LINEAR BODY MEASUREMENTS OF THE WEST AFRICAN DWARF GOAT: PRACTICAL IMPLICATIONS

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Abstract

Live weight (LW) and some linear body measurements (body length BL, heart girth HG, and height at withers HW) were obtained from 151 does (aged between 2 and 36 months) and 51 bucks (aged between 2 and 15 months) reared under humid tropical conditions of Nigeria, correlated and evaluated. The ratio of BL to LW decreased with advancing age of the goats. HG:LW and HW:LW ratios followed a trend similar to BL:LW. The HG:BL, HW:BL and HW:HG ratios were fairly constant for all age groups and sexes and can be used to characterise the breed.

Live weight was predicted better by HG than BL ($P < 0.001$) among 2 - 8 month old does. BL predicted LW better than HG ($P < 0.001$) among 9 - 15 month old does and ($P < 0.01$) among 2 - 8 month old bucks.

Heart girth was the best predictor of LW ($P < 0.001$) in 2 - 8 month bucks while HW was best ($P < 0.001$ LW predictor in 9 - 15 month does.

Body length, HG and HW can reliably be used to predict the LW of goats depending on their age and sex.

Introduction

The estimated 34.5 million goats form about 49% of the total grazing livestock in Nigeria. (Nigerian Livestock Resources, Federal Government of Nigeria, 1992). Available evidence suggests that goats are owned by a large proportion of the rural dwellers in the humid zone of Nigeria. Goats are of great importance to the people of Nigeria: they serve as an insurance against crop

failure, a status symbol as well as helping maintain an acceptable cash flow throughout the year. Goats play an important socio-cultural role by providing meat for both nutritional and religious purposes as well as cementing bonds of friendship and kinship among rural communities through loaning out breeding does to caretakers and sharing the resultant Offspring.

Predicting the live weight (LW) of farm animals using body linear demensions such as body length (BL), heart girth (HG), and height at withers (HW) has been reported for pigs (Petherick 1983) and cattle (Nwosu et al., 1985; Touchberry and Bereskin 1956; Ross 1958) under intensive management. Other workers found positive correleations between LW and HG, LW and BL, BL and HG, and HW and HG of goats in the Philippines (Galeon, 1951) and India (Tandon, 1966). Devendra and Burns (1970) have classified goats, based on HW, into large (over 65cm), small (51 - 65cm), and dwarf (less than 50cm) breeds.

Information on the relationship between LW and body linear measurements for stall-fed/extensively managed goats in south-eastern humid Nigeria is lacking. Therefore, the predictability of LW in indigenous goats using these parameters should be investigated with the aim of providing a pragmatic tool for quick visual appraisal of the LW of the animals in the livestock market in the absence of a weighing scale. The study was also intended to establish the best predictor of LW using the three parameters and the interrelationships among them. This method might be preferable to body weight estimation using parameters from slaughtered animals, e.g. muscle length (Essien and Fetuga, 1988).

Materials and Methods

Two hundred and two goats aged between 2 and 36 months were randomly selected for body linear and weight measurements from 13 farming households in 3 study locations in SE Nigeria. The study locations were Itu, Uyo and Etinan Local Government Areas of Akwa Ibom State, Nigeria. The state lies between 04°32' and

05°33' N and 07°25' and 08°25' E, characterised by a humid climate with a mean annual rainfall of 2115mm, bimodal in nature, a mean monthly temperature of 27°C, and a mean relative humidity of 81.60% (range 62% to 88%).

Each animal was put in a tared sack and weighed using a hanging spring balance of 50kg limit. Body linear measurements were taken using a calibrated leather tape. Body length was taken from the tip of shoulder to tubercoxae, height at withers from the forehoof to the ridge between the shoulder bones, and heart girth at the narrowest point just behind the shoulders.

Ages of the animals were as provided by the farmers and where the accuracy was doubtful, these were estimated using the animals' dentition(Sastry and Thomas 1980). The animals were then stratified into 2 - 8, 9 - 15, 16 - 22, 23 - 29 and 30 - 36 month age groups and according to sex, for analysis.

The data were statistically analysed using linear regression and correlation techniques as outlined by Steel and Torrie (1980). The data were also fitted into the log - log (or log linear) regression model ($\log y = \log a + b \log x$) to enable the derivation of the equation

$$W = aL^3$$

where W is the live weight, and

L is the body linear measurement

The constant 'a' was estimated using least squares procedure.

Data for bucks were limited to the 9 - 15 - month age range due to the very few males beyond 15 months, the bulk having been sold and/or slaughtered.

Results

Mean live weight and body linear measurements.

The mean LW and body linear measurements of the survey animals are presented in Table 1. Does of 2 - 8 months of age averaged 7.66kg ± 1.47 in LW while bucks of comparable age weighed 7.49kg ± 1.70. The bucks were heavier than the does in the 9 - 15

month age range. Does aged 30 - 36 months averaged 16.50kg ± 2 .10 in LW. A similar comparison with the bucks beyond the 9 - 15 month age range was not possible since there were too few of them for meaningful statistical interpretation of their data: they are, therefore, not included in the Table.

The mean BL in does increased from 41.43cm ± 2.46 in the 2 - 8 month age group to 54.36cm ± 1.98 in the oldest age group. The rate of BL increase was greater between the 2 - 8 month and 9 - 15 month age groups. Thereafter the increase was at a decreasing rate. Does aged 9 - 15 months had longer bodies (46.71cm ± 3.17) than bucks (43. 36cm ± 11.01) of the same age.

Both bucks and does aged 2 - 8 months had about the same (46.00cm) heart girth. However, as the bucks grew older (9 - 15 months) they had a bigger heart girth than does of equivalent age (53.64cm vs 51.51cm). The biggest rate of change in HG among the does was between those of the 2 - 8 months and the 9 - 15 month age ranges. Thereafter the rate of change in HG was decreasing.

The mean HW for both sexes aged 2 - 8 months were quite close: 35.66cm for does, 36.86cm for bucks. However, at the 9 - 15 month age range the bucks were higher (43.36cm) at the withers than the does (39.71cm). By the time the does were 29 months old and between 30 and 36 months of age their height at withers had stabilized at about 44.00cm.

Ratio among parameters

In Table 2 the numerical ratios relating one parameter to the other are shown. The BL:LW ratio showed a decreasing trend with increasing age of does: from 5.41 in the 2 - 8 month age group to 3.29 in the 30 - 36 months old goats. The trend in the HG:LW ratios was similar to that of the BL:LW ratio. The BL:LW, HG:LW, and HW:LW ratios of does aged 23 - 29 months and 30 - 36 months were similar; so were the ratios of does and bucks of comparable age ranges. The HG:BL, HW:BL, and HW:HG ratios were

fairly constant, averaging 1.13, 0.88, and 0.78, respectively, for all age groups and sexes.

Prediction of live weight from body linear measurements using a simple linear model.

The prediction equations for estimating the LW of goats using BL, HG, and HW are given in Table 3. LW was predicted better by HG than by BL (R^2 0.74 vs. 0.64, $P < 0.001$) among the 2 - 8 month old does. As the animals grew older (9 - 15 months) BL predicted LW better than HG (R^2 0.90 vs 0.69, $P < 0.001$). In both age groups, HW was a poor predictor ($P > 0.05$) of live weight of the does. BL fairly (R^2 0.34, $P < 0.01$) predicted LW in 2 - 8 month-old bucks while in 9 - 15 month-old bucks it did not do so with a reasonable degree of reliability ($P > 0.05$). While HG was the best predictor of LW (R^2 0.55, $P < 0.001$) among bucks aged 2 - 8 months, HW was the best (R^2 0.42, $P < 0.001$) LW predictor in the 9 - 15 month range.

Prediction of live weight from body linear measurements using allometric model

Table 4 shows the allometric model of LW estimation using the various body linear measurements. BL and HG were interchangeably the best predictors of LW in each age group for the does. HW was consistently a poor predictor of LW as judged by the R^2 values. With respect to the backs, however, HG followed by HW were better predictors of LW than BL in the two age groups studied. Generally, as the animals advanced in age, the predictive ability of the parameters decreased.

Interrelationships among various body measurements

The interrelationships among the various body measurements are presented in Table 5. BL was better correlated with HG than with HW, with the closest relationship occurring in the 16 - 22 month age group for the does (R^2 0.49, $P < 0.001$). Beyond 22 months of age the relationships among the parameters became weak and statistically non-significant. HG was never a good predictor of HW.

Discussion

The does appear to be heavier than the bucks at 2 - 8 months of age but at 9 - 15 months the bucks weigh more than the does (Table 1). This is in agreement with Devendra and Burns (1970), who reported marked sex difference in live weight increase after 16 weeks of age. They reported further that while the growth of females slowed down to about 0.2kg per head per week, that of males continued at the rate of about 0.5kg per head per week. These sex-related differences in LW might be partly due to androgens (especially testosterone), which are not released early in male animals until the testes are well developed and which are known to have growth - and weight-stimulating effects. The dec decreasing LW differences between consecutive age ranges for does (e.g. 3.05kg between 2 - 8 and 9 - 15 months and 0.82kg between 23 - 29 and 30 - 36 months) tend to suggest that mature LW is attained before 36 months of age. Based on the two comparable age groups the does have slightly longer bodies than the bucks.

The constancy of the ratios HG:BL (about 1.13), HW:BL (about 0.88), and HW:HG (about 0.78) for all age ranges and sexes (Table 2) seems to be indicative of genotypic traits which could be used as identification criteria for the indigenous goats of southeast Nigeria.

The relationship between LW and BL for does 30 - 36 months of age appears non-significant ($P > 0.05$, Table 3) probably due to visceral fat accumulation of the does, which may tend to exaggerate or undermine the parameters depending on the condition of the animals. Generally, however, the various body linear dimensions were of dininishing reliability in predicting the LW as the animals matured. The prediction equations using an allometric model gave higher values of LW - predictive indices than the simple linear model. This could be ascribed to the fact that the growth pattern as a physiological process is better described by allometric than simple linear functions (cf. Petherick 1981).

Linear body dimension - BL, HG, and HW - appear to have attained their mature body size during the early stage of growth approximately from 15 - 22 months of age indicating early maturit. These body dimensions, which also serve as indices of early maturity, probably have a genetic basis. Though the BL and LW of goats increased with the age of the animals, the increase in LW after maturity (approximately 22 months of age) could be due to an increasing rate of fat deposition. Variation in LW among animals of identical sex and age range could have been attributable to management, nutrition, breeding regime and genotype - environment interactions.

The correlation coefficients (R) obtained from allometric equations relating LW to different body linear measurements (Table 4) were highly significant and similar to those reported by Tandon (1966). The high positive R values for LW and BL, and LW and HG in young goats (2 - 15 months for males and 2 - 22 months for females) seem to indicate that the rate of change in body linear dimensions was more rapid within these periods.

The significant positive correlations between HL and HG in does are similar to the findings by Galeon (1951) working on k kids of Philippine goats. The low and non-significant correlation between LW and HW obtained in this study also confirms Galeon's (1951) findings. This is probably because HW is less affected by environmental fluctuations, and hence the reason for using it as one of the classification criteria in goats by Devendra and Burns (1970). The differences in the ability of body linear dimensions to predict the LW in males and females in this study could be attributable to differences in the rate of development of both the rib cage and the vertebral column.

BL and HW and HW and HG (Table 5) are not significantly related ($P > 0.05$), probably because they (BL, HW, HG) are simultaneously affected by the same nutritional and environmental factors. This appears to be confirmed by the constancy

of the HG:BL, HW:BL, and HW:HG ratios (Table 2). BL has to do with the vertebral column growth, HW with fore limbs bone growth, and HG with ribs growth. Thus, though these are different parts of the skeletal system and would be affected similarly by the same set of factors, they appear to be independent of one another for the age and sex groups. The most significant relationship between BL and HG ($P < 0.01$, R^2 0.49) observed for goats aged between 16 and 22 months concerns the period of attainment of mature body size. It appears then that it would be beneficial to step up the feeding of goats especially does during this period so as to encourage them to realise their potential mature body size in time.

Body length, HG and HW can reliably be used to predict the LW of goats depending on their age and sex. The HG:BL constant ratio of 1.13, HW:BL constant ratio of 0.88 or HW:HG ratio of 0.78 can be used to characterise a goat, irrespective of age or sex, as belonging to the West African Dwarf breed.

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Table 1: Mean live weight and body linear measurements of indigenous goats of southeastern tropical humid Nigeria.

Age (months)	N	LW (kg)		BL (cm)		HG (cm)		HW (cm)	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Females									
2 - 8	30	7.66	1.47	41.43	2.46	46.48	3.03	35.66	2.29
9 -15	35	10.71	2.12	46.71	3.17	51.57	3.98	39.71	1.54
16 -22	30	13.36	1.72	49.50	2.95	55.35	2.54	42.95	2.83
23 -29	31	15.68	2.22	53.06	3.28	58.10	2.92	44.03	2.37
30 -36	25	16.50	2.10	54.36	1.98	59.58	2.54	44.52	2.32
Males									
2 - 8	27	7.49	1.70	40.99	2.65	45.95	3.71	36.86	3.03
9 -15	24	11.25	3.48	43.36	11.01	53.64	3.24	43.36	2.53

Table 2: Ratios of live weight and other body linear measurements of indigenous goats of Southeastern tropical humid Nigeria.

Age (months)	BL:LW	HG:LW	HW:LW	HG:BL	HW:BL	HW:HG
Does						
2- 8	5.41	6.07	4.66	1.12	0.86	0.77
9-19	4.36	4.82	3.71	1.10	0.85	0.77
16-22	3.71	4.14	3.21	1.12	0.87	0.78
23-29	3.38	3.70	2.81	1.09	0.83	0.76
30-36	3.29	3.61	2.70	1.10	0.82	0.75
Bucks						
2- 8	5.47	6.13	4.92	1.12	0.90	0.80
9-15	3.85	4.77	3.85	1.24	1.00	0.81

Table 3: Simple linear regression equations relating live weight to various body dimensions of indigenous goats of Southeastern tropical humid Nigeria.

Age (months)	Number (N)	Live Weight(Y)	Body dimension (X)	Prediction equation Y= a+bx	R	R^2
Females						
2- 9	30	LW	BL	Y=0.48x-12.22	0.80	0.64***
			HG	Y=0.41x-11.43	0.86	0.74***
			HW	Y=0.08x+ 4.65	0.09	0.009NS
9-15	35	LW	BL	Y=0.64x-19.06	0.95	0.90***
			HG	Y=0.67x-24.49	0.83	0.69***
			HW	Y=0.32x- 1.98	0.23	0.05NS
16-22	20	LW	BL	Y=0.33x- 2.63	0.68	0.46***
			HG	Y=0.51x-14.89	0.76	0.58***
			HW	Y=0.32x- 0.15	0.53	0.28*
23-29	31	LW	BL	Y=0.48x- 9.76	0.70	0.49***
			HG	Y=0.45x-10.67	0.61	0.37***
			HW	Y=0.49x- 5.93	0.52	0.27***
30-36	25	LW	BL	Y=0.31x-0.44	0.32	0.10NS
			HG	Y=0.48x-12.11	0.63	0.40***
			HW	Y=0.15x-10.03	0.22	0.05NS
Males						
2- 8	27	LW	BL	Y=0.30x- 4.75	0.58	0.34**
			HG	Y=0.35x- 8.83	0.74	0.55***
			HW	Y=0.30x- 4.16	0.64	0.44**
9-15	24	LW	BL	Y=0.29x- 0.27	0.36	0.13NS
			HG	Y=0.35x- 6.79	0.60	0.36**
			HW	Y=0.48x- 8.97	0.65	0.42**

*P<0.05, **P<0.01, ***P<0.001, NS = not significant

Table 4: Allometric relationships between liveweight and various body dimensions of indigenous goats of southeastern tropical humid Nigeria.

Age (months)	Variables Y	X	N	Prediction equation $W=aL^3$	R	R^2
Females						
2- 8	LW	BL	30	$W=0.00011L^3$	0.71	0.51^{***}
		HG	30	$W=0.0000074L^3$	0.88	0.78^{***}
		HW	30	$W=0.00016L^3$	0.11	0.01^{NS}
9-15	LW	BL	35	$W=0.00010L^3$	0.91	0.83^{***}
		HG	35	$W=0.000074L^3$	0.85	0.73^{***}
		HW	35	$W=0.00017L^3$	0.39	0.15^{*}
16-22	LW	BL	20	$W=0.00011L^3$	0.76	0.58^{***}
		HG	20	$W=0.000078L^3$	0.71	0.51^{***}
		HW	20	$W=0.00017L^3$	0.48	0.23^{*}
23-29	LW	BL	31	$W=0.000010L^3$	0.69	0.48^{***}
		HG	31	$W=0.000079L^3$	0.58	0.34^{**}
		HW	31	$W=0.00018L^3$	0.52	0.27^{**}
30-36	LW	BL	25	$W=0.00010L^3$	0.38	0.15^{NS}
		HG	25	$W=0.000076L^3$	0.56	0.32^{**}
		HW	25	$W=0.00019L^3$	0.34	0.12^{NS}
Males						
2- 8	LW	BL	27	$W=0.00011L^3$	0.50	0.25^{**}
		HG	27	$W=0.000074L^3$	0.86	0.74^{***}
		HW	27	$W=0.00013L^3$	0.62	0.38^{***}
9-15	LW	BL	24	$W=0.00012L^3$	0.32	0.10^{NS}
		HG	24	$W=0.00076L^3$	0.65	0.43^{**}
		HW	24	$W=0.00014L^3$	0.58	0.34^{**}

$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$, NS = not significant.

Table 5: Interrelationships among various body measurements of indignous goats using regression and correlation analyses.

Age (months	N	Variables Y	X	Prediction equations Y = a b :	R	R^2
2- 8	57[x]	BL	HG	Y= 6.01+0.98x	0.59	0.53*
		BL	HW	Y=36.73−0.87x	0.02	0.004NS
		HW	HG	Y=31.74+0.41x	0.35	0.12NS
9-15	59[x]	BL	HG	Y=24.76+0.59x	0.72	0.51**
		BL	HW	Y=20.61+0.41x	0.56	0.32*
		HW	HG	Y=30.05+0.56x	0.33	0.11NS
16-22	30	BL	HG	Y=30.80+0.50x	0.70	0.49***
		BL	HW	Y=23.93+0.38x	0.48	0.23*
		HW	HG	Y=35.29+0.47x	0.17	0.03NS
23-29	31	BL	HG	Y=51.17+0.45x	0.39	0.15NS
		BL	HW	Y=34.21+0.20x	0.25	0.06NS
		HW	HG	Y=48,57+0.22x	0.17	0.03NS
30-36	25	BL	HG	Y=32.03+0.50x	0.44	0.19NS
		BL	HG	Y=13.75+0.51x	0.35	0.12NS
		HW	HG	Y=55.60+0.09x	0.12	0.10NS

[x]Pooled for male and female sexes

*P< 0.05, **P< 0.01, ***P < 0.001, NS = not significant.