The Development Of Lean Muscle, Bone And Fat In The West African Dwarf Goat Of Nigeria Maintained On Good Plane Of Nutrition.

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Keywords: Dwarf goat – Lean muscle – Bone – Fat.

Summary

Thirty West African Dwarf goat kids were raised on good diets intensively from 5 days to 52 weeks of age. Six animals (3 males and 3 females) were serially slaughtered at 2, 8, 12, 24 and 52 weeks of age to study changes in liveweight and the development of lean muscle, bone and fat.
Lean muscle and fat expressed as the percentage of empty body weight (E.B.W.) increased from 31.8% and 3.8% at 2 weeks to 43.2% and 14.2% at 52 weeks respectively.
These increases at 52 weeks old were about 673.2% and 2090.8% over their respective weights at 2 weeks old. The bone tissue also increased to about 220.7% at 52 weeks old over the weight at 2 weeks of age, but decreased from 17.4% E.B.W. at 2 weeks to 9.8% E.B.W. at 52 weeks of age.
At 2 weeks old, muscle was the largest tissue, followed by bone, while fat was the least. The bone grew at a low impetus rate, muscle at intermediate rate and fat at high impetus rate so that at 52 weeks of age, fat became the second largest tissue and bone the least.
Male goat kids entered the rapid fattening phase later in life (about 43 weeks of age) and at heavier liveweight (about 12 kg liveweight) than the female goat kids (about 28 weeks of age and 9 kg liveweight respectively).

Résumé

Trente jeunes chèvres naines d'Afrique occidentale ont été nourries en aliments de qualité depuis 5 jours jusqu'à 52 semaines. Six animaux (3 mâles et 3 femelles) ont été abattus à 2, 8, 12, 24 et 52 semaines pour déterminer les modifications du poids vif et le développement du muscle de l'os et de la graisse.
Le muscle (maigre) et la graisse exprimés en pourcentage du poids du corps vide a augmenté de 31.8% et 3,8% à 2 semaines jusqu'à 43.2% et 14.2% à 52 semaines respectivement.
Ces augmentations à 52 semaines furent à peu près de 673.2% et 2090.8% par rapport à leur poids respectif à 2 semaines.
Le tissu osseux a augmenté à peu près de 220.7% à 52 semaines, mais a diminué de 17.4% à 2 semaines à 9.89% à 52 semaines sur base du poids du corps vide.
A 2 semaines le muscle était le plus important tissu suivi de l'os et enfin de la graisse. L'os poussait à une vitesse moindre, le muscle à un doux intermédiaire et la graisse à un taux élevé en sorte qu'à 52 semaines la graisse devint le deuxième tissu en importance et l'os le dernier.
Les jeunes chèvres mâles développent la graisse plus tard (environ à 43 semaines) et à un poids vif plus élevé (à peu près 12 kg de poids vif) que les jeunes chèvres femelles (à peu près à 28 semaines et 9 kg de poids vif).

Introduction

The West African Dwarf goat (*Fouta Djallon*) is kept mainly for the provision of meat. Its capacity to produce milk is very low. They are often slaughtered for meat in Nigeria from about 6 months old (6 to 8 kg liveweight) to any time later in life (8 to 20 kg liveweight). They attain mature liveweight of about 20 kg in the tropical forest belt, tending to be larger as the savannah zone is approached (5). The usefulness of the West African Dwarf (WAD) goat as meat type animal makes it necessary to understand their growth pattern in order to highlight the developmental sequence of the three major carcass tissues, lean muscle, bone and fat, relating the higher proportions of the more desireable components of the carcass at the expense of the less valuable ones. It is well known that only high amounts of lean muscle command higher prices because it is most desired by the consumer. Therefore, for economic reasons, it is necessary that the production and slaughter of the WAD goat for market should coincide with the period the carcass has a maximum of muscle, a minimum of bone and optimum amount of fat.

Most studies so far reported on the body composition of ruminant animals have been made on exotic breeds of sheep and cattle (2,6,10). There is little known of the physical composition and growth of the carcass of the WAD goat from birth to maturity. The present study was designed to pro-

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vide information on the growth pattern of the major carcass tissues namely, lean muscle, bone and fat of the WAD goats maintained on good plane of nutrition from 5 days to 52 weeks of age.

Material and Methods

Thirty WAD goat kids were obtained from the University of Ibadan Teaching and Research Farm at 5 days of age after they had suckled their dams to obtain colostrum.
They were separated into two groups consisting of 15 males and 15 females to avoid indiscriminate mating at later age. The management of the two groups of experimental animals was the same.

TABLE 1
Ingredient and Chemical Composition of Pre- and Post-weaning creep feeds

a. INGREDIENT COMPOSITION

Ingredient (%)	Pre-weaning feed	Post-weaning feed
Cassava flour	31.5	39.0
Soya bean (meal)	40.0	40.0
Brewers grain	20.0	20.0
Sucrose	2.5	-
Glucose	5.0	-
Dicalcium phosphate	0.5	0.5
Mineral/Vitamin Mix	0.5	0.5
	100.0	100.0

b. CHEMICAL COMPOSITION

Constituent (%)	Pre-weaning feed	Post-weaning feed
Dry matter	54.5	95.0
Crude protein (Nx6.25)	19.7	18.8
Ether extract	7.0	9.0
Crude fibre	7.4	8.0
Ash	3.5	3.5
Organic matter	91.0	91.5
Nitrogen free extractives	56.9	55.7
Gross energy (Koal/100g)	384.1	410.4

From 5 days to 2 weeks of age, the kids were fed to satisfy with fresh cow milk warmed to 37°C thrice daily (0800, 1300 and 1800 hrs). From 2 weeks of age the milk diet was supplemented with pre-weaning creep feed (Table 1) and chopped giant star grass (*Cynodon nlemfuensis var Robustus*) *ad libitum*. A gradual withdrawal of milk from the diet of the kids was embarked upon during the 5th week of life. This was accomplished by feeding the kids with warmed milk twice daily (0800 and 1300 hrs) for the first 4 days and once daily (0800 hr.) for the last 3 days of week five. By the end of the 5th week, milk feeding was completely stopped and all kids were on pre-weaning creep feed and chopped grass. All animals had free access to salt lick and fresh water. From the 13th week of age, the pre-weaning creep feed was replaced with post-weaning feed (Table 1).
Six animals (3 males and 3 females) were serially slaughtered at 2, 8, 12, 24 and 52 weeks of age to study the growth of lean muscle, bone and fat in the carcass.

Slaughter method

A day prior to slaughtering, all animals to be slaughtered were weighed to obtain their liveweight. They were then subjected to an 18 hr. fast, weighed and then slaughtered, dressed, chilled and then dissected according to the standard muscle groups (4). Briefly, this involved separation of the right side of the carcass into its individual muscle groups, associated bones and four major fat depots (intermuscular, subcutaneous, kidney and channel).

Analytical procedure

All dissected lean muscle, bones and fat were weighed according to their anatomical locations, then combined, weighed and multiplied by two for subsequent calculations of total lean muscle, bone and fat.
The growth coefficients for the lean muscle, bone and fat were estimated by the use of the allometric growth equation, $Y = aX^b$ (2).

Where Y = the respective tissue weight (or part); X = the corresponding weights of muscle plus bone (or whole); a = intercept; b = the growth coefficient of the respective tissues. Date obtained from this study were subjected to analysis of variance. Significant differences were estimated by the use of Duncan's multiple range test (13).

Results

The growth of the WAD goats at the five different stages is presented in Table 2. The mean liveweight at 52 weeks of age was 13.8 ± 0.37 kg. The empty body weight (E.B.W.), the dressing out percentage and all carcass tissues studied increased with advancing age. Lean muscle increased from 566.7 ± 20.27 g (31.8% E.B.W.) at 2 weeks to 4382.0 ±

TABLE 2
Liveweight and weights to certain body components of the West African Dwarf goat as affected by age.

	AGE OF GOAT KIDS				
Parameters	2 weeks	8 weeks	12 weeks	24 weeks	52 weeks
Liveweight at slaughter (kg)	1.95±0.09	5.50±0.07	6.24±0.12	8.86±0.29	13.77±0.37
Empty body weight (E.B.W.)* (kg)	1.78±0.02	4.65±0.07	5.15±0.05	6.49±0.28	10.15±0.31
E.B.W. as % of liveweight (%)	91.28	84.50	83.53	73.57	73.25
Dressing-out percentage (%)	46.95±0.40	47.49±0.26	47.62±0.60	48.11±0.61	48.53±0.67
Total loan muscle (side tissue x 2) (g)	566.72±20.27	1795.94±36.63	2125.69±18.69	2763.01±124.90	4381.95±158.62
As % of E.B.W. (%)	31.84±0.46	38.62±0.33	41.28±0.13	42.57±0.18	43.15±0.28
Total carcass bones (side tissue x 2) (g)	294.43±14.49	601.32±9.22	616.99±4.29	706.34±28.24	944.37±30.23
As % of E.B.W. (%)	17.43±0.13	13.69±0.06	11.98±0.03	10.88±0.05	9.80±0.03
Total dissectible fat (side tissue x 2) (g)	64.75±6.03	188.64±4.75	268.04±9.37	554.67±35.90	1418.54±165.87
As % of E.B.W. (%)	3.76±0.21	4.24±0.05	5.21±0.18	8.61±0.71	14.16±2.07
Muscle: Bone ratio	1.93±0.07	2.95±0.03	3.45±0.02	3.91±0.06	4.41±0.05

*Empty body weight (E.B.W.) = Live weight at slaughter minus the gut contents.

TABLE 3
Sex effect on the liveweight and the weights of muscle, bone and fat (size tissue x 2) of the West African Dwarf goat as affected by age.

	Live weight at Slaughter (kg)		Total loan muscle (g)		Total carcass bones (g)		Total dissectible fat (g)	
Age of goat kids	males	females	males	females	males	females	males	females
2 weeks	1.98 ±0.10	1.91 ±0.18	582.26 ±50.17	551.18 ±50.01	302.05 ±13.29	286.80 ±31.09	68.88 ±10.91	60.62 ±8.37
8 weeks	5.56 ±0.04	5.40 ±0.10	1853.43 ±12.59	1738.45 ±35.82	621.49 ±2.11	592.92 ±9.77	195.49 ±1.12	180.79 ±3.27
12 weeks	6.25 ±0.25	6.18 ±0.15	2135.67 ±27.04	2115.92 ±34.23	617.31 ±6.21	616.67 ±8.47	252.70 ±6.23	283.38 ±4.19
24 weeks	9.15 ±0.15	8.58 ±0.58	2931.88 ±31.75	2594.14 ±189.59	743.37 ±71.37	669.31 ±41.74	510.17 ±22.50	599.17 ±57.17
52 weeks	14.35 ±0.33	13.18 ±0.17	4649.15 ±25.15	4114.75 ±86.96	1044.86 ±8.86	943.88 ±17.44	1134.17 ±21.11	1702.91 ±53.95

158.62 g (43.2% E.B.W.) at 52 weeks of age. Total dissectible fat increased from 64.8 ± 6.03 g. (3.8% E.B.W.) at 2 weeks to 1418.5 ± 168.87 g (14.2% E.B.W.) at 52 weeks of age. Total carcass bones also increased from 294.4 ± 14.49 g at 2 weeks old to 944.4 ± 23 g at 52 weeks of age, but when expressed as the percentage of E.B.W., decreased from 17.4% to 9.8% at 2 and 52 weeks respectively. Lean muscle was the biggest of the three carcass tissues at 2 weeks old, followed by the bone and fat was the smallest. At 52 weeks of age, lean muscle still comprised the biggest carcass tissue, followed by fat while the bone tissue became the smallest.

Accelerated impetus for carcass fat accretion across the experiment began at about 5.5 kg liveweight (Table 2) and extrapolation of tissue weights on age showed that fat tissue equalled the bone tissue in magnitude at about 10.06 kg liveweight and thereafter exceeded the bone tissues.

Table 3 shows the effect of sex on the liveweight and growth of the carcass tissues in the WAD goat kids. Male kids had significantly ($P<0.05$) more lean muscle weight than the females at 24 and 52 weeks of age and significantly ($P<0.05$) more bone weight than the females only at 52 weeks old. Female kids laid more fat in their carcasses than the males at 24 and 52 weeks of age, but the differences was only significant ($P<0.05$) at 52 weeks of age. Again, extrapolations show that fat in the carcasses of the female goat kids equalled the bones in magnitude at about 28 weeks of age, while those of the males equalled the bones in magnitude at about 43 weeks of age. The corresponding liveweights were about 9.02 kg and 12.06 kg respectively.

The ratio of muscle to bone (Table 2) was about 2:1 at 2 weeks old and about 4:1 at 52 weeks of age. The growth coefficients (Table 4) was less than one for bone (0.72), intermediate for muscle (1.10) and high for fat (1.59).

TABLE 4
Growth coefficients (b) of component tissues (Y) from the relationship $\log_{10}X$. Where X = muscle plus bone, from dissection data for West African Dwarf goats maintained under adequate condition of nutrition.

Dependent Variable (Y)	Intercept (a)	Regression Coefficient (b)	Standard error (SE)	Correlation Coefficient (r)
Muscle	-0.456	1.100	0.004	.99**
Bone	0.322	0.718	0.011	.99**
Fat	-2.898	1.586	0.047	.95**

** = ($P<0.01$)

Discussion

The fastest growth rate of about 79 g/day by the goat kids was obtained at between 2 and 8 weeks of age. Values on the rate of gain after birth are extremely limited for goats. A range from 18 g/day for native goats to over 200 g/day post weaning for improved breeds on high plane of nutrition has been reported (9).

Results obtained for post weaning growth rate in this study were about 28 g/day for goat kids between 12 and 24 weeks of age and 27 g/day for those between 24 and 52 weeks of age. Differences among breeds in size at maturity, as well as other factors affect growth rate (9). The WAD goat a part from being small in size even at maturity, is a slow growing animal (5), reaching a mean liveweight of only about 13.8 kg in 12 months in the present study.

This compared favourably with the liveweights reported for small breed of goats at the same age; 12.9 kg for WAD goat of Ghana (11), 13.0 kg for Black Bengal goat of India (7), or about 14.0 kg for Barbari goat (medium breed) of India (12). Limited information shows the goat is not a strong competitor to lamb and beef because it does not excel in rate of growth or rate of gain (9). Nevertheless, the goat will obviously continue to be exploited by man in most of its current habitats for cultural and economic reasons.

The dressing out percentages changed very little with age from 46.95 ± 0.40% to 48.53 ± 0.67%. Many factors like age, sex, breed, level of feeding etc. are known to affect the dressing out percentage (6). The E.B.W. increased progressively with age, but when expressed as the percentage of liveweight, E.B.W. showed consistent decrease from 91.3% at 2 weeks to 73.6% at 52 weeks of age. This is indicative of the fact that the digestive tract and its contents were increasing at a faster rate than the liveweight. Early in life (2 weeks old), lean muscle comprised the major component of the carcass, then followed by the bone, while fat was the least. Later in life (52 weeks), lean muscle (673.2% increase) still comprised the major component of the carcass, followed by fat (2090.8% increase), while the bones became the least (220.7% increase). Information in the literature mostly from sheep and cattle show that muscle comprised the highest percentage of the carcass at birth, then followed by fat and that bone at no stage exerted a dominant role in the determination of the relative proportions of the three major tissues (3). Again at comparable E.B.W., lambs laid about 3.5 times more fat in the carcass than goats and lambs on similar feed appeared to lay on more fat than goats. Also at the best mar-

keting age goat meat is low in flavour, juiciness and tenderness compared to lamb and beef (8).

All of the above characteristics should explain in part why there is basic variation in the proportions of fat in the carcasses of goats compared with those of sheep and cattle early in life.

Sex influence on the relative growth of carcass muscle, bone and fat showed that male goat kids at 52 weeks old had more ($P<0.05$) lean muscle and bone than the females probably due to effect of gonadal androgen in the males which is necessary to complete a full pattern of muscle development (3). The female goat kids significantly ($P<0.05$) exceeded the males in accretion of fat in the carcass and also entered the rapid fattening phase earlier. The rapid fattening phase refers to the period when carcass fat equalls the bone tissue in weight, being about 28 weeks of age (9.02 kg liveweight) for the females and about 43 weeks of age (12.06 kg liveweight) for the males. The male goat kids thus, had better desireable components of the carcass in terms of lean meat yield, entering the rapid fattening phase later and enabling them to reach optimum slaughter weight at heavier liveweight. The WAD goat farmer can thus utilize these growth advantages to either manage entire male goat kids in a fattening programme for a market situation or feed animals of each sex in a manner appropriate to their growth characteristics to achieve the best combination of slaughter weight and carcass composition.

Due to early development of bone and later development of muscle, the ratio of lean muscle to bone at 2 weeks of age was about two parts of lean muscle to one part of bone. During subsequent growth, bone tissue grew at a steady but slow rate and muscle at a relatively fast rate so that at 52 weeks of age, the ratio increased to about four parts of lean muscle to one part of bone. The results from the application of the allometric growth equation, $Y=aX^b$, (1) further substantiated the above statements.

Thus, the growth coefficient for bone was below one (0.72) and which infers that the bone was growing at a low impetus rate, intermediate for muscle (1.10), which was growing at an intermediate impetus rate and high for fat (1.59), which was growing at high impetus rate.

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