The effect of individual variation on litter weight in Boer and Jawarandu goat crossbreed

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Abstract. This study aims to determine the effect of individual variations on litter weight in Boer and Jawarandu goat crossbreed in CV. Kambing Burja (farm), East Java. Records from 2012 to 2015 consisted of breed of does, date of birth, litter size and birth weight of kids; along with individual identity, season and year of birth were obtained. There were 107 Boer, 687 Jawarandu, and 495 Boerja does with a total of 3804 kids in the records. Data analysis was conducted using Analysis of Variance (ANOVA) incorporating the factors of season of birth (rainy and dry season) and doe’s breed (Boer, Jawarandu, and Boerja F1). Mixed model analysis using Restricted Maximum Likelihood (REML) method was used to estimate the individual variations. The results showed that both doe’s breed and season of birth had a significant effect (p<0.05) on litter weight; while the individual variations contributed 36.28% to the total variance. We concluded that the individual variation of litter weight was considerably high which reflects high genetic diversity within each breed. Hence, selection to improve the reproductive performance of these goats is highly possible.

1. Introduction
Litter weight is one of the performances that can measure the reproductive quality of goats, which are multiparous animals. Litter weight is defined as the sum of the birth weights of kids born by the dam [1], which means that the main components of litter weight are the litter size and birth weight. Litter weight can be used to see how well the ability and fertility of the dam in producing kids in the breeding program. Litter weight can be used as a reference for how large the uterine capacity of the dam in accommodating the kids in one pregnancy period. The large capacity of the dam's uterus allows for the large number of kids and the high birth weight of the kids. Twinning of litter size in goats is highly expected because it can provide economic benefits for farmers. Meanwhile, high birth weight in each kid can affect the individual's ability to survive in the post-natal period.

In Indonesia, goat breeding still focused on selection to produce high litter size or high birth weight which is expected to provide benefits. Whereas litter size and birth weight are interrelated where, if the litter size is high, it can be followed by a high rate of newborn mortality and also a decrease in kid birth weight [2]. So in breeding multiparous animal, it is necessary to pay attention to the litter weight where litter size and birth weight are taken into account as a one unit. Litter weight can be influenced by various environmental and genetic factors. Environmental factors that can be recognized include the litter size, sex, breed, parity which are factors that are consistent and can be adjusted mathematically [3]. In
addition to environmental factors, litter weight is influenced by individual factors of doe, including the age and the weight of the doe [4] as well as genetic factors.

Genetic factors are determined by the arrangement of genes in pairs of chromosomes owned by individuals. Due to the non-uniform composition of the genes possessed by livestock, in a group of livestock there will always be a variation of the gene arrangement. Knowledge of the genetic variation of a population or group of livestock is important as the basis for implementing a selection program to facilitate the selection of superior traits from a group of livestock with high genetic variation. Research on the components of genetic variation is very important to facilitate decision making on livestock selection in the selection program. Thus, identification of livestock genetic traits in livestock companies or breeding units is very necessary to provide data in the context of evaluating the breeding process [5]. This Study aims to examine the effect of individual variation on litter weight in Jawarandu and Boer goat crossbreed.

2. Methodology

2.1. Litter weight data collection
This retrospective study used the data that was obtained from the records of litter weight of Boerja goats from 2012 to 2015 in CV. Kambing Burja, East Java, Indonesia. The data consisted of systematic factors including season and year of birth of kids and dam breed. Season and year of birth of kids was obtained from the difference in rainfall each year from the birth of kids in 2012-2015. The records of litter weight were equipped with pedigree, date of birth, and dam breed. The goat population consisted of 26 sire boer goats, 107 dam boer goats, 687 dam jawarandu goats, and 495 dam boerja goats.

Boer bucks and does are purebreed that were imported from Australia with selection program, but some Boer does were born in Indonesia. Jawarandu does are crossbred of Etawa Grade buck with Kacang doe. Jawarandu dam was obtained from local market without any information of parity and age. A total of 3,804 offsprings with three different compositions of breed was produced. The data were collected in the form of merging, filtering, and managing by removing incomplete data and obtained 2,378 data of litter weight. The litter weight data was obtained from the sum of the birth weights of kids born by dam.

2.2. Data analysis
Statistical analysis of litter weight. In the present study, season and year of birth and dam breed were selected as factors which affect litter weight. data were tabulated as mean ± standard deviation. Data were statistically analyzed by a linear model at α=0.05 according to the following basic model [6]:

\[ y_{ijk} = \mu + SYB_i + B_j + e_{ij} \]

where \( y \) is a response of litter weight, \( \mu \) is a general mean, \( SYB_i \) is a season and year of birth effect, \( B_j \) is a dam breed effect (\( j = \) Boer, Jawarandu, Boerja F1), and \( e_{ij} \) is the residuals.

Variance component analysis of litter weight on the individual goat dam. A linear model was built as preliminary analysis to check the significance of season and year of birth of kids and dam breed as factor(s) affecting the litter weight. Later, we employed a mixed model procedure including the significant fixed effect(s) and individual goat dam as random effect to estimate the variance components as in the following equation:
where \( y \) is a vector of observed variables, \( b \) is a vector of fixed effects accounted for season and year of birth of kids and dam breed and \( X \) is the incidence matrix corresponded to the fixed effects. \( I \) is an identity matrix corresponding to the random individual effect (a) where \( a|\sigma_a^2 \sim M\mathcal{N}(0,AI_a^2) \). Random residual vector is \( e \) with \( e|\sigma_e^2 \sim M\mathcal{N}(0,I\sigma_e^2) \). The equation was solved with maximum likelihood estimator in R programming language [7].

3. Results and discussions

3.1. The effect of systematic factors on dam’s litter weight

In total, 2,378 data of litter weight. The result showed that dam breed also the season and year of birth gave a significant effect (\( p<0.05 \)) of litter weight (Table 1).

| Variable                  | Level   | N   | Mean ± sd       |
|---------------------------|---------|-----|-----------------|
| Dam Breed                 | Boer    | 273 | 4.97±1.59\(^a\) |
|                           | Jawarandu | 1346 | 4.07±1.36\(^b\) |
|                           | Boerja F1 | 759 | 4.03±1.22\(^b\) |
|                           |         | P Value | 2 x 10\(^{-16}\) |
| Season and year of birth  | Rainy 2012 | 246 | 4.08±1.42\(^{cd}\) |
|                           | Dry 2012    | 199 | 3.22±1.25\(^f\) |
|                           | Rainy 2013 | 477 | 3.86±1.23\(^{ce}\) |
|                           | Dry 2013     | 181 | 3.79±1.24\(^c\) |
|                           | Rainy 2014  | 530 | 4.66±1.37\(^a\) |
|                           | Dry 2014    | 324 | 4.51±1.30\(^{ab}\) |
|                           | Rainy 2015  | 334 | 4.29±1.33\(^{bc}\) |
|                           | Dry 2015    | 87  | 4.10±1.35\(^{cd}\) |
|                           | P Value     |     | 2 x 10\(^{-16}\) |

Note: Different superscripts show significantly different (\( p < 0.05 \)).

Based from the results, dam breed affects the litter weight of Boerja goats (Table 1). The highest to the lowest litter weights were obtained by Boer, Jawarandu and Boerja F1 breeds, respectively. Litter weight has two main components, which are litter size and birth weight. Boer has the highest litter weight, presumably because it is influenced by the high birth weight of Boer goats. Boer goats have a high genetic potential as meat producer; which expected to produce kids with high birth weights as well. Birth weight of the goat family is largely determined by the conformation and body size of the parents [8]. Boer goats have superior characteristics as meat goats because they have a high growth rate and body weight. The birth weight of Boer goats can reach 3-4 kg per head [9]. In addition, the high litter weight of Boer goats can also be influenced by the high litter size. Based on several research results, the litter size of Boer goats can reach 1.74±0.081 [10], 1.71±0.66 in Boer goats in Brazil [11], and 1.76±0.67 in Boer in China [12]. The high of litter size and birth weight of Boer goats can make the litter weight of Boer goat is highest.

The weight of litters with Jawarandu does were thought to be more influenced by litter size. Jawarandu goats are known to have superior reproductive characteristics with more than one kid in each birth [13]. The litter size of the Jawarandu goat can reach 1.81 [14]. Based on the results of the analysis, the litter weight of the goats with the Jawarandu does had a lower mean litter weight than the goats with the Boer does. This is because in terms of birth weight, the Jawarandu goat has a lower birth weight than the Boer goat. The crossbreed of Boerawa goats (F1) has a lower birth weight than Boer but higher than PE [15]. The litter weight of the goats with the Jawarandu and Boerja F1 goats based on the results of the analysis had a mean litter weight that was not significantly different. This is presumably because in terms of birth weight of goats with Jawarandu and Boerja F1 dams are also not much different [9].
Season and year of birth factor based on the results of the analysis showed that season and year of birth affects the litter weight of Boerja goats (Table 1). Kids born in the rainy season tend to have a high mean. The kidding season is related to rainfall and the effect of differences in air temperature. Rainfall will affect the quality of forage while differences in air temperature can affect the level of broodstock reproduction [16]. The dry season can decrease goat’s reproduction because goats are susceptible to heat stress so that it affects the decrease in body heat, decreased intake of forage to reduce heat production in the body. Decrease feed and water intake can interfere with fetal development and cause the fetus to become small which can ultimately increase prenatal mortality [17]. The ability of the dam goat to provide sufficient nutrients to the uterus influences the rate of fetal growth and subsequently birth weights. Environmental factors such as heat stress and maternal nutrient restriction decrease nutrient delivery to the uterus [18] and these environmental factors can decrease litter weight.

| Variable       | Residual variance | Individual variance |
|----------------|-------------------|---------------------|
| Litter weight  | 1.154±0.967       | 63.72%              |
|                | 0.657±0.130       | 36.28%              |

3.2. Variance component of dam’s litter size

Based on the result of observed variable (Table 2), individual variations contributed 36.28% of the overall components of the Boerja goat litter weight trait. Individual variation among the goat is caused by several factors, including genetic factors, environmental factors, and goat rearing management [19]. All systematic factors in this study including the dam breed also the season and year of birth have been corrected. Since the breeding does were reared under the same management, environment and feed; thus, aside from the systematic effects which had been corrected for, the only difference presumably due to genetic variations among the does. In the simple way, we could say that variation among does has large influence on the variation of litter weight. Litter weight has two main components, that is litter size and birth weight.

Variations in litter weight can occur because in the early stages of pregnancy ovulation and embryo death rates occur which cause differences in litter size [20]. Each individual has a different ovulation rate. Variations in different litter weights are also due to parental genetic variations that directly affect genetic regulation in terms of uterine nutrition and uterine capacity. Genetic variation in the uterus is three times higher than genetic variation directly from the fetus [21]. Uterine capacity is a limiting factor for litter weight. If there is more than one fetus in the womb (twins), then the prospective kid will be stunted due to having to squeeze in a narrow uterus due to the limited capacity of the uterus.

The increasing litter size will decrease the amount of food obtained by each fetus so that fetal growth will be disrupted [22]. The weight of kids from well-nourished goat dam decreased with supported birth weight, indicating that the decrease in birth weight was not only due to maternal nutritional factors [18]. The decrease in the rate of increase in litter weight with increasing litter size indicates that fetal growth increases with increasing litter size. Litter size can also reduce pre-natal growth due to variations in placental function that may limit the supply of nutrients from the dam so that the size of the placenta is small. If there are many placentas in one uterus, the blood flow in the uterine arteries can decrease so that the oxygen supply decreases [22], this affects prenatal growth which in turn can have an impact on waste weight.

4. Conclusions

This study shows that there is a wide variation of litter weight resulted due to variation between individual goat dam in CV. Kambing Burja, East Java, Indonesia. It is mirroring the diverse of boerja goat genetic, which still have a lot of possibility to be improved. Especially in goat dam’s selection for purpose of CV. Kambing Burja, careful selection and the application of genetic standard need to be
concerned in order to maximizing litter weight by considering its capability and limitation of dam goat reproductive capacity

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