

Rectal temperature responses of donkeys administered with ascorbic acid and subjected to load carrying (packing) during the harmattan season in Nigeria

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Abstract The aim of the experiment was to evaluate the effect of 4-h load carrying (packing) on donkeys administered with ascorbic acid (AA) during the harmattan season. Six donkeys administered orally with ascorbic acid (200 mg/kg) and subjected to packing served as experimental animals, while six others given only distilled water served as control animals. The rectal temperature (RT) of each donkey and dry-bulb temperature (DBT) and relative humidity (RH) of the research pen were recorded at 0600 hours pre-packing; while post-packing, the values were obtained at 1430, 1600 and 1800 hours. The DBT values (ranges) recorded before, during and after packing were 13.7 ± 1.3 °C (11–15 °C), 28.4 ± 1.0 °C (22.7–30.3 °C) and 30.6 ± 3.0 °C (19.8–45 °C), respectively. The highest temperature–humidity index (THI) of 83.4 ± 6.9 was obtained at 1430 hours after packing, and the value decreased to 64.2 ± 5.8 at 1800 hours. The thermal environmental conditions were outside the thermoneutral zone for the donkeys. The RT values recorded immediately after packing did not differ ($P > 0.05$) in experimental and control donkeys; but at 1600

and 1800 hours, values obtained in control donkeys (38.48 ± 0.12 and 38.12 ± 0.12 °C, respectively) were significantly higher ($P < 0.05$) than those recorded in experimental donkeys (38.16 ± 0.14 and 37.85 ± 0.14 °C, respectively). In conclusion, administration of ascorbic acid reduced the rise in RT due to packing and may be of value in the amelioration of adverse effects of heat stress associated with work in donkeys.

Keywords Rectal temperature · Ascorbic acid · Load carrying · Harmattan season

Abbreviations

AA	ascorbic acid
DBT	dry-bulb temperature
RH	relative humidity
RT	rectal temperature
THI	temperature–humidity index

Introduction

The rectal temperature (RT) is an important parameter for the immediate evaluation of health status and adaptability of animals (Ayo et al. 2008). It can be measured easily in rural areas and during transportation of animals (Minka and Ayo 2007c). Donkeys adapt well to different environmental conditions by compensatory changes in values of RT (Minka and Ayo 2007a). The act of load carrying (packing) generates heat produced by muscular work (Pal et al. 2002), and the associated heat stress in donkeys induces the generation of reactive oxygen species (Dey et al. 2010).

Reactive oxygen species are generated in large quantities under stressful conditions in horses (Piccione et al. 2007,

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2008) and humans (Tauler et al. 2003; Kurcku 2010) subjected to muscular exercise, and they considerably deplete the natural antioxidants in body tissues. As an ameliorative effect of the antioxidant, ascorbic acid (AA) has been demonstrated in stress due to heat and in transportation by road in poultry (Surai 2006; Minka and Ayo 2008, 2011; Ajakaiye et al. 2011), transportation by road in goats (Minka and Ayo 2007b, 2010) and pigs (Asala et al. 2010a, b; 2011; Adenkola et al. 2010). It is conceivable that AA supplementation may serve as a prophylactic antioxidant and anti-stress agent for use by small-scale donkey farmers in the rural areas. There is paucity of information on the role of AA as a dietary substance in the amelioration of stress in donkeys subjected to packing during the thermally stressful cold-dry (harmattan) season (Ayo et al. 2011) in the West African sub-region.

The harmattan season is one of the three (harmattan, hot-dry and rainy) seasons in the zone, occurring between November and February (Ayo et al. 2011). It is characterised by cold-dry wind laden with dust. The season has generally low dry-bulb temperature (DBT) in the morning and evening hours, while the afternoon hours have high DBT values. The relative humidity (RH) is generally low throughout the day (Ayo et al. 2011).

The aim of the present study was to determine the RT responses of donkeys administered with ascorbic acid subjected to packing during the harmattan season.

Materials and methods

Study area

The study was carried out during the harmattan season. The study area covered an area from Ahmadu Bello University (ABU), Zaria (11°10' N, 7°38' E) to Panhauya village (11°7' N, 7°37' E), Kaduna State, located in the Northern Guinea Savannah zone of Nigeria.

Animals and management

Twelve apparently healthy pack donkeys, between 3–4 years and weighing between 98 and 100 kg served as subjects. The donkeys were obtained from the donkey market at Sheme, Faskari (11°43' N, 7°02' E), Katsina State, Nigeria. They were in good body condition with a score of seven (Pearson and Ouassat 1996). The donkeys were fed with guinea corn straw and groundnut hay in the proportion of 4:1 and supplemented with wheat bran. In addition, 1 kg of whole sorghum grain was fed to each donkey per day throughout the experimental period. The donkeys were given access to water ad libitum during the experimental period, and they had free access to salt lick.

Experimental methods

The experimental donkeys ($n=6$) were administered orally with ascorbic acid at a dose rate of 200 mg/kg, while the control donkeys ($n=6$) were given distilled water only before packing on each day of the experiment, which lasted for 3 days. The donkeys trekked a distance of 20 km (to and fro) from the Research Pen to Panhauya village on the outskirts of ABU, Zaria. The road was narrow with stony terrain and undulating, typical of the route taken by pack donkeys in the zone.

Packing procedure

All the donkeys were loaded according to standard packing rules as described by Oudman (2002). Briefly, all loads were comfortably balanced evenly, with similar weight and bulk on either side of the animal. Two layers of padding material were placed between the pack-load and the donkey's back to protect the skin. The first layer was made of cotton-like material to absorb heat, while the second layer was a sack filled with straw that was stitched into sections to prevent the straw from falling into one end. Two sacks attached at the centre were slung on either side over the back of the donkey and filled with sand weighing 50 % of the body weight (Pal et al. 2002). The donkeys began the journey after loading at 1000 hours on each experimental day. The donkeys were used for work as described by Pal et al. (2002). They were subjected to work for 3 days: 4 h (from 1000 to 1400 hours) each day, interspersed by 1 day's rest between each working day.

Recording of thermal environmental conditions

The pre-packing and post-packing values of DBT and RH were taken at 0600 hours, while post-packing values were recorded at 1430, 1600 and 1800 hours after completion of the work at the experimental site by using a dry- and wet-bulb thermometer (Brannan, England), and RH was determined using a centigrade scale. Temperature–humidity index (THI) was calculated using the method of Yousef (1985):

$$\text{THI} = (0.35 t_d + 0.65 t_{wb}) \times 1.8 + 32$$

where

t_d dry-bulb temperature (in degrees Celsius)

t_{wb} wet-bulb temperature (in degrees Celsius).

Measurement of rectal temperature

The pre-packing and post-packing values of RT were recorded daily from each donkey using a standard method

Table 1 Thermal environment conditions from the study period (mean±SEM)

Period	Dry-bulb temperature (°C)	Relative humidity (%)	THI
Pre-packing 0600 hours	13.70±1.30 (11–15)	20.70±3.33 (14–24)	46.50±2.01
During packing 1000–1400 hours	28.40±0.99 (22.7–30.3)	37.70±15.03 (11–63)	71.80±2.21
Post-packing 1430 hours	36.50±5.22 (27–45)	41.70±16.80 (14–72)	83.40±6.87
1600 hours	28.80±4.66 (19.8–35.3)	13.30±3.83 (9–20)	77.90±2.36
1800 hours	26.50±2.59 (22–31)	15.00±2.08 (11–18)	64.20±5.81
Overall mean±SEM	26.40±2.96	22.70±5.07	68.40±6.78

Values in parentheses are minimum–maximum
 THI temperature–humidity index

(Ayo et al. 2008). Measurements of RT were recorded at 0600 hours before work in the morning. Post-work measurements of RT were done at 1430 hours (30 min after stopping work), 1600 hours (2 h after stopping work) and 1800 hours (4 h after stopping work). The authors (five in number) commenced the measurements and recordings simultaneously. Three authors were responsible for recording the RTs of two donkeys which took 6 min, while two others were responsible for RT recordings of three donkeys each, taking additional 3 min. Altogether, it took the authors 9 min to take all the readings. The additional 6 min covered the time it took to calmly restrain the donkeys. It took 15 min to measure the RTs of all the donkeys. The RT was recorded using a digital clinical thermometer (Electron Thermometer, COCET, Kangfu Medical Equipment, Zhejiang Yueqinq, China), inserted about 3.5-cm deep into the rectum of each donkey until an alarm sound was heard, indicating the end of the reading, usually after 1 min.

Data analysis

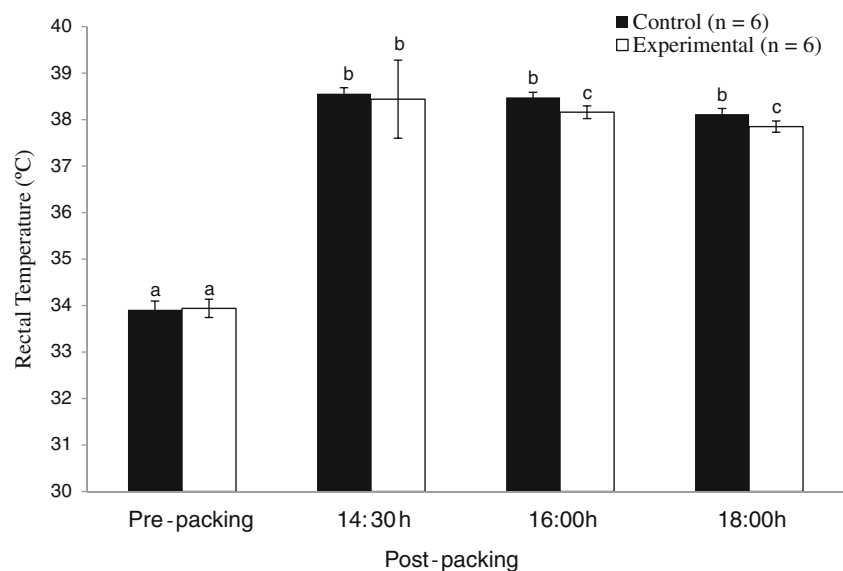
The data obtained were expressed as mean±standard error of the mean (mean±SEM) and subjected to one-way analysis

of variance, followed by Tukey's multiple comparison post hoc test, using GraphPad Prism 4.0 for Windows (GraphPad Software, San Diego, CA, USA) to compare differences between the means obtained from the control and experimental donkeys. Values of $P<0.05$ were considered significant.

Results

The overall mean DBT recorded during the experiment was 26.4 ± 3.0 °C while that of the RH was 22.7 ± 5.1 % (Table 1). At 0600 hours, DBT was lowest (13.7 ± 1.3 °C) but rose ($r=0.7331$, $P<0.01$) gradually as the hours of the day increased to a peak value of 36.5 ± 5.2 °C at 1430 hours after packing. The DBT increased ($P<0.05$) from 13.7 ± 1.3 °C at 0600 hours to 26.5 ± 2.0 °C at 1800 hours. RH was low (20.7 ± 3.3 %) at 0600 hours, but rose to the maximum value of 41.7 ± 16.8 % at 1430 hours, and decreased ($P<0.05$) at 1800 hours to 15.0 ± 2.1 % (Table 1). The highest DBT value (36.5 ± 5.2 °C) was recorded at 1430 h. The DBT and RH ranged from 11–45 °C and 9–72 %, respectively. The mean values of

Fig. 1 Effect of packing on rectal temperature responses of donkeys during the harmattan season. Values are means±SEM. Values with error bars having different letters are significantly ($P<0.05$) different



DBT before, during and after packing were 13.7 ± 1.3 , 28.4 ± 1.0 and 30.6 ± 3.0 °C, respectively; while the corresponding RH values were 20.7 ± 3.3 , 37.7 ± 15.0 and 23.3 ± 9.2 %, respectively. The THI obtained at 0600 hours was 46.5 ± 2.0 . The value increased ($P < 0.05$) to the maximum of 83.4 ± 6.9 at 1430 hours after packing but decreased ($P < 0.05$) to 64.2 ± 5.8 at 1800 hours post-packing (Table 1).

Figure 1 shows the RT responses of pack donkeys during the harmattan season. The highest RT values recorded at 1430 hours in control and experimental donkeys were 38.53 ± 0.09 and 38.45 ± 0.14 °C, respectively ($P > 0.05$). In the control donkeys, the post-packing RT value (38.53 ± 0.09 °C) was significantly ($P < 0.05$) higher than the pre-packing value of 34.91 ± 0.19 °C but did not differ ($P > 0.05$) from 38.44 ± 0.84 °C recorded in the experimental donkeys. At 1600 hours post-packing, the RT value of 38.48 ± 0.12 °C recorded in the control donkeys was significantly higher ($P < 0.05$) than that of 38.16 ± 0.14 °C obtained in the experimental donkeys. Thereafter, the value obtained in control donkeys (38.12 ± 0.12 °C) at 1800 hours was higher ($P > 0.05$) than that recorded in experimental donkeys (37.85 ± 0.14 °C) (Fig. 1).

In the experimental and control donkeys, there were significant ($P < 0.01$) and positive correlations between the thermal environmental conditions and RT values (Table 2). The THI was positively and significantly correlated with the RT of both control ($r = 0.8312$) and experimental ($r = 0.8507$) donkeys (Table 2).

Discussion

The DBT values of 11–45 °C obtained from the study period were predominantly outside the thermoneutral zone of 23–32 °C established for donkeys in tropical and sub-tropical regions (Fielding and Krause 1998; Ayo et al. 2008). The wide DBT range of 34 °C, characteristic of the season, confirmed the established

findings of Ayo et al. (2011) and Adenkola et al. (2010) that the harmattan season is thermally stressful to livestock. The results also showed that the harmattan season had mostly low RH, typical of the season. The mean RH value of 22.7 ± 5.1 %, with the range of 9–72 %, showed that the values were outside the thermoneutral zone of 30–70 %, established for donkeys in the temperate regions (Sainsbury 1989). The THI is an effective means of expressing comfort zone (Marai and Habeeb 2010). Thus, the highest value of THI was recorded at 1430 hours post-packing, when the maximum values of DBT and RH were obtained. This finding agrees with the result obtained by Dzenda et al. (2011) who showed that THI rose with increase in DBT and RH. In donkeys, THI above 80 denotes discomfort (Yousef 1985). Therefore, at values of THI greater than 80, the donkeys must adopt thermoregulatory mechanisms in order to maintain thermal balance. If the mechanisms fail, the body temperature begins to rise. In the present study, a significant increase in RT of control and experimental donkeys subjected to packing under high THI value was recorded at 1430 hours post-packing. The significant difference in RT values obtained between experimental and control donkeys at 1600 and 1800 hours post-packing showed that experimental donkeys exhibited better thermoregulatory mechanisms to maintain thermal equilibrium than the control donkeys not administered with AA. The result agreed with the finding Asala et al. (2010b) that AA decreased RT in pigs subjected to stress due to road transportation during the hot-dry season in the zone.

The significant increase in RT after packing in the Southern Guinea Savannah zone of Nigeria agrees with the finding of Minka and Ayo (2007a) that packing increased the values of RT in donkeys. The significant decrease in RT in experimental group compared to that of the control group at 1600 and 1800 hours shows that AA modulated the body temperature of donkeys which increased due to packing. Minka and Ayo (2007b) demonstrated that AA decreases RT values in goats. AA directly alters thermal set point by decreasing prostaglandin output, whose turnover increases during stress (Candelario-jalil et al. 2006) and which has a direct effect on the hypothalamic thermoregulatory zone. Therefore, AA, apparently, by altering the prostaglandin output, ameliorates the adverse effect of heat stress occurring during work in the donkey.

Conclusion

Administration of ascorbic acid reduced the rise in RT due to packing during the harmattan season and may be of value in the amelioration of adverse effects of heat stress associated with work in donkeys.

Table 2 Relationships between thermal environment parameters and rectal temperature

Correlated parameters	Control (n=6)	Experimental (n=6)
Hour of the day and rectal temperature	0.9130**	0.9091**
Dry-bulb temperature and rectal temperature	0.9267*	0.9355*
Relative humidity and rectal temperature	0.7950*	0.8100*
Temperature–humidity index and rectal temperature	0.8312*	0.8507**

* $P < 0.01$; ** $P < 0.001$

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