



Linear Body Measurement of Indonesian Etawah Crossbred Goat [*Capra aegagrus hircus* (Linnaeus, 1758)] and Its Relationship with Milk Production Ability

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Abstract: Indonesian Etawah crossbred goat [*Capra aegagrus hircus* (Linnaeus, 1758)] was crossbred between Indonesian local goat, namely *Kacang*, and Etawah, imported from Jamnapari, India. Although Etawah goat is for dual-purpose, its milk production is high enough. The purpose of this study was to obtain information on genetic variation and genetic potential of the Indonesian Etawah crossbred goat based on linear body measurements of this goat. This study also aimed at investigating milk production ability of the goat in relation to its body measurements. This study comprised of 100 heads of Etawah crossbred goat kept by the farmers. The linear body measurement variables included body length (BL), body height (BH), chest girth (CG), udder circumference (UC) and body weight (BW). The average milk production of goat was 2.92 L/head. The linear body measurements of goat were related to milk production ($r = 0.33$); udder circumference had maximum influence on milk production. Thus, to improve genetic potential for milk production, the selection of goat based on udder circumference would be desirable.

Keywords: Body linier, *Capra aegagrus hircus* (Linnaeus, 1758), Etawah cross breed, milk production, genetic

1. INTRODUCTION

Indonesia is a typical tropical country (6° North Latitude to 11° South Latitude; 95° to 141° East Longitude), thus, this country always gets adequate sunshine throughout the year. The change of season in Indonesia happens only from summer to rainy and vice versa; so Indonesia is tremendously rich in biological resources. One of the precious biological resources in this country is its goat (*Capra aegagrus hircus*). There are two breeds of goat which are dominant in Indonesia, namely *Kacang* and Etawah goat. *Kacang* goat exists in Indonesia since the 1900's, this is followed by Etawah goat. *Kacang* goat is smaller in size than Etawah goat and the former is

generally a meat type breed. Etawah goat was imported by Indonesian government from Jamunapari, India; this breed of goat is dual-purpose type, i.e., meant both for meat and milk. Etawah goat was imported with the objective of improving genetic potential or upgrading of *Kacang* goat through crossbreeding. Over the time period, now the crossbred goat has become one of Indonesia's local goats and generally is known as Indonesian Etawah crossbred goat [1]. In general, Etawah crossbred goat possesses more positive attributes than *Kacang* goat. Although the average of goat milk production in Indonesia is still low, between 0.83 L d⁻¹ to 0.87 L d⁻¹ [2], but this composite goat has potential to increase the local goat production by changing from meat type into a

dual-purpose type. Because crossbreeding between *Kacang* and Etawah goat that was resulted Etawah crossbred has done by farmer community independently, consequently the genetic control becomes difficult and the goat has more variation in genetics. However, for the people in the region of Kaligesing district of Purworejo regency and Senduro district of Lumajang regency at East Java Province are still consistent to do the selection activity based on the local wisdom in order to get the best genetics of Etawah offspring goat. Thus, Etawah offspring goats that exist at those regions have closely genetic to pure breed of Etawah goat. The size of animal biometrics can be used to assess several traits of livestock. These measurements could provide important information for the growth and reproduction as well as another trait that could change due to the effects of environmental factors and feed. In addition, the size of the body is an important data source in terms of reflecting the breed standard. One of the difficult factors in genetic conservation is the identification of characters about animals and the best handling on production systems to maintain the animal productivity. Phenotypic characterization is the one of most important steps in genetic conservation program [3], especially for classification and identification of a nation or breed of livestock that breeder community can do with these techniques easily [4]. Because the body conformation correlates with the performance of the livestock, so the livestock selection must be done with the effort in order to make the animal characteristics are not extinct by naturally selection. The conformation and performance animal in nature can be inherited and influenced by environmental factors [5]. Although some strains of livestock and its production can be decreased separately or independently, but preferably the livestock selection can be performed simultaneously [6]. Therefore, the average value of coefficient of quantitative trait is slow in inheritable and repeatability, so become a complicated in the directly selection of the livestock to the type of linear traits [7].

Thus, recently using the index selection of linear factors that correlated with animal production in accordance with the interests of

economical value are widely use as an alternative strategy in many countries [8]. Although the conformation score of the body, tends to highly subjective and lower inheritance ability, but it had been widely used by the farmers. So, introducing the indicator of the linear body measurement can increase the objectivity of the conformation of body measurement from the viewpoint of easy usage [4]. Thus, the purpose of this study was to obtain the current information about genetic variation and its potential based on the size of the linear body or the morphology of the body of Etawah crossbred goat.

2. MATERIALS AND METHODS

2.1 Location

The goat sample for this research was collected from Etawah crossbred goat breeders in the Batu area, East Java (Fig. 1). Batu area is one part of East Java, Indonesia ($122^{\circ}17'10,90''$ to $122^{\circ}57'00,00''$ East longitude; and $7^{\circ}44'55,11''$ to $8^{\circ}26'35,45''$ South latitude). Batu area has an area of around 202 800 km², equivalent to 20 280 ha. Boundary region encompasses sub district Dau and the district Wagir at Southern part; Pujon at Western part; the Karangploso district and the Dau district at Eastern part as well as Mojokerto and Prigen in the Northern part. Batu area consists of three sub-district and 23 villages. Those three districts are a Batu district with an area of 46,377 km², Bumiaji with the most extensive region, which is about 130,189 km², and the Junrejo district with an area of 26,234 km². Batu climatic conditions have a minimum temperature of 18 °C to 24 °C and a maximum temperature of 28 °C to 32 °C with humidity around 75 % to 98 % and an average rainfall (875 to 3000) mm yr⁻¹. Due to the conditions of geographic area, Batu area is very suitable for development of various agricultural commodities generally [9].

2.2 Materials

The animals used in this study were 100 female Etawah crossbred goats that were kept by 26 breeders, and average milk production was recorded on the second lactation period. Etawah crossbred goat samples were determined by



Fig. 1 Location map of the research. The arrow indicates the place of animal sampling.

purposive based on criteria of Etawah crossbred goat, such as convex face or Roman face, long ears and white hairs. The main equipment which used in this study included a measuring tape, measuring ruler, calipers, livestock scales, measuring beaker glass 1000 mL, test tube 100 mL, digital camera, hygrometer and thermometer.

2.3 Methods

Some variables were set to determine the size of the linear body of goat and the relation to milk production ability as follows:

- (I) The size of the linear body as suggested by Battaglia [10], which includes:
 - Chest Circumference (CC) in cm, measured with wrapping a measuring tape around the chest or sternum on the

back of the shoulder bone and shoulder blade using a measuring tape.

- Body Length (BL) in cm, measured by the yardstick that carried to make slashes from the protrusion shoulder (*tubersitas humeral*) to the hip bones (*tuber ischii*).
- Height (H) in cm, measured with a yardstick. The measurement of height carried from the base ground to shoulder to first back segment as a mark of height goats Udder Circumference (UC) in mL, measured by measuring the circumference of the base of the udder by using a ribbon that is then converted into a measuring tape [11].

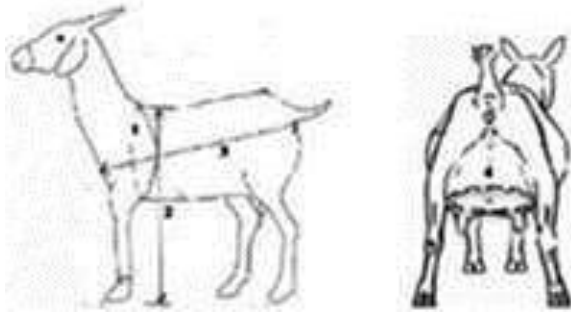


Fig. 2 The areas of linear body measurement [1].

1. Chest Circumference (CC)
2. Height (H)
3. Body length (BL)
4. Udder Circumference (UC) [11]

(II) To estimate the body weight in kg was calculated by Lambourne formula as Eq. 1:

$$W = \frac{L \times G^2}{10\ 840} \quad (1)$$

where:

- L = Body Length (cm)
 G = Chest Circumference (cm)
 W = Weight (kg)

(III) Milk Production (MP) in milliliters (mL), carried out by measuring the production of milk directly using measuring glass with a capacity of 1000 mL. Milk production data recorded by farmer using owner sampling method.

2.4 Data Analysis

The results of linear body measurement variables were used as independent variables that were as variable phenotypes and to be used as a prediction variable that had a functional relationship to the milk production. The prediction was done by using multiple regression analysis. The basic formula of multiple linear regression equations with several independent variables according to Freedman [12] as Eq. 2:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n + e_i \quad (2)$$

Where:

Y_i = the dependent variable of estimated milk production for i

b_0 to b_n = regression coefficient
 X_1 to X_n = independent variables of linear character for i (CC, H, W, BL dan UC)
 e_i = residual error between the independent and dependent variables were observed.

The data analysis to determine the relationship between dependent and independent variables used SPSS ver.16 procedure.

3. RESULTS AND DISCUSSION

3.1 Linear body Variation of *Etawah Crossbred*

Etawah crossbred goat samples were measured based on approach of the characteristics of the Etawah pure line breed. Although slightly vary in hair color, but generally the dominant color is white (Fig. 3). Etawah crossbred goat generally has characteristics like the parental or Etawah pure line goats, which have a very curved nose (Roman face), short horns, long ears and white short hair except long hair at the back of the thigh and leg. For a female Etawah crossbred goat generally can have milked [13].



Fig. 3 Etawah crossbred goat from Batu City, East Java, Indonesia.

Based on the measurement of linear body size of female Etawah crossbred goat, it showed that the average value and standard deviation as follows: Height (H) 77.75 cm \pm 4.46 cm, Body Length (BL) 74.23 cm \pm 6.34 cm, Chest Circumference (CC) 85.45 cm \pm 7.07 cm and Udder Circumference (UC) 29.52 cm \pm 4.49 cm, respectively. (Table 1). Then, if it compared to the FAO standard, variable values of Height, Length and Chest Circumference was not quite different from FAO (1982) to female Etawah pure line goat

as follows: Height 75.20 cm \pm 0.38 cm, Length 75.15 cm \pm 0.46 cm, and Chest Circumference 76.11 cm \pm 0.38 cm, respectively (not available data for Udder Circumference). Then, from value of linear body size variable, the measurement of Chest Circumference has the highest difference, or the range of body size between the biggest and smallest goat is around 50 cm. While, the body Height has the lowest difference around 19.92 cm.

Study on Saanen goat that crossed with Etawah goat (called Sapera) in Cilacap indicates that the average measurement of the linear body as follows: 85.61 cm \pm 4.46 cm (CC), 71.30 cm \pm 4.17 cm (BL), 74.21 cm \pm 3.46 cm (H) and in Bogor is 90.97 cm \pm 2.42 cm (CC), 71.86 cm \pm 3.74 cm (BL), 73.68 cm \pm 3.40 cm (H), respectively [14]. It indicates that although Etawah crossbred goat have been crossbreeding with various goats from another strain in Indonesia but in general linear body character still close to the Etawah purebred goat. Also, the offspring of Etawah crossbred goats were still able to produce milk, so it is advantageous for farmers. Also, has reported that any a correlation between body weight to the linear body size, like body weight had a correlation to the length, height and chest circumference at the Nigerian Red Sokoto goats [15].

Chest Circumference linear size had a close relationship to phenotypic character of body weight on Etawah crossbred goat. [16]. The linear classification on livestock become one of the important tool in the decision process because it aims to select animals that can express *phenotypic* characteristics that will provide a higher productive life through increased of productivity and reproductivity potential [17].

3.2 Relationship between Linear Body Variation and Body Weight to Milk Production

To determine the relationship between the linear body sizes of Etawah crossbred goat which combined with quantitative trait of body weight in the milk production, we used multiple regression analysis. In this case, variations in linear body size and body weight of the Etawah crossbred goat were used as a predictor to milk production ability. Milk production by the crossbred goat was influenced simultaneously by its linear body size and body weight, with correlation coefficient (*r*) of 0.51. It indicated that the correlation between independent variable and dependent variable was categorized in the medium value. From the value of coefficient of determination (R^2) was 0.264; it means that 26.4 % of variation of the independent variable can be explained by the dependent variable in the regression equation, while the rest 73.6 % was determined by other variables (like environmental variables) not included in this study. Even though the regression equation as a prediction line to the relationship between the dependent variable (milk production) with independent variable (H, BL, CC, UC and W) resulted the regression Eq. 3:

$$Y = 10696.105 + 40.796X_1 - 137.075X_2 - 71.384X_3 + 0.883X_4 + 117.281X_5 \quad (3)$$

According to the F test showed that F value was 6.73 by a significance value was 0.000. Therefore, F value bigger than F table (6.73 > 2.31) and significantly value smaller than 0.05 (0.000 < 0.05). So, it can be concluded that the regression model above can be used as an estimator line to predict the production of Ettawah

Table 1. The linear body size of Etawah crossbred goat in this study.

Parameter	Height (H) (cm)	Body Length (BL) (cm)	Chest Circumference (CC) (cm)	Udder Circumference (UC) (cm)
Average	77.75	74.23	85.45	29.52
SD	\pm 4.46	\pm 6.34	\pm 7.07	\pm 4.49
Maximum	91.00	85.00	99.50	39.00
Minimum	66.00	57.00	67.00	18.00
Variants	19.92	40.18	50.00	20.19

crossbred's milk or it can be stated that the UC variables (X_1), CC (X_2), BL (X_3), H (X_4) and W (X_5) simultaneously have significant effect on milk production of Etawah crossbred (Y variable). Vital statistics of animal livestock body measurements include udder circumference, chest circumference, body length, height and weight were used to know the shape of livestock visually and see the growth ideally [18]. The highest genetic correlation between the size of the angle of the legs, rump wide and scores the general body towards milk production in Churra dairy sheep [19].

3.3 Contribution of Linear Variables and Body Weight towards Goat Milk Production

From the results of the partial test, the udder circumference (UC) variables had the highest correlation to the production of Ettawah cross goat milk (0.42) by significantly ($P < 0.05$). Then the udder circumference variable (X_1) gives closet influence on milk production compared to other variables simultaneously with R^2 0.18. (Table 2). Since the udder circumference regression coefficient value was positive, it meant that any increase in the value of udder circumference will improve milk production and otherwise udder circumference reduction would reduce the production of Etawah crossbred goat milk. The correlation between udder circumferences with milk production had a significant relationship, bigger size of udder circumference is tending to the increasing amount of milk production [20]. Udder is milk container organ, so when filled

amount of milk will change its' shape and size of the udder organs [21]. Also, similar results showed that udder circumferences have a closet correlation (0.721) to the production of Akkeçi's goat milk and from the path analysis test (path analysis) showed that 32.4 % of the variation of milk production affected directly by udder circumferences [22]. Udder morphology variables, including the udder circumference showed a highly significant ($P < 0.01$) towards the average of milk production daily on Rohilkhand goats, India [23].

The chest circumference (CC) variable and Body Length (BL) were based on the results of the t test showed have negative correlation to Milk Production (-2.00 and -1.95), it means that if the value of CC and BL variable arises, the value of milk production (Y) will decreased, vice versa. Whereas for body weight (W), it has a positive correlation (0.16), it means that if the body weight increases, the milk production (Y) will be increased. While, for the height (H) variable it was not significantly correlated with milk production (Y).

The chest circumference is a one component of the body that has a close correlation with the body weight on adult Etawah crossbred goat [16]. Livestock have a high body weight, the proportion of energy usage for basic life will become less because the animal needs more energy for milk production [20]. Chest circumference of animal refers to digestive system capacity. The size of the gastric of animal, especially on ruminant animal can be

Table 2. Independent variables' contributions to milk production on Etawah crossbred goat.

No.	Independent Variables (X)	Correlation Coefficient (r)	Coefficient of Determination (R^2) for Milk Production (Y) (%)
1.	Udder circumference (UC) *)	0.42	17.64
2.	Chest circumference (CC) *)	- 0.20	4
3.	Body Length (BL) *)	-1.95	4
4.	Height (H) ^{NS})	0.16	2.56
5.	Weight (W) *)	0.24	5.76

*) Significant ($P = 0.05$)

^{NS}) Non-significant

represented the capacity of feed consumed [24].

The size of the linear body, that is chest circumference, udder dimensions, length, height and body weight has a positive correlation to milk production [25]. Milk production has poor in quantity when the body is longer. This was may the length of the body has no relationship to the volume of udder, so the milk production has not significant relationship to body length [26].

The vital statistics were also having high close relationship to milk production. But, the highest level of the relationship was only shown in the volume of the udder, chest circumference and width of the chest [18]. The similar result showed that any a relationship between chest circumference, body length, height and location with Sapera milk production, but body length and height do not have a relationship to milk production [14].

Weight and other linear body size that were not an economic trait in dairy or livestock, but is a reflection of the potential growth of livestock that have a positive correlation to the growth and development of the mammal's gland which will determine the level of milk production. Body weight had positive correlation to milk production, but it was negative correlation to muscle and fat [18]. The similar study showed that any relationship to the size of the ruminant abdominal, where the abdominal volume was closely related to the volume of rumen, this means that measures will determine the ability of consumption, like coarse meal, and also closely related to body weight [27].

4. CONCLUSIONS

Milk production capacity of Etawah crossbred goat was related to its linear variables of body size, i.e., UC, CC, BL, H and W. The variable having maximum impact on milk production was udder circumference of the goat. Thus, udder circumference is the most important linear body variable for selection or culling of Etawah

crossbred goat by the farmers to predict potency of this crossbred goat for high milk production.

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