Vol 14 No 1, p 21-25

USE OF LINEAR BODY MEASUREMENTS IN ESTIMATING LIVE WEIGHT OF CAMEL (*Camelus dromedarius*) CALVES IN KENYA

S G. Kuria[1], R G. Wahome[2], C K. Gachuiri[3], M M. Wanyoike[4] and J N. Mwangi[5]

Kenya Agricultural Research Institute, Marsabit Research Station[1]; P.O.Box 147; Marsabit, Kenya
Kenya Agricultural Research Institute Headquarters[5]; P.O. Box 57811
University of Nairobi, Department of Animal Production[2, 3 and 4]; P.O.Box 29053, Kabete, Kenya

ABSTRACT

A study was conducted in Kargi and Ngurunit locations of Marsabit district of Kenya to develop a formula for estimating the live weight of camel calves in pastoral situations using linear body measurements. Thoracic girth (TG), hump girth (HG) and shoulder height (SH) measurements were taken using an ordinary tape measure on 64 suckling calves at Kargi and 77 at Ngurunit, aged 3 weeks to 7 months. Analysis of variance revealed that the age and breed influenced ($p<0.05$) the linear measurements of camel calves. However, sex and study site did not ($p>0.05$). Correlation analysis suggested that TG had the greatest influence on live weight of calves ($p<0.05$, $r = 0.96$). Shoulder height had the least influence ($p<0.05$, $r = 0.82$). Regression analysis showed that the combined effect of TG, HG and SH on live weight of calves was higher ($p<0.05$, $R^2 = 0.95$) than that of the individual variables and combinations of any two of them. The formula; *Body weight (kg) = -200.86+105.91 TG(m)+79.63 HG(m)+56.22 SH(m)* was developed. This study concluded that given the values of TG, HG and SH, this formula could be used to estimate the live weight of camel calves with 95% accuracy level.

Key words: Body measurements, calves, dromedary, Kenya, weight

Camel calves provide replacements for breeding females and bulls. Live weight indicates calf growth rate, which is essential for the herder in deciding whether to use such calves to replace the breeding stock or cull them (personal observation). Live weight data is also important for nutritional purposes as it gives an integrated measure of the nutritional response of the calf, which is related to the feed conversion performances (Lambourne *et al,* 1983; Wilson, 1984). In this respect, live weight gains or losses give a sensitive indication of nutritional adequacy or inadequacy. In the modern animal husbandry, information on body weight of animals is important for proper dosing of veterinary drugs (Wilson, 1984; Mwacharo *et al,* 2002). In addition, it is important in estimating the maturity period for breeding heifers and bulls, period of attaining slaughter weight, market price, determination of feed requirements and stocking rate (Wilson, 1984).

Despite the pastoralists' realisation of the importance of weight data, weighing live camels (calves or mature) in pastoral situations is not done at all. This is unlike in commercial ranches where camels are/may be regularly weighed using conventional scales (personal observation). This is associated with lack of weighing facilities, their feasibility considering the relatively large size of the camel and the mobile nature of the pastoral production system (Lambourne *et al,* 1983; Abebe *et al,* 2002). Under the current scenario, live weight is estimated based on visual appraisal. However, only few people can accurately estimate the live weight of animals within defined limits (Mwacharo *et al,* 2002). This is largely to blame for misuse of veterinary drugs observed in the Kenyan pastoral settings today (personal observation).

In the absence of conventional weighing facilities, pastoral communities require simple, rapid, practical and accurate alternative techniques of estimating live weight of particularly the camel calves, for purposes of making key management decisions. One such technique is the use of linear body measurements. It has been used in cattle (Nicholson and Sayers, 1987; Goe *et al,* 2001), horses (Ellis and Hollands, 2002) and goats (Nsoso *et al,* 2003) with varying degrees of success. In mature camels, linear measurements have been used in combination with the formula; Live weight (kg) = abc ′ 50 where; a = shoulder height (m), b = thoracic girth (m), c =

SEND REPRINT REQUEST TO S. G. KURIA

hump girth (m), 50 = a constant factor, developed by Yagil (1994) to estimate live weight. In Kenya, this formula has been successfully used to estimate live weight of mature camels (Simpkin, 1995; Peters, 1999; Hulsebusch *et al,* 2002). The formula; live weight (kg) = 52 ´ shoulder height (m) ´ thoracic girth (m) ´ hump girth (m) ± 25.0 kg has also been used to estimate live weight of mature camels (Manyazewal, 1987; Abebe, 1991). In all these research endeavours, camel calves were not considered. The present study has developed a formula through regression analysis to estimate live weight of camel calves under field situations. Specific objectives of the study were:

- Assess the effect of age, sex, breed, site and their interactions on the linear measurements of camel calves
- Evaluate the correlation between thoracic girth (TG), hump girth (HG), shoulder height (SH) and the scale taken live weight of calves, then determine which of these three linear measurements best estimate the live weight of camel calves
- Evaluate the combined effect of linear measurements on the live weight of camel calves through multiple regression analyses
- Estimate the y intercept and beta values for TG, HG and SH in order to get the prediction formula
- Estimate the live weight of calves using this prediction formula and establish the association between these and those estimated using a formula developed earlier by Yagil (1994).

Materials and Methods

Study area

The study was carried out in the southern and western areas of Marsabit district of Kenya, 460 to 802 masl. The mean annual precipitation varied from less than 250 mm in the plains to 800 mm in mountain slopes, with temperatures ranging from 22.5° to 38°C (Schwartz *et al,* 1991). Soils in the lowlands were of volcanic origin while those in the highlands were metamorphic in nature (Bake and Kekem, 1984). Vegetation in the area was mainly shrubs interspersed with annual grasses and trees (personal observation). The study was carried out in two sites i.e. Kargi, situated on the plains and Ngurunit on the mountain slopes.

Study calves

Sixty-seven female and 74 male healthy suckling calves, aged between 3 weeks and 7 months were selected at random from the local pastoral herds. About 61% of these calves were of Rendille and 39% were crosses of Rendille with Somali and, Rendille with Turkana breeds. Of the 141 calves involved in the study, 64 were in Kargi and 77 in Ngurunit.

Linear measurements

Measurements were taken on the calves in the morning before they were released from the night enclosures, in standing position, with all the readings being taken by one person to reduce variations. The measurements were taken in metres on SH, TG and HG using a measuring tape (Tahir, 2003). Shoulder height was measured from ground to top of the scapula by placing a ruler beam horizontally on top of the scapula while stretching the tape perpendicularly to the ground (Kurtu, 2004). Thoracic girth was taken just behind the sternal pad while HG was taken over the mid-point of the hump and abdomen. For the TG and HG, the tape was placed firmly on the body, ensuring no denting of the skin.

Scale weighing of the calves

Scale weight of the calves was taken using a clock balance suspended on a tree branch with the help of straps and a gunny bag, with the readings being consistently taken by one person.

Data management and analysis

Data entry and cleaning was done in Windows based Statistical Package for Social Scientists (SPSS - Norman *et al*, 1975). The analyses were done using the Statistical Analysis System (SAS) and SPSS. To test whether age factor was important, a univariate analysis of variance was done. To test the effect of sex, breed, site and their interactions on the linear measurements, a multivariate analysis of variance was done using SAS where age was entered as a covariate. Correlation analysis was performed to establish the association between linear measurements and the live weight of calves. All the statistical tests were carried out at 95% significance level. Scatter diagrams depicting these relationships were drawn in SPSS. Simple and multiple regression analyses were done using the GLM procedure in SAS to find out how the linear measurements (independent variables) related to the live weight of calves (dependent variable), singly and in tandem, respectively. Correlation analysis was done to determine the association between body weights of the calves estimated using the prediction formula developed in this study and those estimated using the formula developed by Yagil (1994).

Results and Discussion

The effect of age, sex, breed, site and the interaction between these factors on the linear measurements is summarised in Table 1. The results showed that age of the calf influenced the body linear measurements and was therefore important in determining the live weight. While the sex and study site had no effect, the breed significantly influenced the linear measurements of the calves. Although the male and female calves were statistically similar, the males had higher average TG and SH than the females (Table 1). For the breed, the Rendille×Somali crosses were leading in TG and SH while the Rendille×Turkana crosses trailed in all the linear measurements. The interaction between the factors of calf sex and site were significant while the others were not.

These results were in conformity with the findings of Lambourne *et al* (1983), Abebe *et al* (2002) and Kurtu (2004). Lambourne *et al* (1983) observed that the relationship between linear measurements and live weight depended on the breed and to some extent on body condition and sex. Abebe *et al* (2002) stated that differences in live weight of camels and by extension, linear measurements could result from differences in the age, breed, ecology of the area (site) and general management. Abebe *et al* (2002) reported mean linear measurements and weights that were greater in males than females of the same age class although there was no indication whether the differences were significant or not. Kurtu (2004) reported higher linear measurements in mature males than females although the differences were not significant. The differences in linear measurements between male and female calves were perhaps not clear due to the young age since it is common knowledge that mature males are bigger than females (Personal observation). As the calves continued to grow to assume conformations for dairy (females) and meat/breeding (males), the observed differences may have widened, becoming more clear and significant.

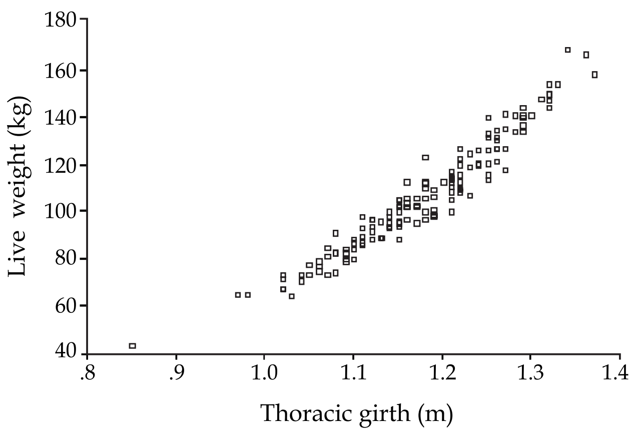

Fig 1. Scatter diagram depicting the relationship between thoracic girth and the live weight of camel calves.

Correlations between the linear measurements and live weight of calves

The relationships are presented in Fig 1 to 3. The results suggested strong positive linear relationship between the measurements and the live weight with very few outliers. The correlation coefficients (r) were 0.96, 0.95 and 0.82 for TG, HG and SH, respectively, suggesting that TG was the best single estimator of the live weight of calves. The results were in harmony with Field (1979), Abebe *et al* (2002) and Mwacharo *et al* (2002). Abebe *et al* (2002) working with camels in Ethiopia reported an r-value of 0.96 between TG and live weight, which, as in the present study was superior to HG versus live weight and SH versus live weight. The authors concluded that the application of linear regression using TG measurements provided an easy and reliable indirect means of estimating live weight of the camel which was in agreement

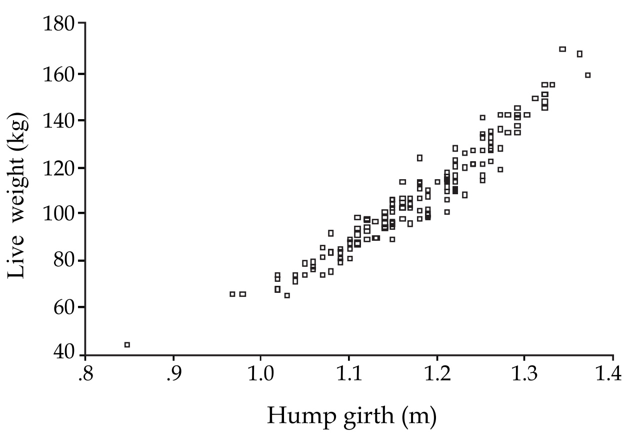

Fig 2. Scatter diagram depicting the relationship between hump girth and the live weight of camel calves.

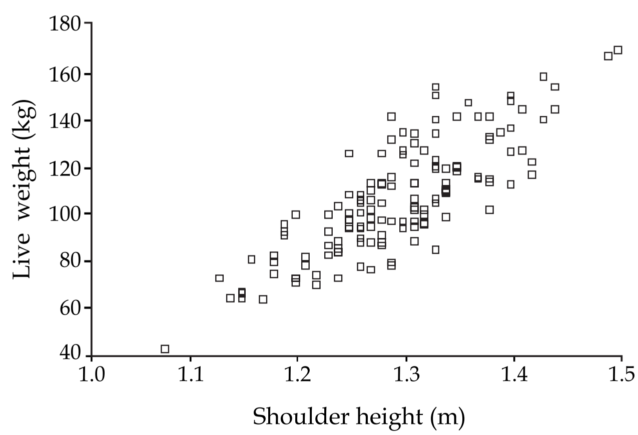

Fig 3. Scatter diagram depicting the relationship between shoulder height and the live weight of camel calves.

Table 1. The effect of age, sex, breed, site and the interaction between these factors on the linear measurements (in metres).

Factors	Thoracic girth		Hump girth	Shoulder height	p value
Age		$R^2 = 0.60$	$R^2 = 0.59$	$R^2 = 0.57$	**s (p<0.00)**
Sex	Males (n=74)	1.18 ± 0.01	1.38 ± 0.02	1.30 ± 0.01	ns (p=0.72)
	Females (n=67)	1.17 ± 0.01	1.40 ± 0.02	1.27 ± 0.01	
Breed	Rendille (n=86)	1.17 ± 0.01[a]	1.40 ± 0.01[a]	1.26 ± 0.01[a]	
	Rendille × Somali (n=52)	1.19 ± 0.01[b]	1.39 ± 0.02[a]	1.33 ± 0.01[b]	s (p<0.00)
	Rendille × Turkana (n=3)	1.08 ± 0.01[c]	1.24 ± 0.07[b]	1.24 ± 0.05[c]	
Site	Kargi (n=64)	1.18 ± 0.01	1.42 ± 0.01	1.27 ± 0.01	ns (p=0.22)
	Ngurunit (n=77)	1.17 ± 0.01	1.37 ± 0.02	1.30 ± 0.01	
Sex * site					s (p=0.02)
Sex * breed					ns (p=0.10)
Site * breed					ns (p=0.09)

s–Significant; ns–Not significant; Column means followed by the same letter superscript are statistically the same (p>0.05)

Table 2. Correlation between live weights estimated using the formula developed in this study and, those estimated using formula given by Yagil (1994).

		Estimated weight (kg)	Scale weight (kg)
Estimated weight (kg – Yagil formula)	Pearson Correlation	1.000	0.992**
	Sig. (2-tailed)	-	0.000
	N	141	141
Estimated weight (kg – Own formula)	Pearson Correlation	0.992**	1.000
	Sig. (2-tailed)	0.000	-
	N	141	141

** Correlation is significant at the 0.01 level (2-tailed)

with Wilson (1984). Mwacharo *et al* (2002) working with Zebu cattle in southern Kenya reported positive correlations in the range of 0.41–0.89 between linear measurements and live weight, with TG having the highest r-value with the live weight. TG was found to be best predictor of live weight suggesting that it was the most variable live weight measurement.

Relationship between linear measurements and the live weight of calves

Simple regression analysis for single variable effect

The F statistic for the regression between TG and live weight was significant ($p<0.05$) with a coefficient of determination (R^2) of 0.93. For the HG versus live weight and SH versus live weight, the F statistics were also significant ($p<0.05$) with R^2 values of 0.89 and 0.67, respectively. The high R^2 and significant F value for the regression between TG and live weight implied that TG explained most of the variation in live weight of camel calves. These results were in agreement with earlier findings by Nicholson and Sayers (1987), Goe *et al* (2001), Mwacharo *et al* 2002 working with cattle, Benyi and Karbo (1998) working with sheep and, Abebe *et al* (2002) working with camels.

Multiple regression analysis for combined variables effect

The F statistic for multiple regressions between TG, HG and live weight was significant ($p<0.00$) with an R^2 value of 0.94. In this multiple regression, the TG explained 72.8% of the variation with the HG explaining only 27.2%. The R^2 value of 0.94 implied that the combined effect of these two variables on the live weight of calves was higher than the effect of each one of them, individually. For the multiple regression of TG and SH versus live weight, the F statistic was significant ($p<0.05$) with an R^2 value of 0.93. The TG explained 98.8% of the variation with the SH explaining a paltry 1.2%. The multiple regression of HG and SH versus live weight was also significant ($p<0.05$) with an R^2 of 0.94. The HG and SH explained 85.4% and 14.6% of the variation, respectively. When all the three variables were put in the regression model, the F statistic was significant ($p<0.05$) with the highest R^2 value of 0.95. Thus, the collective influence of the three variables on the live weight of calves was higher than the individual variables and combinations of any two of them.

The estimated y intercept (a) and the beta values for TG, HG and SH were 200.86, 105.91, 79.63 and 56.22, respectively.

Therefore, these values were inserted in our prediction equation;

ŷ (body weight) = $a+b_1TG+b_2HG+b_3SH$ gives;

Body weight (kg) = -200.86+105.91 TG(m)+79.63 HG(m)+56.22 SH(m)

This formula could be used under pastoral field situations to quickly estimate live weight of camel calves with a 95% level of accuracy. One would only need to take these 3 linear measurements in metres using an ordinary tape measure.

Comparison between live weights estimated using the formula developed in this study and, those estimated using Yagil's 1994 formula

Live weights of the camel calves were estimated using the formula developed in this study and correlated with those estimated using Yagil (1994) formula. The results are presented in Table 2. The correlation coefficient (r) was 0.99 suggesting a strong linear positive relationship between calf weights estimated using both formulae. These results further suggested that given the values of the linear measurements, these two formulae could give accurate estimate of the live weight of both the mature and camel calves.

In conclusion, the linear body measurements are efficient in estimating the live weight of camel calves as they are in mature camels. Thoracic girth has the greatest influence on the live weight of camel calves.

References

Abebe W (1991). Traditional husbandry practices and major health problems of camels in Ogaden. Nomadic Peoples, Uppsala Sweden. Scandinavian Institute of African Studies 29:21-29.

Abebe W, Getinet AM and Mekonnen HM (2002). Study on live weight, carcass weight and dressing percentage of Issa camels in Ethiopia. *Revue De Medecine Veterinaire* 153(11): 713-716.

Bake G and Kekem AV (1984). Climatology, geomorphology, hydrology and soils of Integrated Project for Arid Lands study area. Technical Report A-6. UNESCO, Nairobi Kenya.

Benyi K and Karbo N (1998). Estimation of live weight from chest girth in pure and crossbred West African sheep. Tropical Agriculture (Trinidad) 75(3):380-383.

Ellis JM and Hollands T (2002). Use of height specific weigh tapes to estimate the body weight of horse. Veterinary Record 150:632-634.

Field CR (1979). Camel growth and milk production in Marsabit district of Kenya. In: International Foundation for Science (IFS), International Symposium on Camels held in Sudan 1:209-230.

Goe MR, Alldredge JR and Light D (2001). Use of heart girth to predict body weight of working oxen in the Ethiopian highlands. Livestock Production Science 69(2):187-195.

Hülsebusch CG, Kuria SG, Kamau D and Simpkin SP (2002). Qualitative morphological and body measurement differences between Kenyan camel populations. In: Camel Breeds and Breeding in Northern Kenya, Eds., Hülsebusch CG and Kaufman B. Kenya Agricultural Research Institute, Nairobi, Kenya, pp 91-108.

Kurtu MY (2004). An assessment of the productivity for meat and the carcass yield of camels (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. Tropical Animal Health and Production 36:65-76.

Lambourne LJ, Dicko MS, Semenye P and Butterworth M (1983). Proceedings of the IDRC/ILCA workshop held at ILCA Addis Ababa Ethiopia 21 – 24 March 1983. International Livestock Centre for Africa (currently ILRI), Addis Ababa, Ethiopia.

Manyazewal A (1987). Management and diseases of camels in Keren Awraja. Unpublished D.V.M thesis, Faculty of Veterinary Medicine, Addis Ababa University, Ethiopia.

Mwacharo JM, Okeyo AM, Kamande GK and Rege JEO (2002). Assessment of the effectiveness of the Daltons® weigh band and body measurements in estimating live weights for the Small East African Zebu cattle in Kenya. In: Proceedings of the 8th Biennial Scientific Conference, Eds., Mwangi M, Sitawa OJK, Kimani IW and Ayiemba JA, Kenya Agricultural Research Institute, Nairobi, Kenya.

Nicholson MJ and Sayers AR (1987). Relationship between body weight, condition score and heart girth changes in Boran cattle. Tropical Animal Health and Production 19:115-120.

Norman HN, Hull CH and Bent DH (1975) (eds.,) Statistical Package for Social Sciences, 2nd edition. McGraw Hill, New York.

Nsoso SJ, Aganga AA, Moganetsi BP and Tshwenyane SO (2003). Body weight, body condition score and heart girth in indigenous Tswana goats during the dry and wet seasons in southeast Botswana. Livestock Research for Rural Development (15)4:2003.

Peters C (1999). Gewichtsermittlung von kamelen mittels linearer körpermaâe. Diplomabeit, Institut fur Tierproduktion in Den Tropen und Subtropen, Universität Hohenheim, Deutschland.

Schwartz HJ, Shabaan S and Walther D (1991). Marsabit District Range Management Handbook of Kenya Vol. II (1):164. Ministry of Livestock Development, Nairobi, Kenya.

Simpkin SP (1995). Data collection and herd monitoring. In: Camel keeping in Kenya, Eds., Evans JO, Simpkin SP and Atkins DJ. Range Management Handbook of Kenya Vol. III 8. 8:1-8:3. Ministry of Agriculture Livestock Development and Marketing, Nairobi, Kenya.

Statistical Analysis System (SAS) (1999). SAS Version 8 Institute Inc. Cary, North Carolina, USA.

Tahir MA (2003). Correlation between live body measurements, slaughter offals and carcass traits of camels. Indian Journal of Animal Science 62(9):861-865.

Wilson RT (1984). The Camel. London and New York, Longman, pp 200.

Yagil R (1994). The Camel in Today's World. A handbook on camel management. Research Report 1, *Deutsche Welthungerhilfe*, German Agro Action, Bonn, Germany.