Rizka Larasati et al./Animal Production. 26 (2): 70-81, July 2024
Accredited by Kemendikbudristek Dirjendiktiristek No 225/E/KPT/2022. E-ISSN 2541-5875

Correlation of Linear Body Size with Body Condition Score and Body Weight of Participated Cow Used in Progeny Test

Rizka Larasati[1], Tri Eko Susilorini[2]*, Puguh Surjowardojo[2], Rini Dwi Wahyuni[2]

[1]Students of the Master Program in Animal Science, Faculty of Animal Science, Universitas Brawijaya, Malang 65145, Indonesia
[2] Department of Animal Production Faculty of Animal Science, Universitas Brawijaya, Malang 65145, Indonesia
***Corresponding author: triekos@ub.ac.id**

Abstract. This study aims to classify and analyze the correlation between linear body size with Body Condition Score and Participated Cow body weight used in the progeny test of dairy cows in KAN Jabung, Malang, East Java. The material used was 180 lactating cows used as Participated Cows. The research method is a survey with data collection by purposive sampling and using criteria for lactating cows. The data was analyzed based on correlation analysis and simple linear regression. The results showed a correlation value between body weight, chest circumference, body length, and height with BCS, respectively: 0.35; 0.35; 0.19; 0.32, while the correlation value of chest circumference, body length, and height with consecutive body weights is as follows: 0.99; 0.54; 0.45. This study concludes that the correlation between linear body size and Body Condition Score is low compared to linear body size with body weight, which has a substantial correlation value. The highest correlation of Participated Cow linear body size was obtained on the relationship of chest circumference with body weight. In contrast, the lowest correlation was obtained on the relationship of body length with BCS (Body Condition Score).

Keywords: body condition score, linear body size, participating cows

Abstrak. Penelitian ini bertujuan untuk mengetahui dan menganalisis korelasi antara ukuran linear tubuh dengan *Body Condition Score* dan bobot badan *Participated Cow* yang digunakan pada uji zuriat sapi perah di KAN Jabung, Malang, Jawa Timur. Materi yang digunakan 180 ekor sapi laktasi yang digunakan sebagai *Participated Cow*. Metode penelitian adalah survey dengan pengumpulan data secara *purposive sampling* dan menggunakan kriteria sapi yang sedang laktasi. Data dianalisis berdasarkan analisis korelasi dan regresi linear sederhana. Hasil penelitian menunjukkan nilai korelasi antara bobot badan, lingkar dada, panjang badan, tinggi badan dengan BCS, berturut-turut: 0,35; 0,35; 0,19; 0,32 sedangkan nilai korelasi lingkar dada, panjang badan, serta tinggi badan dengan bobot badan berturut-turut adalah sebagai berikut: 0,99; 0,54; 0,45. Kesimpulan dari penelitian ini yaitu korelasi antara ukuran linear tubuh dengan *Body Condition Score* memiliki korelasi yang rendah jika dibandingkan korelasi ukuran linear tubuh dengan bobot badan yang memiliki nilai korelasi kuat. Korelasi tertinggi ukuran linear tubuh *Participated Cow* diperoleh pada hubungan lingkar dada dengan bobot badan, sedangkan korelasi terendah diperoleh pada hubungan panjang badan dengan BCS (*Body Condition Score*).

Kata kunci: Body Condition Score, ukuran linear tubuh, participated cow

Introduction

The milk production of offspring is determined by the quality of the dam and the sire; the males used in dairy cows undergo several stages of Artificial Insemination Centre (BIB) selection, including both BBIB Singosari and BIB Lembang, to form superior males. To achieve high milk production, selecting cows paired with superior males in the progeny test program, commonly known as participated cows (PC), is essential. Prospective dairy cows designated as PC must meet several requirements before use, including maintaining a healthy physical condition, being free from infectious animal diseases, having an excellent reproductive record, demonstrating satisfactory milk production, possessing a favorable lactation period, and originating from farmers who own at least five dams (Edwar, 2023). According to Atabany et al. (2023), the quality of PC quality and superior males significantly influence the milk production of their offspring (DC), with the milk production of female offspring surpassing that of PC. These findings emphasize the importance of selecting and pairing high-quality

PC and superior males to enhance milk production in the offspring.

Based on data from the East Java Provincial Livestock Office (2022), the progeny test program in East Java has been conducted for four periods since 2004. However, the lies in the fact that milk production remains stagnant at 10-12 liters/head/day or around 3,050 kg/lactation (Mahmud et al., 2020). Consequently, it is necessary to evaluate its implementation, one aspect of which involves understanding and analyzing PC performance. The diversity in PC quality is one factor that can influence the milk production of Daughter Cow. The individual performance of livestock can be assessed through quantitative measures. Quantitative traits, such as height, body length, chest circumference, and body weight, collectively referred to as the linear body size of livestock, play a crucial role in determining livestock productivity (Hamdani et al., 2018). Body Condition Score is an indicator of livestock body condition, derived from the visual assessment of fat deposits around the backbone, base of the tail, ribs, and hip bones (Budiawan et al., 2015). Dairy cows with a lactation period of 4 or 7-8 years typically exhibit a BCS value 3. Body Condition Score is a significant factor affecting dairy cows' body condition and milk production (Siska and Yoshi, 2020).

Additionally, factors influencing dairy cattle management include body weight and body size. Body size indicates livestock growth, facilitating an evaluation of the quality and management practices. Body weight, on the other hand, impacts growth, milk production, and reproduction in dairy cows (Nurfitriani et al., 2021). Therefore, both BCS and body weight are crucial factors requiring attention.

It is necessary to research the correlation of linear body size with Body Condition Score and Participated Cow body weight used in the progeny test in East Java to find out how strong the relationship between linear body size both with Body Condition Score and with body weight and analyzing the causes.

Materials and Methods

This Research was conducted from August to December 2023 at farms belonging to KAN Jabung (Agro Niaga Cooperative) members in Malang, East Java. The research material used was 180 Participated Cow (PC). The tools used include measuring tapes and measuring sticks to measure the vital statistics of livestock, rulers, bows, elbow rulers, ballpoint pens, and paper. The data collected includes primary data and secondary data. Primary data is taken directly when making observations and observations, namely body weight, chest circumference, body length, height, and BCS (Body Condition Score). Secondary data is supporting data, which includes population, age, dry length, and milk quality.

The research method used is the survey method. Sampling is conducted using purposive sampling techniques and classified according to age and lactation period. The observed variables include body weight, chest circumference, length, height, and BCS.

1. Height: Measured using a measuring stick or tape from the highest part of the shoulder passing through the back of the scapula, perpendicular to the ground.
2. Chest circumference: Measured using a circular tape just behind the scapula.
3. Body length: measured with a measuring stick or tape from tuber ischi to tuberus humeri.
4. Body weight is calculated based on the size of chest circumference using the Schoorl formula.

Body Condition Score: The assessment method uses a manual system regarding fat thickness and the health of the tailbone and waist.

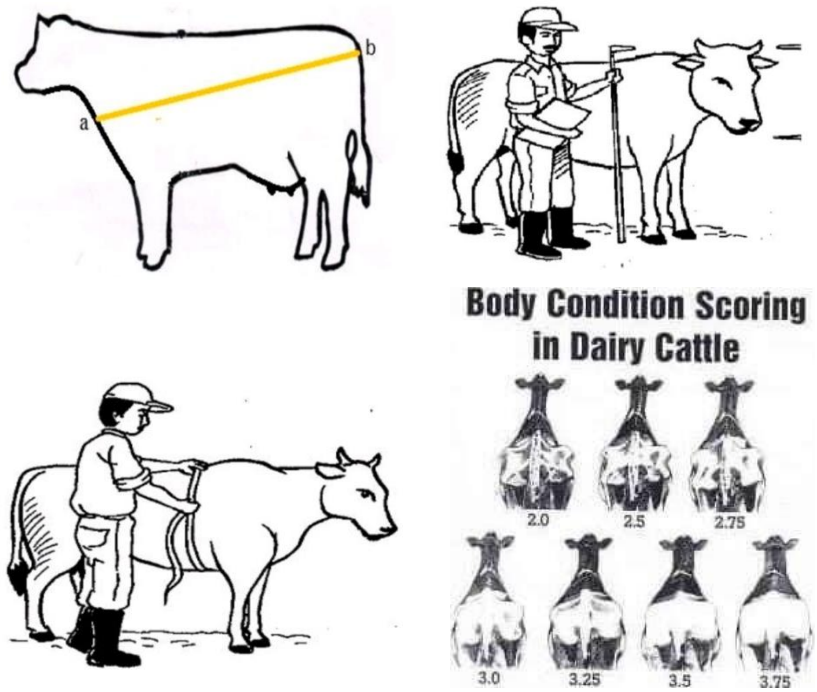


Figure 1. Measurement of body length, height, chest circumference and BCS
Source: Permadi and Aryanto (2011)

The tailbone is assessed by feeling or palpating to determine the amount of fat around the tailbone and the health of the pelvic bone. The waist is judged by the horizontal or vertical feeling of the spine and the amount of fat in between.

The research procedure is:

a. Research Preparation

The stages of research preparation are as follows:

1. Survey the research site.
2. Collecting livestock samples with the provision that PFH dairy cows are lactating and cows used as PCs in the Gading Kembar village and Gunung Kunci hamlet.
3. Prepare equipment prepared for research needs.
4. Coordinate with Keswan KAN Jabung before jumping into the field.

b. Data Collection

The stages of data collection in this study are as follows:

1. Data collection of livestock number, age, and lactation period is carried out in advance
2. Measure vital statistics or linear body measurements, including body length, height, and chest circumference in each livestock.
3. BCS assessment using existing standards and body weight measurement using the Schoorl formula.

The data that has been obtained is then analyzed using correlation analysis and simple linear regression. Data analysis is performed using Excel with regression formulas. The correlation between linear body sizes is calculated using the regression equation formula as follows:

$$Y = \beta X + \alpha$$

Information:

Y = Body Condition Score and Body Weight

α = Constant

β = Intercept

X= Body Weight, Chest Circumference, Body Length, Height

The criteria for interpretation of the correlation between variables X and Y according to Sugiyono (2012) are:

- 0.00-0.199 : Very low correlation
- 0.20-0.399 : Low correlation
- 0.40-0.599 : Moderate correlation
- 0.60-0.799 : High correlation
- 0.80-1.000 : Very high correlation

Results and Discussion

General Conditions of the Research Area

KAN Jabung is a cooperative in agribusiness and general trading located on Jl. Suropati, Kemantren Village, Jabung District, Malang Regency. Since 2011, the Livestock Office of Malang Regency has designated Jabung District as a dairy cattle center area in Malang's eastern and southeastern parts. Geographically, Jabung District is positioned at 7.92110°S – 112.74089°E and encompasses the East Malang area, situated 17 km from the Malang government center. KAN Jabung collaborates with farmers in the Jabung District area who predominantly rely on traditional or community-based farming practices. Currently, there are approximately 5,559 heads of dairy cattle registered in KAN Jabung. Jabung Regency is at an altitude of ± 600 meters above sea level, with an annual rainfall of 550 mm and a maximum temperature of ± 32°C, making it conducive for establishing dairy farms.

Correlation Between Linear Body Size with Body Condition Score and Body Weight

The results of the correlation analysis between linear body size with Body Condition Score and body weight are presented in Table 1. The correlation between body weight, chest circumference, body length, and height with Body Condition Score is 0.35, respectively; 0.35, 0.19, and 0.32. This shows that the linear size of the body weight, chest circumference, body length, and height has a low relationship with the Body Condition Score; this is because the linear size of the body in its growth is not influenced by the BCS value but by the factor of nutritional adequacy and ration, the better the quality of nutrients given to livestock, the increase in linear body size growth will increase. According to Erwinda (2012), body size (body weight, chest circumference, body length, and height) growth is influenced by age; the older a livestock is, the more its body size will increase. In addition, linear body size is also not one of the factors that can affect BCS; factors that can affect it include age, parity, and genetics (Juandhi et al., 2017).

The correlation value between chest circumference, body length, and height with body weight was 0.99, respectively, 0.54 and 0.45. This shows that chest circumference and body weight have a very high relationship, while body length and height have a moderate relationship with body weight. According to Suliani et al. (2017), chest circumference has a strong relationship with body weight because, in the chest cavity, there are organs such as the heart and lungs that will experience enlargement along with growth, so it will increase the volume of the chest circumference. The greater the chest circumference, the more body weight will result in increased body weight because it is related to bone growth. The bones in the cattle body, when experiencing optimum growth, will stop, while the ribs can still grow and develop because they are the bones with the latest growth to increase the length of the chest circumference.

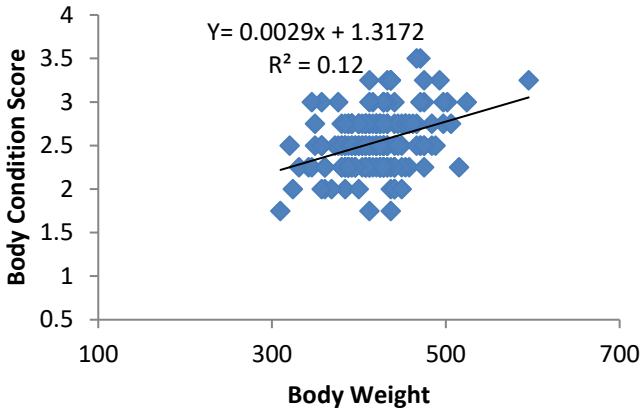
Table 1. Correlation of linear body size with BCS and body weight

No.	Relationship	R	Y	Significant value
1.	Body weight with Body Condition Score (BCS)	0.35	0.0029X + 1.3172	1.07
2.	Chest circumference with BCS	0.35	0.0119X + 0.364	1.23
3.	Body length with Body Condition Score (BCS)	0.19	0.0065X + 1.6608	9.57
4.	Body height with Body Condition Score (BCS)	0.32	0.0144X + 0.5181	1.20
5.	Chest circumference with body weight	0.99	4.1061X – 330.17	2.33
6.	Body length with body weight	0.54	2.1999X + 120.96	6.62
7.	Body height with body weight	0.45	2.4824X + 70.745	1.75

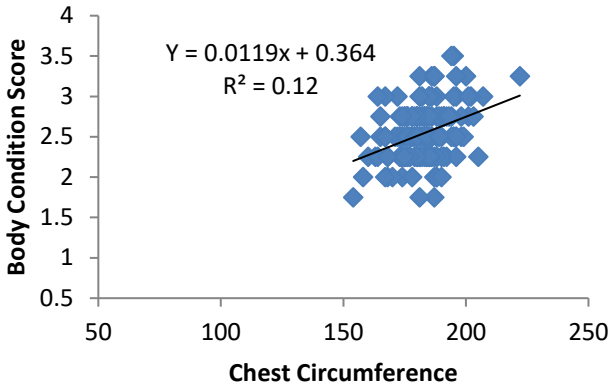
Correlation between Body Weight and Body Condition Score (BCS)

BCS represents the condition of cow bodies, determined by visually assessing fat deposits under the skin around the backbone, base of the tail, ribs, and hip bones. In dairy cows, the BCS score value is measured on a scale of 1-5, where a lower score indicates thin livestock and a higher BCS value categorizes cattle as fat with good productivity (Budiawan, Muhammad, and Sri, 2015). According to Siska and Yoshi's Research in 2020, dairy cows with a lactation period of 4 or 7-8 years predominantly have a BCS value of 3. Body weight, a livestock body size indicator, can reflect the health and body condition of the livestock. The body weight variable is determined using the Schoorl formula (Medina et al., 2021), where the chest circumference of the livestock is a known factor.

Based on the presented graph, the correlation between BCS and body weight is expressed through a regression equation, Y = 0.0029X + 1.3172, with a correlation coefficient value (r) of = 0.35 and a determination coefficient R2 of = 0.12. This indicates a low correlation between the Body Weight variable (X) and BCS. The diversity in BCS values is influenced by body weight at 12%, while 88% is attributed to other factors. These findings differ from the statement by Petrovska and Daina (2014), suggesting that BCS significantly impacts live weight in the BCS group <2.5-3.0 points but lacks substantial effect in the BCS group >3.25. This discrepancy may arise from subjective BCS assessment factors, livestock body condition variables, and environmental influence.



Graph 1. Regression Graph of Body Weight (X) to Body Condition Score (Y)



Graph 2. Regression Graph of Chest Circumference (X) to Body Condition Score (Y)

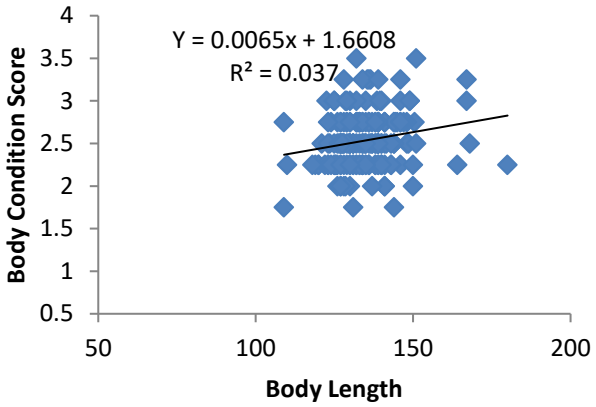
Correlation between Chest Circumference and Body Condition Score (BCS)

The chest circumference of dairy cows is measured circularly in the chest cavity behind the shoulder joint (Os.scapulamen) using a measuring tape in centimeters. Quantitative traits in cattle are measurable characteristics of a dairy cow aimed at evaluating genetic quality improvement. Quantitative calculations can be derived from body length, height, chest circumference, and body weight measurements. As livestock ages, body size changes in specific parts (Christi et al., 2023). Body Condition Score serves as a method to measure the effectiveness of the feeding system in dairy cows, aiming to determine the achievement of adequate standards of body fat reserves that milk production efficiency (Surjowardojo and Sarwiyono, 2013).

According to the presented, the correlation between chest circumference and BCS is expressed through a regression equation, Y = 0.0119X + 0.364, with a correlation coefficient value (r) of = 0.35 and a determination coefficient (R2) of = 0.12. This indicates that the Chest Circumference variable (X) correlates poorly with the BCS variable (Y). The diversity in BCS values is influenced by chest circumference at 12%, while 88% is attributed to other factors. These findings contrast with Muharram (2020) which suggests that the correlation between chest circumference and BCS has a coefficient of 0.78, implying a close relationship between chest circumference and BCS in dairy cows. Chest circumference is related to the slope of the ribs because the slope can also affect the assessment of chest circumference. The ideal rib slope will give an excellent value to the chest circumference, while a pointed rib slope will give a less good value to the chest circumference. At the same time, the hill of the ribs is one of the factors seen based on visuals to assess the body condition score or BCS so that the two have a reasonably close relationship (Aziz et al., 2019). In this study, chest circumference did not correlate strongly with BCS, which errors in measurement and poor maintenance management can cause.

Correlation between Body Length and Body Condition Score (BCS)

BCS values can be influenced by various factors such as differences in the number of samples/cows, the frequency of BCS assessment, the analysis model, the time (year) of assessment, livestock parity, feeding rate, age, and the genetic composition of livestock in a population (Susanto et al., 2018). Body length is defined as the distance between the shoulder joint (humerus) and the sitting bone of the ischia tuber, measured in centimeters using a measuring stick.



Graph 3. Regression Graph of Body Length (X) to Body Condition Score (Y)

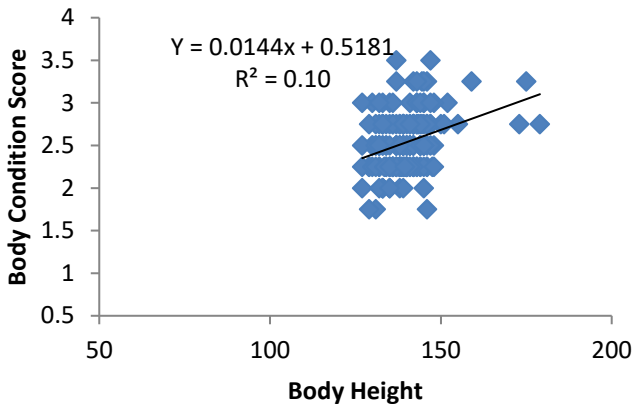
The body length of dairy cows during each lactation period displays variations, possibly due to differences in the age of cattle when they first experience puberty. This period marks an inflection point, the maximum point of growth, initiating a shift in changes that leads to slowed or relatively constant growth (Bahri et al., 2022).

According to the graph above, the correlation between body length and BCS is expressed through a regression equation, Y = 0.0065X + 1.6608, with a correlation coefficient value (r) of = 0.19 and a determination coefficient (R2) of = 0.037. This indicates that the Body Length variable (X) correlates very poorly with the BCS variable (Y). The diversity of BCS values is influenced by body length, at 3.7%, while 96.3% is attributed to other factors. This observation is in line with Purwadi (2017) that livestock body length is not influenced by the livestock body's linear size or BCS but by factors such as nutritional adequacy and ration quality. Quality feed contributes to good digestibility and nutritional values, positively affecting the body length of livestock. The body length variable has the lowest correlation among other variables, possibly due to factors influencing BCS values, including differences in the number of samples cows, the frequency of BCS assessment, analysis models, the time (years) assessed, livestock parity, feeding rate, age, and the genetic composition of livestock in a population. Consequently, there appears to be no significant relationship between body length and BCS (Susanto et al., 2018).

Correlation between Body Height and Body Condition Score (BCS)

The height of dairy cows is measured from ground level to the highest point of the shoulders using a measuring stick in centimeters. Factors influencing the growth of dairy cow height include feed management, genetics, and livestock conditions (Makin, 2011). Inappropriate or non-ideal livestock height be caused by stress, which may affect the animals at any time. Body Condition Score is crucial for measurement as it serves to select and predict milk production in dairy cows. BCS changes typically decrease during the first 2-3 months of lactation, followed by the restoration process until mid-lactation. Body Condition Score is closely related to feed factors; the better the quality of feed provided to livestock, the better the weight gain influencing the BCS value (Kafi et al., 2022).

According to the graph above, a regression equation represents the correlation between height and BCS, Y = 0.0144X + 0.5181, with a correlation coefficient value (r) of = 0.32 and a determination coefficient (R2) of = 0.10. This indicates that the Height variable (X) correlates poorly with the BCS variable (Y). The diversity of BCS values is influenced by height, at 10%, while 90% is attributed to other factors.



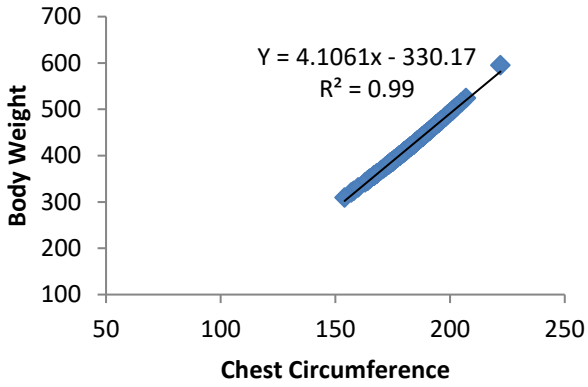
Graph 4. Regression Graph of Body Height (X) to Body Condition Score (Y)

Bahri et al. (2022) also explained that shoulder height has no relationship with body condition scores because the growth of shoulder height or height is influenced by genetic factors or heredity from their elders and will increase with the increase in chest circumference and body weight of livestock, so it is closely related to the variables of chest circumference and body weight.

Correlation between Chest Circumference and Body Weight

Body weight is a livestock body size that can indicate the livestock's health condition and overall condition. The primary factor influencing livestock weight gain is the adequacy of nutrients or feed provided (Herring et al., 2021). In addition, genetic factors can also play a role in determining livestock body weight. The size of the chest circumference has always been a critical factor in estimating the body weight of livestock. Following feed consumption with a good composition, the cattle can experience an increased chest circumference of 10.6 cm in a month, equivalent to an approximate weight gain of 35 kg (Sosiati et al., 2021).

As depicted in the graph above, the correlation between chest circumference and body is expressed through a regression equation, Y = 4.1061X – 330.17, with a correlation coefficient value (r) of = 0.99 and a determination coefficient (R2) of = 0.99. This indicates that the Chest Circumference as variable (X) strongly correlates with Body Weight as variable (Y). The diversity of body weight values is strongly influenced by chest circumference, at 99%, while 1% is attributed to other factors.



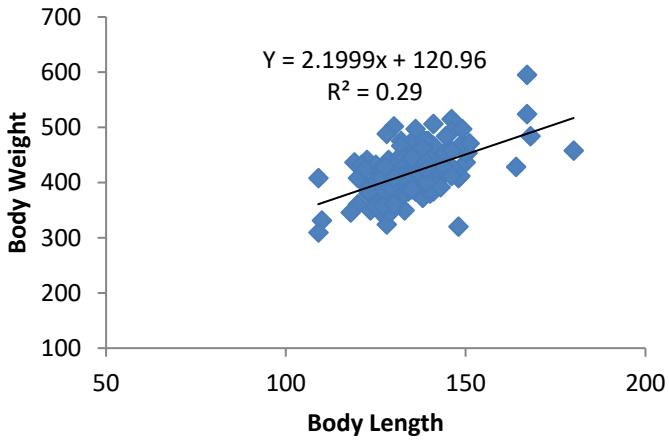
Graph 5. Regression Graph of Chest Circumference (X) to Body Weight (Y)

This finding is supported by Tya (2016) explanation that an increase in chest circumference is one of the factors contributing to the rise in body weight, as chest circumference is closely linked to cow body weight. The body weight variable is determined using the Schoorl formula (Medina et al., 2021), where the chest circumference of the livestock is a known factor. Therefore, the correlation between chest circumference and body weight has the highest value among other variables. The size of the chest circumference increases with the growth and development of muscle tissue in chest. Differences in body dimension are influenced by fat and muscle deposition in body dimensions such as circumference, thickness and body weight (Yolanda et al., 2022).

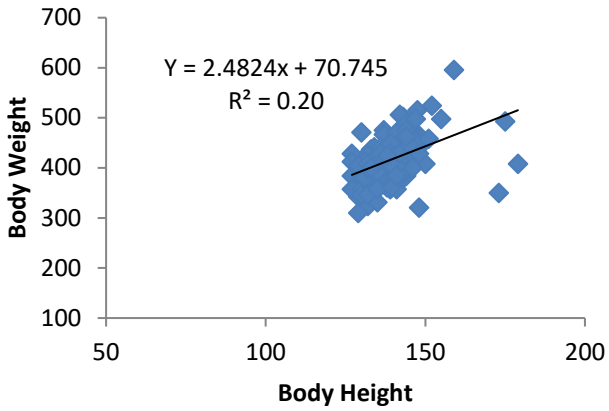
Correlation between Body Length and Body Weight

Body weight plays a vital role in establishing a good maintenance pattern, determining nutritional needs, calculating feed quantities, prescribing medication doses, and establishing the selling value of livestock (Ni'am, 2012). Suliani et al. (2017) stated that body length could be utilized to estimate livestock body weight because it impacts bone growth, particularly the spine. Typically, an increase in body length results in an augmented body weight.

The graph above illustrates that the correlation between body length and body weight is represented by a regression equation, Y = 2.1999X + 120.96, with a correlation coefficient value (r) of = 0.54 and a determination coefficient (R2) of = 0.29. This indicates that the Body Length variable (X) has a moderate correlation with the Body Weight variable (Y). The diversity of body weight values is influenced by body length, at 29%, while 71% is attributed to other factors. This aligns with Hikmawaty et al. (2018) statement, explaining that the correlation between linear body size and body weight in Bali cows is a positive value, as demonstrated by the body length variable having a correlation value of 0.833. Research by Tama et al. (2016) showed that the variable body length in male Senduro goats had a positive correlation with body weight, with a correlation value of 0.92. Body length can be used to estimate the body weight of cattle through their spine; the longer the body of a livestock, the more it will increase its body weight.



Graph 6. Regression Graph of Body Length (X) to Body Weight (Y)



Graph 7. Regression Graph of Body Height (X) to Body Weight (Y)

Correlation between Body Height and Body Weight

Cow weight gain demonstrates a relative relationship with the growth of cattle body size dimensions. An increase in livestock body size accompanies an increase in body weight (Putra et al., 2014). Ni'am et al. (2012) noted that shoulder height and body weight have a close relationship that intensifies with age.

As depicted in the graph above, the correlation between height and body weight is expressed through a regression equation, Y = 2.4824X + 70.745, with a correlation coefficient value (r) of = 0.45 and a determination coefficient (R2) of = 0.20. This indicates that the Height variable (X) has a moderate correlation with the Body Weight variable (Y). The diversity of body weight values is influenced by height, at 20% while 79% is attributed to other factors. This aligns with Ikhsanuddin et al. (2018) statement, asserting that the correlation between body size and body weight is directly proportional. Consequently, an increase in chest circumference, body length, and height is accompanied by increased body weight. However, height has the lowest correlation value with body weight when compared to chest circumference and body length; this can be because the growth of leg bones influences height size, while the muscle tissue attached to the legs is less when compared to the amount of muscle tissue attached to the chest area and is not directly related to the abdominal space where the front leg bones only support livestock movement activities (Tama et al., 2016).

Conclusions

This study concludes that the correlation between linear body size and Body Condition Score is low compared to the correlation of linear body size with body weight, which has a substantial correlation value. The highest correlation of Participated Cow linear body size was obtained on the relationship of chest circumference with body weight. In contrast, the lowest correlation was obtained on the relationship of body length with BCS (Body Condition Score). Further and careful Research needs to be done on the correlation between linear body size with Body Condition Score and body weight in participating cows.

Acknowledgments

Thank you to the supervisor who has guided, provided research facilities and provided suggestions to the author while writing this journal. Thank you also to the Professor Grant program at the Faculty of Animal Science, Brawijaya University, which has facilitated this research and also to friends who have helped.

References

Amstrong, DV. 1994. Heat Stress Interaction with Shade and Cooling. Journal of Dairy Science. 77(1): 2044-2050.

Bahri TM, LB Salman, and RF Christi. 2022. The Relationship Between Chest Circumference, Shoulder Height, and Body Length with Milk Production of FH Lactation Dairy Cows at BPPIBTSP Bunikasih Cianjur. Journal of Tropical Livestock. 23(2): 99-109.

Budiawan A, MN Ihsan, and S Wahjuningsih. 2015. The Relationship of Body Condition Score to Service Per Conception and Calving Interval of Ongole Breed Beef Cattle in Babat District, Lamongan Regency. Journal of Tropical Livestock. 16(1): 34-40.

Christi RF, LB Salman, P Edianingsih, and SNA. Aziz. 2023. Qualitative and Quantitative Characteristics of Female and Male Calves Aged 4-5 Months in Holstein Friesian Dairy Cattle in the Bojong Kawung Ciwidey Bandung Livestock Group. Zootec. 43(2): 208-214.

Edwar. 2023. National Dairy Cattle Zuriat Test Program. Associate Livestock Breed Supervisor. 1-4.

Hamdani MDI, A Husni, and A Setyawan. 2018. Quantitative Performance of Post-Weaning Ongole Breed Cattle in the Center for Prosperous Advanced People's Livestock, South Lampung Regency. Journal of Livestock. 15(2): 68-73.

Herring CM, FW Bazer, and G Wu. 2021. Amino Acid Nutrition for Optimum Growth, Development, Reproduction, and Health of Zoo Animals. Amino Acid in the Nutrition of Companion. 1285: 233-253.

Hikmawaty, A Gunawan, R Noor, and Jakaria. 2014. Identification of Body Size and Body Shape of Bali Cattle in Several Breeding Centers through a Major Component Analysis Approach. Journal of Animal Product Production Science and Technology. 2(1): 231-237.

Ikhsanuddin, VMA Nurgiatiningsih, Uswati, and Zainuddin. 2018. Correlation of Body Size to Body Weight of Sapo Aceh Weaning Age and One Year Age. Journal of Livestock Agribusiness. 18(2): 117-122.

Indonesian National Standard. 2014. Indonesian Holstein Dairy Breed. National Standardization Agency, Jakarta.

Juandhi, MD, D Kurnia, and P Anwar. 2019. Body Condition Score Estimation of Body Weight, Carcass Weight and Brahman Cross Cattle Carcass Percentage at RPH Pekanbaru City. Journal of Animal Center. 1 (1): 37-45.

Kafi AS, D Suryanto, and I Kentjonowaty. 2022. Analysis of Body Condition Score, Milk and Feed Production in Friesian Holstein Dairy Cows in Pandesari Village, Pujon District, Malang Regency. Journal of Dynamics Rekasatwa. 5(1): 95-100.

Makin M. 2011. Dairy Farm Management. Graha Ilmu, Yogyakarta.

Medina L, A Jaelani, and M. I. Zakir. 2021. Comparison of Accuracy of Male and Female Body Weight Estimation in Bali Cattle (Bos sondaicus) Using the Winter and Schooll Calculation Method. Indonesian Journal of Livestock. 23(1): 17-24.

Ni'am HUM, A Purnomoadi, and S Dartosukarno. 2012. The Relationship Between Body Measurements and Body Weight of Balinese Female Cattle in Various Age Groups. Journal of Animal Agriculture. 1(1): 541-556.

Nurfitriani RA, A Fahrudin, HI At Thariq, MA Santriagung, ESM Putra, Nurkholis, H Subagja, E Kustiawan, A Awaludin, and M Adhyatma. 2021. The Relationship Between Body Size and Body Weight in First Lactation Holstein Friesian Dairy Cows. Journal of Animal Science and Technology. 3(1): 19-26.

Permadi AG, and R Aryanto. 2011. Body Weight and Body Size of Beef Cattle in the Working Area of the South Garut Livestock Cooperative. J. Buana Science. 11 (2): 163-170.

Petrovska S, and D Jonkus. 2014. Relationship Between Body Condition Score, Milk Productivity and Live Weight of Dairy Cows. Research for Rural Development. 1(1): 100-106.

Purwadi. 2017. The Effect of Differences in Concentrate Quality on the Display of Body Sizes and Feed Consumption of Weaning Female FH Calves. Journal of Tropical Animal Science. 1(1): 1-5.

Putra WPB, Sumadi, and T Hartatik. 2014. The Estimation of Body Weight of Aceh Cattle Using Some Measurements of Body Dimension. Journal of Tropical Livestock Science. 3 (2): 76-80.

Siska I, and YL Anggraeni. 2020. Body Condition Score (BCS), Lactation Rate and Its Relationship to Milk Production of Friesian Holstein (PFH) Dairy Cows. Journal of Animal Science. 20(2): 115-125.

Sosiati H, T Wahyono, AR Azhar, and YN Fatwaeni. 2021. Utilization of Corn Cob Waste for Nutritious Animal Feed. Community Empowerment. 6(4): 656-661.

Suliani S, A Pramono, J Riyanto, and S Prastowo. 2017. The Relationship of Body Sizes to Body Weight of Simmental Cattle of Male Ongole Breeds in Various Age Groups in the Surakarta Slaughterhouse of Slaughterhouses. Journal of Animal Science. 15(1): 16-21.

Surjowardojo P, and Sarwiyono. 2013. Effect of Body Condition Score of Old Friesian Holstein Bunting Dairy Cows on the Number and Protein Levels of

Colostrum. Faculty of Animal Science Universitas Brawijaya.

Susanto A, L Hakim, Suyadi, and VMA Nurgiatiningsih. 2018. Phenotypic Parameters of Linear Properties of the Body of FH Cows: Properties of Legs and Udder. Proceedings of Livestock Technology and Agribusiness Seminar VI. 89-93.

Syaiful FL, Khasrad, and S Maulida. 2020. Identification of Body Size of Bali Cattle and Cymbals (Simmental-Bali) in Luhak Nan Duo District, West Pasaman Regency. Indonesian Journal of Livestock Science. 15(2): 219-226.

Tama WA, M Nasich, and S Wahjuningsih. 2016. The Relationship Between Chest Circumference, Badn Length and Body Height with Body Weight of Male Senduro Goat in Senduro District, Lumajang Regency. Journal of Animal Sciences. 26 (1): 37-42.

Tya M. 2016. Relationship Between Body Size Increase and Body Weight Increase of Bali Female Cows in PTPN VI Jambi Province. Journal of Jambi University. 1(7).

Yolanda GF, RK Dewi, and Wardoyo. 2022. Growth Pattern of Different Body Dimensions in Female Kacang Goats. Journal of Animal Production. 24 (1): 6-11.

Zainuddin M, MN Ihsan, and Suyadi. 2014. Reproductive Efficiency of PFH Dairy Cows at Various Ages in CV. Milkindo Berka Abadi Tegalsari Village, Kepanjen District, Malang Regency. Journal of Animal Sciences. 24(3): 32-37.