ESTIMATION OF LIVE WEIGHT OF HOLSTEIN-FRIESIAN BULLS BY USING BODY LINEAR MEASUREMENTS

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Abstract. The objective of this study was to estimate the body weight of Holstein-Friesian cattle by using multiple regression analysis. Data were collected from 29 Holstein-Friesian bulls, whose live weight, body length (BL), height at withers, chest depth, heart girth (HG), shin circumference (SC), rump height, and back rump height were measured. There was a relationship between dependent and independent variables. The estimated multiple regression equation was –431.8 + 2.438 HG + 21.21 SC + 1.041 BL, with a determination coefficient of 0.9987 and a standard error of the estimate of 5.240.
Keywords: *body weight, Holstein, heart girth, measurement, regression analysis*

Introduction

Estimating the live body weight of animals through body measurements is a practical, faster, easier, and cheaper method in rural areas where resources are scarce (Nsoso et al., 2003). Knowing the animal live weight is important for breeders, since this information allows them to estimate market prices for live animals and to determine the right dosages in drug administration and the amount of feed to be supplied for growth, maintenance, and production (Mahieu et al., 2011; Chitra et al., 2012; Tsegaye et al., 2013).

Body measurements have been widely used for estimating live weight. There is a relationship between live weight and the various body lengths, heights, and girths measured on live animals.

Using body measurements to estimate live weight with a simple measuring stick and tape may provide relative accuracy and consistency.

Live weight forms the basis for a range of research and management activities including assessment of growth rates, animal responses to different diets and environmental conditions, and determination of feed requirements. Knowing the animal weight and weight changes is also important in determining responses to genetic selection (Touchberry and Lush, 1950).

The use of linear body measurements in fattening beef cattle carries some advantages over subjective methods of cattle evaluation that involve visual assessment and scoring (Essien and Adesope, 2003). Some authors have also suggested this approach to be more reliable than weight measured with a weighing scale, since the latter can be subject to short-term effects such as gut fill, urination, and defecation (Russell, 1975).

These measurements can be taken at lower costs (when labor costs are relatively low) with a simple measuring tape and may provide relative accuracy and consistency (Guilbert and Gregory, 1952)

This is not only a sign of adult weight of the breed but also important for prediction of the daily weight gain and making the feeding programs (Tüzemen and Yanar, 2013).

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There are several methods to estimate live weight in cattle. The polynomial regression was used to predict live weight in cattle (Assogba et al., 2017). Body weight and wither height were regressed on the other body traits. Regressions of body weight including the linear, quadratic, and cubic effects of a single independent variable (heart girth, wither height, hip width or body length) indicated that each measurement would be useful in predicting body weight (Heinrichs et al., 1992)

Digital Image Analysis was used in order to predict of body weight and carcass performance of beef cattle as well (Bozkurt et al., 2008)

However, the linear body measurements are used mostly to predict live weight in cattle and small ruminants. It is based on the measurement of heart girth, which is reported to be highly correlated with body weight in cattle (Heinrichs, 2007; Swali et al., 2008).

The objective of this study was to develop the best prediction models to estimate body weight based on linear body measurements.

Materials and methods

The experiment was conducted in Dicle University, Cattle Research Center in Diyarbakir Province, Turkey (37°57'41 N and 40°13'54 E, 650 m asl).

The study material consisted of monthly live weight and body measurement records of 29 male Holstein-Friesian bulls collected between the years 2016 and 2017. The initial weight was taken at age of 4 month. Different amounts of concentrate and roughage were provided ad libitum to the bulls considering the average live weights obtained from the monthly weighings.

A measuring stick was used to determine body length (BL), height at withers (HAW), chest depth (CD), rump height (RH), and back rump height (BRH), whereas a tape measure was used to determine heart girth (HG) and shin circumference (SC). Body measurements were taken once monthly with the bulls standing in a squeeze chute. Bulls were weighed before feeding and drinking water in the early morning.

The animals were weighed monthly using an electronic weighing scale with 1,500-kg capacity. Body measurements were taken by same observers so as to minimize bias. All the data were recorded in centimeters.

Descriptive statistics was used to present the simple means and standard deviation for all variables. Regressions of live weight (LW) on HG, CD, RH, HAW, SC, BRH, and BL were performed using simple and multiple linear regressions with the various body measurements as continuous variables. The obtained data were analyzed using Minitab 18 statistical software (Pearson's correlation coefficients), where correlations between body weight and different body measurements were computed.

Regression analysis was employed to predict live weight from different body measurements. The best-fitting regression model was chosen based on the coefficient of determination (R^2) and standard deviation (SD). Multiple regression models were followed to estimate body weight from body measurements.

The Stepwise regression model of the measurements (all seven linear body measurements) was defined as follows (*Eq. 1*):

$$Y = \beta_0 + b_1 \beta_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e_i, \qquad \text{(Eq.1)}$$

in which:

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Y = dependent variable (live weight),
βo = intercept,
β's = regression coefficients,
$X_{(1\ to\ 7)}$ = independent variables (HG, CD, RH, HAW, SC, BRH, and BL) and
e_i = error.

Results

In the statistical analyses, the mean and standard deviations were calculated for each attribute (*Table 1*).

Table 1. *Descriptive statistics of live weight and body measurements*

Fattening period	N	Live weight Mean±SD	Height at withers Mean±SD	Rump height Mean±SD	Chest depth Mean±SD
Initial	29	99.90±16.03	94.03±4.52	99.03±4.52	35.82±2.36
30 days	29	135.16±17.48	97.93±4.69	102.93±4.83	38.55±2.55
60 days	29	170.99±18.87	102.03±4.66	106.79±4.89	39.03±2.38
90 days	29	207.52±20.05	108.03±4.00	110.79±4.89	41.32±2.85
120 days	29	244.42±21.94	112.76±4.06	116.03±4.33	44.55±3.51
150 days	29	281.38±23.33	116.76±4.07	120.17±4.28	54.18±3.61
180 days	29	317.16±24.58	118.45±4.05	124.10±4.12	56.66±3.77
210 days	29	355.52±29.62	120.41±4.06	127.72±4.02	57.44±3.55
240 days	29	394.24±31.48	121.28±3.97	129.55±3.95	58.27±3.25
270 days	29	432.86±32.14	123.24±3.99	131.03±4.01	60.65±3.19
300 days	29	471.72±35.91	125.21±3.99	131.86±3.96	61.18±2.72
330 days	29	516.38±39.03	126.21±3.98	132.72±4.03	62.55±2.83
Final	29	553.66±34.48	127.31±4.36	133.52±4.09	64.18±3.18

Table 1. (cont.) *Descriptive statistics of live weight and body measurements*

Fattening period	N	Heart girth Mean±SD	Shin circumference Mean± SD	Body length Mean±SD	Back rump height Mean±SD
Initial	29	95.21±6.78	10.24±1.02	81.13±3.92	111.55±3.94
30 days	29	102.38±6.56	10.65±0.81	88.20±3.85	114.69±4.31
60 days	29	106.79±4.89	10.72±0.84	94.13±3.92	118.14±4.21
90 days	29	118.55±5.64	11.55±1.05	100.17±3.01	123.28±4.36
120 days	29	131.17±6.48	11.79±1.14	106.38±2.78	128.14±4.36
150 days	29	137.59±6.01	12.10±1.17	112.83±2.36	132.93±4.33
180 days	29	150.55±6.21	12.37±1.14	119.55±4.88	136.72±4.06
210 days	29	156.48±6.17	12.62±1.26	131.72±2.85	138.66±4.40
240 days	29	157.55±6.23	14.55±1.27	132.69±2.73	140.34±6.63
270 days	29	171.93±6.26	14.55±1.21	134.31±2.69	142.21±8.33
300 days	29	174.07±5.85	15.51±1.18	135.72±2.75	144.07±6.00
330 days	29	176.55±5.77	17.44±1.37	137.59±2.58	146.17±6.97
Final	29	182.83±5.93	18.82±1.97	139.21±2.83	148.52±4.31

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All correlation coefficients were positive and highly significant (P < 0.01), and the highest correlation coefficient was determined between BW and heart girth (*Table 2*).

Table 2. *The correlation coefficients between dependent and independent variables*

	BW	HAW	RH	CD	HG	SR	BL	BRH
BW	1	-	-	-	-	-	-	-
HAW	0.956**	1	-	-	-	-	-	-
RH	0.964**	0.993**	1	-	-	-	-	-
CD	0.956**	0.987**	0.992**	1	-	-	-	-
HG	0.987**	0.981**	0.989**	0.982**	1	-	-	-
SR	0.968**	0.848**	0.854**	0.848**	0.903**	1	-	-
BL	0.978**	0.982**	0.996**	0.983**	0.988**	0.864**	1	-
BRH	0.966**	0.994**	0.996**	0.992**	0.993**	0.885**	0.990**	1

P-value < 0.01

All possible regression equations were employed in the selection of a best fitted regression equation as represented in *Table 2*. The results showed that the multiple regression equation for estimation of body weight of Holstein-Friesian bulls had tree independent variables, x_1 (heart girths), x_2 (shin circumference) and x_3 (body length) with high adjusted coefficients of determination (R^2 = 99.87) and low standard error of estimation (S = 5.240) in equation (Y_3; *Eq. 2*).

$$Y_3 = -431.8 + 2.438\ \mathrm{HG} + 21.21\ \mathrm{SC} + 1.041\ \mathrm{BL} \qquad \text{(Eq.2)}$$

R^2 was calculated as 0.973 by using multiple linear regression analysis based on the HG to design a body-weight prediction model. When SC was added to regression model R^2 value was found as 0.9986. The best-fitting model, with the highest R^2 value (0.9987), was obtained by adding BL to the equation (*Table 3*).

Table 3. *The regression equation for live weights of Holstein bulls*

	1	2	3
Coef	**-378.3**	**-410.457**	**-431.8**
HG	4.876	3.247	2.438
T-Value	20.25	24.20	5.760
P-Value	.000	.000	.000
SR	-	20.0	21.21
T-Value	-	-13.46	14.73
P-Value	-	.000	.000
BL	-	-	1.041
T-Value	-	-	1.99
P-Value	-	-	.012
S	24.865	5.965	5.240
R^2	0.9739	99.86	99.87

$Y_1 = -378.3 + 4.876\ HG\ (R^2 = 0.9739)$
$Y_2 = -410.457 + 3.247\ HG + 20\ SR\ (R^2 = 0.9986)$
$Y_3 = -431.8 + 2.438\ HG + 21.21\ SR + 1.041\ BL\ (R^2 = 0.9987)$

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Live weight and linear body measurements were significantly correlated with each other. Body weight had a higher correlation with HG than with any other body measurements (CD, RH, HAW, SC, BRH, and BL). In all fattening periods evaluated, the highest R^2 was obtained when the SC and BL measurements were included in the regression equations, which suggests that body weight could be more precisely estimated by the association of two or more linear measurements. However, the association of different body measurements (body length and shin circumference) would produce the best prediction equation for body weight, in this study.

The coefficients of correlation between heart girth and body weight were 0.973 for all of the 29 Holstein-Friesian bulls, and highly statistically significant. The relationship between live weight and heart girth was illustrated by graph shown as *Figure 1*.

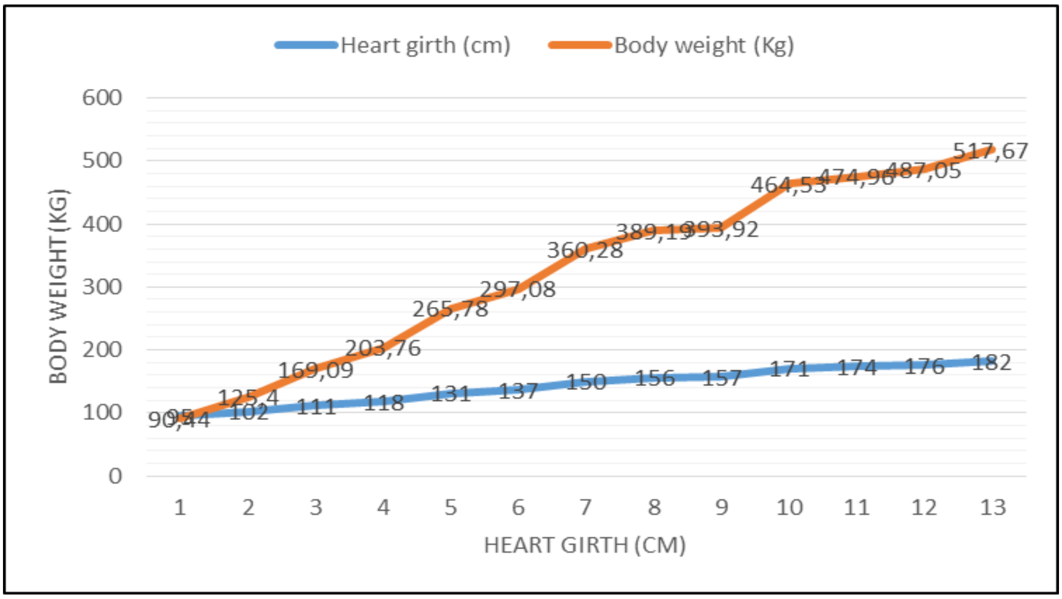

Figure 1. *Relationship between live weight and heart girth*

The regression of body weight on heart girth indicated a straight-line relationship.

The body weight of Holstein- Friesian cattle were estimated by using the multiple regression equation between the live weight and heart girth (Y_1) represented in *Table 4* and the comparison between the real values and the predicted values of body weight of Holstein-Friesian cattle was shown in *Table 5*.

Table 4. *Prediction of body weight of Holstein-Friesian cattle based on heart girth*

Heart girth (cm)	**Predicted body weight (kg)**	**Heart girth (cm)**	**Predicted body weight (kg)**
95	90.44	156	389.19
102	125.40	157	393.92
111	169.09	171	464.53
118	203.76	174	474.96
131	265.78	176	487.05
137	297.08	182	517.67
150	360.28		

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Table 5. *Actual and predicted body weight*

Heart girth (cm)	Actual body weight (kg)	Predicted body weight (kg)
95	99.9	90.44
102	135.16	125.4
111	170.99	169.09
118	207.52	203.76
131	244.42	265.78
137	281.38	297.08
150	317.16	360.28
156	355.52	389.19
157	394.24	393.92
171	432.86	464.53
174	471.72	474.96
176	516.38	487.05
182	553.66	517.67

Actual and predicted body weight of Holstein-Friesian bulls were illustrated by graph shown as *Figure 2*.

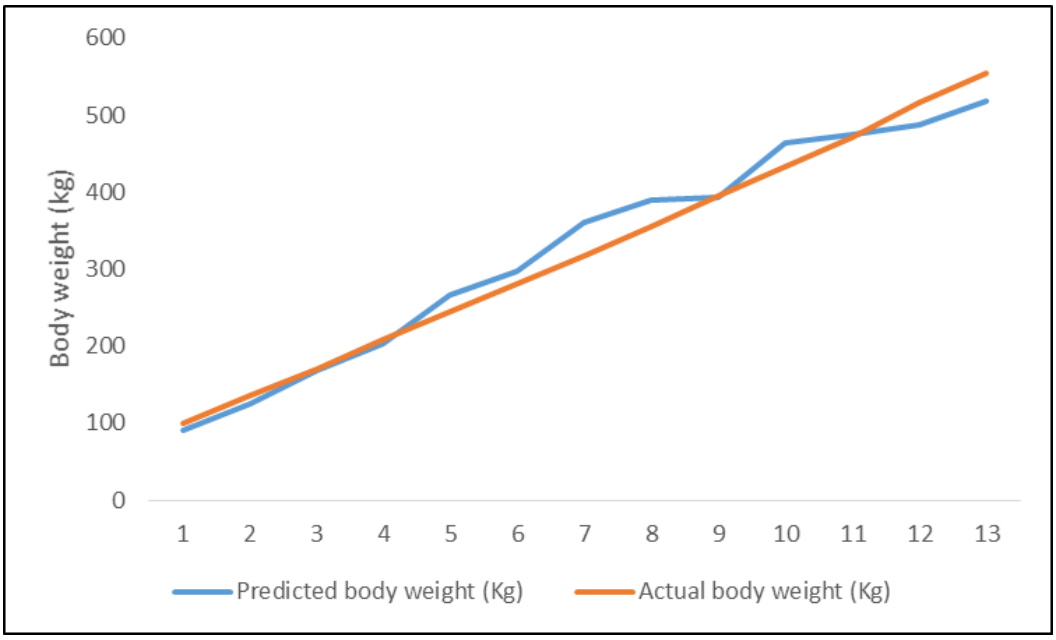

Figure 2. *Actual and predicted live weight values of Holstein bulls*

Discussion

The present findings corroborate Katongole et al. (2013), according to whom HG, WH, and body condition score (BCS) were the variables with the highest R^2 value for predicting body weight. Siddiqui et al. (2015) reported that the HG and BL were the best variables for this purpose, with $R^2 = 0.968$. Our results also agree with those published by Yan et al. (2009), who found that HG, BL, and BCS were better suited parameters for estimating body weight.

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The highest correlation obtained in this study was between LW and HG measurement while the lowest was with CD. The high correlation between LW and HG can be attributed to the fact that, in comparison to length and HW, HG more closely reflects body condition of cows (Goe et al., 2001). This fact may also be supported by the stronger correlation observed in the present study between HG, LW and body condition scores compared to BL. Such correlations have also been reported by other workers (Francis et al., 2002; Gunawan and Jakaria, 2010; Heinrichs et al., 1992, 2007; Kashoma et al., 2011; Msangi et al., 1999; Yan et al., 2009; Lukuyu et al.2016).

The relationship between body linear measurements and LW could be exploited in designing appropriate management and selection programs in that high positive relationships among the traits suggests that an increase in one could lead to a corresponding increase in the other trait (Assan, 2013).

Body weight was highly correlated with heart girth in cattle, as concluded by Abdelhadi and Babiker (2009), Bagui and Valdez (2007) and Nesamvuni et al. (2000).

The current results are similar to those reported by Soysal and Konak (1992), Tüzemen et al. (1995), Yanar et al. (1995), Mantysaari (1996), Seokgeum et al. (1998), Adeyinka and Mohammed (2006), Koç and Akman (2007), Sawanon et al. (2011) and Mekparyup et al. (2013).

Conclusions

The high values coefficients of correlation (R^2) of the equation obtained by multiple regression analysis suggest that heart girth can be practically used alone to estimate live weight. Regression coefficients for heart girth indicate that such estimators could be used independently to estimate body weight in Holstein-Friesian bulls. Estimating the body weight of Holstein-Friesian cattle using three independent variables heart girth, shin circumference and body length appears to be a useful strategy. Linear body measurements, specifically heart girth, are useful predictors of live weight in cattle. Heart girth is the most practical parameter for predicting live weight in field conditions, especially for smallholder farmers.

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