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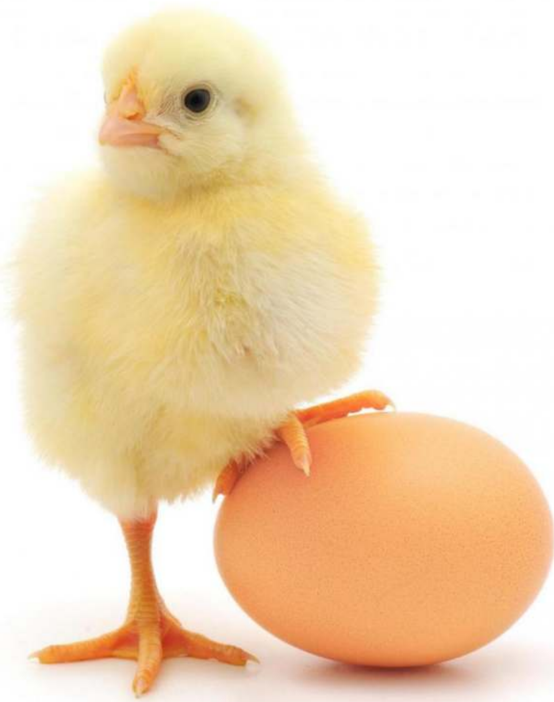

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Effects of Ascorbic Acid on Diurnal Variations in Rectal Temperature of Shaver Brown Pullets During the Hot-Dry Season

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Abstract: Experiments were performed with the aims of determining the fluctuation in rectal temperature (RT) of Shaver Brown pullets and the effect of vitamin C or Ascorbic Acid (AA) administration on the fluctuation during the hot-dry season in the Northern Guinea Savannah zone of Nigeria. The RT of 25 experimental and 25 control pullets were measured every hour from 06:00 to 19:00 hours for three days, three days apart, with a standard clinical thermometer. The experimental pullets were individually administered orally with AA in drinking water at the dose of 52 mg kg^{-1} dissolved in sterile water, while the control pullets were given only normal water, without AA addition. In experimental pullets, the lowest hourly RT of 41.0±0.1°C was obtained at 06:00 hours, while the highest value of 41.6±0.0°C was recorded at 14:00 and 15:00 hours ($p<0.001$). In control pullets, the RT rose significantly from 41.0±0.1°C at 06:00 hours to maximum values, ranging from 41.5±0.0°C to 41.8±0.0°C at 11:00 to 17:00 hours ($p<0.001$). There was a positive and significant ($p<0.05$) correlation between hours of the day and RT values in experimental ($r = 0.589$) and control ($r = 0.542$) pullets. The overall RT of pullets administered with AA was significantly ($p<0.05$) lower than that of control pullets (41.3±0.1°C and 41.5±0.1°C, respectively). The minimum and maximum hourly RTs of experimental pullets were 40.3±0.1 and 42.0±0.0°C, respectively, while those of control pullets were 40.7±0.1 and 41.9±0.0°C, respectively ($p<0.001$). The dry-bulb temperature was negatively correlated with RT in experimental pullets ($r = -0.240$, $p>0.05$); but in control pullets, the relationship was positive and significant ($r = 0.655$, $p<0.05$). The pullets administered with AA had consistently lower RT values than those of control pullets. It is concluded that AA administration, by modulating the body temperature of pullets during the hot hours of the day, ameliorated the thermally stressful effect of the hot-dry season. This mechanism may be partly responsible for AA-induced enhancement of productivity and health of pullets during the season.

Key words: Heat stress, ascorbic acid, diurnal variations, hot-dry season

Introduction

Common stress factors in modern poultry production in the tropics include high ambient temperature (AT) and relative humidity (RH), which often occur concurrently with other stress factors, especially during the hot-dry season (Igono *et al*., 1983). The intensity and duration of the combined effects of AT and RH may vary with hours of the day and their actions on pullets have been shown to induce heat stress (Ayo *et al*., 2005b), which adversely affects poultry production. Therefore, adequate evaluation and efficient prophylactics of its adverse effects may be crucial to poultry productivity in hot-humid zones of the world. It has been established that heat stress is evaluated by measuring the rectal temperature (RT), which is a true reflection of internal body temperature and a reliable index of thermal balance (Bianca, 1976; Ayo *et al*., 1998a, 1998b). The body requirement in ascorbic acid (AA) during heat stress in poultry is greater than the amount synthesized by normal tissues; and its administration to broilers during heat stress has been shown to be beneficial to the body (Balogun *et al*., 1996; Surai, 2002). Also in heat stress, free radicals are generated in the body in such a large quantity that the natural antioxidant defense systems of the body are overwhelmed (Sahota and Gillani, 1995; Altan *et al*., 2003). This results into lipid peroxidation of cytomembranes; and, consequently, cell damage and destruction (Freeman and Crapo, 1982; Meerson, 1986; Seifulla and Borisova, 1990). According to Sen (2001), Tauler *et al*. (2003) and Minka and Ayo (2007a), antioxidant supplementation may provide beneficial effects against stress-induced tissue damage. Balogun *et al*. (1996) showed that AA supplementation improved weight gain and feed efficiency in broiler chickens during the hot-dry season. The Shaver Brown breed is one of the foreign breeds of chickens reared in Nigeria and it is known for its high egg production. Data on the variation in RT of the breed and the effect of AA on the variation during the hot-dry season in hot-humid zones are currently lacking in the available literature.

The aims of the present study were to determine the fluctuation in RT of Shaver Brown pullets and the effect of AA supplementation on the fluctuation during the hot-dry season.

Materials and Methods

The study was performed on Shaver Brown pullets, reared in a Poultry Farm in Zaria ($11^0 10^/$ N, $07^0 38^/$ E),

Table 1: Meteorological Parameters from the Study Period

	Day			
Meteorological Parameter	1	2	3	Mean±SEM
Ambient Temperature,°C:				
Maximum	35	35	36	35.3±0.3
Minimum	22	25	21	22.7±1.2
Dry-Bulb	30.4	30.7	31.9	31.0±0.5
Relative Humidity, %	50	65	63	59.3±4.7
Sunshine Duration, hr/day	5.4	8.2	7.1	6.9±0.8
Wind Direction	South-West	North-West	South-West	

Source: Meteorological Unit, Institute for Agricultural Research, Ahmadu Bello University, Samaru-Zaria

Table 2: Between-Pullet Variations in Rectal Temperature of Shaver Brown Pullets Administered with Ascorbic Acid,°C (Mean±S.E.M; n = 25)

Pullet	Mean±SEM	Minimum	Maximum	Range
V_1	41.3±0.1	40.0	41.8	1.8
V_2	41.4±0.0	40.9	42.0	1.1
V_3	41.4±0.0	40.9	41.8	0.9
V_4	41.3±0.1	40.3	41.9	1.6
V_5	41.3±0.0	40.3	41.8	1.5
V_6	41.4±0.1	40.6	42.0	1.4
V_7	41.4±0.1	40.2	42.0	1.8
V_8	41.4±0.0	40.6	42.0	1.4
V_9	41.3±0.1	40.8	41.9	1.1
V_{10}	41.3±0.1	40.1	42.0	1.9
V_{11}	41.4±0.0	40.9	41.9	1.0
V_{12}	41.3±0.1	40.1	42.0	1.9
V_{13}	41.4±0.0	40.8	42.0	1.2
V_{14}	41.3±0.1	40.0	41.8	1.8
V_{15}	41.3±0.1	40.1	42.0	1.9
V_{16}	41.3±0.1	40.3	42.0	1.7
V_{17}	41.1±0.1	40.0	41.7	1.7
V_{18}	41.3±0.0	40.9	41.9	1.0
V_{19}	41.1±0.1	40.0	41.9	1.9
V_{20}	41.4±0.1	40.7	42.0	1.3
V_{21}	41.4±0.1	40.4	42.0	1.6
V_{22}	41.4±0.1	40.7	42.0	1.3
V_{23}	41.2±0.1	40.3	41.7	1.4
V_{24}	41.4±0.1	40.7	42.0	1.3
V_{25}	41.4±0.1	40.9	42.0	1.1
Mean±S.E.M	41.3±0.01	40.5±0.1	41.9±0.0	1.5±0.1

located in the Northern Guinea Savannah zone of Nigeria. The pullets were obtained at day old from Shimtu Farms, Zaria. Routine vaccinations of birds against common infectious diseases at the recommended doses were carried out. The meteorological parameters of maximum and minimum ambient temperatures, sunshine duration and wind direction for this locality during the study period were collated from the Meteorological Unit of the Institute for Agricultural Research, Ahmadu Bello University, Samaru-Zaria, located at a distance of about 1 km from the experimental site. The dry-bulb temperature (DBT) and RH were recorded in the poultry house during the hourly RT measurements (Table 1). Fifty Shaver Brown pullets, aged 17 weeks and weighing between 0.7-1.8 kg served as subjects. Twelve hours prior to the commencement of the experiment, the pullets were deprived of water. On the experimental day at 05:45 hours, 25 pullets were administered orally with AA individually at the dose of 52 mg kg^{-1} in sterile water. Following total drinking of the medicated water, the pullets, which served as the experimental birds, were immediately given water *ad libitum*. The remaining 25 pullets, which served as control birds, were given normal water *ad libitum,* without AA supplementation throughout the experimental period. During the period, all pullets were fed growers' mash (Feed Masters' Ltd., Kaduna, Nigeria) *ad libitum*. The feed contained: Protein-14.0%; Fat-5.0%; Fibre-7.5%; Calcium-1.0%; Phosphorus-0.4%; Lysine-0.55%; Methionine-0.25%; Energy-2500 Kcal/Kg. Measurements of RT in pullets were taken for three days, three days apart, every hour from 06:00-19:00 hours in April using standard digital clinical thermometers (The Hartman's Company PLC, England), inserted about 2 cm via the cloaca into the rectum for about a minute.

The data obtained were subjected to Student's *t*-test and correlation analysis. Data were expressed as mean±standard error of the mean (mean±SEM). Values of $p<0.05$ were considered significant.

Results

The meteorological parameters from the study period are given in Table 1. The RT minima and maxima together with the standard errors and ranges, shown in Table 2 and 3 described the extent of between-pullet variation at each hour of observation in the experimental and control pullets, respectively. The overall mean hourly RTs for the experimental and control pullets were 41.3±0.1°C and 41.5±0.1°C, respectively ($p<0.001$) (Table 4 and 5). The minimum hourly RT of experimental pullets was 40.3±0.1°C, while that of the maximum was 42.0±0.0°C ($p<0.001$). The difference between minimum and maximum hourly RT of experimental pullets was 1.7±0.1°C, while that of control pullets, with very close minimum and maximum RT values, was 1.2±0.1°C ($p<0.001$) (Table 4 and 5). The mean hourly RT for experimental pullets (Table 4) was lowest at 06:00 hours with the value of 41.0±0.1°C and highest at 13:00 and 16:00 hours with the values ranging between 41.5 to 41.6°C ($p<0.001$). In control pullets, the mean hourly

Table 3: Between-Pullet Variations in Rectal Temperature of Control (without Ascorbic Acid Supplementation) Shaver Brown Pullets,°C (Mean±S.E.M; n = 25)

Pullet	Mean±SEM	Minimum	Maximum	Range
C_1	41.4±0.1	40.7	42.0	1.3
C_2	41.3±0.1	40.2	41.8	1.6
C_3	41.5±0.1	40.9	42.0	1.1
C_4	41.4±0.0	40.7	41.8	1.1
C_5	41.5±0.0	40.7	42.0	1.3
C_6	41.4±0.1	40.2	42.0	1.8
C_7	41.4±0.1	40.6	42.0	1.4
C_8	41.5±0.1	40.9	42.0	1.1
C_9	41.5±0.1	40.9	42.0	1.1
C_{10}	41.4±0.1	40.2	41.9	1.7
C_{11}	41.5±0.0	40.9	42.0	1.1
C_{12}	41.5±0.0	40.8	42.0	1.2
C_{13}	41.5±0.0	40.6	42.0	1.4
C_{14}	41.3±0.1	40.3	42.0	1.7
C_{15}	41.5±0.0	41.1	42.0	0.8
C_{16}	41.4±0.1	40.0	42.0	2.0
C_{17}	41.5±0.1	40.8	41.9	1.1
C_{18}	41.5±0.1	40.7	42.0	1.3
C_{19}	41.5±0.1	40.7	42.0	1.3
C_{20}	41.5±0.1	40.9	42.0	1.1
C_{21}	41.4±0.1	40.0	42.0	2.0
C_{22}	41.5±0.1	40.5	42.0	1.5
C_{23}	41.4±0.1	40.2	42.0	1.8
C_{24}	41.4±0.1	40.0	41.9	1.9
C_{25}	41.4±0.1	40.6	42.0	1.4
Mean±S.E.M	41.4±0.01	40.6±0.1	42±0.0	1.4±0.1

Table 4: Hourly Fluctuations in Rectal Temperature of Shaver Brown Pullets administered with Ascorbic Acid during the Hot-Dry Season,°C (n = 25)

Hour	Mean±SEM	Minimum	Maximum	Range
06:00	41.0±0.1	40.2	41.9	1.7
07:00	41.1±0.1	40.1	42.0	1.9
08:00	41.1±0.1	40.0	41.9	1.9
09:00	41.2±0.1	40.2	41.8	1.6
10:00	41.3±0.1	40.3	42.0	1.7
11:00	41.3±0.1	40.1	42.0	1.9
12:00	41.4±0.0	40.7	42.0	1.3
13:00	41.5±0.0	40.1	42.0	1.9
14:00	41.6±0.0	41.0	42.0	1.0
15:00	41.6±0.0	40.7	42.0	1.3
16:00	41.5±0.1	40.0	42.0	2.0
17:00	41.4±0.1	40.0	42.0	2.0
18:00	41.3±0.1	40.0	42.0	2.0
19:00	41.2±0.1	40.1	41.9	1.8
Mean±SEM	41.3±0.1	40.3±0.1	42.0±0.0	1.7±0.1

RT rose significantly ($p<0.001$) from 41.0±0.1°C at 06:00 hours to the maximum RT values of 41.5-41.8°C from 11:00-17:00 hours (Table 5). During these hours, the birds were observed to be panting. The RT increased concurrently with hours of the day with the correlation coefficients of 0.589 and 0.542, in experimental and control pullets, respectively ($p<0.05$). In experimental pullets, the RT decreased insignificantly as the dry-bulb temperature rose ($r = -0.240$, $p>0.05$). In control pullets, the RT increased concurrently with the dry-bulb temperature ($r = 0.655$, $p<0.05$) There was a negative

Table 5: Hourly Fluctuations in Rectal Temperature of Control (Non-supplemented with Ascorbic Acid) Shaver Brown Pullets during the Hot-Dry Season,°C (n = 25)

Hour	Mean±SEM	Minimum	Maximum	Range
06:00	41.0±0.1	40.2	41.9	1.7
07:00	41.1±0.1	40.0	41.8	1.8
08:00	41.2±0.0	40.4	41.7	1.3
09:00	41.3±0.1	40.4	41.6	1.2
10:00	41.4±0.0	40.8	41.7	0.9
11:00	41.5±0.0	40.9	42.0	1.1
12:00	41.7±0.0	41.3	42.0	0.7
13:00	41.7±0.0	41.3	42.0	0.7
14:00	41.7±0.0	40.8	42.0	1.2
15:00	41.8±0.0	41.3	42.0	0.7
16:00	41.7±0.0	40.7	42.0	1.3
17:00	41.5±0.1	40.0	42.0	2.0
18:00	41.4±0.0	40.9	42.0	1.1
19:00	41.3±0.0	40.3	42.0	1.7
Mean±SEM	41.5±0.1	40.7±0.1	41.9±0.0	1.2±0.1

and significant correlation between the RH and RT in experimental pullets; but in control pullets the relationship was not significant (Table 6).

Discussion

The results of the present study indicated that RT values of Shaver Brown pullets were within the established normal range of 39.5-42°C for the avian species (Freeman, 1971). All the RT parameters showed distinct diurnal fluctuations. Such fluctuations in RT values are consistent with the findings in most mammals and they are driven by a biological clock in the brain (Piccione and Caola, 2002). The variations observed in RT values of all the pullets were in agreement with the findings of Selyansky (1975) that the RT varies with AT and hours of the day in temperate poultry breeds. Similar variations have been obtained in the ostriches (Minka and Ayo, 2007b). The high mean hourly RT of 41.5°C in control pullets was attained two hours earlier than that of experimental pullets. The difference was due to hypothermic effect of AA, which became manifest not immediately after its administration in pullets; but about five hours later, from 11:00 hours (Table 4 and 5). The effect was sustained up to 17:00 hours, when the AT was particularly high, rising to the maximum of 36°C (Table 1). Although pullets were exposed to AT range of 21-36°C, predominantly outside the established thermoneutral zone of 12-24°C (Selyansky, 1975), dietary supplementation of AA in pullets resulted in the maintenance of their RT within the normal range. The results further suggest that during the afternoon hours of 11:00-17:00 hours concomitant actions of other stress factors in the hot-dry season of the year should be avoided, especially in pullets not supplemented with AA in order to reduce the risk of adverse effects. The ameliorative effect of AA on heat stress obtained in the present study agrees with similar findings that AA alleviates road transportation stress in goats (Ayo *et al.*

Table 6: The Relationship between Meteorological Parameters and Rectal Temperatures of Shaver Brown Pullets (n = 25)

Correlated parameters	Experimental	Control
Hour of the day and rectal temperature	0.589*	0.542*
Maximum ambient temperature and rectal temperature	-0.052[NS]	0.786**
Minimum ambient temperature and rectal temperature	-0.683**	-0.991***
Dry-bulb temperature and rectal temperature	-0.240[NS]	0.655**
Relative humidity and rectal temperature	-0.940***	-0.263[NS]
Sunshine duration and rectal temperature	-0.998***	-0.517*

[NS] = Non-significant correlation (p>0.05), * = p<0.05, ** = p<0.01, *** = p<0.001

2006; Minka and Ayo, 2007a) and pullets (Ayo *et al.*, 2005a). Although the mechanism of action of AA-induced alleviation of heat stress was not investigated in the present study, Altan *et al.* (2003) has demonstrated the production of free radicals in birds subjected to heat stress. The antioxidant activities of AA have also been well established (Ayo and Oladele, 1996; Surai, 2002; Whitehead and Keller, 2003). The results obtained in the present study strongly suggest that the antioxidant AA modulated the RT fluctuations in the pullets by reducing, through its antioxidant activities, the free radicals generated in the pullets subjected to heat stress, especially during the hot hours of the day. During this period, the birds were observed to pant. Panting is an evaporative cooling mechanism in birds aimed at maintaining the body temperature within the normal range (Freeman, 1971; Ayo *et al.*, 1996). Further studies are required on the antioxidant thermoregulatory effects of AA on heat-stressed pullets during the hot-dry season. The results obtained in the present study for the first time demonstrated diurnal fluctuations in RT values of pullets and the modulation of the fluctuations by AA.

Conclusion: It is concluded that AA, by modulating the body temperature of pullets during the hot hours of the day, ameliorated the adverse effect of high AT and RH on pullets during the hot-dry season. This mechanism may be partly responsible for the AA-induced enhancement of poultry productivity and health during the hot-dry season.'

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