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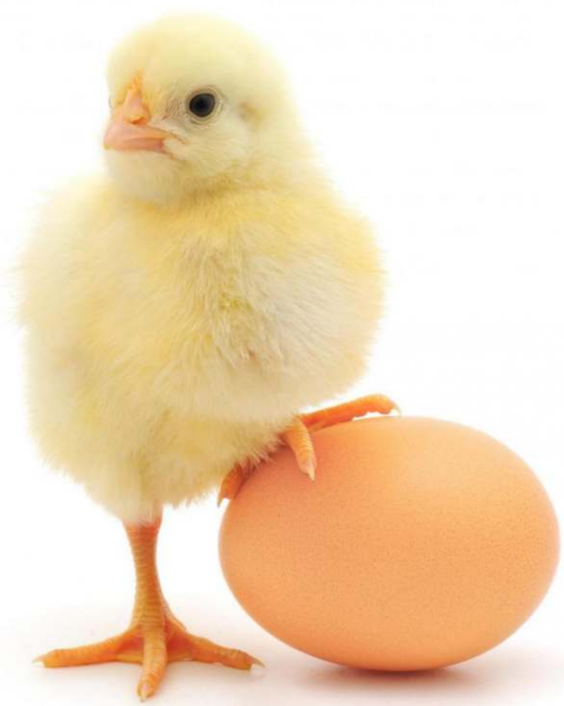

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Effects of Ascorbic Acid on Diurnal Variations in Rectal Temperature of Bovan Nera Pullets During the Harmattan Season

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Abstract: Experiments were performed with the aim of determining the effect of Ascorbic Acid (AA) on diurnal fluctuations in Rectal Temperature (RT) of Bovan Nera pullets during the harmattan season. Thirty experimental pullets were administered AA orally at the dose of 60 mg kg^{-1}, while 20 control birds were given only clean water. Measurements of RT were taken for three days from 07:00 to 18:00 hours during the season using a standard clinical thermometer, inserted through the cloaca into the rectum of each pullet. The overall mean RT of experimental and control pullets were 41.3±0.09°C and 41.3±0.06°C, respectively. The recorded RT in the experimental pullets was lowest at 07:00 hours with the value of 41.2±0.04°C and highest at 15:00 hours with the value of 41.5±0.04°C ($p<0.001$). In the control pullets, the lowest RT was also recorded at 07:00 hours with the value of 41.0±0.09°C, while the highest value of 41.5±0.07°C ($p<0.05$) was recorded at 15:00 hours. The RT in both experimental and control pullets rose significantly ($p<0.05$) and concurrently with the hour of the day (r = 0.668 and 0.457, respectively). The dry-bulb temperature was positively correlated with the RT of both experimental and control pullets (r = 0.991 and 0.948, respectively). The fluctuation in RT of the experimental pullets was 1.1±0.05°C, while that of the control was 1.3±0.08°C ($p<0.001$). The RT values of both the experimental and control pullets showed distinct diurnal fluctuations. It is concluded that AA administration to pullets ameliorated the thermally stressful effect of the harmattan season and may enhance their productivity and health during the season.

Key words: Variations, rectal temperature, pullets, harmattan season

Introduction

It has been established that during stress the generation of Reactive Oxygen Species (ROS) is often elevated to a level that overwhelms tissue antioxidant defense systems. The result is oxidative stress (Meerson, 1986; Zhuravlev, 1991). The magnitude of stress depends on the ability of the tissue to detoxify ROS; that is, the level of antioxidant defenses in the body. It has been established that antioxidant supplementation provides beneficial effect against stress-induced tissue damages (Minka and Ayo, 2007a, 2007b). Compounds that have antioxidant property include phenols, quinines, tocopherols, garlic acid and vitamin C or Ascorbic Acid (AA) (Ayo and Oladele, 1996). AA protects unsaturated bonds of cytomembranes from lipid peroxidation. It has been reported that chickens can synthesize AA in sufficient quantity for normal growth and metabolism (Sealock and Silberstein, 1940). Therefore, they do not require an exogenous supply of AA for maintenance of normal health (Sykes, 1978). This indicates that endogenous synthesis of AA can only meet a portion of the total requirements of the intensively managed fowl, where high production is to be achieved under stressful conditions. Heat stress has been shown to cause a significant reduction in kidney AA of pullets. It has also been observed that AA concentration in the liver, duodenum and adrenal tissue decreased considerably when chicks were subjected to heat stress (Sahota *et al*., 1993). In quails, AA supplementation in drinking water reduced fear and increased water intake (Jones *et al*., 1996), which may be helpful in relieving stress. McKee and Harrison (1995) showed that AA significantly alleviated heat stress-related reduction in weight gain of birds. The available information in the literature indicates the potential role of AA as an antioxidant in ameliorating adverse effects of environmental, including meteorological, stress on modern poultry production, especially during the dry season (Ayo and Sinkalu, 2003; Adenkola and Ayo, 2006). The RT has been shown to be a reliable index of thermal balance in the body (Bianca, 1976; Ayo *et al*., 1996) and of value in the assessment of responses of birds to thermally stressful environment (Selyansky, 1975). There is paucity of information on the RT responses of poultry to the harmattan season and the effects of antioxidants on the responses.

The aim of the experiment was to determine the modulatory role of AA on fluctuations in RT of Bovan Nera pullets during the harmattan season.

Materials and Methods

Fifty Black Bovan Nera breed of pullets, 15 weeks old and with live weights ranging between 0.9-1.1 kg served as subjects of the experiment. During the study period, the pullets were fed standard commercial growers'

Table 1: Meteorological Data from the Study Period

Day	Ambient Temperature (°C) *Maximum	*Minimum	Dry-Bulb (Mean±SEM)	Relative Humidity (%)	*Wind Direction
1	32	16	26.3±1.7	21	North-East
2	28	17	24.4±1.0	28	North-East
3	28	17	23.9±1.4	28	North-East
Mean±SEM	29.3±2.3	16.7±0.3	24.9±0.7	22.3±2.9	North-East

*Data Collated from Institute for Agricultural Research, Meteorological Unit, Ahmadu Bello University, Samaru, Zaria

Table 2: Variations in Rectal Temperature of Individual Pullets administered with Ascorbic Acid (n = 30)

Pullets	Rectal temperature (°C) Mean±SEM	Minimum	Maximum	Range
V_1	41.3±0.04	40.8	41.6	0.8
V_2	41.2±0.04	40.9	41.7	0.8
V_3	41.4±0.04	41.0	41.9	0.9
V_4	41.4±0.05	40.9	42.0	1.1
V_5	41.3±0.04	41.0	42.0	1.0
V_6	41.3±0.04	41.0	41.7	0.7
V_7	41.3±0.05	40.7	41.9	1.2
V_8	41.3±0.04	40.7	41.8	1.1
V_9	41.2±0.04	41.0	41.6	0.6
V_{10}	41.3±0.04	40.9	41.6	0.7
V_{11}	41.3±0.04	40.7	41.6	0.9
V_{12}	41.3±0.05	40.8	41.8	1.0
V_{13}	41.4±0.04	40.9	41.7	0.8
V_{14}	41.4±0.04	41.0	41.8	0.8
V_{15}	41.4±0.04	40.9	42.0	1.1
V_{16}	41.3±0.05	40.6	41.8	1.2
V_{17}	41.4±0.05	40.7	41.8	1.1
V_{18}	41.3±0.04	40.6	41.9	1.3
V_{19}	41.4±0.05	40.9	41.9	1.0
V_{20}	41.3±0.04	40.8	42.0	1.2
V_{21}	41.2±0.04	40.8	41.6	0.8
V_{22}	41.3±0.05	40.7	41.9	1.2
V_{23}	41.4±0.05	41.0	42.0	1.0
V_{24}	41.3±0.05	40.9	41.7	0.8
V_{25}	41.2±0.04	40.8	41.9	1.1
V_{26}	41.4±0.05	40.6	42.0	1.4
V_{27}	41.3±0.05	40.9	41.7	0.8
V_{28}	41.4±0.04	41.1	42.0	0.9
V_{29}	41.4±0.05	40.9	42.0	1.1
V_{30}	41.3±0.04	40.9	41.8	0.9
Overall Mean±SEM	41.3±0.01	40.9±0.05	41.8±0.03	0.98±0.03

mash, obtained from Nana Feeds Limited, Samaru, Zaria. Water was given *ad libitum*. The experiment was performed on a farm in Samaru (11°10'N, 07°38'E), Zaria, located in the Northern Guinea Savannah zone of Nigeria. The farm operated on an intensive deep litter system with a capacity of 21,000 birds. The birds were all layers. Measurements were taken from 7:00 to 18:00 hours for three days, two days apart, during the harmattan season in December. The meteorological data for this locality during the period of study are given in Table 1. Prior to the commencement of the experiment, the pullets were divided into two groups.

Group 1 comprised experimental pullets, administered AA (SPARTAN-C, Kunimed Pharmachem Ltd., Ikeja, Nigeria) in drinking water on experimental days only. On each day of the experiment at 05:45 h, a total dose of 60 mg/kg of AA dissolved in 10 ml of drinking water was given to each of the 30 experimental pullets. Following total drinking of the medicated water, the pullets were then given normal clean water immediately. 20 pullets in group II were given clean water and they served as control. From each pullet, RTs were recorded as an indicator of the body temperature every 2 h, using a digital clinical thermometer (The Hartman's Company PLC, England). The thermometer was inserted, via the cloaca, about 2 cm into the rectum and in direct contact with the mucosal wall of the rectum of each pullet (Zaytsev *et al.*, 1971). The readings were taken after the thermometer gave an alarm signal, usually after 1 minute. Each two-hourly measurement lasted about 15 minutes. Feeds and water were withdrawn during the measurements. The dry- and wet-bulb temperatures were taken also two hourly and concurrently with the RT measurements in the poultry house. Relative humidity values were calculated from the dry- and wet-bulb temperature values obtained. Other meteorological data during the study period were obtained from the Meteorological Unit of the Institute of Agriculture Research, Samaru-Zaria, located at a distance of about 3 km from the experimental site.

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

Results

The results are presented in Table 1-4. During the harmattan season, there was a relatively high Ambient Temperature (AT) maximum of 32°C and AT minimum of 16°C. The difference between the maximum and minimum temperatures during the study period was 16°C. The dry-bulb temperature and relative humidity were 24.1±1.4°C and 22.3±2.9%, respectively. Throughout the experimental period, the harmattan season had no rainfall and it was characterized by hot-dry and cold weather with a dust-laden wind. The wind direction was north-east (Table 1). The highest mean individual RT value was recorded in 11 experimental pullets, with the value of 41.4°C, while the same highest value was also recorded in five control pullets (Table 2 and 3). Table 4 shows the extent of the variations recorded throughout the day in experimental and control pullets, respectively. The RT of both experimental and control pullets showed distinct diurnal fluctuations. The

Table 3: Variations in Rectal Temperature of Individual Pullets without Ascorbic Acid Supplementation (n =20)

	Rectal temperature (°C)			
Pullets	Mean±SEM	Minimum	Maximum	Range
C_1	41.1±0.07	40.1	41.9	1.8
C_2	41.3±0.09	40.1	41.9	1.8
C_3	41.3±0.07	40.8	42.0	1.2
C_4	41.3±0.11	40.2	41.9	1.7
C_5	41.3±0.09	40.4	41.8	1.4
C_6	41.3±0.07	40.8	42.0	1.2
C_7	41.4±0.07	40.9	41.9	1.0
C_8	41.3±0.05	40.8	41.8	1.0
C_9	41.4±0.09	40.8	42.0	1.2
C_{10}	41.4±0.07	40.9	42.0	1.1
C_{11}	41.2±0.09	40.5	41.9	1.4
C_{12}	41.3±0.09	40.4	41.9	1.5
C_{13}	41.4±0.07	40.9	42.0	1.1
C_{14}	41.4±0.07	40.9	42.0	1.1
C_{15}	41.2±0.09	40.6	41.8	1.2
C_{16}	41.2±0.09	40.6	41.8	1.2
C_{17}	41.3±0.07	40.8	41.8	1.0
C_{18}	41.2±0.09	40.1	41.7	1.6
C_{19}	41.2±0.09	40.5	42.0	1.5
C_{20}	41.3±0.09	40.3	41.6	1.3
Overall Mean±SEM	41.3±0.02	40.6±0.06	41.9±0.02	1.3±0.06

maximum RT was significantly (p<0.01) higher than the minimum RT in both experimental (41.9±0.07°C and 40.8±0.06°C, respectively) and control pullets (41.9±0.04°C and 40.6±0.09°C, respectively). The diurnal range between the minimum and maximum RTs of the experimental pullets was 1.1±0.05°C, while that of the control pullets was 1.3±0.08°C (p<0.01). The overall mean RT of experimental pullets was not significantly different from that of the control pullets. The RT recorded in the experimental pullets (Table 4) was lowest at 07:00 and 09:00 hours with the value of 41.2±0.04°C, but highest at 15:00 hours with the value of 41.5±0.04°C (p>0.01). Thus, the highest diurnal variation was 0.3°C. However in control pullets, the RT was lowest at 07:00 hours with the value of 41.0±0.09°C and the maximum RT value of 41.5±0.07°C was obtained at 15:00 hours with the maximum diurnal variation of 0.5°C. In the experimental pullets, the extreme maximum temperature of 42°C was recorded as from 13:00 to 18:00 hours, while the extreme minimum RT of 40.6°C was recorded at 07:00 and 09:00 hours. In control pullets, the extreme minimum RT value of 40.1°C was obtained at 7:00 hours, while the extreme maximum RT value of 42.0°C was also recorded as from 13:00 to 18:00 hours (Table 4).

Discussion

The AT range during the harmattan season, which was 16-32°C, fell outside the established thermoneutral zone of 12-24°C for poultry species in the temperate region (Selyansky, 1975; Plyaschenko and Sidorov, 1987) and 18-26°C in the tropics (Oluyemi and Roberts, 2000). The RT values obtained were within the established normal range of 40-42°C for the poultry species (Zaytsev *et al*., 1971). The results of the present study demonstrated that the Bovan Nera breed of pullets was stable to the meteorological conditions, prevailing during the harmattan season in the Northern Guinea Savannah zone of Nigeria. They showed that the season characterized by relatively high diurnal RT range, but very low RH was not thermally stressful to the pullets. The diurnal fluctuations observed in the RT of the pullets agreed with the findings of Ayo and Sinkalu (2003), who observed that the RT values of the Shaver Brown pullets vary with the time of the day during the hot-dry season. The diurnal fluctuations recorded in the present study also agreed with the findings of Piccione and Caola (2002) that such variations, classical of most animals and birds, were driven by a biological clock. The fact that the maximum RT values of the control pullets were about 0.2-0.3°C higher than those of the experimental pullets as from 07.00 to 11.00 hours showed that AA reduced the tendency for increase in RT values right from the morning hours of the day in experimental pullets. The fact that the RT range of 1.3±0.08°C recorded in control pullets was significantly (p<0.05) higher than the corresponding value of 1.1±0.05°C obtained in experimental pullets demonstrated that the RT fluctuation in pullets not administered with AA was greater than that recorded in AA-administered pullets. Thus, AA reduced the body temperature of pullets as evidenced by the significant decrease in the values of the RT range in the experimental pullets. This again showed that AA decreased the difference between the minimum and maximum RT values. Therefore in experimental birds, the RT values were relatively constant. It is of interest to note that in spite of the fact that the dose of AA administered to the pullets in the present study was slightly higher than that of Ayo and Sinkalu (2003) (60 mg kg^{-1} vs. 52 mg kg^{-1}, respectively), the AA-induced hypothermic effect was more pronounced during the hot-dry season than in the harmattan season. The different results obtained in the two studies agreed with the findings of Gubegrits and Linevsky (1989) that AA effect on the body is related to the AT values. If the values are low, AA tends to enhance heat production in the body, resulting in increase in RT and if they are high AA exerts a hypothermic effect. In the control pullets, the fluctuation between the minimum and the maximum temperature was relatively higher. Such a wide variation (above 1°C) is known to be thermally stressful to birds (Selyansky, 1975). The present findings demonstrated the mild and relatively stable hypothermic effects of AA during the harmattan season, which has been described as the most thermally stressful to livestock of all the three seasons (hot-dry,

Table 4: Diurnal Variations in Rectal Temperature of Pullets administered (experimental, n=30) and not administered (control, n=20) with Ascorbic Acid

	Rectal temperature (°C)							
	Mean±SEM		Minimum		Maximum		Range	
Hour	Experimental	Control	Experimental	Control	Experimental	Control	Experimental	Control
07:00	41.20±0.04	41.0±0.09	40.60	40.10	41.70	41.80	1.10	1.70
09:00	41.20±0.04	41.2±0.07	40.60	40.60	41.60	41.80	1.00	1.20
11:00	41.34±0.04	41.4±0.07	40.80	40.80	41.70	41.90	0.90	1.10
13:00	41.40±0.04	41.4±0.05	41.00	40.90	42.00	42.00	1.00	1.10
15:00	41.50±0.04	41.5±0.07	41.00	40.70	42.00	42.00	1.00	1.30
17:00	41.40±0.04	41.3±0.07	40.90	40.50	42.00	42.00	1.10	1.50
18:00	41.30±0.04	41.2±0.07	40.70	40.70	42.00	42.00	1.30	1.30
Overall Mean±SEM	41.30±0.04	41.3±0.06	40.80±0.06	40.6±0.09	41.90±0.02	41.9±0.03	1.1±0.05	1.3±0.08

rainy and harmattan seasons), prevailing in the Northern Guinea Savannah zone of Nigeria (Igono and Aliu, 1982). The highest mean RT of 41.5°C was obtained in the present study, both in the experimental and control pullets at 15.00 hours. Therefore, additional stress factors at 15.00 hours should be minimized or avoided in order to reduce the adverse affects of heat stress on poultry during the season. The results of the present study further demonstrated that AA modulated the body temperature of the pullets during the harmattan season. The finding is in agreement with that of Khmelevsky and Poberezkina (1990) and Sahota *et al*. (1993) that AA storage in the body is exhausted during stress situations, especially in the plasma and other tissues. The result also agrees with that of Sahota *et al*. (1993) that AA supplementation during stressful conditions is beneficial to poultry. Further investigations are required to elucidate the thermoregulatory mechanisms of AA in poultry during the harmattan season. The findings of such studies may be of value in increasing poultry productivity in the zone, especially during the stressful harmattan and hot-dry seasons. The results of the present study for the first time provided information on the RT fluctuations of pullets during the harmattan season, which have been previously lacking.

Conclusion: It is concluded that the adverse effects of high diurnal AT fluctuations on poultry during the harmattan season may be ameliorated by AA administration to Bovan Nera pullets and thus enhance their productivity and health in the zone.

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