The estimation of live weight from body measurements in Yankasa sheep

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ABSTRACT: Live body measurements of weight, height, length, girth, stifle- and hip-width and a measure of muscularity (ratio of stifle to hip width) were monitored on 258 Yankasa sheep stratified into age categories of 1 to over 3 years determined mostly from records and partly by dentition. These animals are from purebred Yankasa sheep kept as a part of the open nucleus-breeding scheme of the National Animal Production Research Institute, Shika, Zaria, Nigeria. The effect of sex, type of birth and age group of lambs on live measurements and muscularity were analyzed by least-squares procedures. All variables examined, except sex, had significant ($P < 0.001$) effects on all body measurements. At birth, male and single-born lambs were significantly heavier than female and twin-born lambs. At early age, most factors significantly ($P < 0.01$) influenced the body weight, body dimensions and muscularity traits with single-born lambs being 31% heavier, 10% taller and 11% bigger in girth; more highly muscled than the twin-born lambs. This advantage of male over female born lambs (except in hip-width and girth) for growth and developmental traits was maintained reasonably well to the advanced ages. All phenotypic correlations between body measurements were positive and significant ($P < 0.001$). The highest correlation coefficient was found between chest girth and body weight. The polynomial equation using chest girth as an independent variable predicted body weight more accurately as compared to the linear equation.

Keywords: sheep; body measurements; live weight

Growth usually defined as the increase in size or body weight at a given age is one of the important selection criteria for the improvement of meat animals such as sheep. Within the indigenous sheep breeds of about 22.3 millions (FDLPCS, 1991) mainly kept for meat in Nigeria, Yankasa sheep is the most numerous and most widely distributed throughout the various ecological zones, particularly Guinea and Sudan savanna vegetation belts. It is estimated to constitute 60% of the total national flock. Being a medium-sized breed (intermediate between Balami and Uda breeds in the far north and West African Dwarf in the south), in addition to its hardiness, it seems to be very popular among sheep farmers most especially in Northern Nigeria (Afolayan, 1996).

In the past, the potential of sheep for possible carcass yield was based on weight and changes in weight alone (Osinowo et al., 1994; Iyeghe et al., 1996). However, feedlot trials with beef cattle crossbreds (Rutley et al., 1995) showed that weight, height, fat depth and visual muscle score (score developed by McKiernan, 1990) could be sufficient to describe variation in feedlot performance of the most economically important traits (average daily gain, carcass weight, fat depth and saleable beef yield). In the same species, objective body dimensions and measures of muscular development were shown to serve either to supplement body weight as a measure of productivity (Afolayan et al., 2002a,b) or as predictors of some less visible characteristics (Gilbert et al., 1993). In addition, body measurements could be used to predict live weight fairly well in the situation where weighbridges are not available (Berge, 1977; Buvanendran et al., 1980; Goonerwardene and Sahaayuraban, 1983). The objective of the present study was to estimate live weight based on a linear body measurement or a combination of body measurements in Yankasa sheep.

MATERIAL AND METHODS

Animals

The data for this study were obtained from 258 male and female adult sheep (born from the year 2000 to date) that consisted of 94 yearlings, 104 (1.5 to 3 years old) and 60 (> 3 years old) from a purebred Yankasa sheep flock kept as a part of the open nucleus breeding scheme of the National Animal Production Research Institute, Shika, Zaria. The detailed management and feeding from birth to maturity were described elsewhere (Afolayan et al., 2001, 2002a). Animals were housed in cross-ventilated pens and had free access to water and mineral salt licks. The routine health management system involves regular de-worming and de-ticking (dip bath). The ewes are routinely bred to rams through controlled natural mating following heat detection using apron fitted rams in a twice-yearly accelerated lambing program. Mating ratio is 1 ram to 10 ewes.

Live animal measurement

At birth, all lambs were weighed and tagged. The live weights were taken again at other ages for the sheep to be categorized as yearlings, 1.5 to 3 and > 3 years old, respectively. Body dimensional measurements were taken for all ages except at birth. The body measurements using a tape included the following traits: height (Ht, measured as the distance from the top of midline between the hips to the ground), length (Lh, measured as the distance between the point of the shoulder corresponding to the outer and central tuberosity of the left humerus to the left tuber ischii), and girth (Gh, measured as the body circumference immediately posterior to the front leg). Other measurements besides those mentioned above were hip width (Hp, bone) and stifle width (St, muscle) measured with callipers. Stifle width as the proportion (%) of hip width (only considered in the second experiment) was used as an indication of muscularity (Mus) previously (Afolayan et al., 2001) based on visual techniques for assessing meat yield developed by McKiernan (1990).

Statistical analysis

The traits analyzed included weight, body dimensions and muscularity as described above. The GLM procedure in SAS (1992) was used to test the effects of sex, type of birth and age in linear models on birth weight, live-weight and five (Ht, Lh, Gh, Hp, St and Mus) other body dimensional traits. The model used for the least-squares analysis was as follows:

$$Y_{ijkl} = U + S_i + T_j + A_k + E_{ijkl}$$

where: Y_{ijkl} = the observation of the l^{th} animal within the k^{th} age group of the j^{th} type of birth and i^{th} sex category
U = overall mean
S_i = effect of the i^{th} sex (i = 1, 2)
T_j = effect of the j^{th} type of birth (j = 1, 2)
A_k = effect of the k^{th} age (k = 1, 3)
E_{ijkl} = residual error

Linear, polynomial and stepwise multiple regressions were fitted to obtain prediction equations of body weight from body measurement variables. The REG procedure in SAS (1992) was used to de-

Table 1. Summary of live-measurement traits

Item	Acronyms	Mean	*CV* (%)	Minimum value	Maximum value
Weight	Wt (kg)	21.0	20.4	7.0	47.0
Height	Ht (cm)	62.1	7.2	45.0	79.0
Length	Lh (cm)	37.5	8.3	24.0	56.0
Girth	Gh (cm)	69.7	8.6	47.0	95.0
Hip	Hp (cm)	17.3	14.3	9.0	24.9
Stifle	St (cm)	17.9	12.1	12.0	25.4
Muscularity	Mus (%)	106.0	12.8	69.9	200.0

termine the relative importance of live-animal variable in a model designed to estimate body weight. The stepwise method was used and the inclusion and exclusion significance were set at a common specific level. The variables included by the stepwise regression method were then used to develop the equations for body weight. Similarly, raw correlations between all live measurements under considerations were computed.

RESULTS

Means and ranges for the live body measurements were determined. Of the live measurements, live weight (Wt) is the most variable, followed by the measure of bone (Hp) and muscle (Mus and St), while body dimensional traits (Ht, Lh, Gh) were the least variable (Table 1).

The result of the least squares analyses (not presented) indicated that birth weights were different for the sex of lambs and type of birth of lambs. At the growth phase, sex differences were highly significant for all body dimensional traits except height and girth. However, the type of birth effect was highly significant for weight, height, length, girth, hip- and stifle- width but not for muscle at the same age. As expected, age effects very highly significantly ($P < 0.001$) influenced all dependent variables.

Male lambs were heavier at birth (2.92 ± 0.07 vs 2.64 ± 0.07) than the female counterparts. At the growth phase, male lambs were 8% longer and had 17% more muscles than female lambs. At the same age, single-born lambs were 31% heavier, 10% taller and 11% bigger in girth; more muscled than the twin-born lambs (Table 2). As expected, yearlings were smaller in weight, shorter in height, length, girth, hip-width as well as less muscular than older animals (1.5–3 years). While the much older animals (> 3 years) were higher than the middle age animals (1.5–3 years) in weight, height and girth, the former were less muscular compared with the latter (Table 2).

With Pearson (raw) correlation modules, live weight was very highly ($P < 0.001$) correlated with body dimensional traits (0.76–0.94). Of the body dimensional characters, girth was the most related trait to weight and the correlation between these two traits was 0.94 (Table 3). Variables such as height, length, girth, which are directly related to the size and weight of animal, displayed moderate

Table 2. Least-squares means for body developmental traits in Yankasa sheep

Classification	No.	Birth weight	Wt	Ht	Lh	Gh	Hp	St	Mus
Overall mean	258	2.91 ± 0.03	22.01 ± 0.29	62.72 ± 0.30	38.27 ± 0.21	70.86 ± 0.40	17.35 ± 0.17	18.11 ± 0.15	107.16 ± 0.92
Sex									
Male	103	2.92 ± 0.07[b]	22.55 ± 0.35	62.80 ± 0.49	39.67 ± 0.34[b]	70.50 ± 0.66	15.82 ± 0.27[a]	17.59 ± 0.24[a]	115.52 ± 1.5[b]
Female	155	2.64 ± 0.07[a]	21.48 ± 0.48	62.65 ± 0.48	36.87 ± 0.25[a]	71.22 ± 0.48	18.88 ± 0.20[b]	18.62 ± 0.17[b]	99.10 ± 1.10[a]
Type of birth									
Single	190	3.02 ± 0.05[b]	26.52 ± 0.24[b]	66.55 ± 0.38[b]	27.99 ± 0.25[b]	51.92 ± 0.47[b]	17.47 ± 0.16[b]	18.74 ± 0.15[b]	100.60 ± 1.02
Twins	68	2.55 ± 0.09[a]	17.62 ± 0.37[a]	59.99 ± 0.59[a]	25.52 ± 0.40[a]	46.88 ± 0.74[a]	16.32 ± 0.25[a]	17.14 ± 0.23[a]	99.43 ± 1.59
Age (years)									
1	94	2.79 ± 0.08	12.99 ± 0.44[a]	55.07 ± 0.46[a]	32.10 ± 0.32[a]	59.27 ± 0.62[a]	17.10 ± 0.26[b]	16.84 ± 0.22[a]	99.11 ± 1.40[a]
1.5–3	104	2.78 ± 0.07	22.25 ± 0.42[b]	64.91 ± 0.44[b]	40.26 ± 0.30[b]	72.76 ± 0.59[b]	15.54 ± 0.24[a]	17.44 ± 0.21[b]	115.58 ±1.34[b]
> 3	60	2.78 ± 0.08	30.79 ± 0.62[c]	68.19 ± 0.64[c]	42.44 ± 0.44[b]	80.55 ± 0.87[c]	19.40 ± 0.36[c]	20.04 ± 0.31[b]	107.24 ± 1.97[a]

[a,b,c]differences between means with different superscripts within the same column and class within the experiment are statistically different ($P < 0.05$)

Table 3. Phenotypic correlations between body measurements

Variables	Ht	Lh	Gh	Hp	St	Mus
Wt	0.84***	0.76***	0.94***	0.49**	0.66**	–0.04ns
Ht		0.79***	0.87***	0.24*	0.49*	–0.34*
Lh			0.82***	0.05ns	0.36*	–0.15ns
Gh				0.38*	0.61**	–0.18*
Hp					0.68**	–0.40***
St						0.10ns

ns = non-significant; $^*P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

to very high positive correlations with one another (0.79–0.87). However, the measure of bone (hip width) was negatively correlated (–0.40) with the measure of muscularity (defined as stifle/hip × 100). Similarly, low and sometimes non-significant correlations were obtained between muscularity and all the body dimensional traits (–0.34–0.10). The weight is generally unrelated (zero correlation) to the muscularity (Table 3).

The relationships between live weight and chest girth or height or length were further studied using second degree polynomial regression (Table 4). The chest girth accounted for 89% of variation in body weight. The second best relationship was found with body weight and height (71%) and the least was for body weight and length (59%). The multiple linear regressions using the three body measurements in the equation did not result in better estimate of variation for body weight changes (88%).

A stepwise multiple regression analysis was also carried out when other body measurements were added, one at a time, to chest girth (Table 5). The essence was to determine how other body measurements would influence the precision of live weight predictions compared to using chest girth alone. It was observed that animal height with animal hip-width appeared to be important additional variables to chest girth to obtain up to 91% prediction of body weight.

Table 4. Second degree polynomial regression of live weight on body dimension traits

Variable	Intercept	B	b1	R^2
Ht	–21.47	0.37	0.01	71
Lh	–55.28	2.90	–0.02	59
Gh	2.43	–0.24	0.01	89

DISCUSSION

The accuracy of functions used to predict live weight or growth characteristics from live animal measurements is of immense financial contribution to livestock production enterprises. The ability of the producer and buyers of livestock to relate live animal measurements to growth characteristics is essential for optimum production and value-based trading systems. This ability will also adequately reward livestock farmers rather than the middlemen that tend to gain more profit in livestock production business, especially in the developing countries.

In this study, female lambs were lighter (though not significantly except at birth) in weight and shorter in height, length and girth as well as less muscular than male lambs. This might partly be due to the pre-natal (Williams, 1968) and pre-weaning advantage in male as compared to female lambs

Table 5. Multiple regression analysis of live weight on chest girth plus other variables

Variable	Intercept	b1	b2	b3	b4	b5	R^2	R^2 change
Gh	–30.55	0.74	–	–	–	–	0.88	0.00
Gh + Hp	–33.61	0.69	0.37	–	–	–	0.90	+0.02
Gh + Hp + Ht	–38.31	0.57	0.41	0.20	–	–	0.91	+0.03
Gh + Hp + Ht + Lh	–39.75	0.50	0.49	0.17	0.18	–	0.91	+0.03
Gh + Hp + Ht + Lh + St	–40.35	0.49	0.42	0.17	0.17	0.17	0.91	+0.03

as suggested by Iyeghe et al. (1996). However, the maintenance of birth growth advantage to later ages (Adu and Ngere, 1979; Tuah and Baah, 1985), as observed herein, is supported by the maternal ability of ewes when suckling heavier lambs which tend to be male (Newman et al., 1993) or of lamb's subsequent ability to eat grass. These differences between male and female lambs were similar to those reported in beef cattle (Gilbert et al., 1993; Afolayan et al., 2002a,b). In those reports, steers were heavier, taller and bigger in girth; more muscled but with less fat compared to heifers both at weaning and post-weaning ages.

The advantage of single lambs over twin lambs in terms of weight and body developmental traits could probably be due to less or no competition both in the uterus and after birth that allows for extra nourishment from dams on the former as compared to the latter (Iyeghe et al., 1996). As expected, similar patterns of growth performance were observed for early and later ages in weight, height, length, girth and muscularity.

The chest girth accounted for close to 90% of the body weight in this study. It was found to predict body weight with higher precision, and also better than the other measurements (e.g. body height and length) in estimating live weight. The second best correlation with body weight was found for body height. This observation agrees with that reported for some Nigerian cattle breeds (Umoh and Buvanendran, 1982). Similarly, Afolayan (2003) obtained a higher genetic correlation between weight and girth as compared to the correlation between weight and height across weaning and post-weaning ages of some bos taurus cattle breeds. Thus (in some practical management situations where the scale could not be accessed), measurement of girth may be a better indicator of weight than height as suggested by Vargas et al. (2000) for Brahman cattle.

The result of the multiple regression analyses indicated that the addition of other measurements to chest girth would result in significant improvements in accuracy of prediction even though the extra gain was small. However, under field conditions, live weight estimation using chest girth alone would be preferable to combinations with other measurements because of difficulty of the proper animal restraint during measurement. This thus reduces the practical usefulness of using other body measurements in conjunction with chest girth (Berge, 1977).

CONCLUSION

This report has demonstrated that the relationships between body weight and body dimensional traits are influenced by factors of sex differences and type of birth. Thus, adjustment for these factors may be necessary in developing a prediction equation for live weight using any of them or their combinations. Moreover, the high correlations between body weight and chest girth would imply that live weight could be predicted fairly accurately from chest girth rather than body height or length in Yankasa sheep.

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