Morphometrics of Etawah Grade goat females as dairy breeding stocks under intensive management system in Central Java

A Anggraeni¹, L Praharani¹, F Saputra¹ and C Sumantri²

¹Indonesian Research Institute for Animal Production (IRIAP), Bogor 16720, Indonesia
²Department of Animal Production and Technology, Faculty of Animal Science, Bogor 16680, Indonesia

Email: ria.anneke@yahoo.co.id

Abstract. Body measurements and their intercorrelations can be used as initial indicators of measurements, and to estimate chest girth from other body measurements in EG goat females kept under intensive management at one government dairy station in Purwokerto District, Central Java. Samples were Etawah Grade (EG) goat performance-based selection for good EG dairy breeding stocks. The aims of this research were to study characteristics of morphometric, to investigate intercorrelation among body females specified as breeding stocks of dairy goat type kept under intensive management of the Government Dairy Breeding Station at BBPTU Baturaden, Purwokerto District, Central Java. A total of 50 EG females between the ages of 1-6 years old were measured for some body measurements. Averages of body measurements of the observed EG goat females increased by the ages. The averages of body sizes at the ages of 2 years old for SH, HH, BL, CG, and HG were successively 75.0±11.1 cm, 79.8±1.8 cm, 65.3±1.8 cm, 77.0±3.9 cm, and 82.8±0.4 cm. At the mature ages (5 years old), compared to the young ones (2 years old), EG females had higher values of SH, HH, BL, CG, and HG by 6.3%, 1.8%, 17.9%, 18.0%, and 16.3%. CG had the highest correlation to HG (rs = 0.837-0.858) and CG was accurately predicted by HG or by the combination of HG to other body sizes. High intercorrelations were found among certain body measurement(s) of the EG dairy goat females.

1. Introduction

Demand on national fresh milk and its processed products are currently amounts of 912,740 tons [1]. Only a small portion (about 20%) of fresh milk is fulfilled from the country. Most of the domestic fresh milk is produced by Holstein Friesian dairy cows, so milk from dairy goats contributes very low to the need of the community. However, there has been a tendency for the increasing demand for milk from a dairy goat. This can be a good situation to encourage the development of dairy goat agribusinesses. Raising dairy goat is more appropriate for small farmers compared to that of dairy cattle. Farmers commonly faced with limited capital and land should be able to keep well dairy goats [2]. From the side of nutrients, goat milk is a source of important nutrients for humans, especially for those having problems of lactose intolerance and sensitive to milk from other species. Some important nutrients found in goat milk are fat, protein, lactose, vitamins, enzymes, and minerals. Most of the milk components of the dairy goat are higher contents than those of other dairying animals. Many people also consider the function of goat milk as medical food [2,3]. Because of some of those reasons, goat
milk promises more profits by generating higher selling prices (2-3 times) than cow milk. This will provide good conditions for economic value added for small farmers operating in dairy goat agribusiness.

Commercial dairy goat farming requires breeding stocks of females by possessing high milk ability. These breeding stocks can be produced by selecting local dairy goats based on milk production traits and other relevant traits. Etawah Grade (EG) goat is a local dairy goat breed as the crossed breed of local kacang goat females to Etawah goat males for long periods. This EG goat is well known as a dual purpose and kept widely by farmers and communities as a milk producer, beside of its meat. The general appearance of EG goat is most likely Etawah goat as its ancestor with the shape of upwards curve or convex head, long and thick hair on the back, and slim and tall body shape. EG goat has adapted widely in various areas in Indonesia. However, the cultivation of EG goat that is specified as a milk producer is still limited. One of the well-known breeding areas in resulting breeding stocks of EG dairy goat for possessing a good milk-producing ability and a good dairy goat type that from some villages of Kaligesing Subdistrict, Kulonprogo District in Central Java Province.

Body measurements are important as data sources in terms of reflecting the breed standards and giving information on morphological structures and development of animals [4]. Morphology can be considered as a selection criterion for the ideal body shape of dairy goat. The closer to the ideal dairy body shape, an animal could be predicted for producing more milk, compared to the others of less ideal body conformation. Morphometrics can explain the growth rates of the skeleton at various ages that could be considered as an early indicator of selection for milk production in dairy goat [5]. It is necessary to get data of body measurements of EG dairy goat as breeding stocks, particularly from the central dairy goat breeding area. These morphometric data can be used as a standard to choose EG goat from other locations to be considered as candidates of breeding stocks. Correlations among body sizes are also used variables to confirm dairy goat type through the availability of other body sizes. The availability of Individual body measurements and information for the degree of the relationships among these variables could be possible to be used as initial selection criteria in identifying good breeding stocks in dairy goats [6].

This study was aimed to determine morphometric characteristics, to examine intercorrelation among body measurements, and to estimate chest girth from other body sizes in EG dairy goat females as milk-producing breeding stocks kept at the Dairy Breeding Breeding Center at BBPTU Baturraden, Purwokerto, Central Java. These EG goat females were originated from Kaligesing District, Kulonprogo Regency in Central Java Province.

2. Materials and methods

2.1. Location
This research was carried out at the Dairy Breeding Center and Feed Forages at BBPTU Baturraden, Purwokerto District, Central Java. BBPTU Baturraden has the function to produce dairy cattle and dairy goat as national sources of dairy breeding stocks. The station is located on the southern part of the food of Slamet mountain at an altitude of 600-700 m asl, rainfall between 3,000-3,500 mm/yr, air temperature between 21-30°C, and relative humidity between 70-80%.

2.2. Materials
Etawah Grade (EG) goat females observed were EG dairy type that well known for having good milk ability and kept by BBPTU Baturraden since the year 2015. These EG goat females were under the ages of 1-6 years old. These EG females originally came from several villages as good dairy goat breeding stock sources in Kaligesing Sub-district, Purworejo District, Central Java Province. Determination of the ages of animals was based on birth date records and information on the changes in milk teeth. If there were still milk teeth (temporary), then the goat was determined for one-year-old. If there were 1, 2, 3, and 4 pairs of permanent teeth, then goats were identified at the ages successively 2, 3, 4, and 5 years old. While goats experiencing permanent tooth erosion were determined as >5 years old.
Body measurements were measured (cm) for shoulder height (SH), hip height (HH), body length (BL), chest girth (CG), and hip girth (HG). A measuring tape with a length of 150 cm at a sensitivity of 0.1 cm was used to measure chest girth and hip girth, while a measuring stick with a length of 100 cm at a sensitivity of 0.1 cm was used to measure shoulder height, body length, and hip height.

2.3. Data analysis
One-way variance analysis was used to describe body measurements based on both real ages (1-6 years) and classified ages (1-4 and 5-6 years old). Both of the two ages were then used in statistical analysis. The degree of relationship among body measurements was analyzed by simple correlation analysis. Chest girth was considered an important variable for estimating bodyweight of the animal. Analysis of the best subset regression was used to determine which body size provided the best predictions of chest girth. Information obtained was then used to develop simple and multiple regressions to predict chest girth from other body sizes.

3. Results and discussion
3.1. Body measurements
Morphometric data are very commonly used to determine body measurements of animals. Morphometrics reflects the conformational and skeletal development of the body. Body frameworks become an important variable in selection activities, such as for identifying well-developed body frame of an individual animal in a population to be considered as a candidate for breeding stocks [7]. Among others are shoulder height (SH), hip height (HH), body length (BL), chest girth (CG) and hip girth (HG). Various body sizes are useful information for the approaching body conformation at a mature-age of the dairy goat to be expected for having an ideal dairy goat type. Variation in body sizes is one of the criteria used in classifying breeds of goats [8]. Body measurement is an essential factor in reflecting the rates of bone growth and in determining dairy type at mature ages. Body measurement also shows the typical conformation of animal breeds in a controlled environment [9].

Growth, however, can be seen from the changes in body dimensions, both linear and nonlinear, which will determine the shape and type of an animal. The growth of the skeleton of an animal during its life will form the sigmoid curve (S). Growth experiences a phase of acceleration and deceleration, rapid growth occurs at birth until puberty, while the slowing stage occurs from puberty until reaching adulthood [10]. Averages of body sizes of EG dairy goat females based on different ages from this study are shown in table 1. Results showed that the observed EG females for the respective ages of 1, 2, 3, 4, 5 and 6 years had the averages of chest girth successively 73.0 cm, 77.0±3.9 cm, 87.0±3.7 cm, 89.0±3.7 cm, 91.0±6.6 cm, and 93.8±6.7 cm; while those for body length successively 57.5 cm, 65.3±4.3 cm, 76.1±4.5 cm, 77.0±4.5 cm, and 78.5±4.8 cm. In general body sizes of the observed EG dairy goat females increased by the increasing ages. However, the faster growth rates of body sizes were achieved at 2-3 years old, especially for body length (13.57% and 14.54%), hip-width (15.00% and 14.49%) and chest girth (5.48% and 12.99%). While the growth rates of shoulder height (2.74% and 4.27%) and hip height (7.84% and 1.00%) at the same ages were slower. These results indicated that at the younger ages, animals had fast growth rates for all body measurements. After reaching adulthood, the growth rates began to slow down. The growth pattern of the observed EG females followed a sigmoid curve (S).

The growth of chest girth showed the growth of ribs and muscles, while that for body length was a reflection of spinal growth that continues to increase by the ages [11]. Relatively slow growth rates occurred at shoulder height and hip height. Body sizes on the classified ages of the observed EG dairy goat females showed that the growth rates of shoulder height and hip height were relatively slower compared to body length, chest girth, and hip girth. Body sizes of EG male goats kept by farmers in Klaten District in Central Java as reported by [12] showed at the ages between 24-26 months (2 years) was higher than those of the EG dairy goat females in this study. Shoulder height, body length and chest girth were reported successively 86.8±3.9 cm, 79.1±3.7 cm, and 84.6±4.8 cm. Whilst those for
EG male goats at the ages between 36-60 months (3-5 years) for the respective body measurement against the ages of 24-26 months (2 years) were consecutively 0.5%, 3.7%, and 1.1%. A study of EG goat females as a female parent population of the crossing Sapera goat, with saanen as a male parent, obtained the significantly increasing body measurements by the adding ages [13]. At the ages of 1.5-2, 3-4, and 5 years old, EG males had higher body sizes against EG females in chest girth by 2.8%, 2.7% and 1.8%; shoulder height by 1.5%, 0.1%, and 0.9%; and hip height by 0.8%, 0.01% and 0.6%. At the ages of 1.5-2, 3-4, and 5 years, EG females had chest girth by 75.7±0.6 cm, 83.6±3.5 cm, and 85.6±3.3 cm; body length by 72.2±1.6 cm, 73.5±2.1 cm, and 75.6±3.8 cm, shoulder height 72.8±10.2 cm, 82.5±7.0 cm, and 82.0±2.9 cm; and hip height by 80.0±4.0 cm, 82.9±7.0, and 83.9±2.5 cm.

| Age (Years) | Goat (head) | Shoulder Height | Δ SH (%) | Hip Height | Δ HH | Body Length | Δ BL | Chest Girth | Δ CG | Hip Girth | Δ HG |
|------------|-------------|-----------------|--------|------------|------|-------------|------|-------------|------|-----------|------|
| 1          | 1           | 73.0            |        | 74.0       | 57.5 | 73.0        |      |             |      |           |      |
| 2          | 2           | 75.0±11.1       | 2.74   | 79.8±1.8   | 7.84 | 65.3±1.8    | 13.57 | 77.0±3.9   | 5.48 | 82.8±0.4  | 15.0 |
| 3          | 3           | 78.2±6.4        | 4.27   | 80.6±1.5   | 1.00 | 74.8±4.3    | 14.54 | 87.0±3.7   | 12.99| 94.8±2.8  | 14.4 |
| 4          | 15          | 79.7±3.3        | 1.92   | 81.6±2.3   | 1.23 | 76.1±4.5    | 1.74  | 89.0±3.7   | 2.30 | 95.5±2.9  | 0.74 |
| 5          | 26          | 79.9±2.9        | 0.25   | 81.9±1.1   | 0.37 | 77.0±4.5    | 1.18  | 91.0±6.6   | 2.25 | 96.3±8.8  | 0.84 |
| 6          | 3           | 80.2±3.0        | 0.38   | 82.1±1.5   | 0.24 | 78.5±4.8    | 1.95  | 93.8±6.7   | 3.08 | 98.2±9.4  | 1.97 |
| 1-4        | 21          | 79.6±5.2        |        | 80.8±2.7   | 6.3±2 | 76.3±7.2    | 86.8±5.8 | 91.6±6.2 |      |           |      |
| 5-6        | 29          | 79.8±2.9        | 0.25   | 81.1±1.0   | 0.37 | 77.2±4.5    | 1.18  | 91.3±6.5   | 5.18 | 96.5±8.7  | 5.35 |

Description: CG is chest girth, SH is shoulder height, HG is hip girth, HH is hip height, and BL is body length; Δ is the growth rate.

3.2. Intercorrelation among body measurements
Correlation values indicate the closeness of the relationship between one part to another [14] which can also be used to examine the relationship between one body size and another body size from the animal. It is possible to consider that the existing relationships among body sizes can provide useful information on performance, productivity and possible milk production in a dairy goat type. Intercorrelation among body sizes could be considered as initial information on selection criteria for dairy goats as candidates of breeding stocks. Examination on the correlations among body sizes through simple correlation analysis for those two age classes of the observed EG dairy goat females presents correlation values (rs) as in table 2.

| Body size | rs for 1-4 years old | rs for 5-6 years old |
|-----------|----------------------|----------------------|
| H. height | 0.484                | *                    |
| B. length | 0.250                | 0.435                |
| C. girth  | 0.503                | 0.642                |
| H. girth  | 0.519                | 0.632                |

Description: CG is chest girth, SH is shoulder height, HG is hip girth, HH is hip height, and BL is body length; rs is correlation value.

For both 1-4 years old and 5-6 years old of EG dairy goat females, chest girth was proved to have a very high correlation with hip girth, with rs = 0.837-0.885. Body length has a fairly high closeness with chest girth and hip girth. However, shoulder height and hip height had a low correlation in EG females at young ages (rs = 0.484) than adult ages (rs = 0.719). Low correlation was obtained between shoulder height and body length in young females, and between shoulder height and hip girth in adult
ones. These results indicate that there were strong relationships among body sizes and different growth rates possible to be occurred by the ages of animals.

3.3. Prediction of chest girth from body sizes

Bodyweight is a good indicator of skeleton growth, the composition of cell tissues, body conformation and quality of carcasses in animals. Since various body measurements have a high correlation with body weight, these variables may be used as selection criteria to identify good breeding stocks in animals [15]. Many studies have developed statistical equations in estimating body weight based on a number of body sizes, both linear and nonlinear. Simple statistical equations with good accuracy in estimating body weight will be very helpful in generating data of body weight in difficult conditions for weighing animals such as in the fields.

Many studies have found chest girth as a very good predictor for predicting body weight. Simple regression equations to estimate body weight in Barbari and Jamunapari goats by pooling sex reported at age 3 mo. old chest girth gave good accuracy [16]. At the age of 6 mo. yr. olds, therefore, chest girth and wither height contributed greatly. Further at 9 mo. yr. old so chest girth became the best predictor of body weight, but at one-year-old chest girth and paunch girth were the best predictors. Regarding [17] bodyweight of goats can be predicted from heart girth, body condition, rump length, wither height and pelvic width with a coefficient of 0.95 for males and 0.90 for females. Easy measurement of chest girth by a tape measurement can assist farmers in estimating body weight to put better management purposes [18]. Simple and multiple regression equations to estimate chest girth from one and others of body measurements in EG female dairy goats based on age class are shown in table 3.

Table 3. Simple and multiple regression equations to estimate chest girth from body sizes in EG dairy goat females based on age class.

| Body size | Regression Equation                     | R² adj. |
|-----------|----------------------------------------|--------|
| 1-4 years old |                                        |        |
| 1         | CG = 14.40 + 0.7904 HG.                | 68.4   |
| 2         | CG = 14.4 + 0.187BL + 0.636HG          | 69.7   |
| 2         | CG = -8.4 + 0.410SH + 0.667HG         | 69.0   |
| 3         | CG = -9.0 + 0.420SH + 0.191BL + 0.516HG | 70.5   |
| 3         | CG = 8.4 + 0.152 SH + 0.213 BL + 0.547 HG | 69.4   |
| 4         | CG = -10.3 + 0.111 SH + 0.365 HH + 0.209 BL + 0.468 HG | 69.5   |
| 5-6 years old |                                        |        |
| 1         | CG = 29.47 + 0.6409 HG                | 72.7   |
| 2         | CG = 4.3 + 0.433 SH + 0.537 HG        | 77.0   |
| 2         | CG = 2.4 + 0.407 SH + 0.585 HG       | 74.4   |
| 3         | CG = 1.6 + 0.072 SH + 0.397 HH + 0.536 CG | 76.2   |
| 4         | CG = 2.1 + 0.113 SH + 0.438 HH - 0.088 BL + 0.553 CG | 75.4   |

CG is chest girth, SH is shoulder height, HG is hip girth, HH is hip height, and BL is body length; R² adj is the coefficient determination.

Based on the results in table 3 shows that chest girth using simple linear regression can be accurately predicted by the only one variable of hip girth for both of young females at 1-4 years old (R² = 68.4%) and adult females at 5-6 years old (R² = 72.7%). By adding one or more other body measurements improved the accuracy in estimating chest girth. Nevertheless, the level of accuracy only increased relatively small for both of the young ages (1.0-2.1%) and mature ages(1.7-4.3%). Chest girth is expected to have a good correlation and predictor of body weight as many were reported from the previous studies. In a certain dairy goat population from the selected-milk production result, so high growths or high body weights of dairy goat females in that population could be an early indicator for selecting animals having a good milk ability. Thus body weights, as well as body
conformation, can expectedly be used as indirect selection criteria for the milk production ability in dairy goat type.

4. Conclusion
EG dairy goat females in this study had fast growth rates for all body measurements at the younger ages, and the growth rates began to slow down after reaching adulthood. Chest girth was accurately predicted by HG or by the combination of HG to other body sizes. High intercorrelations among certain body measurement(s) of the EG females showed as initial indicators for growth performance-based selection in identifying females as candidates of good dairy breeding stocks.

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