Scientific Papers. Series D. Animal Science. Vol. LX, 2017
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

# PREDICTION OF BODYWEIGHT OF HOLSTEIN AND BROWN-SWISS MALE CATTLE BY USING DIGITAL IMAGES

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***Abstract***

*This research aimed to develop prediction models for accurate estimation of performance and body measurements of beef cattle grown in feedlot beef system by using Digital Image Analysis (DIA). For this purpose, 40 animals were used in total and composed of 20 animals of the Brown Swiss breed and 20 animals of the Holstein breed with the age of about 4-5 months at the beginning of the experiment. Animals were fed the same dietary rations throughout the experimental period of 12 months. When the animals reached 500-550 kg bodyweights (BW), they were slaughtered.*
*The digital images of each live animal were taken and the same parameters (digital wither height (DJWH), digital body length (DJBL), digital body depth (DJBD), digital hip width (DJHW), digital hip height (DJHH) and digital pin bone length (DJPL) were also determined from the images, using the data with 1069 observations for each traits. Then, prediction models were developed by DIA.*
*The linear, quadratic and cubic regression models were performed to predict BW for both breeds and since there was no statistically significant differences (P>0.05) in body measurements between breeds. The data of these breeds were combined and found that DJBL and DJWH would be the best possible traits in predicting BW ($R^2$=93.9% and 90.7% respectively) among the other measurements. The linear terms of all body measurements by DIA were considered for analysis and they were significant and $R^2$ values for other body measurements DJHW, DJBD, DJHH and DJPL were approximately 78.4, 81.4, 87.7 and 67.7% respectively.*
*It can be concluded that in management situations where BW cannot be measured it can be predicted accurately by measuring DJBL and DJWH alone or both DJBD and even DJHH and different models may be needed to predict BW in different feeding and environmental conditions and breeds.*

**Key words:** *Prediction, Body weight, Digital Body Measurements, Digital Image Analysis.*

## INTRODUCTION

The decisions on agricultural activities are primarily depended on trials and errors at small farming level, especially in developing countries where small scale farming is characterised by poor resources and investments.
Body measurements of beef cattle are used for several purposes, especially since ration preparations are based on animal's body weight and very important for prediction of body weight, including growth rate, body condition and conformation (Wilson et al., 1997; Fourie et al., 2002)
Generally, marketing of animals between farmers is based on visual assessment in especially developing countries. Most of the veterinary medicines are prescribed on the basis of live weight criteria. However, prescriptions and dose of drug estimation is mostly performed by approximate estimations. The use of live weight criteria in ration formulation, drug estimation, body condition score and marketing requires sophisticated facilities which are expensive and hardly affordable to many small-scale farmers.
As long as scientists appreciate the importance of accurate prediction of animal's bodyweight, on managerial decisions a simple and reasonable technique should be considered. Several studies have indicated that there is a relationship between some body measurements and body weight (Peters and Ball, 1995; Nesamvuni et al., 2000). It is also important to know the bodyweight of cattle for a number of

reasons, related to breeding especially for selection, feeding and health care.
The results of the most studies have recognised that the accuracy of estimating body weight from heart girth or other body traits may be affected by breed, type, age, size and condition of the animal (Heinrichs et al., 1992) and also by different environmental conditions (Enevoldsen et al., 1997).
Therefore, the objective of this study was to gain further information about the relationship between body weight and some digital body measurements of different breeds such as Brown Swiss and Holstein cattle and also to determine the value of using one body measurement as a single variable entry to the model to predict body weight and to validate the potential of this method as a means of predicting body weight under small scale farming conditions by using DIA.

## MATERIALS AND METHODS

*Animals*

The animals used in this study were comprised of 40 Brown Swiss and Holstein cattle in total, divided into two groups on the basis of weight. The average weight was 132 and 158 kg for Brown Swiss and Holstein groups respectively. The digital images of various measurements were collected using a digital camera (canon) and a reference card to eliminate the distance between the object and the camera. Data were collected starting from December 2011 from the animals experimented on Suleyman Demirel University research farm and lasted for 12 months. A total of 1069 observations were used for each trait measured. The animals were weighed using a mobile weighing bridge once fortnight. Body weights were recorded to the nearest kilogram (kg) and the digital body measurements in centimetre (cm).

*Digital Body Measurements*

Digital images and digital body measurements were taken by the same person throughout the experimental period to avoid the experimenter error in measuring the digital parameters which are as follows:
1- Digital Wither Height (DJWH)- was the distance from the ground beneath the animal to the top of the withers directly above the centre of the shoulder,
2- Digital Body Length (DJBL)- was the distance from the point of the shoulders to the ischium; in other words, from the sternum (manubrium) to the aitchbone (tuber ischiadicum),
3- Digital Hip Width (DJHW)- was the widest point at the centre of the stifle,
4- Digital Body Depth (DJBD)- from sternum area immediately caudal to the forelimbs to top of the thoracic vertebra.
5- Digital Pin Bone Length (DJPL)- was the distance between two pin bones at the back
6- Digital Hip Height (DJHH)- was the distance from the ground beneath the animal rear legs to the top of the vertebra.

*Statistical Analysis*

The best prediction equations for body weight from other traits as independent variables, including DJBL, DJWH, DJHW, DJBD, DJHH, and DJPL were determined. Descriptive statistics on a monthly basis and regression analysis of BW on each of the independent variables was performed using the General Linear Models procedure of Minitab, 16 Inc. (Minitab, 2016).

Correlation coefficients were also obtained between digital body traits. Polynomial regression analysis of body weight on DJWH, DJBL, DJHW, DJBD, DJPL and DJHH were performed.

Linear, quadratic and cubic effects of independent variables on BW were included in the following model:

$$y_i = b_0+b_1X_i+b_2X_i^2+b_3X_i^3+e_i$$

Where
$y_i$= BW observation of an i' th animal,
$b_0$= intercept, $b_1$, $b_2$, $b_3$= corresponding linear, quadratic and cubic regression coefficients I,
$X_i$ = Digital body measurement (DJBL, DJWH, DJHW, DJBD, DJPL, DJHH) and
$e_i$ = residual error term
Several different regression analyses were conducted;
1- All seven digital body measurements, expressed as linear functions, were combined in BW prediction equation
2- Each digital body measurement was included separately in regression analysis as

linear, quadratic and cubic expressions to predict BW; and

3- The linear regression of each other digital measurement was then also added to the model as described previously.

## RESULTS AND DISCUSSIONS

There were no statistically significant differences in digital body measurements between breeds (P >0.05). Therefore, data of these breeds were combined for all statistical analysis. Descriptive statistics of body weight and digital body traits on a monthly basis are shown in Table 1.

The average values for BW increased throughout the experimental period from 144.7 kg to 507.8 kg with 363.1 kg difference.

The corresponding ranges for DJHW, DJBL, DJWH, DJBD, DJHH and DJPL were 27.92 cm to 42.8 cm with 14.88 cm difference, 102.77 cm to 153.16 cm with 50.39 cm difference, 98.56 cm to 134.19 cm with 35.63 cm difference, 50.11 cm to 72.64 cm with 22.53 cm difference, 103.38 cm to 138.13 cm with 34.75 cm difference and 19.77 cm to 30.98 cm with 11.21 cm difference, respectively.

Table 1. Descriptive statistics of body weight and digital body traits by weighing times on 1-12 months intervals

| Weighing Time (month) | Holstein | | | Brown Swiss | | | Both Breeds Means | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1. | 12. | Difference | 1. | 12. | Difference | 1. | 12. | Difference |
| BW(kg) | 158.37 | 520.32 | 361.95 | 131.07 | 495.2 | 364.19 | 144.7 | 507.8 | 363.1 |
| DJWH (cm) | 101.14 | 137.15 | 36.01 | 96.05 | 131.24 | 35.19 | 98.56 | 134.19 | 35.63 |
| DJHH (cm) | 105.62 | 140.5 | 34.88 | 101.14 | 135.76 | 34.62 | 103.38 | 138.13 | 34.75 |
| DJHW (cm) | 29.11 | 44.5 | 15.39 | 26.73 | 41.1 | 14.37 | 27.92 | 42.8 | 14.88 |
| DJBL (cm) | 105.59 | 155.89 | 50.3 | 99.95 | 150.43 | 50.48 | 102.77 | 153.16 | 50.39 |
| DJBD (cm) | 52.87 | 74.74 | 21.87 | 47.35 | 70.54 | 23.19 | 50.11 | 72.64 | 22.53 |
| DJPL (cm) | 20.24 | 31.07 | 10.83 | 19.29 | 30.89 | 11.6 | 19.77 | 30.98 | 11.21 |

BW: Body Weights, DJWH: Digital Wither Height, DJBL: Digital Body Length, DJBD: Digital Body Depth, DJHW: Digital Hip Width, DJHH: Digital Hip Height, DJPL: Digital Pin Bone Length

Table 2. Prediction equations of body weight and the linear effects of other digital body traits

| Models With One Variable | $R^2$ % |
|---|---|
| BW = - 738 + 8.92 DJWH | 90.7 |
| BW = - 525 + 6.49 DJBL | 93.9 |
| BW = - 401 + 19.3 DJHW | 78.4 |
| BW = - 536 + 13.7 DJBD | 81.4 |
| BW = - 215 + 19.7 DJPL | 67.7 |
| BW = - 793 + 9.09 HH | 87.7 |

Regression models of animal body weight on various digital body measurements using individual observations are shown in Table 2. As Table 2 shows models with one variable together with determination coefficients it was found that DJBL and DJWH would be the best possible traits in predicting BW ($R^2$=93.9% and 90.7% respectively) among the other digital measurements. In other words, the $R^2$ values in the models with one predictor shows the proportion of variation in the dependent variable that is predictable from the independent variable. Therefore, in this study 93.9% of the variation in BW can be explained by DJBL.

It was observed that in every steps of regression analysis inclusion of DJBL and DJWH in the equation increased $R^2$ substantially. It was also found that when all variables were included in the regression DJPL, DJHH and DJBD were not significant while the rest gave significant slope values. The table containing the equations with all combinations of all digital body traits were cumbersome therefore it was not presented in this paper. However, the highest $R^2$ values were obtained from the equation contained all digital body traits ($R^2$=95.6%) and the equation that included all digital body measurements except DJWH, DJHW and DJBD ($R^2$=95.2%) and those equations that included DJWH, DJBL and DJHH ($R^2$=95.2 %), DJWH and DJBL ($R^2$ =95 %) and only DJBL ($R^2$=93.9 %). These results were in line with the findings of Tuzemen et al. (1993), Ulutas et al. (2001) Bozkurt et al. (2007), Bozkurt et al. (2008) and

Bozkurt (2006) who reported high $R^2$ value from the equation including all body traits. Bozkurt (2006) found that when considering individual equations with one predictor hip width and body depth have the lowest $R^2$ values; 69% and 66.2%, respectively. Heart girth and wither height had the highest $R^2$ values, approximately 90% and 77% respectively. However, in this study, the individual equations with one predictor DJHW and DJPL had the lowest $R^2$ values; 78.4% and 67.7%, respectively. DJBL and DJWH had the highest $R^2$ values, approximately 93.9% and 90.7% respectively (Table 2).

Results of regression analysis of body weight on the linear, quadratic and cubic effects of each digital body measurement are presented in Table 3.

Table 3. Regressions of body weight on the linear, quadratic and cubic effects of each digital body measurement#

| Measurements | Model | Intercept | $b_1$ | $b_2$ | $b_3$ | $R^2$ % |
|---|---|---|---|---|---|---|
| Digital Hip Width (DJHW) | Linear | -401.3 | 19.3 | - | - | 78.4 |
| | Quadratic | -354.8 | 16.7 | $0.03565^{ns}$ | - | 78.4 |
| | Cubic | 2839 | -255.6 | $7.637^{ns}$ | -0.06958 | 81 |
| Digital Body Length (DJBL) | Linear | -525.4 | 6.49 | - | - | 93.9 |
| | Quadratic | -124 | 0.1772 | 0.02439 | - | 94.3 |
| | Cubic | 813.6 | -22.22 | 0.2007 | -0.000457 | 94.3 |
| Digital Wither Height (DJWH) | Linear | -737.8 | 8.921 | - | - | 90.7 |
| | Quadratic | 109.9 | -5.658 | 0.06201 | - | 91.3 |
| | Cubic | 6998 | -184 | 1.591 | -0.004336 | 91.8 |
| Digital Body Depth (DJBD) | Linear | -535.6 | 13.68 | - | - | 81.4 |
| | Quadratic | -318.7 | 6.566 | 0.05747 | - | 81.5 |
| | Cubic | 4389 | -227.3 | 3.884 | -0.02062 | 83 |
| Digital Pin Bone Length (DJPL) | Linear | -214.7 | 19.67 | - | - | 67.7 |
| | Quadratic | -578.5 | 48.15 | -0.5266 | - | 69 |
| | Cubic | 570.3 | -84.89 | 4.445 | -0.06054 | 69.8 |
| Digital Hip Height (DJHH) | Linear | -793.1 | 9.089 | - | - | 87.7 |
| | Quadratic | 262.8 | -8.431 | 0.07198 | - | 88.5 |
| | Cubic | 12363 | -311.9 | 2.592 | -0.00693 | 89.9 |

#Only none significant regression coefficients had superscripts (ns), the rest were significant at P<0.05.

It was observed in this study that a 1 cm increase in DJBL resulted in almost 6.5 kg increase in weight. Similarly, a 1 cm change in DJWH, DJHH, DJBD, DJHW, DJPL, and resulted in 8.92, 9.09, 13.7, 19.3 and 19.7 kg change in weight respectively (Table 3).

Higher order polynomial equations were examined. The $R^2$ values from the regression models indicate that digital body length and digital wither height to be the most highly related to body weight considering all linear, quadratic and cubic coefficient terms. For all digital body traits, addition of the cubic term increased the $R^2$ slightly. In this study DJBL and DJWH contributed 93.9% and 90.7% of variation respectively. However, while all linear, quadratic and cubic terms of DJBL and DJWH were significant (P <0.05) DJHW has not significant quadratic term (P >0.05). Moreover, DJBL produced the highest quadratic and cubic terms with $R^2$ of 94.3% for both. However, Heinrichs et al. (1992) reported that non-significant cubic term for heart girth and significant term for wither height. The quadratic term of body length was not significant (P >0.05). In contrast Heinrichs et al. (1992) found that quadratic term of body length was significant. Digital body depth has not significant both quadratic and cubic coefficients term either. All linear terms of all body measurements were significant (P <0.05). These results were in line with Heinrichs et al. (1992), Wilson et al. (1997), Ulutas et al. (2001), Bozkurt (2006), Bozkurt et al. (2007) and Bozkurt et al. (2008). The results in this study also showed that linear, quadratic and cubic expressions of both DJBL and DJWH are the most useful predictors, and support the findings of Wilson et al. (1997), Bozkurt (2006), Bozkurt et al. (2007) and Bozkurt et al.(2008).

It can be noted that, in the correctness of body weight estimates, the additional digital body measurements of the equations provide a slight increase except DJBL alone.

Correlation coefficients of the traits are shown in Table 4.

Table 4. Pearson correlations between digital body traits in both breed cattle

| Variables | BW | DJWH | DJBL | DJHW | DJBD | DJPL |
|---|---|---|---|---|---|---|
| DJWH | 0.95 | | | | | |
| DJBL | 0.97 | 0.95 | | | | |
| DJHW | 0.89 | 0.86 | 0.89 | | | |
| DJBD | 0.90 | 0.90 | 0.91 | 0.88 | | |
| DJPL | 0.82 | 0.78 | 0.81 | 0.85 | 0.77 | |
| DJHH | 0.94 | 0.94 | 0.93 | 0.84 | 0.89 | 0.76 |

All correlation values were found to be statistically significant ($P < 0.05$). Amongst all the digital body measurements, the highest correlation was found between DJBL and BW (r=0.97). The second highest correlation was between DJWH and BW (r=0.95). In addition the correlation value between DJBL and DJWH (r=0.95) was higher than the correlation between the rest of the traits. It was expected that DJBL would give higher correlation coefficient value than the other digital body measurements since the $R^2$ value between BW and DJBL was also high.

## CONCLUSIONS

As the most of previous studies showed, this study also indicated that digital body length and digital wither height can be used with great accuracy in predicting the body weight for Brown Swiss and Holstein cattle grown under small-scale farming condition. Digital body length and digital wither height exhibited the highest correlation to bodyweight of the traits studied.

When any of the other six digital measurements were used in the models that contained linear, quadratic and cubic terms, DJBL generally made the most important contribution compared with other digital body dimensions. DJWH can be considered the second best predictor. Therefore, the use of digital body length and digital wither height provide a simple way of predicting body weight confidently which is the overall purpose applying the technique in the practice.

However, there is always a need for further studies for the breeds in this study and other breeds as well to determine and develop different models to predict bodyweight in different management and environmental conditions. It is also important to pay a great attention when measuring digital body dimensions to reduce the experimental errors.


## ACKNOWLEDGEMENTS

This study was presented here as a part of project number 111O269 and project number 114O778 and the authors thank TUBITAK (The Scientific and Technological Research Council of Turkey) for financially supporting these projects.


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