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Live Weight Estimation by Chest Girth, Body Length and Body Volume Formula in Minahasa Local Horse

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ABSTRAK

Penelitian ini dilaksanakan di Kabupaten Minahasa untuk mengestimasi berat hidup kuda dengan menggunakan ukuran lingkar dada, panjang badan, dan rumus volume tubuh (ukuran lingkar dada dan panjang badan). Data berat hidup (LW), panjang badan (BL), lingkar dada (CG), dan volume tubuh diambil dari kuda jantan (n= 221). Volume tubuh kuda dihitung menggunakan rumus volume silinder dengan CG dan BL sebagai komponen dalam rumus. Analisis regresi digunakan untuk LW dengan semua ukuran linear tubuh. Data dikelompokkan berdasarkan umur ternak. Umur mempengaruhi ukuran-ukuran tubuh secara signifikan (P<0,05), kecuali BL ternak (P>0,05). Berat hidup dapat diprediksi melalui model regresi sederhana yang menggunakan variabel tidak bebas (Y) untuk berat hidup ternak dan variabel bebas (X) dari ukuran tubuh ternak, baik BL, CG, dan volume tubuh. Korelasi antara semua pasangan ukuran ternak adalah sangat signifikan (P<0,01) pada semua kelompok umur. Analisis regresi menunjukkan bahwa LW dapat diprediksi dengan tepat dari volume tubuh (R2= 0.92) dan dari CG (R2= 0.90). Model regresi sederhana yang direkomendasikan untuk memprediksi LW kuda berdasarkan volume tubuh dengan kelompok umur berkisar dari umur 3 sampai ≥10 tahun adalah: LW (kg)= 5.044 + 1.87 volume tubuh (liter). Analisis data dari CG, BL, dan rumus volume tubuh memberikan ukuran kuantitatif dari bentuk dan ukuran tubuh yang dapat menjadi parameter genetik untuk tujuan program pemuliaan.

Kata kunci: kuda lokal Minahasa, estimasi bobot hidup, ukuran linear tubuh

ABSTRACT

Study was conducted in the regency of Minahasa to estimate horse live weight using its chest girth, body length and body volume formula (cylinder volume formula) represented by animal chest girth and body length dimensions, particularly focused in Minahasa local horses. Data on animal live weight (LW), body length (BL), chest girth (CG) and body volume were collected from 221 stallions kept by traditional household farmers. Animal body volume was calculated using cylinder volume formula with CG and BL as the components of its formula. Regression analysis was carried out for LW with all the linear body measurements. The data were classified on the basis of age. Age significantly (P<0.05) influenced the body measurements except animal body length (P>0.05). Animal live weight was predicted by simple regression models using dependent variable (Y) of the animal live weight and independent variable (X) of the animal body measurement, either body length, chest girth, or body volume. The correlations between all pairs of measurements were highly significant (P<0.01) for all age groups. Regression analysis showed that live weight could be predicted accurately from body volume (R2= 0.92) and chest girth (R2= 0.90). Simple regression model that can be recommended to predict horse live weight based on body volume with their age groups ranging from 3 to ≥10 years old was as follow: Live weight (kg)= 5.044 + 1.87088 body volume (liters). The analyses of data on horse chest girth, body length and body volume formula provided quantitative measure of body size and shape that were desirable, as they enable genetic parameters for these traits to be estimated and also included in breeding programs.

Key words: Minahasa local horse, live weight estimation, body linear measurements

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INTRODUCTION

Live weight of horses represented a unique genetic resource in improving the proper use of the related variety, mainly used in agriculture, light traction, riding and leisure activities (WHSA, 2004). Positive correlation between the live weight and most of the body measurements in big domestic animals was found in several scientific reports (Afolayan *et al*., 2006; Bene *et al*., 2007; Ozkaya & Bozkurt, 2009; Sawanon *et al*. 2011; Udeh *et al*. 2011). This fact repeatedly calls the attention to the importance of taking horse body measurement and offers opportunity for estimating parameters in relation to the various body measurements.

Several scientific reports suggested that body measurements have been of recurring interest in horses and other ruminant animals for selection and breeding programs (Bene *et al*., 2007; Fajemilehin & Salako, 2008; Jimmy *et al*., 2010, Takaendengan *et al*. 2011). Ulatus *et al.* (2001) reported that body weight of animals was an important factor associated with several management practices including selection for breeding, determining feeding levels and also it was good indicator of animal condition. Genetic live weight of horse belongs to local household farmers was difficult to be practically predicted because of limited availability of animal weighing scale machine on the field.

Animal growth in developed farm system was generally measured by average daily gain, and body size was generally detected by increase of chest girth and body length (Willeke & Dursch, 2002; Bozkurt, 2006; Ozkaya & Bozkurt, 2008). Dimensions of animal chest girth and animal body length in *cm* unit were very simple to be practically applied for measurement of horse body size, mainly by local household farmers. Horse body weight had positive correlation with body dimensions including body length, hip height and chest girth (Takaendengan *et al*, 2011). Takaendengan *et al*. (2011) reported that body weight was moderately correlated with chest girth and body length of 0.79 to 0.90 and 0.70 to 0.76, respectively in local horses. Moderate correlation values indicated relatively low accuracy for estimation of animal body weight in case of using single variable of either chest girth or body length as predictor variable (Fajemilehin & Salako, 2008).

In this research, chest girth and body length were combined to be applied in a formula of cylinder shape representing animal body volume. Animal chest girth dimension represented circular line of the circle in cylinder shape, and animal body length represented height of cylinder shape. Therefore, cylinder shape volume represented animal body volume that can be calculated by cylinder volume formula.

The cylinder formula using animal chest girth and body length dimensions has not been exploited and applied to estimate animal body weight, mainly Minahasa local horses. The objective of this research was to estimate horse live weight using volume formula of cylinder shape represented by animal chest girth and body length dimensions, particularly focused in Minahasa local horses.

MATERIALS AND METHODS

Location of Study

Research was carried out in Minahasa regency, dictricts of Tondano, Tomohon and Langowan, North Sulawesi province. This regency is categorized as agricultural areas with altitude of 600-700 m above sea level. It is characterized by ambient temperature and humidity of 25-28 ^oC and 70%-80%, respectively.

Experimental Animals

The total of 221 male local horses were randomly chosen in this research. Age was ranged from three to ten yr old. Age was primarily determined by dentition as described by Owen & Bullock (2002). The unhealthy horses were excluded in this study.

Measured Traits

Measurements of body dimensions were taken on each horse. Body length (BL) was measured from distance between the site of pins (*tuber ischii*) to tail drop (*tuberositas humeri*), and chest girth (CG) was measured as body circumference at behind the forelegs. Animal body volume (BV) was estimated by cylinder volume formula. It was theoretically found that cylinder volume was calculated as follows: $V= \pi r^2 h$, where, π= 3.14, r= radius and h= height (length). Animal chest girth (CG) dimension represented circular line of the circle (C) was calculated by formula: $C= 2\ \pi.r$, or $r= [(½\ C)/\ \pi]$. Size squared area (S) of the circle was calculated by formula: $S= \pi\ r^2$, or $S= \pi\ [(½\ C)/\ \pi\ ]^2$. Animal body dimension was simulated as representation of solid cylinder shape. Volume of cylinder shape (V) was calculated by formula as follows: $V= H.S = H.\ \pi[(½\ C)/\ \pi]^2$, where H was height of cylinder shape. Volume of cylinder shape (V) was simulated as representation of animal body volume (BV); and height (H) of cylinder shape was also simulated as representation of animal body length (BL).

Volume (V) of cylinder shape represented an animal body volume (BV) and height (H) of cylinder shape represented animal body length (BL), BV was also estimated by adopting formula of cylinder shape volume by converting cylinder height (H) into animal body length (BL) and converting circular line of the circle (C) into animal chest girth (CG). Therefore, BV was estimated by formula: $BV= BL.\pi[(½\ CG)/\ \pi]^2$. Body length was calculated in *cm* length and CG was calculated in *squared cm* size (cm^2), therefore BV was calculated in *cubic cm* (cm^3) by formula as follows: $BV\ (cm^3) = BL.\pi[(½\ CG)/\ \pi]^2$. Body volume was found in unit of *cm^3*, this unit was also converted into unit of *liter (*L*)* that was equal to unit of *dm^3*. As a result, BV in unit of *liter (*L*)* was calculated in formula as follows: $BV\ (liter)= [BL.\pi\{(½\ CG)/\ \pi\}^2]/1000$. All measurements of animal dimensions were taken in the morning before the animals were fed. Each dimension of CG and BL was recorded in centimeter while BV and live weight (LW) were recorded in liter and in kilogram, respectively.

Statistical Analysis

The data collected on each animal were analysed using the general linear model to evaluate the significance of sources of variation affecting measurements of each animal. The interrelationship of body weights and body measurements were estimated by simple correlation and regression (Steel & Torrie, 1980). The fixed effect considered was age. The model used was as follows:

$$Yij = \mu + \alpha i + eij$$

Where, Y_{ij}= record of live weight and body measurements of each animal; μ= overall mean; α_i= the fixed effect of i^{th} age of the animal and e_{ij}= random error associated with record of each animal. Age of the animals consisted of eight age groups with the first age group of 3 yr to the eighth age group of 10 yr and more.

To predict live weight from body measure, simple regression analysis was used. Simple regression model for predicting live weight from chest girth, body length and body volume in each age group of the animals was as follows:

$$Y= a + bX$$

Where, Y= dependent variable of the animal live weight; a= intercept; and X= independent variable of the animal body measurements, either body length, chest girth, or body volume.

RESULTS AND DISCUSSION

The least square means and standard errors from the general linear model analysis of live weight (LW) and measurements of chest girth (CG) and body length (BL) of horses at the various age groups were as presented in Table 1. Age was found to significantly influence ($P<0.05$) chest girth, live weight and body volume up till age groups of 7 yr old, but do not differ significantly ($P>0.05$) at age groups of 8 to ≥ 10 yr old and trait of body length.

Table 1 showed that age strongly influenced ($P<0.01$) animal live weight and body linear traits in Minahasa local horses, as there were changes in all traits studied as the animal aged. This was however not surprising since the size and shape of the animal was expected to increase as the animal was growing with age; on the other hand, the animal changed to decrease in body size as the animal was mainly used in agriculture, light traction, riding and leisure activities of local household farmer. There was wide variability as the age of the animals increased most particularly in the live weight and chest girth.

The variability as the animals' aged sharply reduced among age groups of 8 to 10 yr old in all traits examined as shown in the table most probably because the matured body weight of the animal was almost fully attained. This finding was in agreement with the study of Sadek *et al*. (2006) who reported that at maturity, linear body measurements were essentially a constant, thereby reflecting haritable size of the skeleton. The body conditions of the animals investigated coud be said to be good and the skeletal development was normal and consistent with the animal age. Correlations between live weight and body linear measurements were positive and highly significant ($P<0.01$). This implies that live weight and all linear measurements covary positively. The correlation between all pairs of linear body measurements indicated that frame size of the animals was complementary and that the total size of the animals was a function body length and circumference measurements of animal body or chest girth. Low correlation is a confirmation of non-suitability of the parameters as a measure of the other parameter in the breed under study.

Table 2 presented the coefficients of correlation between trait pairs of animal live weight, chest girth and body length. The correlations between all pairs of measurements were highly significant ($P<0.001$) for all age groups.

Based on linear regression model, live weight changes with linear body measurements and were strongly predictable with R^2 values ranging from 0.30–0.96 though the significance of the differences between the regression models was not tested. The R^2 values

Table 1. Least square means of live weight and body measurements of Minahasa local horses

Age (yr)	N	CG (cm)	BL (cm)	LW (kg)	BV (L)
3	25	145.48±12.01^{ab}	78.00±12.01	254.52±53.93^{bc}	133.38±29.31^{bc}
4	23	143.43± 9.55^{ab}	78.30± 4.65	246.56±48.70^{bc}	129.52±24.62^{ab}
5	41	144.88± 9.46^{ab}	76.58± 6.85	248.07±48.77^{bc}	129.24±24.97^{ab}
6	29	143.48± 7.82^{ab}	77.59± 3.44	243.14±33.12^{b}	127.84±17.33^{bc}
7	41	147.68±10.42^{b}	78.93± 5.52	264.90±50.43^{c}	138.30±25.93^{c}
8	22	143.36± 9.36^{ab}	77.41± 4.67	243.18±45.57^{bc}	127.91±23.58^{bc}
9	21	145.76±11.34^{ab}	77.95± 3.68	254.81±52.07^{bc}	133.21±26.35^{bc}
≥10	19	140.41±10.03^{a}	76.26± 4.51	229.32±41.73^{ab}	120.71±21.26^{ab}
3 to ≥10	221	144.68±10.05	77.67± 5.16	249.66±47.66	130.75±24.59

Note: Means in the same column with different superscript differ significantly ($P<0.05$). CG= chest girth; BL= body length, LW= live weight; BV= body volume.

Table 2. Coefficients of correlation between the variables

Age (Yr)	Variables	BL	LW	BV
3	CG	0.76	0.93	0.97
	BL		0.82	0.87
	LW			0.95
4	CG	0.71	0.93	0.97
	B L		0.80	0.86
	LW			0.96
5	CG	0.49	0.95	0.92
	BL		0.64	0.79
	LW			0.96
6	CG	0.53	0.93	0.95
	BL		0.66	0.75
	LW			0.95
7	CG	0.43	0.95	0.93
	BL		0.60	0.73
	LW			0.96
8	CG	0.75	0.96	0.97
	BL		0.84	0.88
	LW			0.98
9	CG	0.62	0.98	0.98
	BL		0.68	0.74
	LW			0.98
≥10	CG	0.42	0.96	0.95
	BL		0.55	0.68
	LW			0.97
3 to ≥10	CG	0.56	0.95	0.95
	BL		0.68	0.78
	LW			0.96

Note: CG= chest girth; BL= body length; LW= live weight; BV= body volume.

Table 3. Simple regression models for predicting live weight from chest girth, body length, and body volume

Age (yr)	Dependent (Y)	Independent (X)	Regression equation	R^2 value
3	LW	CG	-351.819 + 4.16785 X	0.86
		BL	-389.428 + 8.25575 X	0.67
		BV	22.040 + 1.74293 X	0.90
4	LW	CG	-436.860 + 4.76471 X	0.86
		BL	-413.028 + 8.42346 X	0.64
		BV	-0.284 + 1.90581 X	0.92
5	LW	CG	-462.584 + 4.90521 X	0.90
		BL	-102.942 + 4.58332 X	0.41
		BV	5.534 + 1.87660 X	0.92
6	LW	CG	-319.412 + 3.92068 X	0.86
		BL	-253.891 + 6.40615 X	0.44
		BV	10.865 + 1.81683 X	0.90
7	LW	CG	-413.831 + 4.59588 X	0.90
		BL	-165.213 +5.44955 X	0.36
		BV	5.510 + 1.87553 X	0.92
8	LW	CG	-424.922 + 4.66021 X	0.92
		BL	-391.463 + 8.19859 X	0.71
		BV	1.001 + 1.89331 X	0.96
9	LW	CG	-401.114 + 4.49996 X	0.96
		BL	-492.287 + 9.58401 X	0.46
		BV	-4.318 + 1.94521 X	0.96
≥10	LW	CG	-332.364 + 3.99997 X	0.92
		BL	-157.631 + 5.07383 X	0.30
		BV	-0.793 + 1.90630 X	0.94
3 to ≥10	LW	CG	-401.082 + 4.49770 X	0.90
		BL	-238.165 + 6.28040 X	0.46
		BV	5.044 + 1.87088 X	0.92

Note: CG= chest girth; BL= body length; LW= live weight; BV= body volume.

showed that 30% to 96% of every one kilogram change in live weight was caused by the variables while other factors not considered were responsible for between 70% and 4%. Unambiguously therefore, body volume, chest girth and body length in the arranged order of suitability could be used to predict the live weight of the horses accurately.

Table 3 presented the summary of simple linear regression analysis and generating models for predicting overall traits from live weight dan animal body measurements. The analysis showed that overall horse live weight can be predicted from horse body volume (R^2= 0.92), horse chest girth (R^2= 0.90) and body length (R^2= 0.46). The coefficients of determination (R^2) between horse live weight and body volume ranged between 0.90 and 0.96 for all animal age groups.

Determination coefficient (R^2) values of simple regressions using independent variable of body volume were higher and more consistent (0.90-0.96) compared with those using independent variables of chest girth (0.86-0.96) and body length (0.30-0.71) among animal age groups. In animals of cattle breeds, Ozkaya & Bozkurt (2009) reported that chest girth was the best parameter of all prediction of body weight for Brown Swiss (R^2= 0.91) and crossbred cattle (R^2= 0.89) in comparison to Holstein cattle breed (R^2= 0.61). In other animal of sheep, Afolayan *et al*. (2006) reported that the determination coefficient (R^2) value of simple regression analysis of live body weight by chest girth was 0.88 and the (R^2) value of multiple regression analysis of live body weight by chest girth plus hip height plus height plus body length was 0.91. This study revealed that the more the independent variables included in the model for prediction of live body weight, the higher the prediction accuracy of body weight by those variables. In this study, body volume formula involved both chest girth and body length measurements as the independent variables. Therefore, it was found that using body volume as the independent variable was consistent with multiple regression using animal body measurement as the indepenpent variables (Afolayan *et al*., 2006) and the best parameter of all for prediction of body weight in local horse.

According to these results, the body weight estimation of local horse using body volume formula produced higher prediction accuracies among all body measurements. The prediction accuracy of prediction of body weight from body volume formula could be defined by body measurements of both chest girth and body length. Consequently, as one of these measurements was decreased then the animal frame size was also decresed, affecting animal body weight. In this study, simple regression models when measurment was to be based on live body weight alone were shown below:

Live weight= 1.87088 body volume + 5.044 (R^2= 0.92)
Live weight= 4.49770 chest girth – 401.082 (R^2= 0.90)
Live weight= 6.28040 body length – 238.165 (R^2= 0.46)

Among those simple regressions, the simple regression using independent variable of body volume had the higest determination coefficient of 0.92 that can also be recommended in this study.

CONCLUSION

The high correlations between all pairs of body measurements for all age groups imply that live weight could be predicted fairly accurately from body volume formula rather than chest girth or body length in local horse following the formula of: Live weight (kg)= 5.044 + 1.87 body volume (liters).

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