LIVE WEIGHT ESTIMATION FROM BODY MEASUREMENTS OF SWAMP BUFFALOES *(Bubalus B. Carabanensis*)

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ABSTRACT

The objectives of this study was to select nonlinear regression model of relationship between body parameters and live weight of swamp buffaloes for live weight estimation. The animals of Department of Animal Science, Faculty of Agriculture at Kampaeng Saen, Kasetsart University, Kampaeng Saen Campus were used in this study. A total of 172 animals were 41 male and 131 female 0 to 25 months old of swamp buffaloes. Parameters of body measurements were shoulder height (SH), hip height (HH), shoulder width (SW), hip width (HW), body length (BL) and hearth girth (HG) were measured in centimeters during weighting. Three of nonlinear regression models including exponential, polynomial quadratic and power models were analyzed relationship between body parameters and live weight in each body parameter. The results revealed that power model gave the best fit model of HG and live weight relationship with highest R^2 (0.9662, 0.9748 and 0.9702) in male, female and both sex of swamp buffaloes, respectively. In addition, percentage error and accuracy of 3 models were investigated between HG and live weight of swamp buffaloes (n=492). The result revealed that polynomial quadratic model showed highly accuracy (98.92%) between actual live weight and calculated weight from the equation of $y = 0.0233x^2 -2.9263x+129.81$ with R^2 value of 0.9678, when y = estimated live weight (kg); x = heart girth (cm). In conclusion, this model provides a highly reliable and accurate method for estimating weights of swamp buffaloes using a single heart girth measurement which can be easily obtained with a girth tape in the field work.

Keywords: *Bubalus bubalis*, buffaloes, live weight, estimation, body measurements, swamp buffaloes

INTRODUCTION

Although weighing scales are defined to important tool in livestock farm, but are not commonly available in a small farm. The precise estimation of live body weight is essential importance for many aspects of animal husbandry and veterinary medicine. The prediction of live weight from body measurements had been studied in dairy cattle (Ozkaya and Bozkurt, 2009; Yan *et al*., 2009), beef cattle (Kashoma *et al*., 2011; Lesosky *et al*., 2013). There is a few number of study in buffaloes. However, prediction of body weight had been used various linear body measurement by

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multiple linear regression analysis in river buffalo (Paul and Das, 2012) and swamp buffalo (Galip *et al*., 2017). Estimated weights from many body measurements per animal are inconvenient, time-consuming. Thus, single body measurements are essential for estimating body weights. Single body measurement of heart girth had been reported to be highly correlated with live body weight in cattle (Heinrichs *et al*., 2007; Swali *et al*., 2008). The purposes of this study was to examine nonlinear regression model of relationship between body parameters and live weight for high accurate estimated weight from single body measurement of swamp buffaloes.

MATERIALS AND MATHODS

Animals for body measurements

A total of 172 animals were 41 male and 131 female 0 to 25 months old of swamp buffaloes of Department of Animal Science, Faculty of Agriculture at Kampaeng Saen, Kasetsart University, Kampaeng Saen Campus. Six parameters of body measurements including shoulder height (SH), hip height (HH), shoulder width (SW), hip width (HW), body length (BL) and hearth girth (HG) were measured in centimeters (Figure 1), while body weights were determined in kilograms using weighing scale.

Data analysis

The data were separated according to male, female and both sex, then all calculations of mean, standard error. Scatter plot of body weight versus 6 parameters by nonlinear regression model including exponential, polynomial quadratic and power models using the NLIN procedure by Gauss-Newton method of SAS software. The highest value of coefficient of determination (R^2) was a criteria for the best fit model from body parameters. Percentage accuracy of the models for heart girth and live weight was calculated as follow,

$$\% \text{ accuracy} = 100 - \% \text{ Error},$$

$$\text{where } \% \text{ Error} = \text{Relative error} \times 100$$

$$\text{Relative error} = [x_{cal} - x_i]/x_i\,,$$

where x_{cal} was calculated body weight from equations and x_i was real body weight.

RESULTS AND DISCUSSION

The mean body weights of new born male and female swamp buffaloes were 34.00±1.41 and 30.66±3.32 kg respectively, as well as 645.66±80.82 and 659.60±52.50 kg of 25 months old of male and female swamp buffaloes respectively. The mean heart girth (HG) of new born male and female swamp buffaloes were 77.83±5.41 and 74.83±5.63 cm, respectively, as well as 222.00±10.09 and 222.20±8.13 cm of 25 months old of male and female swamp buffaloes, respectively (Table 1 and Table 2).

The nonlinear regression model of power model in relationship between heart girth IHG) and body weight showed the best fit model in male, female and both sex swamp buffaloes. In which, the coefficient of determination (R^2) were highest (0.9662, 0.9748 and 0.9702) respectively among body parameters (Table 3, Table 4).

In Figure 2, Scatter plots of nonlinear regression of actual live weights versus hip height (Figure 2A), body length (Figure 2B) and

Table 1. Mean±SD of 6 parameters from body measurements in male 0-25 months old of male swamp buffaloes.

Age	Wt.	SH	HH	SW	HW	BL	HG
(month)	(kg)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
0	34.00±1.41	73.00±3.68	nd	nd	nd	60.66±4.54	77.83±5.41
1	61.00±4.81	78.83±3.18	nd	nd	nd	69.33±4.22	86.83±7.22
2	90.66±7.61	90.66±7.61	nd	nd	nd	78.66±4.08	101.66±9.00
3	121.33±6.80	121.33±6.80	nd	nd	nd	90.66±5.78	122.83±9.82
4	197.10±55.87	105.05±6.53	107.73±6.55	34.89±4.96	39.26±4.36	103.05±9.03	146.21±13.92
5	219.33±54.52	108.60±6.23	110.53±6.63	33.86±4.73	39.40±6.40	107.53±8.62	150.00±14.93
6	238.40±55.93	112.26±5.58	114.33±6.11	35.93±4.66	41.60±4.73	112.80±7.63	153.80±11.95
7	277.40±53.71	113.40±6.11	115.53±5.96	37.93±4.63	42.80±3.36	113.66±8.26	162.46±9.44
8	305.22±48.14	117.44±5.12	118.66±5.40	41.00±5.17	44.00±2,91	124.66±15.71	160.44±22.07
9	329.33±62.27	118.66±5.23	120.00±5.45	40.33±6.27	46.20±3.64	126.20±11.27	173.40±14.13
10	355.40±61.09	120.53±4.80	122.73±5.70	39.40±3.60	43.86±4.42	125.06±6.46	178.20±10.95
11	380.53±64.31	121.48±4.63	123.95±5.00	45.33±5.45	48.40±4.27	127.80±6.24	182.20±11.27
12	392.06±64.36	123.60±5.02	126.06±5.16	38.06±3.55	39.86±2.64	127.20±6.34	187.20±10.60
13	418.46±67.43	124.46±3.79	126.13±4/43	43.26±3.63	47.66±4.15	134.00±6.93	189.86±11.16
14	448.73±75.12	126.66±3.63	127.73±4.66	43.26±4.23	49.00±4.40	143.60±19.76	185.46±25.02
15	469.11±87.75	127.66±3.74	128.66±3.46	44.55±4.85	46.22±3.49	133.77±5.28	196.11±15.05
16	477.86±79.42	129.00±4.64	130.60±4.15	45.80±3.74	50.93±4.78	134.73±7.49	197.80±11.26
17	494.33±88.77	130.60±4.46	131.46±4.61	46.26±3.63	48.46±3.39	139.06±6.23	202.93±13.18
18	518.46±91.55	131.40±4.56	133.00±4.19	45.26±6.31	49.60±4.79	139.93±7.00	202.93±11.70
19	542.35±102.65	133.21±3.80	134.78±3.84	47.21±5,46	50.42±4.18	141.42±7.64	209.07±14.41
20	572.63±86.31	134.18±3.78	134.63±3.74	49.90±4.88	51.72±3.74	143.81±12.67	212.81±11.26
21	592.40±91.91	133.30±4.98	136.20±3.99	49.00±4.16	50.30±4.52	153.90±15.05	217.20±10.59
22	621.60±108.38	135.60±5.12	135.60±4.97	48.40±4.22	51.60±3.36	146.40±5.59	219.60±17.58
23	629.63±91.88	135.27±2.76	137.27±3.63	51.90±6.41	55.90±5.73	148.09±7.63	222.00±11.18
24	639.11±81.43	136.66±4.58	136.88±4.25	49.77±3.99	52.88±3.29	143.33±7.10	221.44±7.92
25	645.66±80.82	136.88±4.13	137.33±3.93	51.88±3.88	53.22±4.08	144.77±4.46	222.00±10.09

Table 2. Mean±SD of 6 parameters from body measurements in female 0-25 months old of female swamp buffaloes.

Age	Wt.	SH	HH	SW	HW	BL	HG
(month)	(kg)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
0	30.66±3.32	70.50±3.83	nd	nd	nd	59.50±1.64	74.83±5.63
1	57.50±3.61	76.66±3.82	nd	nd	nd	68.50±2.42	87.66±7.00
2	88.20±3.54	85.0±4.33	nd	nd	nd	77.66±3.77	100.66±9.93
3	119.83±5.26	94.50±5.08	nd	nd	nd	89.16±4.49	123.50±10.63
4	181.69±36.66	105.15±4.98	107.14±51.96	39.91±40.82	40.46±26.24	105.00±5.67	147.46±11.81
5	226.57±36.06	108.57±4.42	108.00±4.54	31.42±2.50	34.28±2.92	110.57±6.02	152.85±10.43
6	238.50±35.76	110.33±3.26	112.83±1.16	36.00±3.28	38.83±2.31	111.66±5.24	156.66±9.89
7	320.87±45.93	115.87±5.35	119.12±5.16	40.37±2.19	48.00±5.42	120.12±4.58	170.75±11.28
8	339.50±44.83	119.00±4.78	119.25±5.23	39.25±3.37	41.00±4.59	121.62±5.68	167.87±21.89
9	352.00±38.66	118.30±3.77	120.40±4.32	41.50±4.16	48.00±2.70	124.30±4.85	179.80±11.23
10	380.33±44.90	120.66±3.67	123.55±4.33	40.11±6.21	42.22±3.76	128.88±4.40	183.44±7.09
11	395.88±43.29	120.77±4.38	123.88±4.42	45.55±3.32	46.44±3.74	130.22±6.99	187.11±8.43
12	428.87±43.66	123.12±4.32	125.00±2.39	42.75±5.23	43.62±5.87	132.37±7.13	191.12±11.41
13	439.55±43.41	124.33±3.20	126.11±2.26	44.22±3.99	46.22±1.85	130.88±3.51	191.22±7.61
14	465.22±36.35	125.11±4.22	127.33±3.96	43.55±2.12	46.11±1.96	142.11±19.27	193.22±23.32
15	490.25±40.15	130.50±12.63	128.75±3.57	45.37±3.29	48.37±4.30	132.62±7.28	202.25±9.01
16	503.33±40.91	127.66±3.80	129.66±3.46	46.44±3.43	47.66±2.06	137.88±5.53	202.33±4.66
17	532.50±54.08	127.75±5.09	129.50±4.27	46.37±2.97	49.87±2.47	136.00±10.65	207.62±7.87
18	536.77±41.96	127.22±2.58	130.44±4.15	47.55±4.33	47.77±4.29	141.55±8.33	206.66±13.34
19	550.88±45.29	131.77±8.56	133.77±7.31	48.44±2.24	49.66±2.34	140.22±5.28	210.44±7.97
20	552.88±46.49	129.00±6.10	131.11±3.78	48.66±2.00	51.00±2.59	144.00±9.50	212.44±8.18
21	585.55±51.69	130.66±4.87	133.44±3.81	48.44±4.12	50.33±4.00	143.88±6.52	217.00±6.30
22	596.66±50.57	132.00±5.19	133.33±4.87	50.00±1.32	50.44±1.87	142.88±7.40	217.66±7.24
23	615.44±56.99	132.00±6.16	133.44±4.18	48.55±3.08	50.44±3.28	145.88±6.41	218.55±8.91
24	629.00±73.45	131.50±5.54	133.50±5.16	49.16±3.60	50.66±2.16	146.83±6.85	219.83±13.80
25	659.60±52.50	135.80±2.16	136.40±2.40	51.20±2.68	51.80±1.64	149.20±7.79	222.20±8.13

Table 3. The coefficient of determination (R^2) values obtained from relationship between 6 body parameters and body weight by exponential, polynomial quadratic and power models in male and female swamp buffaloes.

Sex	Parameter	Model		
		Exponential	Polynomial	Power
Male	HG (n=308)	0.9511	0.9657	0.9662
	SH (n=313)	0.9434	0.9050	0.9604
	SW (n=280)	0.7020	0.7107	0.7221
	HH (n=286)	0.8806	0.9490	0.8825
	HW (n=280)	0.5865	0.6027	0.5869
	BL (n=286)	0.7437	0.7304	0.7857
Female	HG (n=208)	0.9563	0.9718	0.9748
	SH (n=209)	0.9497	0.9214	0.9573
	SW (n=180)	0.9218	0.7015	0.7336
	HH (n= 180)	0.8689	0.8383	0.8779
	HW (n=180)	0.6021	0.5772	0.6086
	BL (n=210)	0.9110	0.8504	0.9483

Table 4. The coefficient of determination (R^2) obtained from relationship between 6 body parameters and body weight by exponential, polynomial quadratic and power models in both sex swamp buffaloes.

Sex	Parameter	Model		
		Exponential	Polynomial	Power
Male and Female	HG (n=516)	0.9531	0.9678	0.9702
	SH (n=516)	0.9381	0.8970	0.9460
	SW (n=465)	0.7022	0.7079	0.7205
	HH (n=516)	0.9480	0.9121	0.9529
	HW (n=465)	0.5673	0.5754	0.5715
	BL (n=517)	0.9382	0.9035	0.9559

Table 5. Standard error of estimation, percentage error and accuracy of nonlinear regression models from relationship between HG parameters and calculated/actual live weight in both sex of swamp buffaloes (n=492).

Model	S. E. est	% Error	% Accuracy
Power	73.23	16.58	83.42
Exponential	35.08	3.77	96.23
Polynomial quadratic	31.15	1.08	98.92

Figure 1. Six parameters of body measurements in swamp buffaloes. (A) shoulder height (SH); (B) heart girth (HG); (C) shoulder width (SW); (D) body length (BL); (E) hip height (HH) and (F) hip width (HW).

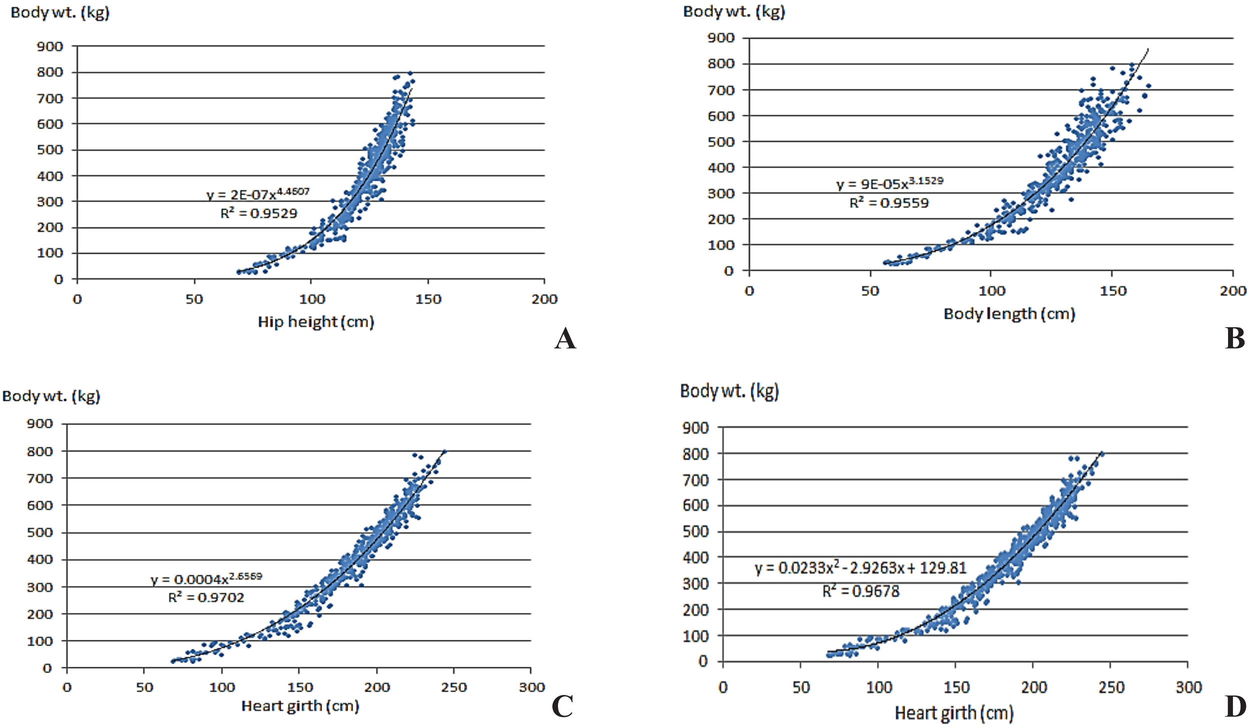

Figure 2. Scatter plot of body weight versus measured hip height (A) body length; (B) heart girth; (C) by power model and by polynomial quadratic (D) in in both sex swamp buffaloes (n=492).

heart girth (Figure 2C)) measurement indicated a curve-line of power model relationship with R^2 of 0.9529, 0.9559 and 0.9702 respectively. The power model gave best fit model of HG and live weight relationship with highest R^2 value.

In addition, percentage error and accuracy of 3 models were investigated between HG and live weight of swamp buffaloes (n=492). The result revealed that polynomial quadratic model (Figure 2D) showed highly accuracy (98.92%) between actual live weight and calculated weight (Table 4) from the equation of $y = 0.0233x^2 - 2.9263x + 129.81$ with R^2 value of 0.9678, when y = estimated live weight (kg); x = heart girth (cm).

The results of this study indicated that heart girth was found to be the best parameter of body measurement for estimating weight using a polynomial quadratic model (polynomial two) similarly to a study of Macdonald et al. (2021).

CONCLUSION

This study was implemented of the relationship between body measurement and body weight of 41 male and 131 female 0-25 months old of swamp buffaloes ranging in weight from 30.66 to 659.60 kilograms. The coefficient of determination (R^2) by power model was highest value and was best fit model for heart girth - body weight relationship in both sex of swamp buffaloes. Percentage accuracy of estimated weight was highest (98.9%) derived from the equation of polynomial quadratic model. Estimation of the body weights of swamp buffaloes using a single heart girth measurement were very accurate method. Future research is needed for developing a girth tape to evaluate the possibility of weight estimation in the field.

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