Predicting Live Body Weight of Yearling Beef Heifers Using 3D Imaging

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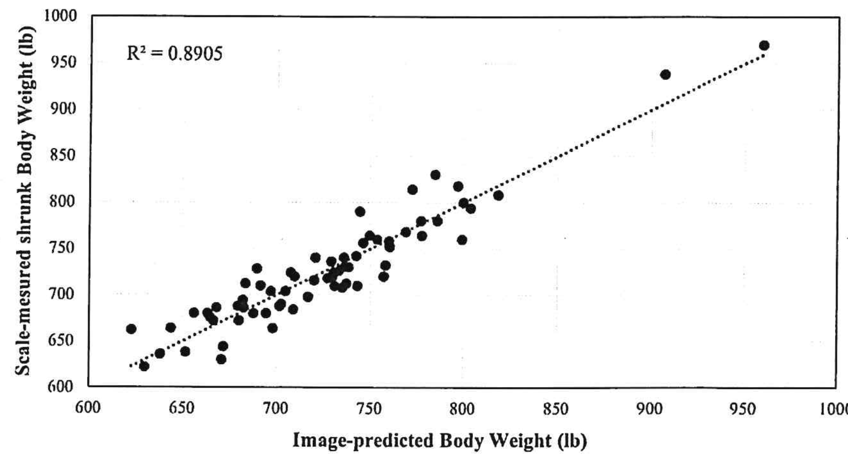

Fig. 1. Regression of scale-measured shrunk body weight (BW) of 69 yearling heifers vs. image-predicted BW. Results generated a R^2=.8905 and a small standard error of the means (SEM =1.54 lb).

Summary with Implications

This study was conducted to determine the accuracy of using 3D imaging technology as a method to predict shrunk body weight (BW) of growing yearling beef heifers. Red Angus × Simmental heifers (n = 69, BW = 726 ± 62 lb; 12 months of age) were utilized for data collection. A time-of-flight depth camera (Azure Kinect, Microsoft) was used to collect depth videos as heifers walked out of the chute. Ideal image frames were identified from videos and used to determine the body volume of each heifer. Prediction of BW using images produced an R^2 (estimate of model fit) = 0.89 and SEM (standard error of the mean, estimate of variation) = 7.28 lb. These results indicate it is possible to accurately predict heifer BW using dorsal depth images. This presents producers with the potential to improve management of grazing livestock without the need for moving cattle across a scale, which can reduce cattle stress and labor costs.

Introduction

Body weight (BW) and changes in BW are important measurements for nutritional and management decisions in cow-calf and rangeland cattle operations. Accurate BW measurements can be used for replacement heifer selection, determining nutrient supplementation strategies, and monitoring average daily gain. However, many cow-calf producers cannot measure BW accurately or often. Using a depth camera and 3D imaging technology is gaining popularity as another method that can be used to predict BW of livestock without the need to walk cattle over a scale. If the depth camera is able to predict BW accurately, it provides an alternative method for producers to measure BW and BW changes on grazing livestock and make better informed management decisions.

There has been substantial research conducted regarding estimation of BW with 3D imagery in the swine and dairy production systems, but limited research is present utilizing grazing livestock, specifically in the United States. Therefore, the objective of this study was to determine the efficacy of 3D imaging technology as a method to predict BW in yearling beef heifers. It was hypothesized that 3D imaging technology would be able to accurately predict BW, and thus, serve as an alternative sensing tool to obtain BW of grazing livestock.

Procedure

This study was conducted at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, Nebraska from May to August 2022. A total of 69 Red Angus × Simmental crossbred yearling beef heifers were used for video collection. Heifers were approximately 12 months of age and weighed between 620 to 970 lb. Heifers were restricted from feed and water for approximately 24 hours before data collection to estimate shrunk BW of the heifers. Prior to feed restriction, heifers were grazing upland native range. Dorsal 3D depth videos were taken of these heifers using an Azure Kinect depth camera that was positioned approximately 10 feet above floor level. These videos were taken as cattle exited the working chute.

These videos were analyzed to select individual frames that met specific criteria to be used for further data analysis. Criteria included the heifer having all four feet on the ground at the same time and no obstruction from other objects or animals in the image. Corresponding scale-measured BW were recorded for each animal during video collection. The depth images were analyzed using a customized program written in MATLAB (R2022a). From this program, height pixel values that form the heifers' dorsal area were produced. The summation of these height pixel values was then used to determine the heifer dorsal volume. The head region of all animals was excluded from the image analysis to reduce the variation associated with different head positions (e.g., bending, swinging, shaking, etc.).

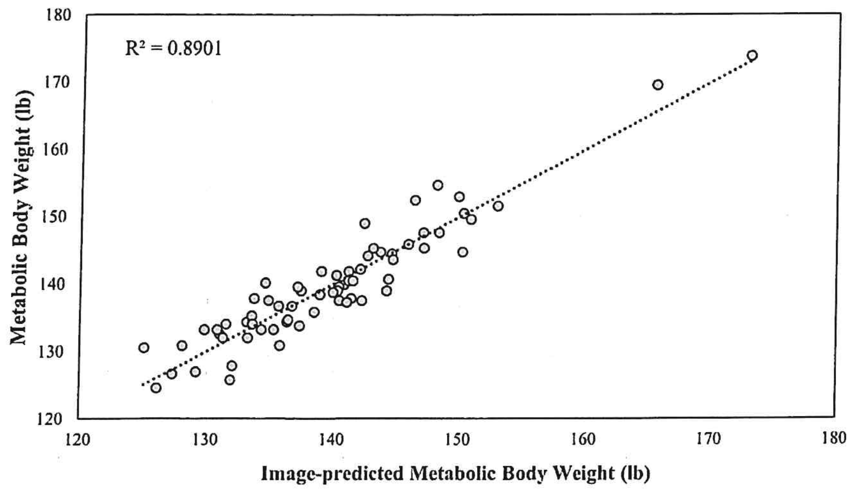

Fig. 2. Regression of calculated metabolic BW (MBW) vs predicted MBW generated from 3D image analyses. MBW was calculated by taking the shrunk BW to the ¾ power. Results of an $R^2 = 0.89$ and a 0.49 lb standard error of the mean (SEM) were obtained.

After obtaining the image-extracted dorsal body volumes, scale-measured BW were regressed against heifers' dorsal volumes to develop an equation for calculating the BW of the heifers when a scale is not accessible (Predicted BW=b×dorsal volumes+a; where b and a are linear regression coefficients). The heifer dorsal body volumes were then inserted into to the equation to calculate a predicted shrunk BW. To assess the accuracy of this approach estimating heifer shrunk BW using imaging analysis, the predicted BW was then regressed against scale measured BW (Figure 1).

Scale-measured shrunk BW was also converted to metabolic body weight (MBW) to look at the accuracy of the prediction model when using metabolic BW (Figure 2). Heifer MBW was calculated by taking BW to the ¾ power.

Data were analyzed using the PROC REG and PROC CORR procedures in SAS (v 9.4), summary statistics and common regression and correlation evaluation parameters are provided (i.e., standard error of the means (SEM), coefficient of the determination (R^2) and the Pearson coefficient, r). In this case, a small SEM means more accurate predication, a higher R^2 value indicates the better goodness-of-fit of the model, and a high r value indicates the scale-measured heifer shrunk BW is highly correlated with the image predicted dorsal volume, meaning one can estimate one input from the other.

Results

The regression of scale-measured shrunk BW versus predicted body volume produced an $R^2 = 0.8905$ (Figure 1). Prediction of BW using the regression equation produced an $R^2 = 0.8905$ and a SEM = 1.54 lb when compared to scale-measured shrunk BWs. The average difference between the scale-measured shrunk BW and the predicted BW was 16.30 lb. Pearson correlation coefficient comparing scale-measured shrunk BW and predicted BW produced an $r = 0.9437$ ($P < 0.0001$). When comparing predicted and actual MBW, there was an average difference of 5.11 lb. Coefficient of determination $R^2 = 0.8901$ was obtained when comparing predicted and actual MBW and the SEM of the difference between predicted and actual MBW was equal to 0.49 lb (Figure 2). The high correlation that was seen in these two models demonstrates the ability to accurately predict BW or MBW from yearling beef heifer body volume. However, more data is needed to validate these results, preferably with animals of different ages and breeds.

Conclusion

The results of this study show that there is great potential to accurately predict body weights of yearling beef heifers using 3D imaging technology. The regression model was able to predict BW of Red Angus × Simmental crossbred beef heifers using the linear equation developed from the image-extracted body volumes. A larger sample size is needed to validate the model for prediction of BW of growing beef heifers. Further research is advised to apply this model to different ages and breeds of beef cattle to determine the accuracy of prediction.

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