Effect of Coat Colour on Water Intake and Feed Utilization of Intensively Reared West African Dwarf Sheep in the Humid Tropics

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Abstract
The effect of coat colour on water intake and feed utilization of intensively reared West African Dwarf (WAD) sheep in the humid tropics was examined. 60 WAD sheep of different coat colours were used for the experiment which lasted for 6 months. Prominent coat colour types in the region are black, brown and badgerface. Animals were grouped into sexes. Daily free water intake (DFWI), DFWI/metabolic weight, daily total water intake (DTWI), DTWI/metabolic weight, daily feed intake (DFI), DFI/metabolic weight, DFWI/DFI, daily weight gain (DWG) and feed efficiency (FE) were measured. Analysis of data revealed that coat colour and sex had significant ($P<0.05$) effect on parameters measured except DTWI and DTWI/metabolic weight. Brown sheep had the highest value for the parameters measured except DFWI/DFI and FE. There was no significant ($P>0.05$) difference in DWG of black sheep (96.64±3.42 g) and brown sheep (95.24±2.77 g). Best feed efficiency (0.17±0.01) was observed in black sheep. Rams had the highest value for the parameters measured except DFWI/DFI and FE. Based on our results, we concluded that brown WAD sheep and rams consumed more feed and water, while black sheep consumed less feed and they are better feed utilizers.
Keywords: Colour variant, feed intake, qualitative trait, sex, sheep, water consumption

1.0 Introduction

Sheep need water for normal body functions (Gatenby, 2002). Water is the most important nutrient in animal feeding and animal health. It is the most abundant ingredient of the animal body in all phases of growth and development (Harris and VanHorn, 2008). Water is the medium in which chemical reactions in the body take place. Water functions included control of body temperature, digestion and absorption of food, transport of nutrients, elimination of water products, via urine, from the body (Jafari *et al*., 2006) and acts as buffering agent to regulate the pH of body fluid (Harris and VanHorn, 2008). Sources of water are metabolic water obtained from the oxidation of fat, carbohydrate and protein in the body, water in feed supplied and free water given to the animals to drink.

Feed is normally the largest single expense of a sheep operation (Neary, 1997) and plays a major role in the overall productivity, health and well-being of the sheep flock. Feed cost alone accounts for approximately two-third of the total cost of production on most sheep farms (Umberger, 2009). One could logically infer that if feed cost can be kept under control, producers have a better chance of maximizing profit and this can be achieved by the use of qualitative trait such as coat colour which is a possible indicator of genetic superiority. The use of coat colour in the improvement of production performance in sheep will be through artificial selection of colour variants with low feed intake but high weight gain (best feed utilization) and with minimal or negligible effect on the adaptation of the species.

The knowledge of coat colour of hair sheep can be very important to determine their adaptability to varying environmental conditions (Gordon, 1965) and also to identify animals that can efficiently convert feed to mutton. The different coat colours are clearly visible and appear to be controlled by genes in a Mendelian fashion. Colour is a highly repeatable characteristics of individual animal and has high heritability, estimated at 53% (Schleger, 1982). Importance of coat colour on the performance of livestock species in different environments have been studied in many European and American breeds (Ryder, 1980), but little is known about importance of coat colour on the performance of West African Dwarf sheep. Also, coat colour is a phenotypic expression important in breed identification and distinctiveness (Ozoje and Kadri, 2001). The effect of coat colour variation on water intake and feed utilization needs to be fully investigated, determined and exploited to help WAD sheep breeders in genetic improvement programmes.

This study was conducted to determine optimum water need of WAD sheep with different coat colours so as to know the quantity of water to provide for each colour variant because farm animals are reared in locations and seasons wherein water is not readily available and the effective temperature conditions venture outside their zones of thermal comfort (Abioja *et al*., 2010). It is also logical to know the putative effect of colour variation on feed utilization.

2.0 Materials and Methods

2.1 Experimental site

The experiment was carried out at the Small Ruminant Experimental Unit of the Research Farms, Federal University of Agriculture, Abeokuta, Alabata, Ogun State, Nigeria. Alabata (latitude $7^0$10'N, longitude $3^0$2'E and altitude 76 m above sea level) is in Odeda Local Government Area of Ogun State. The area which lies in the South-western part of Nigeria has a prevailing tropical climate with a mean annual rainfall of about 1037 mm. The mean ambient temperature ranges from 28^{o}C in December to 36^{o}C in February with a yearly average humidity of about 82%. The vegetation represents an interphase between the tropical rainforest and the derived savannah (Ilori *et al*., 2010). This study was carried out between December 2011 and June 2012.

2.2 Experimental animals and management

Sixty West African Dwarf sheep with initial average body weight of 9.60±0.50 kg and 8-9 months old with different coat colour types were used for the experiment. The coat colour types were black, brown and badgerface which are the prominent colours in the region. The definition and analysis of coat colour genes were made in line with the report of Adalsteinsson *et al.* (1994) and Ozoje (1998). Twenty black, twenty brown and twenty badgerface sheep were used for the experiment. Each colour variant comprised ten rams and ten ewes. Animals were sourced from villages and markets in Ogun and Oyo States, Nigeria. The animals were administered with ivomec against endoparasites, ectoparasites and skin infections at a dosage of 0.50 ml/kg, treated with oxytetracycline LA (a broad spectrum antibiotics) at a dosage of 0.20 mg/kg and were vaccinated with *Peste des petits ruminant* vaccine (PPRV) during the quarantine period.

The animals were managed intensively in individual open sided slatted floor pens. The health of the animals was properly monitored to prevent diseases. Equal amount of feed was given to each animal. Measured clean water and feed were provided for each animal. Feed and water troughs were placed inside special wooden box nailed to the slatted floor to prevent feed and water spillage. The animals were fed with only concentrates and the composition of the concentrates given to the experimental animals is shown in Table 1.

2.3 Data collection

2.3.1 Meteorological data

Daily maximum and minimum ambient temperatures, relative humidity, wet and dry-bulb temperatures were measured twice daily, both in the morning and evening using Six's thermometer, hygrometer and wet and dry bulb thermometer, respectively. These meteorological data were measured for the 6-month experimental period.

2.3.2 Measurement of water intake

2.3.2.1 Daily free water intake

The water provided was measured in millilitres. Water was provided for the animals every morning, the volume of the remaining water after drinking was measured every 24 hours and subtracted from the initial volume of water provided to determine the free water intake using measuring cylinder.

2.3.2.2 Daily feed water intake

Daily feed water intake (ml) was computed using the relation:

$$Moisture\ content\ of\ feed\ \times Daily\ feed\ intake$$

2.3.2.3 Daily total water intake

Daily total water intake (ml) was computed using the formula:

$$Daily\ free\ water\ intake\ + Daily\ feed\ water\ intake$$

2.3.3 Measurement of water intake/metabolic weight

2.3.3.1 Daily free water intake/metabolic weight

Daily free water intake/metabolic weight was measured as:

$$\frac{Daily\ free\ water\ intake}{Weight^{0.75}}$$

2.3.3.2 Daily total water intake/metabolic weight

Daily total water intake/metabolic weight was measured as:

$$\frac{Daily\ total\ water\ intake}{Weight^{0.75}}$$

2.3.4 Measurement of daily feed intake, daily feed intake/metabolic weight, daily weight gain and feed efficiency

2.3.4.1 Daily feed intake

Daily feed intake (g) was measured as:

$$Weight\ of\ feed\ provided\ - Weight\ of\ feed\ residue$$

2.3.4.2 Daily feed intake/metabolic weight
Daily feed intake/metabolic weight was computed as:

$$\frac{Daily\ feed\ intake}{Weight^{0.75}}$$

2.3.4.3 Daily weight gain
Daily weight gain (g) was computed as:

$$Weekly\ weight\ gain\ \times 0.142857.$$

Where weekly weight gain (g) = final weight less the initial weight.
2.3.4.4 Feed efficiency
Feed efficiency was computed as: $\frac{Weight\ gain}{Feed\ intake}$

2.4 Statistical analysis
Data obtained were subjected to analysis of variance using SAS (2003). The daily mean temperature, relative humidity and initial weight of the animals were included in the model as covariates. The linear model used was of the form:

$$Y_{ij} = \mu + A_i + B_j + C_1 + \varepsilon_{ij}$$

Where

Y_{ij} is the parameter of interest

μ is the overall mean for the parameter of interest

A_i is the fixed effect of ith coat colour (i =1, 2, 3)

B_j is the fixed effect of jth sex (j = 1, 2)

C_1 are the covariates effects of daily mean temperature, relative humidity and initial weight of the animals, and

ε_{ij} is the random error associated with each record (normally, independently and identically distributed with zero mean and variance)

3.0 Results
The climatic condition of the experimental site during the experimental period is shown in Table 2. The relative humidity, maximum, minimum and mean temperature values were of average of 83.1±1.52%, 35.6±0.52^{o}C, 25.8±0.44^{o}C and 30.7±0.48^{o}C, respectively.
The effect of coat colour on daily water intake, daily feed intake, daily free water intake/daily feed intake, daily weight gain and feed efficiency is shown in Table 3. Daily free water intake, daily feed water intake, daily free water intake/metabolic weight, daily feed intake, daily feed intake/metabolic weight, daily free water intake/daily feed intake, daily weight gain and feed efficiency of intensively reared West African Dwarf sheep were significantly (P<0.05) affected by their coat colour. Brown sheep had the highest daily free water intake (1494.57±19.65 ml), daily feed water intake (89.06±1.94 ml), daily free water intake/metabolic weight (263.92±3.48 ml/$W_{Kg}^{0.75}$) and daily feed intake (890.58±19.39 g). There was no significant (P>0.05) difference in the daily weight gain of black sheep (96.64±3.42 g) and brown sheep (95.24±2.77 g). The best feed efficiency (0.17±0.01) was observed in black sheep, while badgerface sheep recorded the lowest feed efficiency (0.09±0.01). The lowest daily free water intake, daily feed water intake, daily free water intake/metabolic weight and daily feed intake were recorded in black sheep.
The effect of sex on daily water intake, daily feed intake, daily free water intake/daily feed intake, daily weight gain and feed efficiency is shown in Table 4. Sex had significant (P<0.05) effect on daily free water intake, daily feed water intake, daily free water intake/metabolic weight, daily feed intake, daily feed intake/metabolic weight, daily free water intake/daily feed intake and feed efficiency. The least square means revealed that the highest daily free water intake (1391.73±17.65 ml), daily feed water intake (88.71±1.69 ml), daily free water intake/metabolic weight (246.92±3.03 ml/$W_{Kg}^{0.75}$), daily feed intake (887.05±16.86 g), daily feed water intake/metabolic weight (160.84±3.14 g/$W_{Kg}^{0.75}$) were observed in rams. The highest daily free water intake/daily feed intake (1.73±0.10 ml/g) and feed efficiency (0.15±0.01) were observed in ewes.

4.0 Discussion
The mean daily free water intake observed in this study (964.24±16.53 to 1494.57±19.65 ml) differed from the report of Adegbola and Obioha (1984), who reported daily free water intake of 337 to 478 ml. The daily free water intake values observed in this study indicated that the West African Dwarf sheep require less water than other breeds of sheep of both temperate and tropical origin (Adegbola and Obioha, 1984). The highest daily free

water intake observed in brown sheep could have resulted from more dry matter consumed by the brown sheep as research has demonstrated that there is a positive relationship between feed and water intake (Georgai, 2001; Gatenby, 2002).

An animal consuming a large quantity of feed need more water for normal digestion and utilization of the feed nutrients. Brown sheep with highest daily feed intake will need more water for physical softening of feed, removal of undigested residues and excretion of metabolic waste. Intake of more dry matter results in higher metabolic heat production in the body, which must be dissipated into the environment (Brosh *et al.,* 1987) which will invariably lead to consumption of more water. The least daily free water intake and daily feed water intake observed in black sheep might have resulted from intensive management system and low feed intake. Intensive management system reduced the impact of incoming solar radiation. Low feed intake reduced water intake because the higher the feed intake, the higher the free and feed water intake. The implication of the highest daily free water intake/metabolic weight recorded in brown sheep is that they require more water for metabolism as metabolic weight is the unit upon which physiological processes are based (Thonney *et al.,* 1976).

Brown sheep had the highest daily feed intake while black sheep had the least. This could have resulted from low absorption of heat which is directly related to the degree of pigmentation and this enhances appetite of animals. McManus *et al.* (2011) reported that brown WAD sheep absorbed less solar radiation than black sheep. Dark coated animals are predisposed to higher heat load. The feed intake per unit body weight, the digestibility and absorption of nutrient from the intestine decreased with increase in heat stress. Exposure of animals to a high environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite centre in the hypothalamus, causing a decrease in feed intake (Habeeb *et al.,* 1992).

Animals with higher heat load make effort to dissipate body heat resulting in increased body temperature, as well as decline in feed intake. The daily free water intake/daily feed intake observed in this study (1.25±0.08 to 1.76±0.12 ml/g) indicated that water intake was higher than feed intake in all the colour variants. The significant effect of coat colour on daily weight gain among WAD sheep observed in this study is similar with the findings of Adedeji (2009) who observed similar result in WAD goat. There was no significant difference in the daily weight gain of black and brown sheep and this suggests that brown and black sheep utilize feed at the same rate, although brown sheep consumed more feed. Adedeji (2009) reported that West African Dwarf goat having brown with extensive white marking colour were more favoured in body weight gain. The probable reason for the same daily weight gain in black and brown sheep observed in this study is not clear. The highest feed efficiency observed in black sheep indicated that although black sheep consumed less feed, they are better feed utilizers. Very high daily weight gain despite low feed intake recorded in black sheep in this study is in agreement with the report of Cunha *et al.* (2004), but differed from the report of Robertshaw (1986). Cunha *et al.* (2004) reported that Brazilian Santa Ines sheep farmers have preferred black-coated animals due to their faster growth rates whereas Robertshaw (1986) reported slower growth rates with dark-coated animals.

The higher daily free water intake, daily feed water intake and daily feed intake observed in rams could have resulted from high hormonal profile, dominance and aggressive feeding behaviour of male livestock species. The lower daily water intake observed in ewes might be traced to the fact that the ewes were not lactating as lactating ewes are expected to consume more water than non-lactating ewes. The insignificant effect of sex on daily weight gain of West African Dwarf sheep differed from the report of Mandal *et al.* (2003). The results of the study carried out by Mandal *et al.* (2003) on the analysis of growth traits in Muzaffarnagari sheep of India showed that rams were heavier and had a higher weight gain than ewes at all stages of growth and the differences tended to increase with age.

5.0 Conclusion

This study revealed that brown West African Dwarf sheep and rams consumed more feed and drink more water, while black sheep consumed less feed and they are better feed utilizers.

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Table 1: Composition of the concentrate diet given to the animals

Ingredient	Percentage (%)
Wheat offal	55.00
Palm kernel cake	30.00
Maize	5.00
Oyster shell	3.50
Bone meal	5.00
Salt	1.00
Vitamins	0.50
Calculated proximate composition	
Moisture content	10.00
Crude protein	15.25
Ether extract	4.60
Crude fibre	9.34
Ash	5.44
Nitrogen free extract	49.76
Metabolizable energy (Kcal/kg)	2705.53

Table 2: The meteorological data during the experimental period

Climatic factor	Mean	Diurnal variations Morning	Evening
Relative humidity (%)	83.10±1.52	93.20±1.42	72.30±2.30
Maximum temperature (^oC)	35.60±0.52	-	-
Minimum temperature (^oC)	25.80±0.44	-	-
Mean temperature (^oC)	30.70±0.48	-	-
Dry bulb temperature (^oC)	29.40±0.25	27.20±0.55	31.90±0.55
Wet bulb temperature (^oC)	25.70±0.50	25.80±0.45	26.80±0.20
Mean hours of temperature (hr)	5.60±1.04	-	-
Rainfall (mm)	8.10	-	-

Morning readings were recorded at 8:00 hour G.M.T and evening readings were recorded at 14:00 hour G.M.T. respectively.

Table 3: The effect of coat colour on daily water intake, daily feed intake, daily free water intake/daily feed intake, daily weight gain and feed efficiency

Parameters	Coat colour gene Black (aaB-S-)	Brown (aabbS-)	Badgerface (A^b)
Metabolic weight ($W_{Kg}^{0.75}$)	5.22±0.01	5.67±0.05	5.61±0.01
Daily free water intake (ml)	964.24±16.53^c	1494.57±19.65^a	1364.30±26.21^b
Daily feed water intake (ml)	60.13±1.66^c	89.06±1.94^a	84.97±1.88^b
Daily total water intake (ml)	1079.38±61.84	1138.33±52.82	1186.88±60.22
Daily free water intake/metabolic weight (ml/$W_{Kg}^{0.75}$)	184.72±3.15^c	263.92±3.48^a	241.96±4.50^b
Daily total water intake/metabolic weight (ml/$W_{Kg}^{0.75}$)	194.92±10.53	204.19±8.94	214.44±10.29
Daily feed intake (g)	601.34±16.63^c	890.58±19.39^a	849.70±18.76^b
Daily feed intake/metabolic weight (g/$W_{Kg}^{0.75}$)	109.34±3.02^b	161.03±3.58^a	154.71±3.65^a
Daily free water intake/daily feed intake (ml/g)	1.76±0.12^a	1.25±0.08^c	1.35±0.08^b
Daily weight gain (g)	96.64±3.42^a	95.24±2.77^a	70.51±1.85^b
Feed efficiency	0.17±0.01^a	0.11±0.01^b	0.09±0.01^c

$^{a, b, c}$ *Means in the same row with different superscripts are significantly different (P<0.05).*

Table 4: The effect of sex on daily water intake, daily feed intake, daily free water intake/daily feed intake, daily weight gain and feed efficiency

Parameters	Sex Ewes	Rams
Metabolic weight ($W_{Kg}^{0.75}$)	5.39±0.01	5.62±0.01
Daily free water intake (ml)	1186.72±21.45^b	1391.73±17.65^a
Daily feed water intake (ml)	67.52±1.71^b	88.71±1.69^a
Daily total water intake (ml)	1178.06±55.00	1103.33±41.43
Daily free water intake/metabolic weight (ml/$W_{Kg}^{0.75}$)	218.33±3.73^b	246.92±3.03^a
Daily total water intake/metabolic weight (ml/$W_{Kg}^{0.75}$)	211.98±9.28	198.84±7.10
Daily feed intake (g)	675.20±17.13^b	887.05±16.86^a
Daily feed intake/metabolic weight (g/$W_{Kg}^{0.75}$)	122.61±3.14^b	160.84±3.14^a
Daily free water intake/daily feed intake (ml/g)	1.73±0.10^a	1.19±0.06^b
Daily weight gain (g)	94.12±2.14	84.42±2.73
Feed efficiency	0.15±0.01^a	0.10±0.01^b

$^{a, b}$ *Means in the same row with different superscripts are significantly different (P<0.05).*