Effect of feed quality restriction on changes in body measurements and carcass characteristics of West African dwarf sheep

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Abstract

*Twenty seven West African Dwarf (WAD) sheep were used for the 120 day feeding trial to determine the effects of feed quality restriction on changes in body measurements and carcass characteristics. The animals were divided into three groups of nine animals each, the control group (C), the restricted group one (R1) and the restricted group two (R2). The sheep in the control group were fed dried guinea grass (*Panicum maximum*) and concentrate diet for the whole period of the experiment. The R1 and R2 animals were fed dried grass for a period of 30 days and 60 days, respectively before the inclusion of concentrate diet for 60 days. The live weight was measured weekly and body measurements every two weeks. Data obtained were analyzed using one way analysis of variance. Results showed that the average values for chest girth were significantly ($P < 0.05$) affected by duration of feed quality restriction with R2 group sheep having the highest value of 58.67 ± 1.16 cm and R1 group sheep having the lowest mean value of 53.85 ± 0.65 cm. The average values for testes girth and total dry matter intake were significantly ($P < 0.05$) affected by duration of feed quality restriction with C group sheep having the highest values 11.33 ± 0.26 cm and 346.80 ± 0.26 g, respectively. The C group sheep also had significantly higher ($P < 0.05$) values for live weight, withers height, shoulder width, thigh bone weight, dressing percentage and liver weight (12.75 ± 0.73 kg, 55.88 ± 0.00 cm, 19.05 ± 0.42 cm, 0.18 ± 0.03 kg, 60.47 ± 4.76 % and 0.22 ± 0.01 kg, respectively) during realimentation. In conclusion, feed restriction negatively affected live weight, total dry matter intake, chest and testes girth and it was recommended that feed supplementation during periods of feed scarcity be encouraged so as to allow animals maximise their growth and breeding potentials because animals fed grass and concentrate (C group) performed better than those fed grass only for specific periods (R1 and R2 groups).*

Key words: Feed restriction, body measurements, WAD sheep, Carcass

Introduction

The growth of an organism can be defined as changes in shape and size and this is based initially on hyperplasia followed by hypertrophy and finally on cell differentiation. The size and shape of the body of an animal depends on the skeletal structure of the body and any change in body tissues may be associated with the change in skeletal structure (Kamalzadeh *et*

al., 1998). Furthermore, growth is a function of the animal's genetic potential and the extent to which the environment allows this potential to be expressed. Among the main environmental variables that affect animal performance, nutrition is the most important. Therefore, the amount and the composition of the feed available to the animal will dictate its growth pattern, within the constraints imposed by its

genetic potential, climatic and pathological stresses (Oddy and Sainz, 2002). The most complex and limiting production factors for tropical and semi tropical sheep are those concerning nutrition and feed supplies. Annual and seasonal fluctuations of rain cause a periodic restriction in feed quality and quantity (Devendra and McLeroy, 1982; Atti and Ben Salem, 2007). While quality of a diet is affected mainly by the composition and physical form of the diet (Forbes, 1986), feed intake controls the rate of output of all animal products and is a measure of efficiency, regardless if the output is meat, milk, draft, fibre, reproduction, or pleasure. The highly variable nature of the feed normally consumed by tropical sheep makes it difficult to be exact as regards their nutritive requirement (Devendra and McLeroy, 1982).

Body measurements are used to evaluate the characteristics of animals that may vary due to the influence of breed evolution, environment and nutrition (Riva *et al.*, 2004). These body measurements and carcass characteristics are related to growth and can be used to predict growth (Kamalzadeh *et al.*, 1998). The objective of modelling is to combine the power of the human mind with the power of computer to make extended use of data thus, providing greater insights into the input/output relationships between nutrients and animal responses. The mathematical representation and prediction of growth has been a widespread endeavour in biology and a wide range of theoretical approaches have been proposed (Baldwin, 1995). There have been attempts to estimate live weight from chest girth making use of linear and non-linear models (Benyi, 1997, Kamalzadeh *et al.*, 1998). Roux and Meissner (1983) and Meissner and Roux (1983) used multiple measurements of

logarithms of cumulative feed intake, heat production, body protein and fat accretion in growing animals fed *ad libitum* to develop parameters for their model which was later tested on data from restricted-fed animal. This study is aimed at having improved or greater understanding of the influence of feed quality restriction on West African dwarf sheep.

Materials and methods

Animal's management and experimental groups

The experiment was carried out at the Small Ruminant Unit of the Teaching and Research Farm of the University of Agriculture Abeokuta, Ogun State, Nigeria. Thirty West African Dwarf Ram-lambs about 8 months old were purchased from villages around Abeokuta and used in an experiment conducted for 120 days. The animals were quarantined for 28 days during which they were fed the experimental diet made up of concentrate feed (table 1) and dry guinea grass (*Panicum maximum*). Three of the animals were slaughtered at the beginning of the experiment to determine the carcass characteristics. The remaining 27 animals were divided into 3 groups of 9 animals each, the control group (C), the restricted group one (R1) and the restricted group two (R2). The sheep in the control group were fed dried guinea grass (*Panicum maximum*) chopped to about 3cm length and concentrate diet (Groundnut cake, 10.0%; Palm kernel cake, 17.5%; Wheat offal, 40.0%; Maize bran, 30.0%; Bone meal, 1.5% and Salt, 1.0% throughout the 120 days of the experiment. The R1 and R2 animals were fed dry grass for a period of 30 days and 60 days (restriction period), respectively before the inclusion of concentrate diet for 60 days (realimentation period). Feed supply was based on 5%

weekly body weight of the animals.

Data collection

Live weight was measured weekly using a weighing scale while body measurements were taken once every two weeks with the aid of a tape rule with the exception of ulna length and withers height which were measured with the aid of a metre rule. Body dimensions measured included: Trunk length (TL, distance between the pin bone and the most distal point of the major tuberosity of the humerus); Ulna length (UL, distance between the most distal point of the carpus joint and the elbow); Withers height (WH, distance between the midlateral point of the coronet and the most developed spinous process of the thoracic vertebra); Chest depth (CD, distance between the ventral surface of the sternum and the most dorsal point of the wither); Hip width (HW, distance between the two coxal tubers); Shoulder width (SW, distance between the lateral tuberosities of the humerus); Chest girth (CG, chest circumference just behind the forearms) and Testes girth (TG, largest diameter of the testes and scrotum).

Three animals from each treatment were slaughtered at the end of restriction and realimentation periods using the Mohammedan slaughtering method. The head, skin, feet and internal organs were removed and the hot carcass weight taken after slaughter. The carcasses were split into two halves along the backbone using a meat saw.

Chemical analysis

Samples of concentrate feed and dry grass fed to the animals were collected weekly and bulked for chemical analysis of their proximate composition using the procedure of A.O.A.C (1995). Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were determined using the procedure of Van Soest *et al.* (1994).

Statistical analysis

Data collected on live weight, body measurements and carcass characteristics were subjected to one-way analysis of variance in a completely randomized design. The relationship between live weight and body measurements was determined using the ratios of measurement of restricted lambs and control lambs (equation 1) by applying the allometric regression (equation 2) modules of SYSTAT (1992)

$$R_y(t) = \frac{y_{\text{restricted}(t)}}{y_{\text{control}}} \dots \dots \dots (1)$$

(Kamalzadeh *et al.*, 1998)

where:

$R_y(t)$ = ratio of average measurement for restricted group over the average of control group

$y_{\text{restricted}(t)}$ = average measurement for restricted group

y_{control} = average measurement for control group

$$Y = a (X)^b \dots \dots \dots (2)$$

where:

Y = live weight

X = body measurement of interest

a = intercept

b = regression coefficient

Results

The chemical composition of concentrate and forage fed to the experimental animals is shown in Table 1. Dry matter contents (g/kg DM) of forage and concentrate diet were 833.1 and 907.6, respectively. Crude protein in the concentrate diet was 173.5 compared to the 80.6 obtained in the forage. The effect of duration of feed quality

Table 1: Determined analysis of concentrate diet and Guinea grass (g/kg DM)

Nutrients	Concentrate	Guinea grass
Dry matter	907.6	833.1
Crude protein	173.5	80.6
Ether extracts	36.0	67.0
Neutral detergent fibre	384.0	652.5
Acid detergent fibre	767.0	368.8

restriction on live weight and body measurements of the experimental animals during restriction and realimentation is shown in Table 2. At the start of restriction, all measurements were not significantly ($P > 0.05$) different among all the treatment groups. The average values for chest girth and testes girth were significantly ($P < 0.05$) affected by duration of feed quality restriction with R2 and C group animals having the highest values, respectively (58.67cm and 11.33cm). However, at the end of realimentation, the control group had significantly ($P < 0.05$) higher values of live weight, withers height and shoulder width (12.75kg, 55.88cm and 19.05cm, respectively) compared to the restricted groups. Between the restricted groups, live weight and withers height were higher ($P < 0.05$) in R2 than R1 but shoulder width was similar. The values for TL, UL, CD, HW, CG and TG were not significantly ($P > 0.05$) influenced by realimentation. The trends in live weight and body dimension changes during realimentation are presented in figures 1 to 9. The trends were similar for all measurements except for trunk length and testes girth where there were rapid changes in the restricted groups reducing the difference brought about by restriction.

Table 3 shows the effect of duration of feed quality restriction on carcass characteristics of experimental animals. At the end of restriction, total dry matter intake was significantly higher ($P < 0.05$) in the C

group (346.80g/day). All the carcass measurements were not significantly affected ($P > 0.05$) by feed quality restriction. After realimentation, thigh bone weight and liver weight were significantly affected ($P < 0.05$) by feed quality restriction with the C group having the highest values (0.18kg and 0.22kg respectively). Similarly, dressing percentage was higher ($P < 0.05$) in the C group compared to the restricted groups.

Allometric regression parameters indicating the relationship between live weight and body measurements when ratios of the average measurements of restricted group over the control group was used is shown in Table 4. During the restriction phase, animals in R1 group generally exhibited the least regression coefficient which is an indication of the rate of change in the body measurement in relation to live weight. R2 animals exhibited higher regression coefficients in CG, HW, SW, and CG while the C group had higher regression coefficients in TL, UL, WH, and TG. During the realimentation phase, similar trend of regression coefficients were observed as in the restriction phase although negative regression coefficients were recorded in R1 animals for UL, WH, CD, HW and TG. Coefficient of determination (R^2) was generally higher in the realimentation phase than in the restriction phase with R2 animals consistently having

Table 2: Effect of duration of feed quality restriction on live weight and body measurements of West African dwarf sheep

Parameters	Treatment Group		
	C	R1	R2
Start of Restriction			
Live weight (kg)	8.70 ± 0.72	8.00 ± 0.20	9.84 ± 0.84
Trunk length (cm)	44.66 ± 1.55	43.43 ± 1.20	45.97 ± 2.32
Ulna length (cm)	31.96 ± 0.95	30.23 ± 1.41	32.51 ± 0.95
Withers height (cm)	50.59 ± 1.01	49.02 ± 0.86	50.38 ± 1.59
Chest Depth (cm)	25.19 ± 1.16	23.88 ± 0.62	24.38 ± 0.74
Hip width (cm)	17.99 ± 0.76	17.43 ± 0.25	18.03 ± 0.48
Shoulder width (cm)	16.30 ± 1.20	17.78 ± 1.14	17.02 ± 1.03
Chest Girth (cm)	56.52 ± 0.71	54.61 ± 0.90	57.75 ± 1.32
Testes Girth (cm)	10.48 ± 0.46	9.91 ± 0.48	10.67 ± 0.62
End of Restriction			
Live weight (kg)	9.67 ± 0.72	8.00 ± 0.27	8.55 ± 0.64
Trunk length (cm)	46.78 ± 1.16	43.43 ± 1.02	46.99 ± 2.05
Ulna length (cm)	46.78 ± 1.16	30.48 ± 1.56	33.02 ± 1.06
Withers height (cm)	51.86 ± 0.51	50.38 ± 1.64	52.58 ± 1.95
Chest Depth (cm)	26.67 ± 0.57	26.16 ± 0.51	27.94 ± 1.14
Hip width (cm)	17.78 ± 0.57	18.29 ± 0.53	19.05 ± 0.80
Shoulder width (cm)	17.36 ± 0.71	16.51 ± 0.35	17.27 ± 0.65
Chest Girth (cm)	58.00 ^a ± 1.76	53.85 ^b ± 0.65	58.67 ^a ± 1.16
Testes Girth (cm)	11.33 ^a ± 0.26	9.45 ^b ± 0.25	8.89 ^b ± 0.57
End of Realimentation			
Live weight (kg)	12.75 ^a ± 0.73	9.25 ^c ± 0.66	10.50 ^b ± 0.11
Trunk length (cm)	50.17 ± 0.42	45.87 ± 1.60	50.80 ± 0.00
Ulna length (cm)	36.20 ± 0.43	32.17 ± 1.69	33.02 ± 0.00
Withers height (cm)	55.88 ^a ± 0.00	49.53 ^c ± 1.27	52.07 ^b ± 0.64
Chest Depth (cm)	27.40 ± 1.59	23.70 ± 0.85	22.88 ± 1.27
Hip width (cm)	19.05 ± 0.86	16.93 ± 0.42	17.78 ± 0.00
Shoulder width (cm)	19.05 ^a ± 0.42	17.36 ^b ± 0.42	17.48 ^b ± 0.64
Chest Girth (cm)	56.52 ± 1.27	52.49 ± 0.85	54.61 ± 1.27
Testes Girth (cm)	11.75 ± 0.21	9.95 ± 1.29	10.16 ± 0.00

a, b, c means on the same row with different super scripts are significant (P< 0.05).

C= Control R1= 30 days restriction R2= 60 days restriction

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C= Control R1= 30 days restriction R2= 60 days restriction

Figure1. Live weight changes in restricted and control groups during realimentation

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 2: Changes in testes girth of restricted and control group during realimentation.

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 4: Changes in chest depth of restricted and control groups during realimentation

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 4: Changes in chest depth of restricted and control groups during realimentation

Effect of feed quality restriction on changes in body measurements and carcass characteristics of sheep

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 5: Changes in withers height of restricted and control groups during realimentation

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 6: Changes in ulna length of control and restricted groups during realimentation.

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 7: Changes in hip width of control and restricted groups during realimentation

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 8: Changes in shoulder width of restricted and control group during realimentation

Table 3: Effect of duration of feed quality restriction and realimentation on carcass characteristics of West African dwarf sheep

Parameters	Treatment Group		
	C	R1	R2
		Restriction	
Total Dry Matter intake (g/d)	346.80 ^a ± 17.67	265.81 ^b ± 8.34	294.21 ^{ab} ± 22.91
Live weight (kg)	9.25 ± 0.75	8.25 ± 0.25	9.75 ± 0.75
Dressed carcass (kg)	4.50 ± 0.50	3.75 ± 0.25	5.00 ± 0.50
Dressing Percentage (%)	48.53 ± 1.47	45.41 ± 1.66	51.19 ± 1.19
Head and leg (kg)	1.10 ± 0.10	1.10 ± 0.00	1.23 ± 0.75
Thigh bone (kg)	0.20 ± 0.05	0.10 ± 0.00	0.09 ± 0.10
Thigh meat (kg)	0.45 ± 0.05	0.33 ± 0.03	0.35 ± 0.05
Arm bone (kg)	0.15 ± 0.05	0.10 ± 0.00	0.08 ± 0.03
Arm meat (kg)	0.30 ± 0.00	0.23 ± 0.03	0.25 ± 0.05
Trunk (kg)	0.45 ± 0.05	0.49 ± 0.04	0.78 ± 0.10
Kidney (kg)	0.05 ± 0.01	0.03 ± 0.00	0.04 ± 0.01
Liver (kg)	0.17 ± 0.01	0.10 ± 0.00	0.14 ± 0.03
Heart (kg)	0.05 ± 0.01	0.04 ± 0.01	0.05 ± 0.01
		Realimentation	
Total Dry Matter intake (g)	494.40 ± 11.62	507.52 ± 19.87	470.16 ± 14.51
Live weight (kg)	11 ± 0.50	10.5 ± 0.50	10.25 ± 0.25
Dressed carcass (kg)	6.68 ± 0.83	5.68 ± 0.83	5.70 ± 0.30
Dressing Percentage (%)	60.47 ^a ± 4.76	54.25 ^b ± 0.75	55.57 ^b ± 1.57
Head and leg (kg)	1.30 ± 0.20	1.30 ± 0.20	1.15 ± 0.05
Thigh bone (kg)	0.18 ^a ± 0.03	0.07 ^b ± 0.02	0.06 ^b ± 0.01
Thigh meat (kg)	0.53 ± 0.18	0.52 ± 0.07	0.35 ± 0.02
Arm bone (kg)	0.10 ± 0.00	0.07 ± 0.03	0.10 ± 0.00
Arm meat (kg)	0.43 ± 0.13	0.40 ± 0.05	0.43 ± 0.01
Trunk (kg)	1.24 ± 0.16	1.10 ± 0.10	1.15 ± 0.05
Kidney (kg)	0.04 ± 0.01	0.04 ± 0.01	0.04 ± 0.01
Liver (kg)	0.22 ^a ± 0.01	0.20 ^{ab} ± 0.01	0.18 ^b ± 0.01
Heart (kg)	0.08 ± 0.02	0.06 ± 0.01	0.06 ± 0.01

a, b, c means on the same row with different subscripts are significant (P< 0.05).

C= Control R1= 30 days restriction R2= 60 days restriction

the highest R² followed by C and R1 groups, respectively.

Discussion

The chemical composition of the guinea grass (*Panicum maximum*) was similar to that obtained by Aduku (1993) for all fractions except for ether extract that was higher. This difference could have been due

to differences in environmental conditions. The crude protein in the concentrate diet was above the level (9–14%) recommended by Aduku (1993) for sheep.

Body weight was maintained during one month of feed quality restriction but declined after 2 months of feed quality restriction. Although the control group increased in weight, the weight increase

C= Control R1= 30 days restriction R2= 60 days restriction

Figure 9: Changes in chest girth of restricted and control group during realimentation

Table 4: Estimates of the parameters for the growth function for the ratios of measurement of restricted lambs and control lambs

Parameters	Restriction			Realimentation		
	a	b	R ²	a	b	R ²
Trunk length						
C	0.001	2.29	0.58	0.00	4.53	0.58
R1	2.31	0.33	0.05	0.03	1.46	0.48
R2	0.03	1.50	0.76	0.90	4.33	0.90
Ulna length						
C	0.56	3.53	0.56	0.00	5.52	0.56
R1	5.94	0.09	0.02	395.58	-1.08	0.57
R2	0.16	1.13	0.26	1.56	0.55	0.99
Withers height						
C	0.16	5.85	0.61	1.28	0.57	0.61
R1	0.44	0.74	0.51	49.02	-2.19	0.57
R2	0.07	1.22	0.37	1.42	0.51	0.99
Chest depth						
C	0.90	0.72	0.40	0.15	1.35	0.40
R1	0.57	0.81	0.21	31.52	-0.39	0.04
R2	0.07	1.50	0.61	0.03	1.85	0.85
Hip width						
C	2.36	0.49	0.05	0.17	1.43	0.05
R1	1.32	0.62	0.27	54.20	-2.25	0.57
R2	0.31	1.13	0.42	0.13	1.53	0.91
Shoulder width						
C	0.47	1.06	0.33	3.47	0.44	0.33
R1	1.82	0.53	0.10	1.92	0.55	0.04
R2	0.06	1.74	0.73	0.13	1.53	0.90
Chest girth						
C	0.001	2.28	0.91	0.00	2.92	0.91
R1	0.03	1.99	0.51	0.57	3.42	0.57
R2	0.55	2.88	0.55	0.99	5.15	0.99
Testes girth						
C	0.12	1.80	0.25	0.002	3.61	0.25
R1	3.47	0.37	0.08	2.79	0.52	0.91
R2	1.62	0.76	0.43	10.50	-0.01	0.99
C= Control R1= 30 days restriction R2= 60 days restriction						

was not large enough to bring about a significant difference between the control and the restricted animals. The decline in body weight of restricted groups is in line with earlier findings in sheep (Kamalzadeh *et al.*, 1998), goats (Muna and Ammar, 2001) and cattle (Cole *et al.*, 2003; Tolla *et al.*, 2003). Comparable CG observed in C and R2 animals is contrary to the findings of Kamalzadeh *et al.* (1998) who stated that the restricted group had significantly lower CG than the control group and this difference could have been due to the difference in duration of restriction and realimentation as well as the breed of animal used in the experiment. Although the result of CG for animals on R1 agrees with these authors, animals on R2 might have overcome the stress of feed restriction such that nutrients from the diet were better utilised. Testes girth (TG) reduction at the end of restriction period in the restricted animals is in line with previous reports (Kamalzadeh *et al.*, (1998) due to restricted nutrient supply which had an inhibiting effect on the normal development of the testes. Trunk length (TL), ulna length (UL), withers height (WH), chest depth (CD), hip width (HW) and shoulder width (SW) were not affected by duration of feed quality restriction. This implies that live weight loss during period of feed restriction is not due to restriction in growth of the skeletal structure. At the end of realimentation, the animals in the control group were heavier than the restricted animals. Change in live weight was faster in R2 group than R1 group suggesting compensatory growth although full compensation was not achieved. From these findings, compensatory growth seems to depend on the severity of feed quality restriction. Higher WG in the C group suggest that quality of diet determines the rate of growth of long bones and that their growth would

not stop due to shortage of nutrients. Chest girth and TG were fully compensated for after realimentation as indicated by the similar values obtained for both the control and the restricted animals. This result is corroborated by the findings of Kamalzadeh *et al.* (1998). Higher dressing percentage in the C group confirms lack of full compensation during realimentation which is in line with results obtained in cattle (Sainz *et al.*, 1995; Tolla *et al.*, 2003) and goats (Attah *et al.*, 2006). Observations on thigh bone and liver weight are also in consonance with the findings of these authors

Estimates of growth parameters with ratios of average values of body measurements of restricted and control experimental animals showed the R1 group had the lowest rate of change during restriction for all measurements except for chest depth and hip width where the control group had the lowest rate of change. The R2 group had the fastest rate of change for CD, HW, SW, CG, while the control group had the fastest rate of change for TL, UL, WH, and TG.

Conclusion

Weight loss was observed during feed restriction, though there was increased growth rate during realimentation. Total dry matter intake, chest girth and testes girth reduced with feed quality restriction, though these measurements were not affected by realimentation except for testes girth. Live weight, withers height, shoulder width, dressing percentage, thigh bone weight and liver weight increased with realimentation although full compensation was not achieved in some of these parameters.

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