

A Comparative Study of Body Weight Estimation Formulas for Male Bali Cattle under a Semi-Intensive Management System in Mbawa Village, West Nusa Tenggara

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ABSTRACT

Bali cattle are an indigenous Indonesian beef cattle breed with an important role in supporting beef production and rural livelihoods. In Bima, Bali cattle are an important livestock resource, and accurate body weight information is useful for supporting feeding and other management practices. However, the availability of weighing facilities at the farm level is often limited, making body weight estimation based on morphometric measurements a practical alternative. This study aimed to compare body weight estimates obtained using the Djagra, Winter, and Schoorl formulas and to determine their deviations from the reference body weight in 1–2-year-old male Bali cattle raised under a semi-intensive management system. The study was conducted in March 2023 in Mbawa Village, Donggo District, Bima Regency, West Nusa Tenggara Province, Indonesia. Data were collected from 50 male Bali cattle using heart girth and body length measurements for body weight estimation. The results showed that the mean heart girth and body length were 129 ± 5.31 cm and 114.50 ± 5.34 cm, respectively. The estimated body weights were 268.48 ± 28.87 kg using the Djagra formula, 271.44 ± 29.19 kg using the Winter formula, and 228.10 ± 16.23 kg using the Schoorl formula. Relative to the reference body weight of 223.75 kg, the percentage deviations were 18.48%, 19.61%, and 5.49%, respectively. Among the three formulas evaluated, the Schoorl formula produced the estimate closest to the reference value in the study population. However, its performance should be interpreted as population-specific because the accuracy of body weight estimation formulas may vary according to animal characteristics and management conditions. Further validation using actual body weight measurements is required before applying the formulas to other Bali cattle populations.

Keywords: *Bali cattle; body weight estimation; morphometric measurements; semi-intensive management; Schoorl formula*

INTRODUCTION

Indonesia possesses diverse indigenous livestock genetic resources that contribute to national food production and the development of the livestock sector. One of these resources is Bali cattle (*Bos javanicus*), an indigenous cattle breed originating from the domestication of banteng. Bali cattle have been widely distributed in Indonesia and are valued for their adaptation to local environmental conditions and their contribution to beef production, particularly within smallholder farming systems. The conservation and development of Bali cattle are therefore important for maintaining Indonesia's livestock genetic resources and supporting sustainable cattle production (Sutarno & Setyawan, 2016). Differences in environmental conditions, feed availability, and management practices among production areas may, however, result in variation in the growth and physical characteristics of Bali cattle.

Body weight is an important parameter in beef cattle production because it is related to growth assessment, feed management, health management, breeding decisions, and the economic value of animals. Direct measurement using a weighing scale provides an objective estimate of body weight, but such equipment is not always available to smallholder farmers. Consequently, body measurements can be used as an alternative approach for estimating body weight. Morphometric traits such as heart girth, body length, and withers height have been reported to have significant relationships with body weight in Bali cattle. Agung et al. (2018) demonstrated that several morphometric measurements could be used to estimate the

body weight of Bali cattle in Banyumulek, West Nusa Tenggara. Similarly, Azis et al. (2023) reported significant relationships between body weight and several body measurements in Bali cattle, indicating the potential application of morphometric characteristics for body weight prediction.

The estimation of body weight from morphometric measurements is particularly useful in smallholder production systems because it can be conducted using simple measuring equipment without requiring a livestock weighing scale. A meta-analysis of beef cattle studies also demonstrated positive associations between body weight and linear body measurements, with heart girth showing a relatively strong relationship with body weight across different breeds, sexes, and age categories (Firdaus et al., 2023). Nevertheless, the accuracy of body weight prediction may differ according to breed, sex, age, and population characteristics. Therefore, evaluating the relationship between body weight and morphometric traits in Bali cattle under specific local production conditions is necessary to develop an estimation model that is appropriate for the characteristics of the observed population. Such a model can provide a practical tool for farmers in estimating body weight and supporting routine management and production decisions.

MATERIALS AND METHODS

Materials and Equipment

The equipment used in this study included a measuring tape with a precision of 0.1 cm, a measuring stick, writing materials, and a camera for documentation. The study material consisted of male Bali cattle classified as Poel 1, corresponding to cattle aged 1–2 years, raised in Mbawa Village, Donggo District, Bima Regency, West Nusa Tenggara Province, Indonesia.

Sampling Method

This study was conducted on smallholder Bali cattle farms using body weight estimation formulas as the data collection method. The research animals consisted of Bali cattle raised by farmers in Mbawa Village, Donggo District, Bima Regency, West Nusa Tenggara Province, Indonesia, under a semi-intensive management system. The study was conducted through direct field observations and measurements involving 50 male Bali cattle. Each animal was measured according to the body measurements required for estimating body weight. Three body weight estimation formulas were used in this study: the Djagra, Winter, and Schoorl formulas.

1. Djagra Formula

The Djagra formula is one of the methods used to estimate cattle body weight. The body weight of male Bali cattle was estimated using the following Djagra formula:

$$\text{Live weight (male)} = (\text{BL} \times \text{HG}^2) / 11,045$$

where:

BL = Body length (cm)

HG = Heart girth (cm)

2. Winter Formula

The Winter formula facilitates body weight estimation and helps reduce errors in determining cattle body weight. The deviation of the Winter formula from actual weighing has been reported to range from 2–6%, representing a relatively small error for estimating cattle body weight. Therefore, its accuracy needs to be evaluated by comparing the actual body weight obtained through weighing with the body weight estimated using the Winter formula.

$$\text{BW} = (\text{HG}^2 \times \text{BL}) / 300$$

where:

BW = Body weight (pounds)

HG = Heart girth (inches)

BL = Body length (inches)

3. Schoorl Formula

The Schoorl formula is another method used to estimate livestock body weight. This formula is considered to provide a relatively accurate estimate of actual body weight; however, cattle body weight can be influenced by environmental conditions and management factors.

$$\text{Schoorl formula (kg)} = (\text{HG} + 22)^2 / 100$$

where:

HG = Heart girth (cm)

RESULTS AND DISCUSSION

Body Measurements of the Cattle

The results of morphometric measurements of 1–2-year-old male Bali cattle (*Bos javanicus*) raised under a semi-intensive management system in Mbawa Village showed that the mean heart girth was 129 ± 5.31 cm, while the mean body length was 114.50 ± 5.34 cm. These values indicate variation in body size among individual animals, as reflected by the standard deviations of each parameter. Morphometric variation in cattle can be influenced by age, sex, genetic factors, as well as management practices and environmental conditions.

Table 1. Morphometric measurements and estimated body weight of male Bali cattle.

Parameter	Mean
Heart girth (cm)	129 ± 5.31
Body length (cm)	114.5 ± 5.34
Body weight based on Djagra formula (kg)	268.48 ± 28.87
Body weight based on Winter formula (kg)	271.44 ± 29.19
Body weight based on Schoorl formula (kg)	228.10 ± 16.23

Heart girth is one of the body measurements widely used for estimating body weight because it reflects body development associated with body capacity and tissue deposition. Adinata et al. (2023), in a study involving various Indonesian beef cattle breeds, demonstrated that heart girth was one of the most important variables for explaining variation in body weight. Their study involved 1,034 cattle from eight breed groups and showed that heart girth made an important contribution to body weight estimation. Similarly, Zurahmah and The (2011), who evaluated young male Bali cattle aged 1.5–2 years, reported that heart girth was the best single predictor of body weight when only one body measurement was used. Their study also showed that combining heart girth and body length provided an effective model for body weight estimation. These findings support the biological relevance of heart girth as an indicator of body size in the present study, particularly because the animals evaluated were also young male Bali cattle within a comparable age range.

The mean body length of 114.50 ± 5.34 cm indicates that the longitudinal development of the animals observed in this study had progressed relatively well. For comparison, SNI 7651-4:2020 specifies minimum body-length requirements for 24-month-old male Bali cattle of 121 cm for Class I, 117 cm for Class II, and 112 cm for Class III. Thus, the mean body length observed in this study exceeded the minimum requirement for Class III at 24 months of age. However, because the animals examined were 1–2 years old, this finding should be interpreted as a description of the morphometric characteristics of the study population rather than as a direct classification of breeding-stock quality.

Differences in body size among individuals may also occur because animal growth does not proceed uniformly. Genetic factors determine growth potential, whereas feed quality and availability, management practices, and environmental conditions can influence the attainment of body dimensions. Previous research on the morphometric characteristics of Indonesian beef cattle has demonstrated differences in body measurements among populations and breeds. Therefore, the use of body measurements as a basis for body weight estimation should take into account the characteristics of the population being evaluated.

Body Weight Estimation Using the Djagra Formula

Based on calculations for 50 male Bali cattle, the mean estimated body weight obtained using the Djagra formula was 268.48 ± 28.87 kg. This value indicates that the simultaneous use of body length and heart girth produced a relatively high estimated body weight in the study population.

The use of more than one body measurement for estimating body weight can theoretically provide more comprehensive information about animal body size. Body length represents the longitudinal dimension of the body, whereas heart girth provides information on the development of body regions associated with overall body size and mass. Agung et al. (2018), in a study of Bali cattle in Banyumulek, West Nusa Tenggara, also used a combination of morphometric parameters, including withers height, body

length, and heart girth, to develop equations for estimating body weight. This demonstrates that body-measurement-based approaches can serve as an alternative when direct weighing facilities are unavailable.

Nevertheless, the accuracy of an estimation formula is not determined solely by the number of parameters included. Body weight estimation equations are generally developed from specific animal populations and characteristics; therefore, their application to other populations may result in different levels of deviation. Differences in age, body conformation, physiological condition, and management environment may cause the relationship between body measurements and body weight to vary among populations. Therefore, the Djagra estimate obtained in this study should be interpreted as the result of applying the formula to 1–2-year-old male Bali cattle in the study area rather than as their actual body weight.

The relatively substantial deviation observed in the present study also needs to be interpreted in relation to previous studies. Septyan et al. (2023), using 43 male Bali cattle aged 1.5–2.5 years in East Kalimantan, reported a mean deviation of 8.54% for the Djagra formula. In contrast, the present study recorded a deviation of 18.48%. This difference suggests that the performance of the Djagra formula may vary among cattle populations, even when the animals belong to the same breed and have a comparable age range. Differences in body conformation, management conditions, measurement ranges, and reference body weight may contribute to variation in estimation error. Therefore, the relatively high deviation observed in the present study highlights the importance of locally validating body weight estimation formulas before their routine application to populations with different characteristics.

Body Weight Estimation Using the Winter Formula

The mean estimated body weight obtained using the Winter formula was 271.44 ± 29.19 kg. This represented the highest estimated body weight among the Djagra, Winter, and Schoorl formulas evaluated in this study. Compared with the reference value of 223.75 kg used in the study, the Winter estimate showed a deviation of 19.61%.

The Winter formula incorporates two body measurements, namely heart girth and body length. Biologically, the use of these two measurements can provide a broader representation of animal body dimensions. However, the results of this study indicate that the use of both parameters does not necessarily produce an estimate closest to the reference value. This may occur because the coefficients of an estimation formula are developed based on the characteristics of a particular population; consequently, its performance may change when applied to populations with different body conformations or ranges of body measurements.

This finding is consistent with the study by Meidina et al. (2021), which compared the Winter and Schoorl methods in Bali cattle. Their study indicated that the performance of body weight estimation methods may differ according to sex and the characteristics of the animals examined. The relationship between body weight and body measurements should therefore be considered when applying a particular formula to a specific population. The performance of the Winter formula may also vary among cattle populations. Samosir et al. (2016), who evaluated Brahman Cross, Aceh, and Bali cattle, reported differences in body weight estimation among cattle groups when body measurements were used as predictors. Their findings demonstrate that the relationship between body measurements and body weight may vary according to breed and population characteristics. Therefore, the performance of a particular estimation formula should not necessarily be assumed to be consistent across different cattle populations.

Accordingly, the Winter estimate of 271.44 ± 29.19 kg obtained in this study should not be interpreted as evidence that the formula is unsuitable for Bali cattle in general. Rather, it indicates that the Winter formula produced a relatively greater deviation in the group of 1–2-year-old male Bali cattle raised under a semi-intensive management system in Mbawa Village. Application of the formula to other populations should be further evaluated using actual body weight measurements as the reference.

Body Weight Estimation Using the Schoorl Formula

Calculation using the Schoorl formula resulted in a mean estimated body weight of 228.10 ± 16.23 kg. This estimate was closest to the reference body weight used in this study, namely 223.75 kg, with a deviation of 5.49%. Compared with the Djagra and Winter formulas, the Schoorl method produced a smaller deviation in the observed cattle population. However, the relatively low deviation of the Schoorl formula observed in the present study differs from the findings of Septyan et al. (2023). In their study of male Bali cattle aged 1.5–2.5 years, the Schoorl formula produced a substantially higher deviation of 37.37%, whereas the Djagra formula produced a lower deviation of 8.54%. This contrasting result indicates that the performance of the Schoorl formula cannot be generalized across Bali cattle populations. Differences in body size, body conformation, age distribution, management conditions, and the reference body weight used for validation may influence the magnitude of estimation error.

One characteristic of the Schoorl formula is that it primarily uses heart girth as the body measurement parameter. The results of this study demonstrate that a single body measurement can produce an estimate relatively close to the reference value in 1–2-year-old male Bali cattle. This finding has a biological basis because heart girth is associated with overall body size and has been reported in various studies to have a strong relationship with body weight. Adinata et al. (2023), in a study involving Indonesian beef cattle, reported that heart girth was an important variable for body weight estimation.

Previous studies on Bali cattle also support the importance of heart girth as an indicator for estimating body weight. Research on body weight estimation in prospective Bali cattle sires has shown that heart girth can be an effective variable when estimation is based on a single body measurement, whereas a combination of heart girth and body length can be applied when multiple variables are incorporated into an estimation equation. Other studies on Bali cattle have also demonstrated that heart-girth-based methods may produce different results depending on the characteristics of the animal population to which they are applied.

Although the Schoorl formula produced the smallest deviation in this study, this finding does not mean that the formula will always provide the most accurate estimates across all Bali cattle populations. The accuracy of an estimation formula is strongly influenced by the similarity between the characteristics of the animals and those of the population from which the formula was developed. Therefore, the 5.49% value should be reported as the lowest deviation within this study, rather than as a universal measure of the accuracy of the Schoorl formula for Bali cattle.

Comparison of Body Weight Estimation Results

Comparison of the three estimation methods showed that the mean estimated body weights were 268.48 ± 28.87 kg for Djagra, 271.44 ± 29.19 kg for Winter, and 228.10 ± 16.23 kg for Schoorl, compared with the reference body weight of 223.75 kg. The corresponding deviations were 18.48%, 19.61%, and 5.49%, respectively. These results indicate that the three formulas produced different levels of agreement with the reference value in the cattle population examined.

Table 2. Percentage deviation of estimated body weight from the reference value.

Parameter	Body weight (kg)	Deviation from reference (%)
Djagra formula	268.48 ± 28.87	18.48
Winter formula	271.44 ± 29.19	19.61
Schoorl formula	228.10 ± 16.23	5.49

The contrasting results with previous studies further demonstrate that the performance of body weight estimation formulas is population-specific. Septyan et al. (2023), for example, reported a deviation of 8.54% for the Djagra formula and 37.37% for the Schoorl formula in male Bali cattle aged 1.5–2.5 years. In the present study, the corresponding deviations were 18.48% and 5.49%, respectively. The different pattern between the two studies suggests that the accuracy of an estimation formula may be affected by differences in body conformation, age distribution, management conditions, measurement ranges, and the reference body weight used for validation. Samosir et al. (2016) similarly demonstrated differences in body weight estimation among cattle populations, supporting the need to consider population characteristics when applying morphometric-based equations.

Within the population examined in the present study, the Schoorl formula generated an estimate closest to the reference value. However, this result should be interpreted specifically for 1–2-year-old male Bali cattle raised under a semi-intensive management system in Mbawa Village and should not be generalized to Bali cattle populations elsewhere. Further studies involving actual body weight measurements obtained from a weighing scale are needed to validate the performance of these formulas and to develop population-specific prediction equations based on heart girth, body length, and other relevant morphometric variables.

From a practical perspective, body weight estimation based on morphometric measurements can provide useful approximate information when weighing scales are unavailable. Such estimates may support routine livestock management, although they should not be regarded as substitutes for direct weighing when accurate body weight information is required.

Conclusion

Male Bali cattle aged 1–2 years raised under a semi-intensive management system in Mbawa Village had mean heart girth and body length of 129 ± 5.31 and 114.50 ± 5.34 cm, respectively. Body weight estimates differed among the three formulas evaluated, with mean values of 268.48 ± 28.87 kg for Djagra,

271.44 ± 29.19 kg for Winter, and 228.10 ± 16.23 kg for Schoorl. Relative to the reference body weight of 223.75 kg, the corresponding deviations were 18.48%, 19.61%, and 5.49%. Thus, within the population examined in this study, the Schoorl formula produced the estimate closest to the reference value. However, comparison with previous studies indicates that the performance of body weight estimation formulas may vary among Bali cattle populations. Therefore, the findings should be interpreted as population-specific, and further validation using actual body weight measurements is recommended before applying these formulas to other populations.

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