Predicting live weight using body volume formula in lactating water buffalo

Remedio Ramos-Zapata, Camila Dominguez-Madrigal, Ricardo-A. García-Herrera; Enrique Camacho-Perez; Jesús Manuel Lugo-Quintal, Thobela Louis Tyasi, Antonio Leandro Chaves Gurgel; Luís Carlos Vinhas Ítavo and Alfonso Juventino Chay-Canul

SUPPLEMENTARY FILE

Material and methods

The animals included in the present study were managed in compliance with the ethical guidelines and regulations for animal experimentation of División Académica de Ciencias Agropecuarias at Universidad Juárez Autónoma de Tabasco (approval code: UJAT-2012-IA-18).

The experiment was conducted in a commercial farm located in Isla (18°01'N 94°23'W) in the state of Veracruz, México. The climate of the region is hot-humid with rain in summer and average annual temperature and rainfall of 25 °C and 2750 mm, respectively.

Live weight (LW, kg), heart girth (HG, cm), and body length (BL, cm) data were obtained from 165 lactating Murrah buffalo of 3-10 years age. The animals were reared in production systems based on extensive grazing, including native trees, shrubs, grasses, and herbs such as *Paspalum* conjugatum bergius, *Echynochloa polystachya*, *Paspalum fasciculatum*, *Oryza perennis Moench*, *Panicum decolorans*, and aquatic plants: *Heliconia latispatha* benth and *Eichhornia crassipes*. The animals were provided water *ad libitum* and none of the animals received supplements. LW was recorded by weighing the animals on a fixed platform scale with a capacity of 2000 kg and precision

of 0.5 kg, whereas HG and BL were recorded using a flexible fiberglass tape measure (Truper®). Body volume (BV) was estimated using the formula to calculate the volume of a cylinder, by including the measurements of HG and BL in its composition (Paputungan *et al.*, 2015). The calculation was as follows:

$$\text{Radius (cm)} = HG/ 2\pi$$

$$\text{Body volume } (dm^3) = (\pi \times r^2 \times BL)/1000,$$

where r = circumference radius (cm); π = 3.1416; HG = heart girth (cm); and BL = body length (cm).

Additionally, three mathematical models were evaluated to predict the Murrah buffalo LW based on BV, namely:

1) Linear equation (Eq. 1): LW (kg) = $\mu + \beta 1 \times BV$;

2) Quadratic equation (Eq. 2): LW (kg) = $\mu + \beta 1 \times BV + \beta 2 \times BV^2$; and

3) Allometric equation (Eq. 2): LW (kg) = $\mu \times BV^{\beta 1}$,

where LW = live weight (kg); BV = Body volume (dm^3), "$\beta 1$" and " $\beta 2$" = model parameters.

Statistical analysis

For the statistical analysis and internal validation of the model, the data were read in the Python environment as follows: descriptive statistics were obtained using the description function of the “pandas” package. The ratio between BV and LW was determined by linear (Eq. 1), quadratic (Eq. 2) and allometric (Eq. 3) equations using the “lmfit” package. The following allometric equation was fitted: Y = aX ** b, where Y represents LW, X represents BV and a and b are parameters of the model. The models and their residuals were plotted with the “matplotlib” package. The goodness-of-fit of the regression models was evaluated using the Akaike Information Criterion (AIC), the

Bayesian Information Criterion (BIC), the coefficient of determination (R^2), the mean square error (MSE), and the root MSE (RMSE). The last three parameters were obtained using the "scikit-learn" package.

The predictive capacity of the three models for LW was evaluated by cross-validating *k*-folds (*k* = 4). This approach was undertaken by randomly dividing the set of observation values into non-overlapping k-folds of approximately the same size. The first fold is treated as a validation set, and the model fits the remaining *k*-1 folds (training data). The ability of the fitted model to predict the actual observed values was evaluated using MSE, R^2, and the mean absolute error (MAE). The mean absolute error is an alternative to the mean squared prediction error (MSPE) that is less sensitive to outliers and is related to the mean absolute difference between observed and predicted results. Lower values of root MSPE and MAE indicate a better fit. The *k*-folds cross-validation was performed using the "scikit-learn" package, which allowed a comparison of numerous multivariate calibration models.

Supplementary Table S1. Descriptive analysis of the live weight (kg), body measurements (cm) and body volume in lactating Murrah buffalo reared in Mexican humid tropical conditions (*n* = 165).

Variable	Mean ± SD	CV (%)	Minimum	Maximum
LW (kg)	487.17 ± 89.61	18.39	314.00	722.50
HG (cm)	201.35 ± 14.99	7.44	166.00	230.00
BL (cm)	102.26 ± 11.89	11.52	78.00	133.00
BV (dm^3)	333.62 ± 58.51	17.54	204.68	495.12

LW: live weight; BL: body length; HG: heart girth; BV: body volume; SD: standard deviation; CV: coefficient of variation; *n*: number of animals.