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Estimation of live bodyweight from linear body measurements and body condition score in the West African Savannah Shorthorn cattle in North-West Benin

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Abstract: This study was undertaken to provide easy and optimal live bodyweight (LW) estimate models for the West African Shorthorn Somba cattle breed under field conditions using morphometric traits. Based on data from 289 animals of different age categories (calves: suckling < 1 year; young: 1–3 years and adults>3 years) kept under smallholder management conditions, simple (linear, quadratic, allometric) and multiple (linear, quadratic) regression models were used to explore the relationships between LW, body condition score (BCS) and six linear body measurements, while taking animal's age and sex into consideration. On the contrary to the BCS, all morphometric measurements were positively and highly correlated with Somba cattle LW (r = 0.90–0.97; p < 0.001). Of all linear body measurements, the chest girth (CG) gave the highest correlation coefficient with LW and fitted best Somba cattle LW predicting model in allometric regression ($LW = 1.33 \times 10^{-4} \times CG^{2.89}$; $R^2 = 0.97$) irrespective of age and sex categories. Age and sex influenced the relationships between morphometric measurements and LW. However, their inclusion in the regression equations did not improve the predictive

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PUBLIC INTEREST STATEMENT

Monitoring livestock performances in African rural farms is still challenging due to the lack or readily availability of weighing scales. Meanwhile, farm animal resources are mismanaged and strategies to improve herd management practices are inexistent. This study proposes to farmers, researchers and other stakeholders a practicable and reliable tool to estimate and then monitor the live bodyweight of the West African Shorthorn cattle type from their linear body measurements. This work is a crucial step towards the sustainable use of valuable indigenous breeds as it could help to record and monitor animal performances and design appropriate breeding program to optimize herd productivity in local farming systems.

power of the models. The measurement of CG only proved sufficient for the estimation of LW in allometric regression model. Furthermore, it could be easily and accurately measured by everyone. Hence, this model could be used by farmers and researchers to efficiently predict and monitor LW, and optimize productivity of the West African Shorthorn Somba cattle herds in smallholder farming systems.

Subjects: Agricultural Development; Agricultural Engineering; Agriculture

Keywords: chest girth; growth performance prediction; regression analysis; taurine breed; West Africa

1. Introduction

The West African Savannah Shorthorn Cattle plays an important role in the livelihood's strategies of the local people in northwestern Benin and Togo (West Africa) (Rege, 1999). This indigenous animal resource is threatened due to poor feeding, poor health and reproduction management systems (Dossa & Vanvanhossou, 2016). Its sustainable use requires the development of strategies that better integrate genetic improvement, adequate nutrition, good animal health, marketing and other management aspects as recommended by FAO (2011). To achieve this goal, a proper recording of the animal characteristics and performances, including the measurement and monitoring of its live bodyweight (LW) is crucial. Apart from its use in assessing animals' growth, health and feed use efficiency, LW is used to evaluate the type, function and potential values of animals intended for use as breeding stock, meat production, milk production and draught power (Lesosky et al., 2013).

In rural areas, where weighing scales are not readily available on farm to monitor cattle performance, LW is often estimated by visual appreciation, method which is wildly inaccurate (Chitra, Rajendran, Prasanna, & Kirubakaran, 2012), especially when performed by different evaluators. An easy and reliable way to evaluate LW under farm conditions is therefore needed. Several authors have found a strong relationship between animals' LW and their linear measurements and then developed LW prediction models using body measurements (Lesosky et al., 2013; Lukuyu et al., 2016). However, accurate estimation of LW could be influenced by several parameters including animal breed, sex and age. Hence, these variables were used in LW prediction by various authors (Rashid, Hoque, Huque, & Bhuiyan, 2016; Tsegaye, Belay, & Haile, 2013). Tariq, Younas, Khan, and Schlecht (2013) have developed LW prediction model for three age groups of buffaloes with morphometric measurements and body condition score (BCS). According to Nicholson and Sayers (1987), BCS could be used to rapidly and easily estimate LW in absence of weighing scale or tape if it is directly related to LW.

To our best knowledge, only one study (Adanléhoussi et al., 2003) has produced estimates of LW in Somba cattle using morphometric measurements. Although this study was conducted on a relatively large sample, its findings have not yet been validated and the suggested regressions equations can only be considered preliminary. Furthermore, these authors did not take account of the effect of sex on LW estimates, nor did they examine the relationships between BCS and LW. Given the importance of accurate LW estimation in monitoring herd's productivity for proper feeding and breeding management under smallholder production systems; the aim of the present study is to determine if the accuracy of LW prediction model for Somba cattle from linear body measurements can be improved using separate equations for sex groups and by including the animals' BCS estimations.

2. Material and methods

2.1. Study area

This study was conducted in Boukombe District), the original habitat of the Somba cattle breed in north-west Benin. Yearly precipitations vary from 800 to 1500 mm, and are distributed through a unimodal rainfall pattern. Growing up mainly on rocky soils, the vegetation of this hilly area is dominated by clear forest, woody and shrubby savannas (Tchegnon, 2006). Crop production is the main activity and source of income. Livestock production including cattle, goat, pigs and poultry keeping plays an important role in farmer's livelihood strategies. Cattle are kept in low input-output production systems with two types of herds: family-managed and entrusted herds, the latter are kept by professional herders who took on cattle from absentee owners.

2.2. Data collection and sampling procedure

Morphometric measurements, LW and BCS were recorded on a total of 289 cattle in seven entrusted Somba cattle herds kept under traditional management conditions. These herds were randomly chosen in two administrative units (Manta and Natta) which, out of the seven administrative units of the district of Boukombe, hold most of the entrusted herds relatively less affected by crossbreeding (Gbaguidi, Batcho, Tidjani, Yokossi, & Wammasse, 2006). Entrusted herds were preferred in this study because of their higher average size compared with family-managed herds (Dossa & Vanvanhossou, 2016).

Animals were weighed using a digital ID3000 weighing scale (accuracy ±1%, True-Test Limited, New Zealand). The body condition was scored on a scale of 1 (very poor) to 5 (too fat) as described by Vall and Bayala (2004). Measurements (Figure 1) were taken on six morphometric traits following the FAO guidelines (FAO, 2012). A Mason's measuring tape was used to measure chest girth (CG) as the circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body and body length (BL) as the horizontal distance from the point of shoulder to the pin bone. Rump width (RW), which is the distance between the most posterior points of pin bones and chest depth (CD), the vertical distance from the chest floor

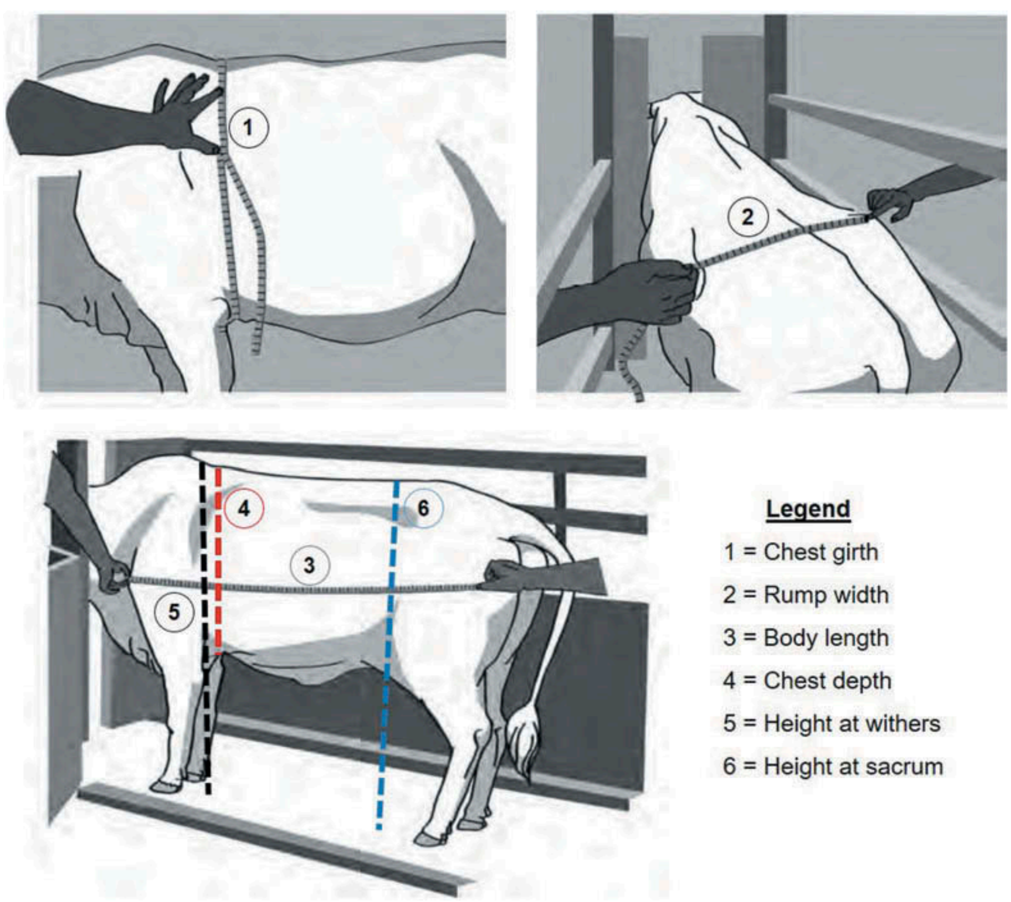


Figure 1. Illustration of morphometric traits measured on Somba cattle (Source: FAO, 2012).

just behind the forelegs to the top of withers, were measured using a metal caliper. A measuring stick was used to measure height at sacrum (HAS) which is the distance from the top of the bone at the base of the tail to the ground. The height at withers (HAW) was measured as the vertical distance from the bottom of the front foot to the highest point of the shoulder between the withers. To minimize experimental errors, all these linear body measurements were taken early in the morning by the same operator just after the weighing when animals were still in the restrained standing position on four legs with their heads maintained in an upright position. The age of each measured animal was obtained from the farmer and confirmed by examining the animal's teeth according to the method described by Khan, Rind, Rind, and Riaz (2003) using eruption of permanent teeth with 2, 4, 6, and 8 erupted permanent incisors, respectively, equivalent to 2, 3, 4 and 5 years approximatively.

2.3. Statistical analysis

All the statistical analyses were performed using the Statistical Analysis System version 9.2 Statistical Analysis System Software (SAS, 2008). The measured animals were grouped in two sex groups (sire, female) and in the three following age groups: calves (suckling <1 year), young (second age = 1–3 years) and adults (>3 years). Different analyses were performed separately for each sex and age group and for all animals. For each body measurement, the least-square means (LSMEANS) and associated standard error (SE) were calculated using the general linear model (GLM) procedure. When necessary, the Tukey adjustment test was applied for pairwise mean comparisons. Pearson's correlation coefficients (*r*) were calculated and tested for significance using the PROC-CORR procedure to assess the linear association between LW, linear measurements, BCS. The LW was then regressed on each of the independent variable using the AUTOREG procedure. The stepwise selection method was applied in multiple regression analyses to determine the variables which best predicted LW in Somba cattle. Linear (Equations 1 and 2), quadratic (Equations 3 and 4) and allometric (Equation 5) effects of the independent variables were considered as follows:

$$\mathrm{LW} = b_0 + b_1X + \varepsilon_0 \tag{1}$$

$$\mathrm{LW} = b_0 + b_1X_1 + b_2X_2 + \ldots + b_iX_i + \varepsilon_0 \tag{2}$$

$$\mathrm{LW} = b_0 + b_1X^2 + b_2X + \varepsilon_0 \tag{3}$$

$$\mathrm{LW} = b_0 + b_1{X_1}^2 + b_2{X_2}^2 + \ldots + b_i{X_i}^2 + \varepsilon_0 \tag{4}$$

$$\mathrm{LW} = \alpha X^{\beta} + \varepsilon_0 \tag{5}$$

where

LW is the live body weight of the animals,

X_1 to X_i is the body measurement or BCS,

b_0 is the intercept or the allometric coefficient,

b_1 to b_i are the regression coefficients of LW on X, or the allometric exponent and

ε_0 is the residual error term.

The different predictive models were evaluated and compared using the coefficient of determination (R^2), the root mean squared error (RMSE) and the Mallows' *Cp* statistics. The R^2 is commonly used to describes the proportion of the variance in measured data explained by the model and ranges from 0 to

1, with higher values (≥0.5) indicating less error variance (Moriasi et al., 2007). However, a regression model with a greater R^2 might not be precise (Barrett, 1974). Therefore, the RMSE was associated with to ensure the prediction accuracy. RMSE is an estimate of the standard deviation of the error term, and the lower the RMSE, the better the model estimation performance (Chai & Draxler, 2014). In multiple regression, we used Mallow's *Cp* statistic to identify the best reduced model from the subset of reduced models provided by the stepwise regression procedure (Venter, Haftka, & Starnes, 1998). For all analyses, values were considered significantly different at $p < 0.05$.

3. Results

3.1. Age and sex differences in physical body measurements

The average LW of Somba cattle was 136.8 ± 3.4kg and ranged from 22.5 kg to 274.5 kg. Out of all the body measurements, CG showed the highest variability with values ranging between 68 cm and 157 cm. It was followed by HAS (61.5–118 cm), BL (45–131 cm), HAW (56–114 cm), CD (23.5–63 cm) and RW (13–43 cm). All these body measurements were significantly and positively related to the animal's age and sex (Table 1). They tended to be higher with bulls and significantly increased with the animal's age until 5–6 years.

3.2. Phenotypic correlations among physical body measurements

LW was significantly and positively associated with each of the linear morphometric traits ($r = 0.90–0.97$; $p < 0.001$). Overall, the highest correlation was obtained between LW and CG and the lowest between LW and HAS (Table 2). Pearson's correlation determined in sex and age groups were lower than those obtained irrespective of the animals' age and sex. Nevertheless, for the same body measurement trait, the coefficients were higher for males than for females. Likewise, the younger the animal, the higher was the correlation between its LW and each of the linear body measurements. The relationships between different morphometric measurements were high ($r = 0.87–0.98$). The highest correlation was observed between HAS and HAW ($r = 0.98$) followed by CG and CD ($r = 0.97$) and the lowest ($r = 0.87$) between HAS and BL; HAS and RW.

3.3. Regression of live bodyweight on linear body measurements

3.3.1. Simple regression models

The regressions of LW in simple linear (i), quadratic (ii) and allometric (iii) models (Figure 2) revealed that all single morphometric measurements were good in predicting the Somba LW ($R^2 > 0.81$). CG predicted best LW in the tree regression models showing the highest coefficients of determination ($R^2 \geq 0.94$) against $R^2 \leq 0.90$ for others measurements except CD in allometric model ($R^2 = 0.93$). LW estimation using allometric regression yielded an average of 3% and 2% higher R^2 value than simple linear and quadratic regression, respectively. Similar trends were obtained when LW was regressed separately for each sex group whereby the accuracy of the prediction of LW was significantly improved for male (Table 3). Moreover, predicted values of LW from allometric equation using CG were really closer to actual measured LW (RMSE = 0.09 kg). In contrast, performing the analyses separately for each age group generally resulted in lower model fit values ($R^2 = 0.75–0.90$ for CG in simple linear regression).

3.3.2. Multiple regression models

Stepwise procedure in multiple linear regression revealed that only BL with RW appeared to be important additional variables to CG to best fit the LW prediction model giving a lower *Cp* value (Table 4). The R^2 values in multiple linear regression models range from 0.92–0.96. Multiple quadratic regressions give better results mostly for male ($R^2 = 0.98$) but the predictive powers of models are relatively poor (RMSE = 8.8–10.3Kg).

3.4. Live bodyweight (LW) and body condition score (BCS)

Somba cattle LW was significantly ($p < 0.001$) affected by BCS, however, the coefficient of correlation between the two parameters was significantly low ($r = 0.31$; $p < 0.001$). Simple linear,

Table 1. Least-squares means (means ±SE) of Somba cattle bodyweight and linear physical measurements by age and sex groups from village herds in Boukombe, Northwestern Benin

		LW (kg)	HAW (cm)	CD (cm)	CG (cm)	HAS (cm)	BL (cm)	RW (cm)
Total	289	136.8 ± 3.4	90.7 ± 0.7	45.2 ± 0.4	118 ± 1.1	95.4 ± 0.7	91.1 ± 1.0	29.7 ± 0.3
Calves*	66	60.1 ± 2.2^{A}	74.0 ± 1.1^{A}	34.7 ± 0.5^{A}	90.5 ± 1.2^{A}	78.5 ± 1.1^{A}	69.2 ± 1.0^{A}	21.8 ± 0.4^{A}
Female	36	57.3 ± 3.0	72.9 ± 1.5	34.3 ± 0.7	89.1 ± 1.6	77.7 ± 1.6	67.3 ± 1.4^{a}	21.4 ± 0.5
Male	30	63.5 ± 3.0	75.4 ± 1.5	35.2 ± 0.8	92.2 ± 1.7	79.5 ± 1.7	71.4 ± 1.5^{b}	22.2 ± 0.5
Young*	93	120 ± 2.8^{B}	90.2 ± 0.7^{B}	43.9 ± 0.4^{B}	115 ± 0.9^{B}	95.5 ± 0.7^{B}	87.7 ± 1.0^{B}	28.6 ± 0.3^{B}
Female	49	121 ± 3.6	90.6 ± 0.9	44.2 ± 0.5	116 ± 1.3	95.9 ± 0.9	89.0 ± 1.4	28.8 ± 0.5
Male	44	118 ± 4.3	89.9 ± 1.0	43.5 ± 0.5	114 ± 1.4	94.9 ± 1.1	86.3 ± 1.4	28.3 ± 0.5
Adults*	130	187 ± 2.7^{C}	99.5 ± 0.5^{C}	51.5 ± 0.3^{C}	135 ± 0.7^{C}	104 ± 0.5^{C}	105 ± 0.8^{C}	34.3 ± 0.3^{C}
Female	111	183 ± 2.7^{a}	98.5 ± 0.4^{a}	50.9 ± 0.3^{a}	133 ± 0.7^{a}	104 ± 0.5^{a}	103 ± 0.8^{a}	34.0 ± 0.3^{a}
Male	19	211 ± 7.9^{b}	105 ± 1.3^{b}	54.8 ± 1.0^{b}	141 ± 2.0^{b}	108 ± 1.3^{b}	112 ± 2.3^{b}	36.4 ± 0.5^{b}

$^{a,b,c;\ A,B,C}$ Different letters within a column denote significant differences, respectively, between sex and age groups ($p \leq 0.05$).

* Calves (<1 year), young (1–3 years), and adults (>3 years).

LW = Live bodyweight; HAW = Height at withers; CD = Chest depth; CG = Chest girth; HAS = Height at sacrum; BL= Body length; RW = Rump width.

Table 2. Pearson's correlation between live bodyweight (LW) and linear body measurements in Somba cattle sex and age groups from village herds in Boukombe, Northwestern Benin

Trait	HAW(cm)	CD (cm)	CG (cm)	HAS (cm)	BL (cm)	RW (cm)
Overall	0.91	0.95	0.97	0.90	0.93	0.94
Sex groups						
Female	0.90	0.94	0.96	0.90	0.92	0.94
Male	0.93	0.95	0.97	0.90	0.93	0.93
Age groups						
Calves	0.92	0.89	0.95	0.94	0.84	0.82
Young	0.79	0.84	0.93	0.79	0.71	0.80
Adults	0.74	0.75	0.87	0.73	0.75	0.76

* Calves (<1 year) and young (1–3 years). All correlation coefficients are significant at $p \leq 0.001$ level. Adults (>3 years). HAW = Height at withers; CD = Chest depth; CG = Chest girth; HAS = Height at sacrum; BL= Body length; RW = Rump width.

quadratic and allometric regression fitted between LW and BCS showed low R^2 (0.09; 0.1; and 0.08, respectively). The inclusion of BCS in any multiple regression model did not significantly increase the accuracy of LW estimation.

4. Discussion

4.1. Somba cattle bodyweight and linear body measurements

The maximum LW value of 274.5 kg found in this study exceeds those of 215 kg and 187 kg observed, respectively, by Rege (1999) and Adanléhoussi et al. (2003) for adult Somba cattle. Furthermore, the latter authors reported slightly lower values for LW and linear body measurements in age group than those obtained in the current study. These findings suggest that Somba cattle might have undergone phenotypic and morphological changes due to farmers' strategic breeding practices, including intentional selection and gene inflow (Bedibete, Kossi, & Habre, 2007). It also clearly shows the need to check if the previously developed equation for the prediction of LW from body measurements in this breed of cattle is still valid.

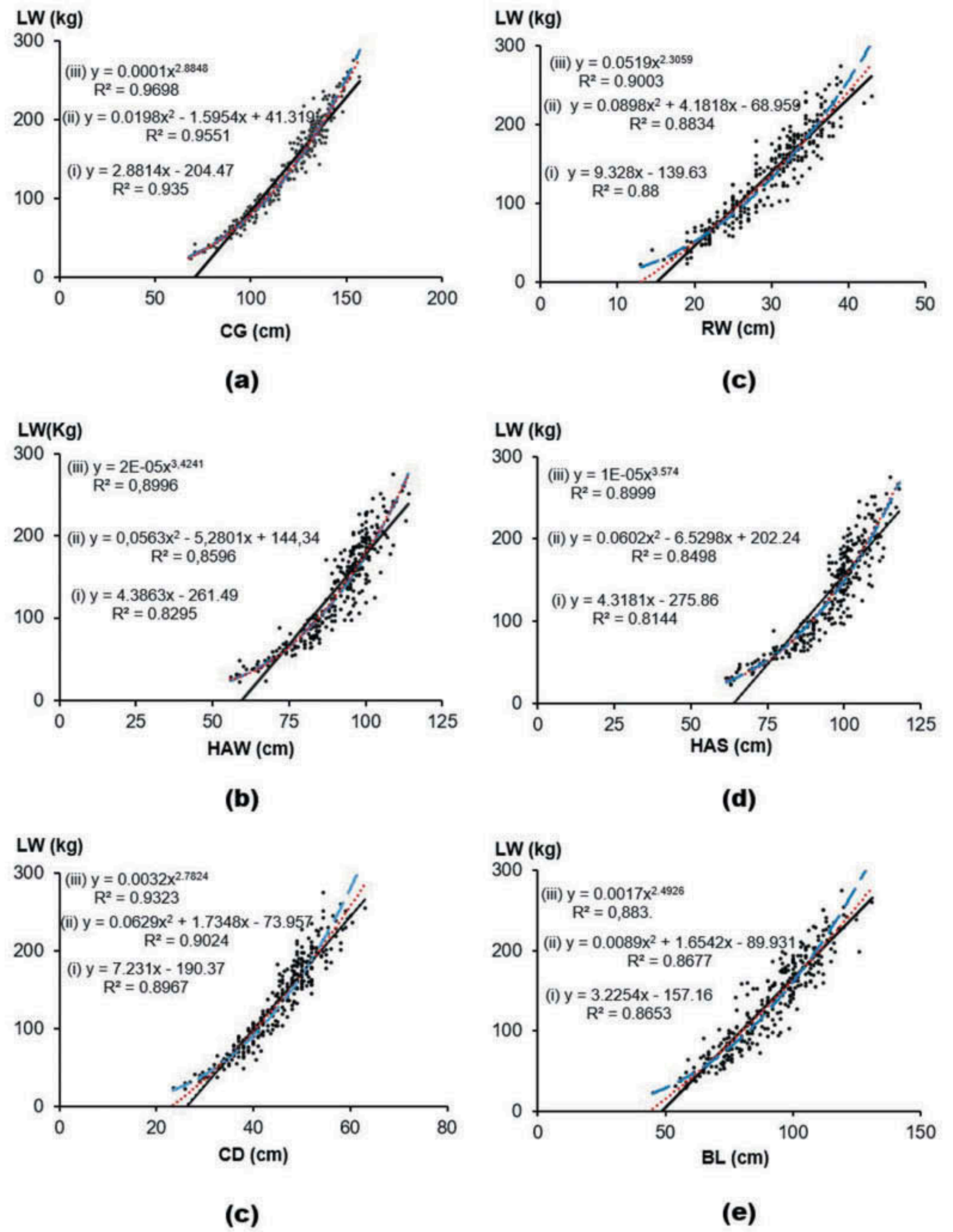
4.2. Predicting live bodyweight from body measurements with inclusion of sex and age effects

Although all linear body measurements included in the current study could provide separately or together a good prediction of Somba cattle LW because of the recorded highly positive and highly significant correlations, CG showed the highest correlation with LW and the lowest value of Root Mean Square Error (RMSE) regardless of the regression model. These results differ from those by Oduguwa, Adedeji, Sowande, Isah, and Amole (2013) which showed that the head length had the highest correlation (0.936) with LW in the three West African cattle breeds of N'dama, Muturu and White Fulani. But they corroborate the findings of a great deal of several studies and giving a higher correlation coefficient value between LW and CG (r = 0.97) than those of 0.94 and 0.95, respectively, reported by Kashoma, Luziga, Werema, Shirima, and Ndossi (2011) for Tanzanian shorthorn zebu and Rashid et al. (2016) for Brahman crossbred.

Correlation coefficients within age and sex groups confirm the influence of these parameters on the relationships between LW and linear measurements (Afolayan et al., 2006; Tsegaye et al., 2013) suggesting that best estimations of LW from body measurements should be developed across age or sex groups. Nevertheless, LW regressions in age groups do not improve model fits. Within sex groups, LW regressions in simple linear or quadratic models have slightly improved the R^2 for bulls. However, allometric regression of LW from CG give the same R^2 (0.97) and RMSE (0.09 kg) across sex groups suggesting that CG could be used as single body measurement to predict LW in Somba cattle regardless of the animal's sex. These findings are consistent with previous studies (Kashoma et al., 2011; Lukuyu et al., 2016) which have retained an overall model for LW prediction after exploring sex and age effects. Moreover, the highest value of R^2 obtained in the allometric model confirms the

Figure 2. Prediction of live bodyweight (*y*) by the independent (*x*) variables: (a) height at withers (HAW); (b) chest depth (CD); (c) chest girth (CG); (d) height at sacrum (HAS); (e) body length (BL); (f) rump width (RW).

*The simple linear (i), quadratic (ii) and allometric effects (iii) of each body linear measurement were shown with their respective equations and R^2.



curvilinear relationship between LW and CG and corroborates findings from previous studies (Sowande & Sobola, 2008; Yakubu, Ladokum, & Adua, 2011) which showed that this model produces better goodness of fit than others in LW prediction.

A combination of CG with BL and rump with (RW) give a highest value of R^2 (0.97) in multiple quadratic regression like single allometric regression with CG. Similarly, Afolayan et al. (2006) and Birteeb and Ozoje (2012) have obtained better-fitted models including, respectively, BL and RW in multiple regression equations. However, in the present study, the multiple quadratic regression predicted LW with less accuracy (RMSE = 11.81–13.00 kg) than the allometric model (RMSE = 0.09 kg). Moreover, BL and RW are highly correlated with CG ($r > 0.87$) supporting the use of CG alone in bodyweight prediction to avoid multicollinearity between morphometric traits (Yakubu, 2010).

Table 3. Sex effect on simple linear, quadratic and allometric regression models using Chest Girth (CG) for the prediction of live bodyweight (LW) of Somba cattle from village herds in Boukombe, Northwestern Benin

	b_0	b_1	b_2	R^2	RMSE
Simple linear					
Overall	**−205**	**2.88**		**0.94**	**14.6**
Female	−203	2.88		0.92	15.3
Male	−204	2.87		0.95	13.0
Quadratic					
Overall	**41.3**	**0.02**	**−1.60**	**0.96**	**12.2**
Female	46.9	0.02	−1.72	0.94	13.3
Male	39.9	0.02	−1.52	0.97	9.39
Allometric					
Overall	**1.33 10^{-4}**	**2.89**		**0.97**	**0.09**
Female	1.12 10^{-4}	2.92		0.97	0.09
Male	1.86 10^{-4}	2.82		0.97	0.09

All parameters are significant at $p \le 0.01$ level.
b_0 is the intercept or the allometric coefficient; b_1 and b_2 are the regression coefficients of LW on CG; RMSE (root-mean-squared error) is an estimate of the standard deviation of the error term.

Table 4. Stepwise selection and multiple regressions for the prediction of live bodyweight (LW) from linear body measurements (Xi) of Somba cattle from village herds in Boukombe, Northwestern Benin

	b_0	b_1 (CG)	b_2 (BL)	b_3 (RW)	R^2	RMSE	C_p
Overall							
CG	−205	2.88			0.94	14.60	88.0
CG+BL	−204	2.12	0.98		0.95	13.08	14.7
CG+BL+RW	−198	1.80	0.82	1.58	0.95	12.76	1.65
$CG^2+BL^2+RW^2$	−44.0	0.01	0.004	0.026	0.97	10.29	
Female							
CG	−203	2.88			0.92	66.6	15.33
CG+BL	−203	2.07	1.03		0.94	13.4	13.63
CG+BL+RW	−196	1.71	0.82	1.88	0.94	2.95	13.23
$CG^2+BL^2+RW^2$	−44.7	0.01	0.005	0.028	0.96	10.84	
Male							
CG	−204	2.87			0.95	21.9	13.00
CG+BL	−203	2.21	0.84		0.96	4.24	11.93
CG+BL+RW	−200	1.99	0.77	1.02^{NS}	0.96	3.52	11.81
$CG^2+BL^2+RW^2$	−43.3	0.01	0.003	0.016*	0.98	8.80	

^{NS} Non-significant ($p > 0.05$); all remaining parameters are significant at $p \le 0.01$ level.
b_0 is the intercept; b_1, b_2, b_3 are the regression coefficients of LW on X;
RMSE (root-mean-squared error) is an estimate of the standard deviation of the error term. CG = Chest girth; BL = Body length; RW = Rump width.

Furthermore, the use by farmers of multiple regression models compared to that of allometric models requires some technical ability and is time consuming (Tsegaye et al., 2013) whereas the measurement of CG is easier and more practical than that of other physical traits (Rodriguez, Munoz, Rojas, & Briones, 2007). We therefore agree with Lesosky et al. (2013) that CG alone satisfies statistical and practical considerations of LW estimation in any selection program that requires the farmers to perform the recording themselves.

Due to the above considerations, we consider the allometric regression model using CG alone, as the most suitable model to predict the weight of Somba cattle irrespective of its age and sex and under its current management context.

4.3. Predicting live bodyweight from body condition score

BCS affects Somba cattle LW, the latter decreases with body condition lose. However, the coefficient of correlations (r) between LW and BCS were very low, even lower than those found by Lukuyu et al. (2016) and Nesamvuni, Mulaudzi, Ramanyimi, and Taylor (2000), respectively, in Kenyan crossbred dairy cattle and Nguni-type cattle. This finding is similar to previous observation by Mäntysaari and Mäntysaari (2008) and does not support the recommendation made by Enevoldsen and Kristensen (1997) to use BCS along with body measurements as a predictor of LW. We therefore recommend the use of BCS as a management tool rather than a LW predictor in Somba cattle herds.

5. Conclusion

All morphometric measurements used in this study were linearly, positively and significantly correlated with LW. BCS was weakly related to LW and then are less reliable to predict Somba LW. Likewise, although bodyweight varied with age and sex, their inclusion did not enhance the accuracy of the prediction models. CG showed the highest correlation coefficients with LW in all age and sex groups and could be used as single predictor of LW in Somba cattle, but more accurately with allometric regression models. By validating a model previously elaborated for the prediction of Somba cattle LW, this study provides smallholder farmers, researchers and livestock extension officers, with a simple but valuable tool for routine herd monitoring and management, as well as for earlier assessment of breeding animals in breed improvement programs.

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Competing interests
The authors declare that they have no conflict of interest.

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