Body Weight and Body Measurement Characteristics of Seven Goat Breeds in Indonesia

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Abstract. The objective of this study was to characterize body weight and body measurement traits of seven goat breeds developing in Indonesia. A total of 202 goats (Boer, Peranakan Ettawa (PE), Bligon, Kacang, Gembrong, Boerja, and Kejobong breeds) were used. Body weight (BW), body length (BL), withers height (WH), and chest girth (CG) were measured. The data were analyzed using general the linear model (GLM) by R program. Tukey's test has been applied to differentiate among breeds. The result showed that BW of Boer breed was 50.73 kg, which belongs to the large breed, PE goat belonged to medium breed with 40.56 kg, and the rest of goat breeds were categorized as small breeds. In term of body measurement traits, BL was significantly different among goat breeds. Boar and PE breeds were completely longer BL than other breeds. Moreover, the PE goat population was found significantly higher WH value than other breeds, except Bligon goat. By following CG value, Boer goat was found having the highest CG value than others. These results suggested that body weight and body measurements were different among seven goat breeds. It may be beneficial for conservation and breeding strategy of Indonesian goats.

1. Introduction
Indonesia is well known as a country with a lot of animal genetic resources, including goats. Based on their origins, goat breeds are distinguished to be a native, imported, and local breeds [1]. The native goat is Indonesian indigenous goat, which is originated and well-developed in the Indonesian environment, while local goat is a goat that has been long in and adapted to Indonesia’s natural condition from generation to generation [2]. Meat producer goat breed, which is generally raised by farmers, is Kacang goat. Kacang goat is well adapted to tropical climate and weather. Also, Peranakan Ettawa (PE) goat, another local goat breed, is usually raised for dual-purpose breeds due to its ability to produce both milk and meat. Other goat breeds than can be found and well-developed in some areas of Indonesia are Bligon (PE and Kacang crossbred), Gembrong, Boer, Boerja (Boer and Bligon crossbred) and Kejobong.

During the domestication process, goat genetic is separated into some regions to produce specific goat breed according to human needs [3]. In general, goat breeds are distinguished by body weight and morphometric sizes into large, medium, and small types [4]. Body weight becomes a reference, which is very important in estimating profit and loss because it is directly related to feed consumption and maintenance efficiency. In the modern era, the estimation of body weight is carried out by evaluating
the body measurement traits of the animal. Body measurements have an important role in estimating body weight where the accuracy can be up to 90% of the actual body weight [5]. Goat body size will increase when it gets older, and its body weight increases [6].

Many previous studies on the characterization of Indonesian local goat breeds have been reported; however, few of them reviewed the type of goat from aspects of body weight and body measurement characteristics. Therefore, this study aimed to determine body weight and body measurement traits of seven Indonesian goat breeds. The benefit of this study is to describe Indonesian goat breeds from the aspects of body weight and body measurements. This information can be critical for the breeding strategy to improve Indonesian goat performance, and also to conserve almost extinct indigenous breed (Gembrong goat).

2. Materials and methods

2.1. Goat population
A total of 202 goats consisted of 119 males, and 83 females were used in the study. The average age of the goat population used in this study was more than a year old, according to their incisors. Samples were obtained from different locations according to the spread map of goats. The Bligon goat was originated from Karanganyar, Sleman, and Malang. Peranakan Ettawa (PE) was collected from Kaligesing and Sleman as the PE goat breeding centers. Kacang goat was collected from Grobogan, Surakarta, Karanganyar, and Klaten. The Gembrong goat, an indigenous breed, was obtained from Karangasem and Tumbu, Bali Island. Boer and Boerja goats were collected from Malang. In addition, Kejobong goat was collected from Kebumen.

2.2. Goat and feed managements
The goats were raised under a semi-intensive system which is commonly used by traditional farmers. In the semi-intensive system, goats were free to access grass about 8 hours after released from stalls. Goats were fed by concentrate consisted of soybean meal, bran, tofu dregs, and pollard before being released. In the stall, farmers also provided legumes such as Mangifera indica and Jackfruit (Artocarpus heterophyllus). The concentrate was given twice a day, in the morning and the afternoon.

2.3. Measurements of body weight and body size
The data observed in this study was body weight and body measurement traits. Body weight (BW) was scaled using analog body weight scale (Camry Scales, China). Observation of body measurement consisted of body length (BL), withers height (WH) and chest girth (CG). Body length and withers height were calculated using ruler, while CG was calculated using measurement tape (Butterfly, China). The BL was measured from the end of the shoulder joint (scapula bone) to the end of the seated bone. The WH was measured from the highest part of the body to the ground perpendicularly. Measuring CG was carried out by circumflex the measuring tape on the chest just behind the shoulder trough the withers. Body weight was recorded in kg and body measurement traits were recorded in cm.

2.4. Statistical analysis
The data was analyzed using general linear model (GLM) by R program. The effect Analysis of variance (ANOVA) was used and 5% alpha was set to see the significance by following formula:

\[ Y_{ijk} = \mu + S_i + B_j + \varepsilon_{ijk} \]

where:
- \( Y_{ijk} \) = Results observed for each variable
- \( \mu \) = Overall mean
- \( S_i \) = Fixed effect of \( i^{th} \) sex
- \( B_j \) = Fixed effect of \( j^{th} \) goat breed
- \( \varepsilon_{ijk} \) = Random effect
If there was significant results, Tukey’s test was conducted to test all pairwise comparisons among means using the formula:

\[ t_s = \frac{M_i - M_j}{\sqrt{\text{MSE} \cdot \frac{1}{n_h}}} \]

where:
- \( t_s \) = The observed results for each variable
- \( M_i - M_j \) = The difference between the \( i^{\text{th}} \) and \( j^{\text{th}} \) means
- \( \text{MSE} \) = Mean square error
- \( n_h \) = The harmonic mean of the sample sizes of groups \( i \) and \( j \)

3. Results and discussion

3.1. Body weight

The average body weight and standard deviation of the seven goat breeds are presented in Table 1. The highest to lowest average body weight were respectively Boer (50.73 kg), PE (40.56 kg) and five other breeds in the range of 21.03-27.87 kg. Kejobong have the highest BW (27.87 kg) among five small breeds, on the other hand Kacang was the smallest (21.03 kg).

| Breed          | n  | Mean±SD (kg)   |
|----------------|----|---------------|
| Bligon         | 44 | 26.65±4.40\(^c\) |
| Peranakan Ettawa | 44 | 40.56±11.63\(^b\) |
| Kacang         | 53 | 21.03±5.90\(^c\) |
| Gembrong       | 13 | 24.20±6.08\(^c\) |
| Boer           | 21 | 50.73±22.33\(^a\) |
| Boerja         | 19 | 27.39±8.48\(^c\) |
| Kejobong       | 8  | 27.87±8.47\(^c\) |

\(^{a,b,c}\)Different superscript in the same column shows highly significant difference among goat breeds \((P<0.01)\). n is number of samples; SD is standard deviation.

Kacang has a half BW of PE and twice smaller than the Boer. The previous study reported that the body weight of Kacang in Bali is in the range of 18.5-23.6 kg [7]. The body weight of Kacang in this study was in the same range as the previous study. Boer was significantly much higher body weight than other breeds \((P<0.01)\). Body weight of buck Boer is ranged from 50 to 70 kg, and doe Boer is ranged from 45 to 65 kg at yearling [8]. The PE goat was significantly categorized as a large goat. This breed was secondly higher body weight than other breeds (Table 1). This result agreed with the previous report that explained that the average BW of female PE was 40.50 kg while male FE can reach 60.00 kg [9].

Boer is a meat type goat that is purposely raised by farmers for meat production (Figure 1. a.). It was indicated by the highest body weight of Boer goat among goat breeds. Boer has shorter BL compared to PE goat (Figure 1. b.); however, it has much more muscle in its body. On the other hand, PE goat is well-known as a dual-purpose breed due to its ability to produce both milk and meat. The PE goat is physically tall and long; therefore, PE goat posture is very suitable for the Indonesian tropical climate. As the increase of human growth has an impact on animal protein need for humans. Humans do everything possible to fulfill their animal protein needs. Creating an adaptable goat breed to tropical climate by cross-breeding is a way to produce meat type goat. The PE goat is a cross-breeding between Indian Ettawa and Indonesian Kacang goat. The Boerja is also cross-breeding between Boer and Bligon (Figure 1. e.). Today, there are various goat breeds in Indonesia.
The analysis showed that goat breeds were distinguished into several types based on the average of BW. The previous study mentioned that there are three types of goats based on their body weight, namely large, medium, and small types [4]. Boer goat was categorized as a large goat. PE goat was a medium breed. The rest of the goat breeds were grouped in small type (Figure 1. c.). Previous studies evaluated eight local Indonesian goats categorized PE in large breed, while Kacang was in small breed [2]. This different result may be due to different population used, and Boer goat was not included in the previous study. The body weight in livestock is an essential trait. It is directly associated with economic value [10]. The higher body weight will generate higher price of a goat.

3.2. Body measurement characteristics

The average body measurement characteristics are quantitative data that can be used to describe the type of goat. The body size characteristics of goat continuously increase by age until their body stops to grow [11]. The average of body measurement of each goat breed is presented in Table 2.

The results of the analysis showed that body measurement traits were significantly different among breeds (P<0.01). The body length of seven goats was classified into two groups. Boer and PE goats were high BL value, 70.30 cm and 68.65 cm, respectively. Other breeds, namely Boerja, Bligon, Kejobong, Gembrong, and Kacang, were categorized into small BL value. The Kacang (Figure 1. g.) and Gembrong (Figure 1. f.) goats have almost identical body lengths of 56.23 cm and 56.67 cm, respectively. According to the WH value, there were three groups of goats. The highest WH in each breed from each group in sequence i.e. PE (73.21 cm) and Bligon (68.36 cm); Boer (67.92 cm) and Kejobong (65.12 cm); and three other breeds with the lowest value on Gembrong (56.08 cm). According to the CG, there are very significant differences between the breed groups. Boer goat has the highest CG compared to other breeds. Overall, Boer has the highest BL and CG among the other breeds. Boer has longer bodies.

Figure 1. Physical appearance of seven goat breeds in Indonesia. a is Boer goat; b is PE goat; c is Kejobong goat; d is Bligon goat; e is Boerja goat; f is Gembrong goat; g is Kacang goat.
than PE but has a lower WH. Boer has a longer and heavier body but shorter in WH than the Jamnapari [12]. Association between BL and BW with WH is also found in cattle population [13].

In terms of body measurements, the goat breeds were classified into three groups. Even though PE and Bligon (Figure 1. d.) have a higher WH than Boer, it did not make the two breeds had a larger BW. Boer was classified as large body sizes, PE as medium body sizes, and five other breeds belonging to the small group. The coefficient value between CG and BW has a closer relationship than BL of 0.97 [14]. The chest girth of livestock is closely related to BW [15]. The CG value is associated with the abdominal cavity of the animals; therefore, high CG value indicates a high body weight of goat. The previous study reported that chest girth also related to the abdominal cavity and digestive tract, which accounts for 10-25% of the live weight [16]. The positive correlation between X (CG) and Y (BW) is an indication that between X and Y have a direct rate of change [17].

Previous studies conducted on Ethiopian goats based on body size characteristic data successfully predicted goat BW without using measuring instruments [18]. Estimation of weights by utilizing CG and BL data is also able to provide a prediction of body weight in Barbari goats [19]. Although the level of estimation accuracy of the BW is not more accurate than directly measuring BW, the estimation of weight through body size is able to provide a picture of the performance and characterize of each breed [20]. Estimation of BW through the characteristics of the goat's body size is also beneficial in classifying the goat type and breeding program [21].

Table 2. Average of body measurement characteristics in seven goat populations

| Breed           | Variable | BL (cm) | WH (cm) | CG (cm) |
|-----------------|----------|---------|---------|---------|
| Bligon          |          | 59.13±5.79b | 68.36±6.43ab | 69.27±5.33c |
| Peranakan Ettawa|          | 68.65±13.64a | 73.21±10.32a | 75.11±9.96b |
| Kacang          |          | 56.23±6.40b | 57.54±7.03c | 64.66±8.55e |
| Gembrong        |          | 56.67±5.00b | 56.08±5.60c | 66.59±6.72e |
| Boer            |          | 70.30±12.95a | 67.92±6.94b | 81.52±10.02a |
| Boerja          |          | 60.13±9.91b | 59.34±8.22c | 64.55±8.47c |
| Kejobong        |          | 57.25±6.11b | 65.12±3.60b | 65.00±6.14c |
| P-value         |          | <0.001   | <0.001   | <0.001   |

ab/c Different superscript in the same column shows highly significant difference among goat breeds (P<0.01).

4. Conclusion
Seven populations of Indonesian goats were categorized into three groups i.e., large, medium and small types based on body weight. Boer goat was large breed, PE goat was medium breed, and others breed was grouped as small breed. Body measurement characteristics were also useful for grouping of Indonesian goats. These findings may be useful for conservation and breeding strategy of Indonesian goats.

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