Comparison and reliability of techniques to estimate live cattle body weight

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ABSTRACT

Five different techniques of estimating the live cattle body weight were evaluated with the objective to identify the most reliable technique for use in the field. Weighbridge was used as the reference for other techniques. The measurement techniques evaluated were Weighbridge, Weigh tape, Rondo tape, Schaeffer's formula, Agarwal's formula, and calculator method. The body weights of 89 Brown Swiss and 34 Jersey Cross cattle were estimated by each technique. Compared with Weighbridge, the body weight estimates in Brown Swiss cattle exceeded by about 70 and 66 kg for Agarwal's formula and Rondo tape, respectively. In Jersey Cross cattle, the estimates exceeded by about 122 and 84 kg for Agarwal's formula and Rondo tape, respectively. In both breeds, the estimates of Schaeffer's formula were not significantly different from the Weighbridge. The estimates of weight tape were also not significantly different from the Weighbridge although the estimates exceeded by over 21 kg in Brown Swiss cattle and over 44 kg in Jersey Cross cattle. The study concluded that Schaeffer's formula is the most reliable of all techniques to estimate live body weight of cattle, followed by weigh tape. Agarwal's formula and Rondo tape are less reliable and their use in the field must be discontinued.

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Introduction

Livestock body weight is the basis for determining ration amounts and sale prices of animals. Body weight plays an important role in reproductive performance of a dairy animal and therefore, influences milk production (Kanuya et al. 2006; Roche et al. 2007). Westwood et al. (2002) reported that cows losing more body weight in early lactation have greater likelihood of conceiving. Heavier cows are found to require more inseminations to conceive (Berry et al. 2002). Body weight is also an indicator of capacity of livestock as draft animals (Bartholomew et al. 1994) and animal power is of utmost importance in a mountainous terrain where mechanization is difficult. Body weight is also used as a trait to evaluate the breeding value of livestock. The body weight also forms the main basis for preparing the correct dose of therapeutic pharmaceutical to treat livestock diseases. In the Southeast Asia, animal diseases and pathogens are the main constraints to livestock production and the use of therapeutic pharmaceuticals is common in treating and controlling diseases and pathogens. Without the proper estimate of body weight, there is risk of over- or under-dosing the animals with pharmaceuticals. While under-dosing may fail to control diseases, overdosing may be wasteful and economically inefficient. Therefore, the accurate estimate of live body weight is of fundamental importance to any livestock research and development.

Several techniques are available to measure or estimate the body weight of livestock. Weighing scale, although accurate, is less preferred by dairy producers because it is cumbersome, time-consuming, costly to implement (Heinrichs et al. 1992), and stressful to the herd (Brandl & Jørgensen 1996). Thus, rapid methods using linear body measurements are applied widely. Studies have made good prediction of live body weights of small ruminants through the use of linear body measurements (Mohammad et al. 2012; Eyduar et al. 2013; Ali et al. 2015). In Bhutan, different methods are used to estimate the live body weight of both local and crossbred cattle. There is lack of standard technique, which questions the reliability of body weights estimated by different techniques. Among several rapid methods, Rondo tape is used widely to estimate the body weight of Bhutanese cattle. It is based on the measurement of heart girth, which is reported to be highly correlated with body weight in cattle (Heinrichs et al. 2007; Swali et al. 2008). However, the conformity of Rondo tape estimates with the actual body weight is yet to be validated in the Bhutanese context. Further, the Rondo tape has been calibrated for cattle breeds that are morphologically different from the Bhutanese cattle, which likely questions the preciseness of this technique in the Bhutanese context. Studies report that the European-based weigh tapes developed for Holstein and other European beef breeds overestimate the true weight of east African cattle (Mwacharo et al. 2006; Machila et al. 2008). Otte et al. (1992) observed greater measurement error of weigh tape in cattle when compared with measurement by scale. Thus, there is a need to validate the preciseness of Rondo tape and compare techniques used to estimate the body weight. Particularly, in resource poor countries such as Bhutan and from economic standpoint, a practical and inexpensive field technique to estimate cattle
body weight without the use of scales is important. In this study, five different techniques were compared with Weighbridge as the reference technique. The primary objective was to evaluate and identify techniques providing precise estimates of live cattle body weight in Bhutan.

Materials and methods

Study site

The cattle farm at Bathpalathang, Bumthang in the east central Bhutan was selected for the study. The farm is located at an altitude of 2650 masl. The farm has Brown Swiss and Jersey Cross cattle.

Cattle breed, measurement techniques, and study design

Brown Swiss and Jersey Cross at the cattle farm were selected since these breeds are popular and reared by livestock farmers. The number of animals included in the study was 89 Brown Swiss and 34 Jersey Cross cattle.

The measurement techniques employed were Weighbridge, Weigh tape, Rondo tape, Schaeffer’s formula, Agarwal’s formula, and calculator method. Weighbridge is the standard calibrated weighing scale, which provides true body weight. Therefore, Weighbridge was used as a reference point for other five techniques. Each Brown Swiss and Jersey Cross cattle body weight was estimated separately by five measurement techniques. The body weight estimates of five techniques were compared with the weights obtained by Weighbridge.

Description of measurement techniques

The experimental animals were kept off feed and water for 12 hours before measurement.

Weighbridge: It is a standard calibrated scale, therefore, in this study, it was used as the main reference point for other techniques. Animals were allowed to approach the Weighbridge and proceed directly onto the platform. Animals were made to stand for about 10–15 seconds and weight measurement on the scale was recorded in kg.

Agarwal’s formula: It is the modified Shaeffer’s formula developed for the Indian cattle. The equation used for calculating live weight was \( W = \frac{(G \times L)}{Y} \), where \( W \) is body weight in kg, \( Y \) is equal to 9.0 if girth is less than 65 inches, \( Y \) is equal to 8.5 if girth is between 65 and 80 inches, \( Y \) is equal to 8.0 if girth is over 80 inches.

Schaeffer’s formula: The equation used for calculating live weight was \( W = \frac{(L \times G^2)}{300} \), where \( W \) is body weight in lbs, \( L \) is length of the animal from point of shoulder to pin bone in inches, and \( G \) is the chest girth of the animal in inches. The final weight was converted into kg.

Rondo tape: During measurement in the morning, the animal was made to stand with head in normal position and with the four legs set squarely under the body. Rondo tape was passed tightly around the body just back of the shoulders at the smallest circumference and the corresponding weight on the tape was read off straight away.

Weigh tape: The heart girth and length of the animal (from point of shoulder to pin bone) were measured in inches. For example, the heart girth was 62 inches and length was 78 inches. Length was converted into decimal pattern that is, length 78 was written as \((7 \times 10) + 8\). The value \((41.0)\) corresponding to length 7 against the girth was read from the body weight chart. Similarly, the value \((47.0)\) corresponding to 8 was read against the same girth. The values obtained were added to get the final weight as \( W = (41.0 \times 10) + 47 = 457 \) kg.

Calculator technique: This technique involved measurement of heart girth and the corresponding body weight was read and recorded from the beef cattle weight table.

Data analysis

The data set was tested for normalcy and homogeneity of variances using Shapiro–Wilk and Levene’s tests, respectively. Wherever required, data were logarithmically transformed to meet the assumptions of ANOVA.

Using the analysis of variance, separate analyses were conducted for Brown Swiss and Jersey Cross cattle to detect differences among techniques in body weight estimates. A Tukey test was performed when significant differences between means of more than two groups were detected. Differences between means were considered significant if \( P \) values were lower than .05. Techniques that did not differ significantly from Weighbridge were considered to agree with measurements of Weighbridge. The entire data set was analysed with SPSS version 23.

Results

Live body weight

The live body weights measured by Weighbridge were about 464 and 383 kg for Brown Swiss and Jersey Cross, respectively (Table 1). Irrespective of statistical differences between techniques, three techniques over-estimated and two techniques under-estimated the body weights of Brown Swiss cattle, whereas in Jersey Cross cattle, all five techniques over-estimated the body weight. In both breeds, the body weight estimates of Agarwal’s formula, Rondo tape, and Weigh tape techniques were significantly greater than the Weighbridge. Compared with weighbidge, the body weight estimates of Brown Swiss cattle exceeded by about 70 and 66 kg for Agarwal’s formula and Rondo tape, respectively. In Jersey Cross cattle, the estimates exceeded by about 122 and 84 kg for Agarwal’s formula and Rondo tape, respectively. In both breeds, the estimates of Schaeffer’s formula were not significantly different from the Weighbridge. Although, the estimates of weight tape were not significantly different from the Weighbridge, the estimates exceeded by over 21 kg in Brown Swiss cattle and over 44 kg in Jersey Cross cattle. The body weight of Brown Swiss cattle estimated by calculator technique was significantly lower than the Weighbridge.

Discussion

The body weight estimates of measurement techniques evaluated in this study deviate from the true weight measured by
Weighbridge. Except for Agarwal’s formula and Rondo tape techniques in Jersey Cross cattle, the body weight estimates of all techniques are within ±20% of true weight, which is acceptable for dosing with veterinary drugs (Williamson 1970; Leach & Roberts 1981). Among techniques, Schaeffer’s formula provides estimates closer to the true body weight and indicates the greater reliability of this technique in estimating the body weight of Bhutanese cattle. This probably explains why Schaeffer’s formula is widely applied by livestock producers in determining the cattle body weight. Therefore, the body weight of local Bhutanese cattle estimated at about 300 kg with Schaeffer’s formula by Wangchuk et al. (2014) appears to be a good estimate. Good estimates of live body weights using linear measurements have been demonstrated (Mohammad et al. 2012; Eyduran et al. 2013; Ali et al. 2015).

The weigh tape technique also gives estimates closer to the true weight in Brown Swiss cattle but the estimates in Jersey Cross cattle exceed by 16% of true body weight. It suggests that weight tape may provide reliable estimates in larger sized Brown Swiss cattle but not in smaller sized Jersey Cross cattle. On the contrary, the calculator technique provides reliable estimates in Jersey Cross but not in Brown Swiss cattle.

Agarwal’s formula and Rondo tape overestimate the body weight and suggests that these techniques are inaccurate and therefore, unreliable. Agarwal’s formula is specifically meant for the Indian cattle that are reared in production and management systems different from that of the Bhutanese cattle. While production system in India is largely based on crop residues and concentrate feed, the production system in Bhutan is largely based on pasture. Difference in production systems has been reported to result in variations in cattle morphology including heart girth and body length (Kugonza et al. 2011). Overestimation by Agarwal’s formula suggests that the technique is less suitable for use in production systems based on pasture. The overestimates of Rondo tape are explained by the fact that the tape is calibrated for the larger sized European cattle that are morphologically different from the Bhutanese cattle. Studies (Mwacharo et al. 2006; Machila et al. 2008) have demonstrated that the weigh tapes developed for Holstein and other European breeds overestimate the true weight of east African cattle. From the feeding standpoint, the heavier body weight has feed implications and would mean more feed demand and intake. Therefore, these techniques are likely to result in overestimation of feed and eventually increase the cost of production. Bhutan faces acute shortages of feed and forage in winter, therefore, a precise estimate of body weight is crucial for proper feed planning.

The body weights of Brown Swiss and Jersey Cross cattle are greater than the standard body weight of one Bhutanese livestock unit that weighs 300 kg (Samdup et al. 2010). Compared with the standard Bhutanese livestock unit, the body weight of Brown Swiss cattle is greater by over 54% and Jersey Cross cattle by over 27%. The findings of this study suggest that the livestock unit for Brown Swiss and Jersey Cross cattle should be defined separately. The currently used livestock unit body weight may apply for the local cattle but not for the exotic breeds of cattle. This holds true since Wangchuk et al. (2014) also estimated the body weight of local cattle at about 300 kg. Based on the standard livestock unit with body weight of 300 kg, this study shows that one adult Brown Swiss animal equates to 1.56 livestock units and one adult Jersey Cross cattle to 1.28 livestock units.

**Conclusions**

Schaeffer’s formula provides good estimate of body weight followed by weigh tape. Agarwal’s formula and Rondo tape overestimate the body weight; therefore, these techniques are not recommended and their use should be discontinued. The adult Brown Swiss and Jersey Cross cattle should be considered as 1.56 and 1.28 livestock units, respectively, while preparing pharmaceutical doses and planning feed.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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| Technique          | Brown Swiss cattle Body weight (kg) | Deviation from true weight | Jersey Cross cattle Body weight (kg) | Deviation from true weight |
|--------------------|-------------------------------------|-----------------------------|--------------------------------------|-----------------------------|
|                    |                                     | kg | %                        | kg | %                        |
| Weighbridge (true weight) | 464.22 ± 7.84 b | – | – | 383.18 ± 14.68 c | – |
| Agarwal’s formula | 534.09 ± 5.93 a | 69.87 | 15.10 | 505.59 ± 10.64 a | 122.41 | 31.95 |
| Rondo tape | 530.12 ± 8.92 a | 65.90 | 14.20 | 467.41 ± 16.34 ab | 84.23 | 22.00 |
| Weigh tape | 485.69 ± 8.26 b | 21.47 | 4.62 | 427.57 ± 14.59 bc | 44.39 | 11.58 |
| Schaeffer’s formula | 442.41 ± 6.79 cd | –23.81 | 4.70 | 401.74 ± 12.22 c | 18.56 | 4.84 |
| Calculator | 431.44 ± 6.64 d | –32.78 | 7.06 | 390.87 ± 11.67 c | 7.69 | 2.01 |

Table 1. Body weights of Brown Swiss and Jersey Cross cattle estimated by different techniques. Means ± SE with different letters are significantly different.
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