal fails to get rid of the heat **[3]**. Prolonged exposure to high temperature causes physical stress, exhaustion and tissue damage or even death **[4]**. When the animal is exposed to a high temperature its blood vessels become dilated and the flow of the blood to the surface of the skin increases **[5-7]**. Heat can be lost in the surrounding atmosphere by evaporation, but continuous exposure might raise the blood volume.

The response of heat stress was found to depend on many factors such as the ambient humidity, wind velocity, level of feeding, hydration, body size, age and acclimatization to heat **[1, 3, 8-10]**. Several changes in the blood constituents were observed under heat stress **[11]**. A change in packed cell volume was found to fluctuate in different animals **[11-14]**. An increase in the level of the blood glucose, urea and plasma enzymes was also reported **[15, 16]**.

In the present study an experiment was designed to determine the lethal temperature of the Nile rat *Arvicanthus niloticus*, the influence of high temperature on the animal body and its response to heat stress. The indicators to heat stress and possible cause of death were also suggested.

MATERIAL AND METHODS

Animals and Treatment

Specimens of the Nile rat *Arvicanthus niolticus* (35 males and 35 females), with mean body weight (117 kg), were collected from the cultivated area in Khartoum. Animals were kept for an acclimatization period of 2 weeks, fed with cucumber and dry bead and supplied with water. Five rats from each sex were used as control.

Experiment Design

Each rat was weight before and after the experiment. All experiments were conducted in a controlled- temperature chamber, with well ventilation and continuous oxygen supply. Five rats of each sex were first exposed to individually to a temperature range of (40°C to 42°C) for about 2 hours, until they became completely helpless. The maximum temperature they tolerated was considered as the “Lethal temperature”.

Each of the remaining rats was kept in a separate cage and exposed to the lethal temperature, previously determined, for one hour.

Blood Sampling and Analysis

Two samples of blood (2ml) were collected from each of the experimental and control rats in to vial tubes containing anticoagulant (EDTA). One samples was used immediately to determine the packed cell volume (PCV) and the red blood cell count (RBCs, erythrocytes) according to **[17]**. The other sample was allowed to clot and centrifuged at 5000g for 10 minute. Blood plasma was then collected and used to determine the blood osmolality by a Klauer-asmometer. Mean and standard deviation (SD) of each parameter were calculated for each group. Student *t-test* was used to compare means according to **[18]**.

RESULTS AND DISCUSSION

After one- hour exposure to 40°C all rats became in active and completely helpless. Significant decrease in the body weight and an increase in plasma osmolality, packed cell volume and erythrocyte number were encountered **(Table 1 & 2)**. Females lose more weight than males **(Figure 1)**. More weight loss was observed for small-sized females while the loss in body weight of males did not show defined patter in relation to the initial body weight. Significant increase in plasma osmolality ($p < 0.01$) was observed in both experimental males and females, compared to control rats **(Figure 2)**. Packed cell volume significantly decreased ($p < 0.05$) in both sexes while erythrocytes number increase only in females **(Figure 3)**.

In the present experiment, the "lethal temperature" if the Nile rat *Arvicanthus niloticus* was found to be 42°C. This agrees with the upper temperature reported for most mammals, including humans **[19]**, but disagree with 40°C reported by **[13]** for the Nile rat. Kilner jars used by Ahmed, probably, prevented the rats to dissipate heat.

The observed decrease in body weight and the increase in plasma osmoloality and packed cells volume of all experimental rats were good indicators of of potential water loss. Excessive loss of water through sweating and evaporation eventually lead to severe circulatory problems, due to decrease in water content of the blood **[6]**. It is clear that many systems and biochemical and physiological mechanisms were involved to promote heat loss and to maintain a set point temperature in the rat. The hypothalamus and respiratory and circulatory systems, probably, coordinated to increase the breathing rate, heartbeat, blood flow and, consequently, heat loss. The presence of water observed in the rat fur under the chin and throat, proved that the rats

lost heat by sweating and evaporation though the skin. **[13]** recorded the same observations in the Nile rat, and **[20]** reported the same observations in rats and rabbits. Respiratory evaporation could, possibly, be another way by which these rats lost heat. Panting increased the movement of the air in the upper respiratory tract and increased the evaporative cooling. These two mechanisms were suggested as the main strategies by which the rats have combated overheating.

The observed increase in packed cells volume and erythrocyte number clearly explained the biochemical response to the rats to heat. The increase in osmolality could be due to an increase in the concentration of hydrogen ions, accumulation of lactic acid and release of potassium ions from the cells. Exposure of the rats to high temperature decreased the affinity of the haemoglobin molecules to oxygen. Hence, anaerobic respiration took place, the level of carbon dioxide increased and lactic acid accumulated. This could eventually decrease the pH of the blood and lead to acidosis, which was, possibly, another cause of system failure and death. Evaporation due to heat exposure potentially deprived the body and its compartment from water and led to dehydration accompanied with hyperthermia. Progressive dehydration and decrease in plasma volume, probably, caused reduction in cardiac output, consequently, there was no sufficient provision of oxygen to transfer heat to the skin.

It was possible that exhaustion had led to "heat stroke" that resulted in the failure of the normal thermoregulatory mechanisms. When heat gained by the rats exceeded the heat lost, the thermoregulatory mechanisms were unable to prevent an excessive rise in the body core temperature. Consequently, heat exhaustion developed and proceeded to collapse and death. Hypothermia was definitely another most important cause of a circulatory system failure and death of these rats.

CONCLUSION

The Nile rat can tolerate a temperature less than (40°C), but exposure to this ambient temperature for one hour led to progressive dehydration and hyperthermia and ended to death of all experimental rats. Water loss was indicated by an increased packed cells volume and hypovolumia that impaired the ability of the body to dissipate heat by peripheral vasodilatation and sweating. Hypovolumia also decreased the efficiency of the thermoregulatory mechanisms and eventually led to failure of the circulatory system and death. The Nile rat *Arvicanthus niloticus* is recommended as a good model for the study

of heat stress syndromes, and osmolality, packed cells volume and erythrocytes number as good measurements for a general condition check.

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Table 1: Water Loss (%) From Males and Females *Arvicanthus niloticus* After Exposure to 42°C for 1 Hour

Number of Rats	Males			Femalex		
	Initial Body Weight (g)	Final Body Weight (g)	Water Loss (%)	Initial body Weight (g)	Final body Weight (g)	Water Loss (%)
4	116.8	112.8	3.4	117.4	113.1	4.2
6	118.5	114.4	3.5	117.7	112.4	4.5
3	117.4	113.8	3.1	117.6	112.7	4.2
8	116.8	113.1	3.2	117.8	112.2	4.6
5	115.8	111.3	3.9	117.7	112.6	4.3
6	114.9	111.3	3.1	116.8	111.6	4.5
3	117.4	113.3	3.5	116.9	111.9	4.3
M ± SD	116.8 ±1.2	112.9 ±1.2	3.4 ± 0.3	117.4 ± 0.4	112.4 ± 0.5	4.3 ± 0.2

Table 2: The Value of Some Blood Parameters in Control and Experimental Rats *Arvicanthus niloticus* According to Sex

Subjects	Plasma osmolality (m.osm/L)	Packed cell volume (%)	Red cells count (cell/ml)
Males: Control	334.2 ± 5.8	38.3 ± 3.1	5.4 ± 0.4
Experimental	335.5 ± 8.7**	32.5 ± 3.9*	5.4 ± 0.3
Females: Control	334.2 ± 8.0	38.2 ± 1.9	5.5 ± 0.3
Experimental	340.7 ± 8.8**	32.3 ± 3.1*	6.4 ± 0.4*

NOTE: **P*<0.05; ***P*<0.01

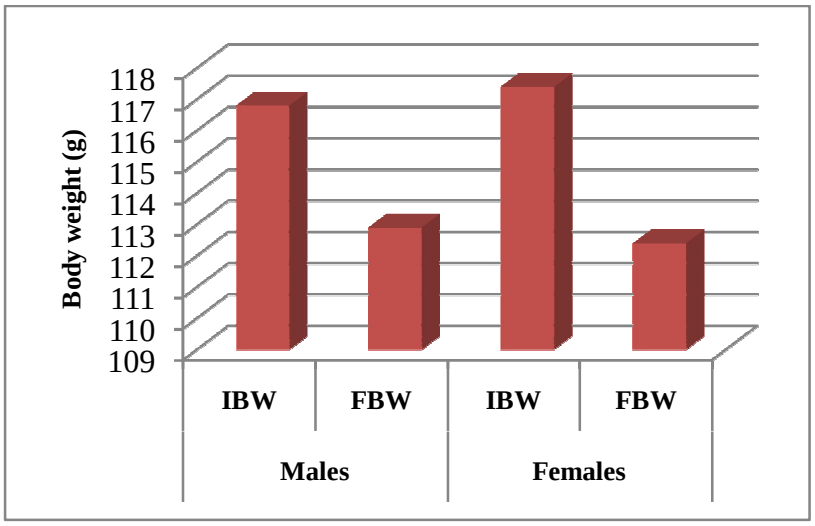

Figure 1: Body Weight in Males and Females *Arvicanthus niloticus* After Exposure to 42°C for 1 Hour

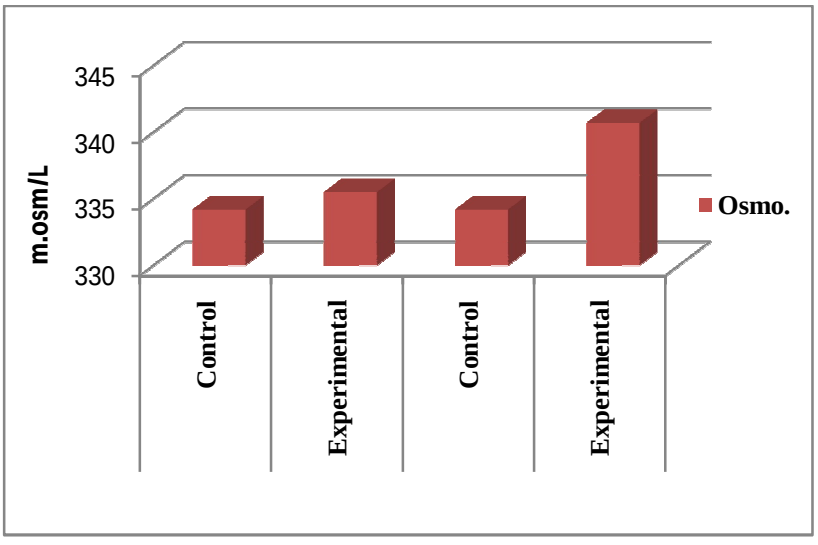

Figure 2: Plasma Osmolality in Males and Females *Arvicanthus niloticus* After Exposure to 42°C for 1 Hour

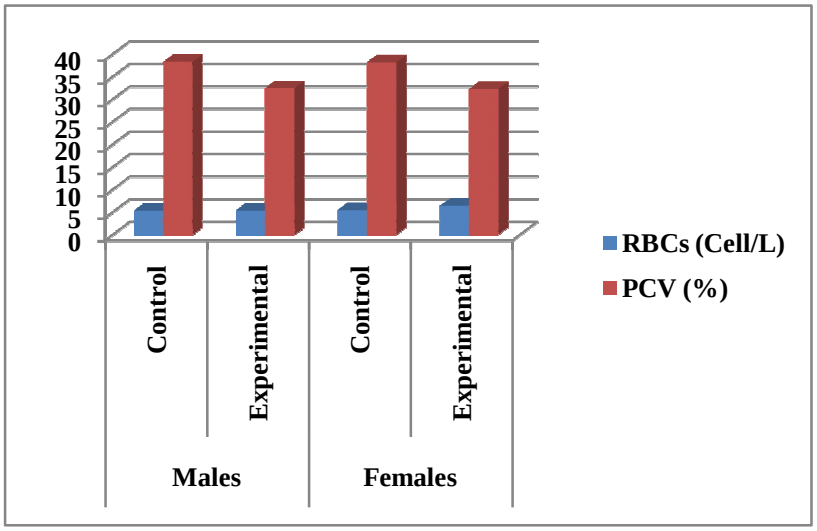

Figure 3: RBC's and PCV in Males and Females *Arvicanthus niloticus* After Exposure to 42°C for 1 Hour