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BODY MORPHOMETRY AND BODY CONDITION SCORE AS INDICATORS OF NUTRITIONAL STATUS IN CATTLE: LITERATURE REVIEW

Morfometri Tubuh dan *Body Condition Score* Sebagai Indikator Status Nutrisi Pada Sapi: Tinjauan Pustaka

Rr. Allamanda Ardia Wardana*, Luh Gde Sri Surya Heryani, Ni Nyoman Werdi Susari

Laboratory of Veterinary Anatomy and Embryology, Faculty of Veterinary Medicine, Udayana University, Jl. PB. Sudirman, Sanglah, Denpasar, Bali, Indonesia, 80234

*Corresponding author email: ardia.wardana@unud.ac.id

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Abstract

Evaluating the nutritional status of cattle is important for supporting productivity, reproductive efficiency, and health. Body morphometry and body condition score (BCS) are widely used methods because they are practical and can directly describe the physiological conditions of cattle. This review analyzed the role of body morphometry and BCS in determining the nutritional status of cattle and their relationship with production and reproductive performances. We used a systematic literature review method by searching scientific articles from the ScienceDirect, PubMed, Google Scholar, Garuda, and DOAJ databases published between 2016 and 2026. Article selection was performed using the PICO approach and PRISMA guidelines to obtain relevant open-access studies. The review showed that chest girth is the most representative morphometric parameter for predicting body weight, production capacity, and nutritional status because of its close relationship with muscle development and fat deposition in the thorax. Body length and withers height also reflect skeletal capacity and growth performance. BCS represents energy reserves and metabolic conditions associated with reproductive efficiency. The combination of morphometry and BCS provides a more comprehensive nutritional evaluation than either method alone. Body morphometry and BCS can be used as objective, economical, and applicable approaches for monitoring the nutritional status of cattle, especially in smallholder farming systems. Future studies should develop breed-based morphometric standards and digital technologies to improve the accuracy of nutritional assessment in cattle.

Keywords**:** Body morphometry, body condition score, cattle, nutritional status

Abstrak

Evaluasi status nutrisi pada sapi merupakan aspek penting dalam mendukung produktivitas, efisiensi reproduksi, dan kesehatan ternak. Pengukuran morfometri tubuh dan *Body Condition*

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Score (BCS) menjadi metode yang banyak digunakan karena praktis dan mampu menggambarkan kondisi fisiologis ternak secara langsung. Kajian pustaka ini bertujuan untuk menganalisis peran morfometri tubuh dan BCS dalam menentukan status nutrisi sapi serta hubungannya dengan performa produksi dan reproduksi. Penelitian dilakukan menggunakan metode *systematic literature review* melalui penelusuran artikel ilmiah dari database ScienceDirect, PubMed, Google Scholar, Garuda, dan DOAJ tahun 2016–2026. Seleksi artikel dilakukan berdasarkan pendekatan PICO dan pedoman PRISMA sehingga diperoleh artikel yang relevan dan *open access*. Hasil kajian menunjukkan bahwa lingkar dada merupakan parameter morfometri yang paling representatif dalam memprediksi bobot badan, kapasitas produksi, dan status nutrisi karena berkaitan erat dengan perkembangan otot dan deposisi lemak pada regio thoraks. Panjang badan dan tinggi pundak juga berperan dalam menggambarkan kapasitas skeletal dan pertumbuhan ternak. Sementara itu, BCS lebih menggambarkan cadangan energi dan kondisi metabolik yang memengaruhi efisiensi reproduksi. Kombinasi morfometri dan BCS memberikan evaluasi status nutrisi yang lebih komprehensif dibandingkan penggunaan salah satu metode saja. Morfometri tubuh dan BCS dapat digunakan sebagai pendekatan objektif, ekonomis, dan aplikatif dalam pemantauan status nutrisi sapi, terutama pada peternakan rakyat. Penelitian selanjutnya perlu mengembangkan standar morfometri berbasis breed dan teknologi digital untuk meningkatkan akurasi evaluasi nutrisi ternak.

Kata kunci**:** *Body condition score*, morfometri tubuh, sapi, status nutrisi

INTRODUCTION

Monitoring the nutritional status is a key pillar that plays a role in the biological efficiency of livestock. Nutritional status not only reflects feed intake but also serves as a vital indicator of reproductive performance, immune response, and carcass quality (D'Occhio *et al.*, 2018). Nutritional imbalances, whether deficiencies or excesses, can lead to reduced production efficiency, increased susceptibility to disease, and metabolic and reproductive disorders (Bezdíček *et al.*, 2020). An accurate and practical assessment of nutritional status is essential in modern livestock management systems, particularly in smallholder farming systems with limited resources and infrastructure.

Various methods have been developed to assess the nutritional status of cattle, ranging from body weight and body condition score (BCS) to blood biochemical parameters. To date, BCS has been the gold standard in the field for assessing nutritional status and body fat reserves through visual inspection and palpation. However, several recent studies have indicated that BCS has significant limitations, including high inter-observer variability and low accuracy in detecting small fluctuations in body weight (Truman *et al.*, 2022). Furthermore, in certain cattle breeds with distinct fat deposition characteristics, visual assessment often does not accurately reflect the actual nutritional status from an anatomical perspective. Body morphometry offers a promising alternative because it is noninvasive, easy to implement, and cost-effective. Body morphometry involves measuring the physical dimensions of livestock, such as chest circumference, body length, and shoulder height, which reflect structural growth and the development of bovine body tissues (Soul *et al.*, 2021; Adinata *et al.*, 2023).

Over the past decade, research on cattle body morphometry has shown significant progress, particularly in its use as a tool for predicting body weight during breeding selection and evaluating growth performance across various cattle breeds. Several studies have reported that morphometric parameters, such as chest circumference, body length, and shoulder height, are strongly correlated with body weight and reflect structural growth influenced by long-term nutritional adequacy, thus potentially serving as indirect indicators of the nutritional status of

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cattle (Soul *et al.*, 2021; Bezdíček *et al.*, 2020; Adinata *et al.*, 2023). Additionally, the relationship between body morphometry and body condition score (BCS) is increasingly recognized as a more comprehensive approach for assessing the energy reserves and physiological condition of livestock (Vanvanhossou *et al.*, 2018). Nevertheless, most publications focus on the technical aspects of body weight prediction, and systematic literature reviews that synthesize the role of body morphometry as an indicator of cattle nutritional status applicable in the field remain limited. Therefore, this article presents a scientific synthesis integrating the latest findings on body morphometry and BCS as a non-invasive, economical, and relevant approach to assessing nutritional status to support cattle nutrition management, particularly in smallholder farming systems.

RESEARCH METHODS

Eligibility Criteria

The articles selected for this review were selected using the PICO (population, intervention, comparison, and outcome) approach. The population in this study consisted of beef or local cattle, and their nutritional status was evaluated. The intervention included body morphometry measurements and assessment of body condition score (BCS). Comparisons included differences in evaluation methods, sex, breed, and morphometric standards used in various studies. The observed outcomes included nutritional status, body weight, production performance, metabolic health, and reproductive efficiency of cattle.

Search Strategy

A systematic literature search was conducted using openly accessible online databases such as ScienceDirect, PubMed, Google Scholar, Garuda, and the Directory of Open Access Journals (DOAJ), using the keywords “cattle morphometry,” “body measurements,” “nutritional status,” “body condition score,” and “live weight prediction.” The reviewed literature was limited to scientific articles in English or Indonesian published within the last ten years, specifically from February 2016 to February 2026.

Inclusion Criteria and Exclusion Criteria

The inclusion criteria were research articles or reviews that discussed morphometry, body condition score (BCS), nutritional status, production, or reproduction in cattle; were available in full-text form; were published between February 2016 and February 2026; and were written in either Indonesian or English. Articles not related to cattle, articles without relevant data, duplicate publications, short proceedings, and articles without full access were excluded from the review.

Study Selection

A total of 186 articles were identified from all databases. After removing 34 duplicate articles, 152 articles were screened based on their title and abstract. A total of 91 articles were eliminated because they were irrelevant to the topic, did not focus on cattle, or were not available through open access. A total of 41 articles were reviewed in full, and 18 articles were deemed to meet the criteria for inclusion in the literature review.

RESULTS AND DISCUSSION

The Anatomical Significance of Body Morphometry as a Nutritional Indicator

Body morphometry reflects the body’s phenotype in terms of energy balance and long-term nutritional status. In cattle, changes in nutrient intake affect muscle and adipose tissue, which are reflected in linear body dimensions, particularly in the thoracic and pelvic regions of the

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body. The BCS parameter is semi-quantitative and influenced by the assessor's subjectivity, whereas morphometric parameters are based on numerical data sources that are more objective, consistent, and easy to apply in practice. Therefore, morphometric measurements can serve as parameters to accurately and measurably monitor nutritional status and energy balance. This advantage can make it easier for researchers or practitioners to draw conclusions regarding nutritional adequacy in relation to the physiological condition of cattle, while also identifying nutritional problems before they impact productivity and animal health.

Adinata *et al.* (2023), through their study of 1,034 cattle of various breeds in Indonesia, confirmed a strong correlation between body dimensions, body weight, and production potential. These results underscore that body morphometry not only indicates physical size but also reflects long-term nutritional status, which affects livestock performance. One of the most commonly used parameters is chest circumference, which is measured by encircling the thoracic region directly behind the scapula. Anatomically, the development of muscle tissues, such as the intercostal, latissimus dorsi, and pectoralis muscles, as well as the deposition of subcutaneous adipose tissue in the thoracic region, are early indicators of adequate livestock nutrition. Under conditions of chronic nutritional deficiency, a reduction in muscle mass and fat tissue causes the thoracic region to appear more prominent, characterized by clearly visible protruding ribs. Therefore, chest girth can be used as a morphometric parameter responsive to nutritional status (Figure 1). Hartati and Putra (2021) demonstrated that chest girth had a high level of accuracy in predicting body weight in local cattle in Indonesia. In smallholder farming settings where weighing facilities are limited, morphometric measurements—particularly chest girth—serve as an applicable, economical, and scientifically grounded method for estimating body weight.

Chest Circumference and Body Length as Measures of Livestock Production

Chest circumference as a morphometric parameter is not only used as an indicator of nutritional evaluation related to body weight but also to the quality of production outputs such as carcass yield. The thoracic region is sensitive to changes in muscle growth and fat deposition resulting from energy balance; thus, an increase in chest circumference is often associated with increased body mass and metabolic capacity in livestock. Furthermore, the development of the thoracic wall is relatively more stable in response to changes in body position than that of the abdominal area, making its measurement more consistent in the field. Therefore, chest circumference is considered more representative than other linear parameters in predicting body weight and livestock production potential. According to Shamad *et al.* (2023), there was a strong correlation ($r = 0.84$) between chest circumference and carcass weight in Madura cattle. This indicates that any increase in thoracic dimensions is accompanied by increases in muscle mass and intramuscular fat. Physiologically, this is associated with an increase in metabolic capacity resulting from optimal nutritional management, which supports the development of organs and tissues.

In addition to chest circumference, body length and body index reflect skeletal capacity and long-term growth potential (Figure 2). Body length is generally measured from the tuber humeri to the tuber ischiadicum, thus reflecting the development of the thoracolumbar vertebrae and pelvis, which are related to skeletal growth. Rahmi *et al.* (2025) and Kamaru *et al.* (2025) reported that variations in the morphometry of female Bali cattle across different regions are significantly influenced by environmental conditions and livestock feed management systems. This study indicates that body dimensions in cattle result from a dynamic interaction between genetic factors and the availability of adequate nutrition in the rearing environment. In young cattle, an increase in body length is primarily driven by skeletal growth, whereas in adult cattle, an increase in chest circumference is more influenced by muscle mass

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development and body fat deposition. Therefore, body morphometry can be used as an indicator of the quality of the rearing environment and for the early evaluation of livestock production potential.

A relationship between morphometric parameters and body weight has generally been observed across various cattle breeds; however, the degree of correlation may vary depending on the genetic type and livestock production objectives. Tropical breeds, such as Bali, Madura, and Peranakan Ongole cattle, generally have more compact bodies and are more efficient in hot environments (Adinata *et al.*, 2023), whereas subtropical breeds have larger skeletal sizes with different muscle deposition patterns (Silva *et al.*, 2024). Additionally, differences between beef and dairy cattle influence the interpretation of morphometric data. Beef cattle tend to exhibit more dominant muscle development in the thoracic and pelvic regions, whereas dairy cattle have a larger abdominal capacity as an adaptation to feed intake and milk production. Therefore, the validity of morphometric parameters must be adjusted according to breed, age, and livestock production type to ensure a more accurate interpretation of nutritional status and production potential.

The analysis of chest circumference and body length in livestock production evaluation is an approach to understanding the physical condition of livestock without the need for invasive procedures. According to Firdaus *et al.* (2023), body length and chest circumference are strongly correlated with body weight in various cattle breeds, sexes, and age categories. Furthermore, the use of these measurements has proven significant in determining the quality of production outcomes, ranging from live weight estimates to the proportions of carcasses and meat produced (Aprilliawan *et al.*, 2024). However, excessive fat deposition can affect the validity of these measurements, particularly in overweight or pregnant cattle. Subcutaneous fat accumulation in the thoracic and abdominal regions can increase body circumference without a proportional increase in muscle mass. In pregnant cattle, uterine enlargement and fetal development can also affect body dimensions; therefore, morphometric interpretation must be performed cautiously. Therefore, morphometry should be combined with BCS assessment to ensure that the evaluation of livestock nutritional status, growth, and production potential is more comprehensive and accurate. Morphometric analysis can serve as a non-invasive and cost-effective diagnostic tool for monitoring growth, assessing body condition, and predicting production potential, thereby supporting more proactive and data-driven livestock management decisions. This is crucial for enhancing cattle productivity to meet the ever-increasing market demand while maintaining the sustainability of the livestock system.

Morphometric Standards and Sex Differences in the Evaluation of Cattle Nutritional Status

The evaluation of cattle nutritional status through morphometry must take into account applicable size standards as well as biological factors such as sex. Cattle body size standards, whether local (such as the SNI for Bali cattle) or general scientific references, play a crucial role in the accurate interpretation of morphometric parameter values. These standards provide reference ranges for linear body measurements, such as chest circumference, body length, and shoulder height, allowing morphometric measurements to be correlated with the nutritional status of cattle.

Sex-based morphometric differences must also be considered in nutritional status analyses. Several local studies have shown variations in body size between male and female cattle. For example, morphological measurements of Bali cattle at two different locations showed that male and female Bali cattle exhibited significant differences in body size, such as chest circumference and shoulder height, even within similar populations, with chest circumference

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being a dominant predictor of body weight in both sexes (Maimunah *et al.*, 2021). Additional research in the Buol Regency also reported that male and female Bali cattle exhibited significantly different average values for body length, chest circumference, and body weight, reflecting the presence of sexual dimorphism in body morphometry (Yusuf *et al.*, 2024). These variations include a higher chest circumference and body length in males than in females within the same age group. These results confirm that the interpretation of morphometric data in nutritional status evaluations must account for sex to avoid bias when assessing the physiological condition of livestock.

Differences in body composition, such as muscle mass and fat proportion, between males and females within a specific age group can influence morphometric measurements as nutritional indicators. This aligns with a meta-analysis that confirmed that the relationship between body size and body weight is influenced by breed category, sex, and age, indicating that morphometric data must be interpreted by considering these variables to yield valid estimates (Firdaus *et al.*, 2023). Minimum standards, as outlined in national or local guidelines, are essential to ensure that morphometric measurements can be linked to the biologically and practically expected nutritional status, for example, for breeding selection, growth evaluation, and genetic improvement programs. On a broader scale, international studies on sexual dimorphism in early weight gain (e.g., weaning weight) have highlighted that male and female cattle respond differently to the environment, which also influences morphometric parameters and sensitivity to nutritional and environmental factors (Santana *et al.*, 2024). In practice, combining morphometric standards with considerations of sexual dimorphism improves the accuracy of interpreting the nutritional status of cattle. Although morphometry provides a structural picture without considering biological factors such as sex and applicable size standards, such interpretations may be biased or fail to reflect actual physiological and nutritional conditions.

The Role of Morphometry and Body Condition Score in Supporting Metabolic and Reproductive Health in Cattle

In beef cattle farming, reproductive success is closely linked to adequate nutrition, and body condition score (BCS) is a useful tool for assessing nutritional status. Therefore, evaluating body condition is a crucial step before determining feed management strategies or breeding programs. The two most commonly used approaches in the field are body morphometric measurements and Body Condition Score (BCS) assessment. Both are often used separately; however, when combined, they provide a more comprehensive picture of the energy status of livestock.

Morphometric measurements, such as chest circumference, body length, and shoulder height, reflect the development of the body structure shaped by long-term nutritional processes. Adinata *et al.* (2023) indicated that morphometric dimensions have a strong linear relationship with body weight and production performance in Indonesian beef cattle. BCS places greater emphasis on subcutaneous fat reserves, which can change more rapidly in response to daily energy balance. An extremely low or high BCS negatively impacts livestock reproductive efficiency. Based on the study by D'Occhio *et al.* (2019), nutritional status and BCS directly influence reproductive hormonal regulation through changes in insulin-like growth factor-1 (IGF-1) and leptin levels, which affect hypothalamic and ovarian activity. Decreases in these hormones suppress gonadotropin-releasing hormone (GnRH) pulsations, which ultimately leads to anestrus and reduced conception rates. The relationship between BCS and pregnancy rates was also confirmed by Chebel *et al.* (2018), who demonstrated that cows with moderate BCS scores had higher conception rates than cows that were too thin.

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Assessment based solely on BCS is insufficient to fully describe the biological conditions of cows. Cows with small frames may have good BCSs; however, their production capacity and energy requirements differ from those of cows with large frames. Morphometry plays a crucial role as a complementary tool for interpreting nutritional status. Technological advancements have further strengthened the synergy between morphometry and BCS. Precision livestock farming systems enable the automatic estimation of body size and BCS using three-dimensional imaging technology (Xiong *et al.*, 2023). Thus, morphometry and BCS should not be viewed as mutually exclusive methods but as complementary approaches. Morphometry helps in understanding the structural capacity and long-term nutritional history, whereas BCS provides a quick snapshot of the energy reserve dynamics that influence metabolic and reproductive functions. Combining both provides a stronger foundation for determining a dam's readiness for breeding, evaluating the success of feed management, and improving reproductive efficiency in beef cattle production systems.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Body morphometry and Body Condition Score (BCS) are complementary methods for assessing the nutritional status of cattle, with heart girth being the most representative morphometric parameter due to its strong association with body weight and body development. The combined use of morphometric measurements and BCS provides a more comprehensive and accurate evaluation of nutritional status and can be easily applied in smallholder farming systems to support feeding management, growth monitoring, and productivity improvement.

Suggestions

Further studies are warranted to develop a more specific nutritional status prediction model based on local Indonesian cattle breeds, considering variations in age, sex, and husbandry systems, to obtain a more precise and practical equation.

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Figures

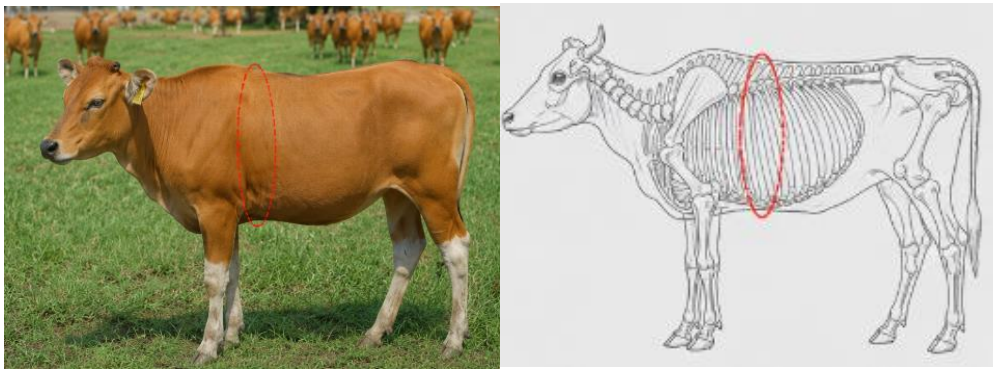

Figure 1. Chest circumference measurement points on cattle.

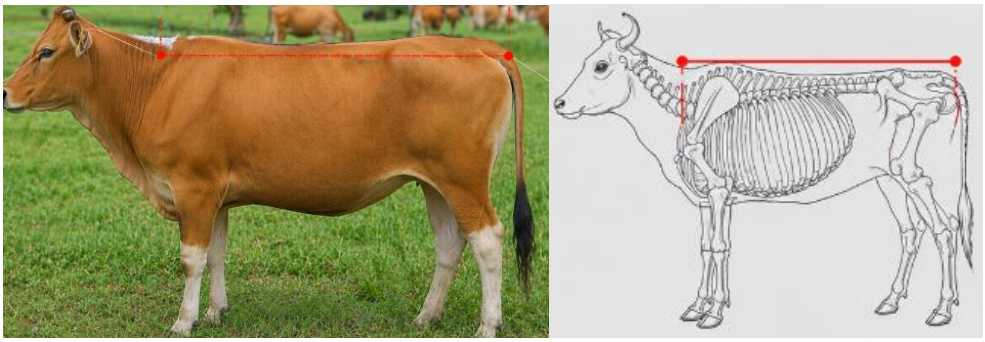

Figure 2. Body length measurement points on cattle.