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PREDICTION OF LIVE BODY WEIGHTS IN DROMEDARY CAMELS (*Camelus dromedarius*) FROM MORPHOMETRIC BODY MEASUREMENTS

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ABSTRACT

The study explores the prediction of body weight in dromedary camels (*Camelus dromedarius*) using morphometric measurements Fifty-one (51) camels, comprising 24 females and 27 males were used for the study. Data were obtained on individual camels, including; estimated body weight (EBW), heart girth (HG), abdominal girth (AG), body length (BL), rump height (RH), shoulder height (SH), face length (FL), foreleg length (FLL), hind leg length (HLL), tail length (TL), neck length (NL), neck circumference (NC), and head length (HL). Data were subjected to statistical analysis. Results obtained showed no-significant ($p>0.05$) effect of sex on body weight in females and males. The correlation coefficients highlight strong relationships, particularly in HG and AG, emphasizing their significance in predicting body weight. The results show moderate to low VIF values, suggesting acceptable levels of multicollinearity in the models. Prediction equations are gender-specific, with separate models for females and males. For both sexes, HG and AG emerge as crucial predictors, with additional contributions from SH and FLL in certain models. The coefficient of determination (R^2) indicates the proportion of variability in body weight explained by the models. For females, a three-variable model achieves an impressive R^2 of 99.1%, while the corresponding male model attains 97.6%. Combining sexes, the models reach R^2 values of 98.1% and 98.3%, showcasing the efficacy of the proposed regression equations in predicting body weights in dromedary camels. The study provides valuable insights for camel management, offering a practical tool for estimating body weight based on readily measurable morphometric traits.

Key word: Body weight, regression equation, variance inflation factor, correlation coefficient.

INTRODUCTION

Dromedary camels (*Camelus dromedarius*) have long been companions to humans, serving as vital sources of transportation, sustenance, and livelihood in the vast landscape of arid and semi-arid regions. Accurate estimation of their body weights is paramount for effective management, yet the logistics of traditional weighing can be challenging.

Morphometric linear body measurements provide a tangible connection to a camel's overall body mass. Assan (2013) reported a direct relationship between live weight, production and profitability. These measurements, collected with relative ease in the field, serve as the foundation for predicting live weights through the utilization of the simple linear regression method. Simple linear regression analysis applied to morphometric linear body measurements is an innovative and non-invasive approach that offers a promising solution to predicting live weights in these resilient desert dwellers.

The practical implications of employing simple linear regression analysis for predicting live weights in dromedary camels are far-reaching. Several important economic characteristics of livestock can be determined from live body weight (Pesmen and Yardimci, 2008). Herders and livestock managers can swiftly estimate individual camel weights in the field, eliminating the need for cumbersome weighing processes and minimizing stress on the animals. The use of linear body measurements in estimating live weight was reported to be more practical in areas where accurate weighing scales and animal restraining facilities are available to livestock farmers and breeders. Several researchers explained the use of linear body measurements as a tool for estimating and predicting the live weight of farm animals (Yakubu *et al.*, 2012; Ishag *et al.*, 2011; Oke and Ogbonnaya, 2011; Tadesse and Gebremariam, 2010; Ozkaya and Bozkurt, 2009).

This streamlined approach empowers decision-making regarding feeding regimens, marketing, healthcare interventions, and transportation planning. Therefore, the main objective of this study was to estimate the live weights of dromedary camels using several live linear body measurements.

MATERIALS AND METHODS

Locations of Study

The study was conducted in two districts namely, Charanchi and Mai'Adua towns in Katsina State. Charanchi is located within latitude 12°43'N and Longitude 7°44'E while Mai'Adua lies between latitude 13°8'N and longitude 8°13'E (Date and time.com, 2023). Mai'adua livestock market is one of the largest livestock markets of camel in northern Nigeria, followed by Charanchi market (Ghude *et al.*, 2017).

Experimental animals and their management

The study used a total of 51 camels (n = 24 females and n = 27 males). Animals were grouped into three age categories for this study (group 1 = 1-5 years, group 2 = 6-10 years and group 3 = 11 and above years). Age of the animals were determined using dentition. Experimental animals used for this study were reared under traditional production system. Sick and pregnant camels were exempted from the study.

Data Collection

Twelve (12) morphometric traits were measured from individual camels, these included; heart girth (HG), abdominal girth (AG), body length (BL), rump height (RH), shoulder height (SH), face length (FL), fore leg length (FLL), hind leg length (HLL), tail length (TL), neck length (NL), neck circumference (NC) and head length (HL). All measurements were taken as described by FAO, (2012) using measuring tapes. Live weight (kg) of the camel was estimated using the formula of Yagil (1994).

EBW (kg) = 50(SH)(AG)(HG)

Where;

SH = Shoulder height (cm)

AG = Abdominal girth (cm)

HG = Heart girth (cm)

Data Analysis

Data collected were subjected to statistical analysis using the statistical procedure of SPSS version 23.0.0 (IBM SPSS 23.0.0). Descriptive statistics and Pearson correlation coefficient analysis were employed.

Best predictive regression equations of body weight as a dependent variable with linear body measurements as independent variables for female, male and the pooled data irrespective of sex were obtained.Variance inflation factors (VIF) as multicollinearity diagnostic tool of the independent variables was incorporated in the regression models.

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics of live weight and morphometric body measurements in dromedary camels. It was observed that the traits studied were not significantly affected (p>0.05) by sex. This report is contrary to the report of other researchers (Abdelaziz *et al*., 2020; Yohannes and Gebru, 2006; Ishag *et al.*, 2011; Yosef *et al.*, 2014) who reported that sex had significant effect on these traits in camels, alluding these variations to sexual dimorphism. However, the result obtained in this study revealed numerical differences in the traits with male camels having higher values, except for RH. The lack of apparent significant manifestation of sexual dimorphism may be as the result of the limited data collected.

Table 2 presents the correlation coefficients of live body weight and the morphometric body measurements in female and male camels. The output indicated that all the traits were all positively correlated with live weight in female camels. Body weight had highly significant (P<0.01) correlations with HG, AG, RG, SH and NL (r = 0.620–0.877). However, body weight had non-significant (P>0.05) relationship with BL, FL, FLL, HLL and TL (r = 0.092 – 0.382). From the correlation result, it was observed that HG, AG, SH and NL are the independent variables that show highly significant (P<0.01) and positive relationships with body weight for female, male and the combined sexes, indicating that such body measurements could be good predictors of live weight. However, only TL shows non-significant (P>05) correlation with body weight for all of them. These findings go in line with the report of Mungai *et al.* (2010) and Abdallah and Faye (2012) in dromedary camel, Ozkaya and Bozkurt (2009) and Mahmud *et al.* (2014) in beef cattle and Boujenane and Halhaly (2015) in sheep.

Table 3 shows the Variance inflation factor (VIF) values for the independent variables in the multiple regression models for female and male camels. The VIF values were generally low, ranging from 1.000 – 2.481, 1.000 – 2.287 and 1.000 – 3.874 for female, male and combined sexes respectively. The range of values indicates lack of multi-collinearity problem among the independent variables in this study. VIF is the measure of the degree of multicollinearity. When VIF is equal to 1, the i^{th} independent variable is not correlated to the remaining ones, which means multicollinearity does not exist in the regression model, indicating that the variance of the i^{th} regression coefficient is not inflated (Johnston *et al*., 2018). Multicollinearity in regression analysis causes the variance of the predictor variables to increase or inflate. This increased variance will affect the coefficients of the predictor variable in the prediction equations. Multicollinearity misleadingly inflates the standard errors, therefore making some variables statistically insignificant when they should be significant. The formula for VIF is: VIF = $\frac{1}{1-R_i^2}$

Table 1. Descriptive statistics of live body weight and linear body measurements in dromedary camels

Traits	Sex	N	Mean	SE	Min	Max.
EBW	Female	24	203.91	14.22	102.56	309.65
	Male	27	229.90	15.85	71.12	393.30
	Total	51	217.67	10.78	71.12	393.30
HG	Female	24	169.00	4.86	130.00	205.00
	Male	27	171.67	5.18	101.10	207.00
	Total	51	170.42	3.54	101.10	207.00
AG	Female	24	141.33	4.28	101.00	174.00
	Male	27	151.57	4.85	90.00	190.00
	Total	51	146.75	3.31	90.00	190.00
BL	Female	24	142.77	5.94	101.00	199.00
	Male	27	151.54	4.32	106.00	188.00
	Total	51	147.42	3.63	101.00	199.00
RH	Female	24	171.07	4.54	119.20	203.00
	Male	27	166.69	5.95	100.00	202.00
	Total	51	168.75	3.78	100.00	203.00
SH	Female	24	165.52	4.75	106.00	203.00
	Male	27	170.15	4.59	100.00	200.00
	Total	51	167.97	3.29	100.00	203.00
FL	Female	24	15.76	1.04	9.00	26.00
	Male	27	16.85	1.08	10.00	29.00
	Total	51	16.34	0.75	9.00	29.00
FLL	Female	24	120.87	4.50	95.00	196.00
	Male	27	123.40	4.18	92.00	170.00
	Total	51	122.21	3.04	92.00	196.00
HLL	Female	24	134.57	3.11	108.00	165.10
	Male	27	137.37	4.08	107.00	172.00
	Total	51	136.05	2.59	107.00	172.00
TL	Female	24	56.85	3.54	30.00	93.00
	Male	27	58.71	2.77	32.00	86.00
	Total	51	57.84	2.20	30.00	93.00
NL	Female	24	127.23	7.51	65.00	192.00
	Male	27	131.78	7.30	80.00	194.00
	Total	51	129.64	5.19	65.00	194.00
NC	Female	24	62.68	2.87	32.00	89.00
	Male	27	66.54	2.44	31.00	91.00
	Total	51	64.72	1.87	31.00	91.00
HL	Female	24	51.53	1.64	38.00	65.00
	Male	27	53.04	1.88	33.00	71.00
	Total	51	52.33	1.25	33.00	71.00

HG = heart girth, AG = abdominal girth, BL = body length, RH = rump height, SH = shoulder height, FL = face length, FLL = fore leg length, HLL = hind leg length, TL = tail length, NL = neck length, NC = neck circumference and HL = head length.

Table 2. Correlation coefficients between body weight and morphometric measurements in dromedary camels at various ages

Sex	N	Morphometric traits											
		HG	AG	BL	RH	SH	FL	FLL	HLL	TL	NL	NC	HL
Female	24	**0.877****	**0.845****	0.202^{NS}	**0.720****	**0.765****	0.382^{NS}	0.125^{NS}	0.380^{NS}	0.096^{NS}	**0.610****	0.252^{NS}	0.420*
Male	27	**0.845****	**0.872****	0.381*	0.421*	**0.789****	**0.540****	**0.573****	**0.511****	0.125^{NS}	**0.645****	0.330^{NS}	**0.740****
Total	51	**0.853****	**0.866****	0.307*	**0.501****	**0.779****	**0.484****	**0.381****	**0.469****	0.118^{NS}	**0.629****	0.310*	**0.622****

HG = heart girth, AG = abdominal girth, BL = body length, RH = rump height, SH = shoulder height, FL = face length, FLL = fore leg length, HLL = hind leg length, TL = tail length, NL = neck length, NC = neck circumference and HL = head length.
Correlation is significant (P< 0.01), *Correlation is significant (P<0.05), NS = not significant (P>0.05), Values in **boldindicatemoderate to strong positive correlation.

Table 3: Variance inflation factors (VIF) of multiple regression models

Sex	Model	Independent variables			
Female		**HG**	**SH**	**AG**	
	1	1.000	-	-	
	2	1.253	1.253	-	-
	3	2.481	1.275	2.399	-
Male		**AG**	**HG**	**SH**	
	1	1.000	-	-	-
	2	1.702	1.702	-	-
	3	2.287	1.710	1.686	-
Combined		**AG**	**SH**	**HG**	**FLL**
	1	1.000	-	-	-
	2	1.431	1.431	-	-
	3	2.163	1.454	1.900	-
	4	3.874	1.529	2.170	1.885

HG = heart girth, AG = abdominal girth, SH = shoulder height and FLL = fore leg length.

The predictive regression equations and coefficient of determination (R^2) expressed as percentage of variation for body weight usingbody measurements in female and male camels are shown in Table 4. The regression model excluded the low and non-significantly correlated independent variables.

Three models were generated in female camels. Model 1 suggests that body weight in female camels can be estimated using the HG with a substantial R^2 of 76.9%. The inclusion of SH in model 2 significantly improves the prediction by 17.3%, resulting in a higher R^2 of 94.2%. Adding the additional variable of AG in model 3, marginally enhances the model by 4.9%, resulting in an impressive R^2 of 99.1%.

Similar to females, AG is a significant predictor of body weight in males, with an R^2 of 76.1% in model 1 while including HG improves the model significantly by 13.8%, resulting in a higher R^2 of 89.9%. The addition of SH however enhances the model marginally by 7.7%, resulting in a higher R^2 of 97.6%.

The combined model for both sexes, based on AG, yields an R^2 of 74.9%. Including SH in the combined model improves the prediction by 13.2%, resulting in a higher R^2 of 88.2%. The combined model further improves by 9.9% with the inclusion of HG, resulting in a higher R^2 of 98.1%. The best-performing model is Model 4, with R^2 of 98.3%, indicating a high level of explanatory power. The model includes predictor variables AG, SH, HG, and FLL, each contributing to the prediction of body weight. The final model, incorporating FLL, achieves a slight increase in R^2 to 98.3%, suggesting that FLL contributes marginally (0.20%) to the prediction.

These findings indicate that the model 2 were the best fit for prediction of body weights in female camels (including HG and SH), male camels (including AG and HG) and combined sexes (including AG and SH).

Inclusion of morphometric body measurements in linear regression models serves as a useful tool for estimation and prediction of live body weight in livestock animals (Keith *et al.*, 2009; Mungai *et al.*, 2010) with high degree of accuracy and ease.

It has been observed that R^2 increased as more independent variables were added to the model, therefore, R^2 alone could not be used to judge the accuracy and precision level of the prediction model (Abdelaziz *et al.*, 2020). Hence, variance inflation factor (VIF) was used to assess the problem of multicollinearity. In this study only independent variables with VIF less than 10 and were positively correlated with body weight were included in the model.

Table 4: Prediction equations and coefficient of determination of variation (R^2) of live body weight in female and male dromedary camels

Sex	Model	Equation	R^2	R^2 Change
Female	1	-229.748 +2.566HG***	76.9	76.9
	2	-356.839 +1.954HG +1.393SH***	94.2	17.3
	3	-380.143 +1.232HG +1.293SH +1.144AG***	99.1	4.9
Male	1	-202.139 +2.850AG***	76.1	76.1
	2	-302.366 +1.834AG +1.481HG***	89.9	13.8
	3	-395.644 +1.138AG +1.402HG +1.248SH***	97.6	7.7
Combined sexes	1	-196.015 +2.819AG***	74.9	74.9
	2	-321.751 +2.042AG +1.427SH***	88.2	13.2
	3	-391.669 +1.164AG +1.269SH +1.322HG***	98.1	09.9
	4	-408.925 +0.975AG +1.309SH +1.393HG +0.216FLL*	98.3	0.2

HG = heart girth, AG = abdominal girth, SH = shoulder height and FLL = fore leg length, * = P<0.05, *** = P<0.001, NS= Not significant (*P*>0.05)

CONCLUSION

The study observed that morphometric body measurements were moderately to highly positively correlated with live body weight in dromedary camels. The study concluded that live body weight in the dromedary camel could be predicted using morphometric body measurements with fair accuracy. The study provides valuable insights for camel management, offering a practical tool for estimating body weight based on readily measurable morphometric traits.

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