Dam effect confirmation on weaning weight of Boer Goat crosses in Indonesia

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Abstract. This study aimed to confirm the present of dam effect on weaning weight trait of Boer goat crosses. A total of 1081 weaning weight records (standardized to 77 days) from 527 does and 16 bucks were analyzed. Data were derived from Boer, Boerja F1 (Boer ♂ × Jawarandu ♀), and Boerja F2 (Boer ♂ × Boerja F1 ♀). Two statistic models namely Model 1 and Model 2 were compared using F-test for overall significance. Model 1 is Analysis of Variance (ANOVA) which consist only fixed effect as factor, while Model 2 is mixed model which includes fixed effect as factor and dam as a random effect. The fixed effects in both models are buck, doe type, parity of the dam, sex of kid, birth type, and year of observation. Results showed that buck, doe type, sex, birth type, and observation year affect significantly (P<0.05) to weaning weight, while parity had no effect (P=0.53). Based on the model’s comparison, there was a significant difference (P<0.05) between Model 1 and Model 2. Therefore, it is confirmed the present of dam effect on the weaning weight trait of Boer goat crosses in the studied population.

1. Introduction

The livestock performance is influenced by genetics, environment, and the genetic and environmental interactions which are well known as genotype by environment [1]. Genetic are permanent hereditary factors from paternal and maternal, inherited started from fertilization. While environmental factors are opportunities to maximize the role of genetic factors. The offspring growth are influenced by both genetic and environment factors. In goats for example, the kid needs milk and maternal care, so its performance is determined not only by genetic potential of the dam but also by the maternal environmental effect (dam effect). Dam effect plays important role in birth and weaning weight which is often used as growth rate parameter [2]. Birth weight is influenced by the ability of the doe to provide good uterine environment during pregnancy, meanwhile weaning weight is manifested through the ability to produce milk and mothering ability [3]. In the study of genetic parameters, fixed effects, direct genetic effects, and maternal genetic effects are accounted as factors. Whereas the dam effect is important in the goat early growth, hence its effect needs to be included as random effect [4]. Eliminating this factor will cause a bias in the assessment of early growth genetic parameters, especially for high diversity doe populations, such as in unselected crossbred goats.

Crossbreeding is a way to improve livestock performance by crossing two genetically distant breeds. The crossbreeding program was intended to improve the performance of local breed or to combine of two breeds trait which bring out the heterosis effect in the resulted offspring by showing superior
The 1st International Conference on Livestock in Tropical Environment (ICLiTE-1)  
IOP Conf. Series: Earth and Environmental Science 902 (2021) 012001  
doi:10.1088/1755-1315/902/1/012001

performance compared to both parents. Backcross method in crossbreeding scheme can be performed to take maximum advantage of heterosis, therefore the optimal performance could be obtained [5]. However, in genetically unselected crossbred of goat with high level of diversity, the performance variation between individual offspring will be resulted.

Crossbreeding between Boer goat and Indonesian local goat (Jawarandu) resulting Boerja goat has been widely practiced to produce a meat-type goat that adaptable to the Indonesian environment [6,7]. Other cross scheme between Boer and Kacang goat produce offspring namely Boerka [8], and cross between Boer with Etawa goat to produce Boerawa [9]. Jawarandu itself is uncontrolled crossbred between Kacang and Etawa grade which is known to be prolific and adaptive to Indonesian environment [10]. To the date, there is no standard which regulates the crossbreeding of Boer goats with Indonesian local goats, therefore crossbreeding becomes irregular and high in diversity. Our previous study reported the dam effect on the birth weight of Boerja goat [11]. For that, in the current study was aimed to confirm the present of dam effect on weaning weight trait of the cross of Boer goat.

2. Materials and methods

A total of 5,735 data from 30 Boer bucks and 1,792 does were collected between time span January 2012 to June 2016. Data quality control was carried out to select data that had information of livestock identity, parental information, doe parity, sex, birth type, birth date, and weaning weight. Through quality control, 1,081 weaning weight records (standardized to 77 days) from 16 Boer bucks and 527 does were selected then analyzed in this study. The data were derived from Boer, Boerja F1 (Boer × Jawarandu), and Boerja F2 (Boer × Boerja F1) with parity 1, 2, and 3. The birth type was categorized as single and twin (≥2), where weaning weight was collected in 2013–2016. All the goats were kept in the same environment and management at CV. Kambing Burja, Indonesia.

Data were analyzed using two statistical models (Model 1 and Model 2), and a custom script written in the R programming language was employed. Model 1 is Analysis of Variance (ANOVA) which includes only fixed effect as a factor, while Model 2 is a mixed model which includes fixed effect as a factor and dam as a random effect. The fixed effects in both models are a buck, doe type, doe parity, sex, birth type, and observation year. The Mean Square Error (MSE) values of the two models were compared using F-test for overall significance [12] using alpha = 0.05 to evaluate the dam effect. Duncan Multiple Range Test (DMRT) then carried out to differentiate each fixed effects level.

The model used in this study was as follow:

\[
\text{Model 1 : } Y = \mu + \text{Buck} + \text{DT} + \text{Par} + \text{BT} + \text{Sex} + \text{Year} + e \\
\text{Model 2 : } Y = \mu + \text{Buck} + \text{DT} + \text{Par} + \text{BT} + \text{Sex} + \text{Year} + \text{Dam} + e
\]

where :

- \(Y\) = responses (weaning weight)
- \(\mu\) = general mean
- \(\text{Buck}\) = individual buck name (Adam, Brett, Cecil, Cecil Junior, Chata, Chata Junior, Chester Junior, Debonair, Ernie, Ernie Junior, Guardian, Guardian Junior, Rocky, Songstar, Terje and Winora)
- \(\text{DT}\) = doe type (Boer, Boerja F1 and Boerja F2)
- \(\text{Par}\) = doe parity (1, 2 dan 3)
- \(\text{BT}\) = birth type (single dan twin)
- \(\text{Sex}\) = kid sex (male, female)
- \(\text{Year}\) = observation year (2013, 2014, 2015 dan 2016)
- \(\text{Dam}\) = individual doe
- \(e\) = random error
3. Result and discussions

3.1. Fixed effect significance for weaning weight of Boer goat crosses

Results showed that buck, doe type, sex, birth type, and observation year significantly affect (P<0.05) weaning weight, while no significant effect (P=0.53, Table 1) for parity. Weaning weight in the present study is in agreement with the previous study on Boer × Spanish cross [13], heavier than Boer × Kacang [8] and Boer × Central Highland goats [14], but its lower than Boer × Etawa [9]. The differences in each fixed effect level were presented in Table 2.

| Fixed effect          | Mean ± sd  | P value* |
|-----------------------|------------|----------|
| Buck                  | 13.79 ± 1.70 | 7.71 x 10^{-08} |
| Doe type              | 14.11 ± 0.61 | 0.03     |
| Doe parity            | 14.36 ± 0.31 | 0.53     |
| Birth type            | 14.53 ± 1.29 | 3.71 x 10^{-12} |
| Sex                   | 14.68 ± 0.08 | 0.02     |
| Observation year      | 13.95 ± 1.25 | 9.59 x 10^{-07} |

*Significance at P < 0.05

Each buck in this study, produces offspring with different or vary of weaning weight. This indicates that the bucks have high variation. Males give a direct effect through direct genetic transmission to the offspring, even though there are environmental effect the genetic potential of weaning weight still depend on its parent. Moreover, we seen that bucks with using last name "Junior" are always produce lower weaning weights compared to the same name without junior (Table 2), although "Junior" may have the same genetic potential as his father, but still not optimal. Similar to the previous studies in Mubende goat showed that large bucks or older would produce higher offspring weaning weight than the small or young one [15,16].

The Boerja F1 doe produced significantly (P<0.05) higher of weaning weight than Boerja F2, while Boer is in between (Table 2). As the crossbreeding in this study is a backcrossing scheme, therefore resulted F1 has optimal effect of heterosis or hybrid vigor [5] compared to F2. In this study, Boerja F1 shows better performance though compared to Boerja F2 which has more Boer blood (75%), but at F2 the heterosis effect is no longer appears. Explained in the previous study [17], higher Boer breed percentage on crossbred increased frequency of allele which carry large bodyweight, however this decreased the value of heterozygosity and body weight.

Doe parity shows no effect to weaning weight. the result in this study is in agreement with previous report [14] on Boer and Central Highland cross. In contrast, Elieser et al [18] shows that the increasing of parity to a certain point can increase weaning weight, while the results from Hasan et al [19] shows a decline of weaning weight as parity increase. Based on the diverse result of this study, we suspect two possible explanations why the doe parity was not affecting weaning weight. First reason, according to the report of Zhang et al [20], weaning weight increase significantly at fourth parity while in our study the analyzed data was only available only up to third parity. Secondly, we suspect that the environment exerts a huge effect than doe parity, such as management. Parity represent doe maturity from the side of uterus which provide environment for fetal growth then could increase birth weight. However age and parity did not have additional effect on mothering ability which affected weaning weight.

Male kids were heavier than females and single kids were heavier than twins in weaning weight. This was not surprising because it was common in goats and sheep [13–15,20]. In terms of sexual size dimorphism, goats are categorized as endothermic animals which males are generally larger than females [21]. Single kids have higher weaning weight because there is no competition between kids both from gestation and milking [20]. Weaning weights also varied for each year of observation. Variations may be caused by different of rearing management, the amount of observational data, climate and
environmental conditions. This condition will affect to the performance of kids, bucks, and does, then to weaning weight.

### Table 2. Number of records (n), mean and standard deviation (sd) of kids weaning weight in various fixed effects

| Fixed effect          | n  | Mean ± sd          |
|-----------------------|----|--------------------|
|                       |    |                    |
| **Buck**              |    |                    |
| Adam                  | 80 | 15.56 ± 4.99<sup>a</sup> |
| Brett                 | 104| 14.33 ± 4.27<sup>ab</sup> |
| Cecil                 | 50 | 15.12 ± 4.19<sup>a</sup> |
| Cecil Junior          | 28 | 11.91 ± 3.86<sup>cd</sup> |
| Chata                 | 114| 13.71 ± 4.42<sup>abc</sup> |
| Chata Junior          | 16 | 10.41 ± 3.00<sup>bc</sup> |
| Chester Junior        | 17 | 13.76 ± 4.04<sup>abc</sup> |
| Debonair              | 123| 15.26 ± 4.42<sup>a</sup> |
| Ernie                 | 68 | 14.87 ± 4.88<sup>ab</sup> |
| Ernie Junior          | 20 | 12.73 ± 2.99<sup>bc</sup> |
| Guardian              | 126| 14.46 ± 4.16<sup>ab</sup> |
| Guardian Junior       | 13 | 9.89 ± 2.91<sup>c</sup> |
| Rocky                 | 102| 14.59 ± 4.77<sup>ab</sup> |
| Songstar              | 138| 14.34 ± 4.28<sup>ab</sup> |
| Terje                 | 59 | 14.64 ± 3.79<sup>ab</sup> |
| Winora                | 23 | 15.07 ± 3.66<sup>a</sup> |
| **Doe type**          |    |                    |
| Boer                  | 80 | 14.34 ± 4.11<sup>ab</sup> |
| Boerja F1             | 853| 14.57 ± 4.44<sup>a</sup> |
| Boerja F2             | 148| 13.42 ± 4.40<sup>b</sup> |
| **Doe parity**        |    |                    |
| 1                     | 642| 14.29 ± 4.57       |
| 2                     | 328| 14.69 ± 4.12       |
| 3                     | 111| 14.09 ± 4.37       |
| **Birth type**        |    |                    |
| Single                | 460| 15.44 ± 4.44<sup>a</sup> |
| Twin (≥2)             | 621| 13.62 ± 4.25<sup>b</sup> |
| **Sex**               |    |                    |
| Male                  | 541| 14.73 ± 4.61<sup>a</sup> |
| Female                | 540| 14.06 ± 4.20<sup>b</sup> |
| **Observation year**  |    |                    |
| 2013                  | 61 | 14.34 ± 5.14<sup>a</sup> |
| 2014                  | 364| 14.93 ± 4.51<sup>a</sup> |
| 2015                  | 565| 14.42 ± 4.35<sup>a</sup> |
| 2016                  | 91 | 12.11 ± 3.12<sup>b</sup> |
| **Total**             | 1081| 14.39 ± 4.42       |

<sup>abcde</sup> Different superscript in the same fixed effect showed significantly different (P<0.05)

#### 3.2. Dam effect confirmation

Based on the model’s comparison, there is a significant difference (P<0.05) between Model 1 and Model 2 (Table 3). According to that result, the present of dam effect is existed on the weaning weight trait of Boer goat crosses in the current studied population. Boerja is basically designed as meat-type goats that are adaptive to the Indonesian environment, which as a combination of Boer and Jawarandu traits.
However, the combined trait was obtained not only from the productivity trait but also from another trait. As a crossbred goat, it will have high heterozygosity, thus allowing a high variation when used as a parent. High variation in terms of milk production and mothering ability then causes a dam effect in this study. Milk production and mothering ability are important factors for female parents, to support their offspring growth which is a dam effect [3].

| Table 3. Statistical model’s comparison |
|----------------------------------------|
| Statistical model | Mean square error value |
|-------------------|-------------------------|
| Model 1           | 17.52                   |
| Model 2           | 16.19                   |
| P value*          | 0.04                    |

*Significant if P<0.05

Dam effect can be distinguished at the time of pre-natal and post-natal. At pre-natal, the ability of the doe to maintain the uterine environment is important to support the normal growth and birth of offspring. Therefore, nutrients balance must be sufficient for fetal growth and also divided for the growth and maintenance of the mother. Insufficient feed nutrition can be a problem, especially for young doe where the body condition is small and growth still going on. Meanwhile, at postnatal until kid weaning, represent the ability of the doe in terms of milk production and mothering ability for the growth of the offspring [2,4]. The dam effect has begun during the early stages of the offspring growth until weaning then begins to disappear as adults.

To conduct a study of early growth genetic parameters, it is necessary to use more appropriate model of genetic and environmental factors which contribute to performance. Fixed effects in statistical models usually include environmental factors that can be grouped, such as herd, year, and season. Dam effect needs to be a concern, especially in populations that have high level of diversity. Since growth characteristics of livestock have more complexity in estimating their genetic parameters, then its efficiency of selection based on genetic parameters will decrease if the dam effects are not included in the calculation.

4. Conclusion
The present of dam effect on the weaning weight trait of Boer goat crosses is confirmed in the current study. For that, we recommending to include dam effect as a random factor in the statistical model to examine factors affected to the offspring performance.

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