The Genetic Parameter for Morphometric Traits and Body Weight in One Day Old Indonesian Sheep

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ABSTRACT
The heritability, estimated breeding value and correlation are the important genetic parameter that determines genetic improvement in animal. The aim of this research was to discover the heritability, breeding value and phenotypic correlation for quantitative traits in one day old Indonesian sheep. This research was conducted from 7th August to 7th December 2022 in PT Juara Agroniaga Sejahtera, Bojonegoro, East Java. The materials used were 72 heads of Indonesian sheep at one day of age, offspring of 6 sires and 28 dams. The research used was quantitative method with direct observation in the field. The variables observed were birth weight (BW) and morphometric traits (chest girth (CG), upper neck circumference (UNC), and lower neck circumference (LNC)). Heritability value was estimated using paternal half-sib correlation method and the variance components were analysed using the Analysis of Variance (ANOVA) single factor. Estimation of breeding values were calculated using the performance of progeny. The result showed that mean of BW, CG, UNC, and LNC for single birth were 2.78±0.74 kg, 32.07±3.56 cm, 15.71±1.38 cm, 17.71±1.38 cm; for twin birth were 1.78±0.48 kg, 27.27±2.70 cm, 13.96±1.38 cm, 17.71±1.38 cm; for triplet birth were 1.35±0.38 kg, 24.23±2.64 cm, 12.60±1.30 cm, 14.03±1.46 cm; for quadruplet birth were 1.06±0.22 kg, 22.63±2.39 cm, 12.06±1.15 cm, 13.94±1.02 cm. Heritability value for BW, CG, UNC, and LNC were 0.64±0.03; 0.62±0.03; 0.87±0.18; 0.43±0.12 respectively. The correlation of CG, UNC and LNC with BW were high positive values (0.86, 0.82 and 0.92, respectively). The body weight is the important selection criterion to improve the production trait due to its high heritability value. However, if the weighing scales are not available, selection could be based on the morphometric trait. LNC is recommended as selection criterion due to its highest correlation with body weight.

Keywords: *Birth Weight, Breeding Value, Chest Girth, Heritability, Neck Circumference.*

1. INTRODUCTION

Sheep are a class of meat-producing ruminants that have the potential to be developed in Indonesia. Sheep have several superior traits, namely adaptive, prolific, and fast reproduction cycle, supported by Ahmad et al [1]. Indonesian local sheep consist of various breeds including Fat Tail Sheep (DEG), Thin Tail Sheep (DET), and Garut sheep, supported by Susilorini et al [2]. Indonesian local sheep are sheep that have been proven to adapt well to local environmental conditions and are resistant to ectoparasites, supported by Salamena et al [3]. Sheep that have superior genetics and are maintained in an appropriate environment will achieve optimum productivity. Facts in the field show that sheep productivity in Indonesia is still relatively low, so efforts are needed to increase sheep productivity. Sheep productivity can be improved through environmental improvement (feed quality and management) and genetic quality improvement.

Breeding programs cannot be separated from selection. Selection is the most basic thing that must be done to achieve increased livestock productivity. Nugiartiningih [4] stated that selection is defined as a process of selecting individuals with superior genetic quality to be chosen as elders. The selected superior elders are bred further to

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produce superior offspring. The selection program will be more effective if it is based on quantitative traits that have high economic value. This statement is supported by Kurnianto [5] that quantitative traits in livestock are production traits that have economic value.

According to Ghasemi [6], birth weight is an indicator of future livestock growth and a measure of survival ability so it is important to measure. Sheep that have a birth weight above the average will have a higher ability to live through the critical period, grow relatively fast, and have a high weaning weight, supported by Gunawan et al [7]. The body size that is often used as an indicator of selection is chest girth because it has been shown to have a high positive correlation to body weight. Syuhada [8] stated that the measurement of the chest girth can represent the volume of the sheep's body because the chest girth describes the cylindrical body of the animal. Neck circumference is a measure of the livestock body that is still rarely used even though the neck is the part of the sheep's body that is easy to control. Sutopo [9] stated that neck circumference has a relatively high correlation with sheep body weight.

Genetic parameters that are very important and influential in the selection process are the heritability value (h2) and breeding value (BV). Nurgiartininsih [4] stated that the heritability value of a trait used as a selection criterion will affect genetic progress. The higher the heritability value of the trait being selected, the higher the expected genetic progress due to selection of the trait. Selection to select superior livestock individuals must be based on breeding value. Livestock that have high breeding value have a high ability to inherit genetic potential to their offspring. Based on the description above, research is needed to determine the heritability value and breeding value of quantitative traits in sheep including birth weight, chest girth, upper neck circumference, and lower neck circumference as criteria in the selection program.

2. MATERIALS AND METHODS

1.1. Location and Time of Research

This research was conducted at PT Juara Agroniaga Sejahtera located in Simbatan Village, Kanor District, Bojonegoro Regency, East Java. Research and data collection were conducted on August 7, 2022 until December 7, 2022.

1.2. Location and Time of Research

The materials used in this study were 58 one-day-old local sheep from the mating of 6 male sheep with 28 mother sheep.

1.3. Research Methods

The method used in this research is a quantitative method with direct data collection in the field. Data taken include the size of the quantitative traits of local sheep and pedigree. The size of the quantitative traits of the body obtained from the weighing of birth weight, measurement of chest girth, upper neck circumference, and lower neck circumference. The data obtained were analysed statistically. Sampling was done by purposive sampling, which is based on one-day-old sheep that have pedigree records.

1.4. Research Variables

The variables observed in this study were quantitative traits consisting of birth weight (BW), chest girth (CG), upper neck circumference (UNC), and lower neck circumference (LNC).

- Birth weight (BW) was expressed in kilogram (kg). BW data was obtained from weighing conducted no more than 24 hours after birth.

- Chest girth (CG) is expressed in centimeters (cm). CG data was obtained from measurements using a measuring tape wrapped around the chest behind the shoulders.

- Upper neck circumference (UNC) is expressed in centimeters (cm). UNC data was obtained from measuring the upper neck using a measuring tape.

- Lower neck circumference (LNC) is expressed in centimeters (cm). LNC data was obtained from measuring the lower neck circumference using a measuring tape.

1.5. Data Analysis

Analysis of the effect of sex was used to determine the effect of sex on quantitative traits of sheep. If there is a significant difference ($P < 0.05$) or highly significant ($P < 0.01$), then proceed with data correction for sex before the data is used for analysis of genetic parameters. Analysis of differences between male and female sexes used an unpaired t-test. The following is the t-test formula according to [10]:

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{s^2(\frac{1}{n_A} - \frac{1}{n_B})}} \quad (1)$$

$$s^2 = \frac{JK_A + JK_B}{(n_A - 1) + (n_B - 1)} \quad (2)$$

Description:

t : calculated t value

s^2 s^2 : variance

n_A n_A : number of male sheep samples

n_B n_B : number of female sheep sample

$\bar{X}_A$ $\bar{X}_A$: ram average

$\bar{X}_B$ $\bar{X}_B$: ewe average

The effect of birth type on quantitative traits of sheep was analyzed using one-way ANOVA (Analysis of Variance). If there is a significant or highly significant effect of birth type, then a further test is required using the Least Significant Difference Test (BNT). The following is a statistical model of the effect of birth type on the quantitative traits of sheep according to Sudarwati et al. [10].

$$Y_{ij} = \mu + \pi_i + \beta_{ij} \quad (3)$$

Description:

Yij : performance of the jth individual on the i-th measurement

μ : population average

πi : the effect of the i-th birth type

βij : environmental and genetic deviations from measurements within an individual.

Quantitative traits of one-day-old lambs were corrected for sex and birth type if the results of the calculation of unpaired t-test and ANOVA test showed significant differences ($P < 0.05$) or highly significant ($P < 0.01$). The following is how to calculate data correction based on sex, supported by Hardjosubroto [18].

$$\text{FKJK} = \frac{\bar{X}\ ram}{\bar{X}\ ewe} \frac{\bar{X}\ ram}{\bar{X}\ ewe} \quad (4)$$

Birth type data was corrected for single birth type. Data correction based on birth type was calculated using the formula follows:

$$\text{FKTL}_{twin} = \frac{\bar{X}\ single}{\bar{X}\ twin} \frac{\bar{X}\ single}{\bar{X}\ twin} \quad (5)$$

$$FKTL_{triplet} = \frac{\bar{X}\ single}{\bar{X}\ triplet}\ \frac{\bar{X}\ single}{\bar{X}\ triplet} \quad (6)$$

$$FKTL_{quadruplet} = \frac{\bar{X}\ single}{\bar{X}\ quadruplet}\ \frac{\bar{X}\ single}{\bar{X}\ quadruplet} \quad (7)$$

Estimation of heritability values (h^2) using the paternal half sib correlation method. The variance component was estimated using the one-way ANOVA (analysis of variance) method as shown in Table 1. Estimated heritability values used data that had been corrected for single birth type. The following is a statistical model of heritability value according to Nurgiartiningsih [4].

$$Y_{ij} = \mu + s_i + e_{ij} \quad (8)$$

Description:

Y_{ij} Y_{ij} : observation on the j-th livestock individual from the i-th half sib group

μ μ : population mean

s_i s_i : influence of the i-th ram

e_{ij} e_{ij} : random error

Table 1 Analysis of variance of half sib correlation

Variance	df	Sum of Squares	Mean Squares	Mean Squares Component
Among Sires	s-1	JKs	KTs = $\frac{JKs}{s-1}$ $\frac{JKs}{s-1}$	σ_w^2 σ_w^2 + $n\sigma_s^2$ $n\sigma_s^2$
Within Sires	s(n-1)	JKw	KTw = $\frac{JKw}{n-d}$ $\frac{JKw}{n-d}$	σ_w^2
Total	ns-1	JKt		

If each ram has a different number of offspring, then n is replaced by k with the following formula, supported by Nugiartiningsih [4]:

$$k = \frac{1}{s-1}\left(n - \Sigma \frac{ni^2}{n}\right) \quad (9)$$

The heritability value estimated based on the analysis of variance using the half-sister method is formulated as follows, supported by Nurgiartiningsih [4]:

$$h^2 = 4\frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}\ h^2 = 4\frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2} \quad (10)$$

Description:

h^2 h^2 : ram heritability

σ_s^2 σ_s^2 : component of variance between rams

σ_w^2 σ_w^2 : component of variance between offspring within parents

Table 2. h^2 Value Category

h^2 Value	Category
<0,15	Low
0,15-0,50	Medium
>0,50	High

Source: [4]

The breeding value of quantitative traits can be estimated based on the offspring test. The formula used to estimate breeding values according to Nurgiartiningsih [4] is as follows:

$$NP = \frac{2nh^2}{4+(n-1)h^2} NP = \frac{2nh^2}{4+(n-1)h^2} (\bar{P} - \bar{\bar{P}} \bar{P} - \bar{\bar{P}}) \quad (11)$$

Description:

NP : breeding value

h^2 h^2 : heritability

$\bar{P}$ $\bar{P}$: individual performance average

$\bar{\bar{P}}$ $\bar{\bar{P}}$: population average

2. RESULTS AND DISCUSSION

2.1. The Effect of Birth Type on The Morphometric traits and Body Weight

Table 3. Mean ($\bar{x}$) and standard deviation (SD) of birth weight (BW), chest girth (CG), upper neck circumference (UNC), and lower neck circumference (LNC) of single, twin, triplet, and quadruplet day-old lambs.

Birth Type	n	BW (kg) ($\bar{x}$ $\bar{x}$ ±SD)	CG (cm) ($\bar{x}$ $\bar{x}$ ±SD)	UNC (cm) ($\bar{x}$ $\bar{x}$ ±SD)	LNC (cm) ($\bar{x}$ $\bar{x}$ ±SD)
Single	7	2,78±0,74^a	32,07±3,56^a	15,71±1,38^a	17,71±1,38^a
Twin	28	1,78±0,48^b	27,27±2,70^b	13,96±1,60^b	15,79±1,90^b
Triplet	15	1,35±0,38^c	24,23±2,64^c	12,60±1,30^c	14,03±1,46^c
Quadruplet	8	1,06±0,22^c	22,63±2,39^c	12,06±1,15^c	13,94±1,02^c

Note: the same superscript in the same column does not indicate significant differences (P>0.05)

The averages of quantitative traits including birth weight, chest girth, upper neck girth, and lower neck girth in one-day-old lambs based on birth type are presented in Table 3. The average birth weight of one-day-old lambs based on birth type in this study was 2.78±0.74 kg single; 1.78±0.48 kg twin; 1.35±0.38 kg triplet; and 1.06±0.22 kg quadruplet, respectively. The average of all quantitative traits of one-day-old lambs of single birth type showed very significant differences with twin, triplet, and quadruplet birth types ($P < 0.01$). Waskito [11] stated that the difference in quantitative traits of single-born sheep is greater than the twin-born type due to the limited volume of the mother's uterus so that there is competition in the uterus. A single fetus in the uterus certainly gets a greater supply of nutrients than twin fetuses because there is no competition in it.

Based on the results of statistical analysis, the mean of all quantitative traits in triplet and quadruplet birth types showed no significant difference (P>0.05). The mean of quantitative traits in triplet birth type showed greater results than the mean of quantitative traits in quadruplet birth type. This is due to the number of fetuses in the uterus. Kurnianto [12] described that the quadruplet birth type has more fetuses than the triplet birth type so that competition in the uterus is greater which ultimately has an impact on low birth weight. The results of this study are higher when compared to Athifa [13]. Reported the average birth weight of single-born Garut sheep in Garut Regency, West Java of 2.21 ± 0.52 kg. The difference is caused by the type of sheep used as the object of research as well as the location of the research. Differences in research locations certainly cause different maintenance procedures that affect the performance of sheep.

2.2. Heritability Value

Table 4. Heritability value (h2) and Standard Error (SE) of Birth Weight (BW), Chest Girth (CG), Upper Neck Circumference (UNC), and Lower Neck Circumference (LNC) of one-day-old sheep.

Variabel	h^2±SE
BW	0,64±0,03
CG	0,62±0,03
UNC	0,87±0,18
LNC	0,43±0,12

The results of statistical analysis of the heritability value (h2) of birth weight of one-day-old lambs obtained 0.64 ± 0.03. This value is included in the high category which means the difference in birth weight of sheep in the population is influenced by additive genetics by 64% and the remaining 36% is influenced by environmental factors. This value is higher than the heritability of birth weight (h2=0.12) in pure breed Garut sheep in UPTD BPPTD Margawati Garut research results, supported by Baehaki et al [14]. This difference is due to the number of animals, type of livestock, time and location of sampling, and the method used to calculate the heritability value, supported by Tribudi et al [15]. The heritability value (h2) of chest circumference of one-day-old sheep in this study was 0.62 ± 0.03. This value is classified as a high category, which means that 62% of the variation in chest circumference phenotype is influenced by additive genetic factors and 38% is influenced by environmental factors. Darmawan et al [16] obtained the results of a higher heritability value estimation (h2) of chest girth of 0.90 on weaning period DEGs totaling 99 heads in Situbondo Regency which was analyzed using the stepbrother and sibling correlation method. This is thought to be due to the larger number of animals used and the different estimation methods used. According to Karnaen [17], estimation of heritability value using paternal half-sib correlation is the best estimation because there is no dominant variation and influence of the mother that can cause the calculation of heritability value to be too high.

The heritability value (h2) of upper neck circumference of 0.87 ± 0.18 is classified as high, which means that 87% of the phenotype variation of upper neck circumference is influenced by additive genetic factors and 13% is influenced by environmental factors. The heritability value of upper neck circumference in this study is the highest heritability value. The heritability value (h2) of lower neck circumference of 0.43 ± 0.12 is classified as moderate, which means that 43% of the phenotype variation of lower neck circumference is influenced by additive genetic factors and 47% is influenced by environmental factors. The heritability value of lower neck circumference is the lowest heritability value from the results of this study. Based on the results of statistical analysis, the heritability values of quantitative traits in this study were in the medium to high category. Body weight, chest girth and upper neck girth had high h2 values with upper neck girth being the highest. Selection is most appropriate on birth weight even though the h2 value is not the highest, it has economic value and a high coefficient of variation. Weighing birth weight is also relatively easy to do. Birth weight influences future growth rate, making birth weight an important selection criterion.

2.3. Estimated Breeding Value

Breeding value is an assessment of the genetic potential of individual livestock on a trait based on its position in a population, supported by Nurgiartiningsih et al [4]. The estimation results of Breeding Value (BV) and stud ranking can be seen in Table 5.

Table 3. Breeding Value (BV) of male sheep based on Birth Weight (BW), Chest Girth (CG), Upper Neck Circumference (UNC), and Lower Neck Circumference (LNC) of one-day-old sheep

No.	**BV BW**	**Mean (kg)**	***Rank***	**BV CG**	**Mean (cm)**	***Rank***	**BV UNC**	**Mean (cm)**	***Rank***	**BV LNC**	**Mean (cm)**	***Rank***

K028	0,42	3,15	1	1,97	33,82	1	1,05	16,51	1	0,88	18,68	1
H009	0,27	3,06	2	0,72	32,82	2	0,89	16,48	2	0,15	17,92	3
H003	0,004	2,78	3	0,06	32,16	3	0,31	16,06	3	0,45	18,57	2
H002	-0,08	2,63	4	-0,13	31,83	4	-0,31	15,28	4	-0,21	17,18	4
H007	-0,26	2,56	5	-0,75	31,44	5	-1,09	14,92	5	-0,70	17,00	5
H004	-0,47	2,13	6	-2,54	28,49	6	-0,99	14,63	6	-0,62	16,54	6

Based on Table 5, it can be concluded that the studs that have positive breeding values in all quantitative traits measured are studs K028, H003, and H009. The male with the highest breeding value of the four quantitative traits BL, LD, LLA, LLB is the male with ear tag number K028. Stud K028 can be said to be a superior stud because it ranks first in each trait measured in this study. According to Hardjotosubroto [18], a male will pass on his superiority to his offspring by half of the breeding value. Male K028 had an average BL of 3.15 kg, LD of 33.82 cm, LLA of 16.51 cm, and LLB of 18.68 cm with population averages for each trait of 2.78 kg; 32.07 cm; 15.71 cm; and 17.71 cm. If the K028 male is mated to any ewe, the estimated birth weight of the next generation is 0.21 kg, chest circumference is 0.982 cm, upper neck circumference is 0.525 cm, and lower neck circumference is 0.44 above the population average. The superiority rank of individual livestock in the population can be known from the breeding value. Prihandini [19] stated that selection should be done by looking at the ranking of livestock sorted from top to bottom, the number is adjusted to the selection needs. According to [18], breeding value is very important to know in order to assess the superiority of a male that will be used as a breeder. The results of this study indicate that male K028 is the most superior male in the population so his presence must be maintained as an elder.

3. CONCLUSION

The heritability values of birth weight, chest girth and upper neck girth are high, while lower neck girth is medium. Based on the high heritability value and economic value, birth weight can be used as a selection criterion. UNC is recommended as a selection criterion due to its highest correlation with body weight. Local Indonesian sheep were more prolific than crossbred sheep.

AUTHORS' CONTRIBUTIONS

Veronica Margareta Ani Nurgiartiningsih designed the research, formal analysis, data curation and writing (original data, review and editing). Dewi Fitria Nabilah, Poppy Satya Puspita, Irida Novianti, Poespitasari Hazanah Ndaru, and M. Pramujo designed the research and conducted the analysis.

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