Genetic Evaluation and Selection Response of Birth Weight and Weaning Weight in Male Saburai Goats

(Evaluasi genetik dan respon seleksi bobot lahir dan bobot sapih pada kambing Saburai jantan)

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ABSTRAK. Penelitian ini bertujuan untuk mengestimasi parameter genetik (heritabilitas, korelasi genetik) dan nilai pemuliaan serta menggunakan parameter-parameter tersebut untuk mengestimasi respon seleksi dan respon seleksi sifat berkorelasi untuk bobot lahir dan bobot sapih kambing Saburai jantan. Data bobot lahir dan bobot sapih 90 cempe jantan kambing Saburai (data dari tahun 2017-2018) yang dihasilkan dari sembilan ekor pejantan dan 45 ekor induk digunakan dalam penelitian ini. Heritabilitas, korelasi genetik dan fenotipik diestimasi menggunakan data saudara tiri sebapak. Hasil penelitian menunjukkan bahwa nilai heritabilitas estimasi untuk bobot lahir dan bobot sapih adalah termasuk kategori sedang (masing-masing 0,30±0,08 dan 0,22±0,07). Korelasi genetik antara bobot lahir dan bobot sapih dikategorikan sebagai positif tinggi (0,42±0,06), sedangkan korelasi fenotip antara kedua sifat ini adalah 0,10 (rendah) dan korelasi lingkungan 0,56 (tinggi). Respon seleksi meningkat dengan meningkatnya intensitas seleksi, berkisar antara 0,11 kg sampai 0,28 kg untuk bobot lahir dan antara 0,60 kg sampai 1,54 kg untuk bobot sapih, pada proporsi seleksi antara 50% sampai 5%. Respon seleksi sifat-sifat berkorelasi yang diharapkan terhadap seleksi bobot lahir secara langsung berdampak pada bobot sapih berkisar antara 0,29 kg hingga 0,75 kg pada proporsi seleksi 50% sampai 5%. Heritabilitas sedang dan korelasi genetik yang positif antara bobot lahir dan bobot sapih menunjukkan bahwa seleksi untuk salah satu dari dua sifat ini bisa berhasil dan peningkatan bobot lahir akan meningkatkan bobot sapih kambing Saburai jantan juga. Seleksi tidak langsung yaitu seleksi bobot lahir akan berdampak pada respon seleksi bobot sapih yang lebih rendah dibandingkan dengan seleksi langsung terhadap bobot sapih.

Kata kunci: bobot lahir, bobot sapih, kambing Saburai, parameter genetik, respon seleksi

ABSTRACT. This research aimed to estimate genetic parameters (heritability, genetic correlation) and breeding value and used these parameters to estimate selection responses and correlated response to selection of birth and weaning weight of male Saburai goats. Data of birth and weaning weight of ninety male Saburai kids (2017-2018) generated from nine bucks and 45 does were used in this study. Heritability, genetic and phenotypic correlation were estimated using paternal half-sib data. The results showed that heritability estimates for birth and weaning weight were moderate category (0.30±0.08 and 0.22±0.07, respectively). Genetic correlation between birth and weaning weight was categorized as a high positive value (0.42±0.06), while phenotype correlations between the two traits were 0.10 (low), and environmental correlations were 0.56 (high). Responses to selection increased with increasing selection intensity ranging from 0.11 kg to 0.28 kg and 0.60 kg to 1.54 kg for birth and weaning weight, respectively, at 50% to 5% selection proportion. The response of the selection of correlated traits expected to direct birth weight selection impacted on weaning weight ranged from 0.29 kg to 0.75 kg at a selection proportion of 50% to 5%. The moderate heritability and positive genetic correlation between birth and weaning weight suggested that selection for any of these two traits should be successful and improving birth weight will improve the weaning weight of male Saburai goats as well. However, indirect selection (birth weight selection) will impact on the lower response for weaning weight compared to direct selection for weaning weight.

Keywords: birth weight, genetic parameters, Saburai goat, selection response, weaning weight

INTRODUCTION

Goats (*Capra hircus*) are important for rural farming communities, because of their multifunctional use, namely as savings that can be sold at any time they need. In addition, the resulting output is higher than the input issued by farmers, and easy to maintain with limited living space because of its small in size.

Saburai goat is new type composite goat in Lampung Province, which is formed from grading-up between female Ettawa Grade goat and male Boer goat with composition of 25% Ettawa grade goat and 75% Boer goat. Population of Saburai goat in 2018 was 3,293 heads (Sulastri et al., 2019). Saburai goat is one of the important types of goat in Lampung Province and its genetic potential has not been explored much. One of the way to improve genetic merit and productivity of Saburai goat is by performing selection programs. Selection program will be successful if variation of goat performance is medium to high and this variation of a trait can be utilized to increase the trait productivity using the selection programs. The high variation of Saburai goat performance in

a population can be caused by variation of genetic and environmental factors.

The potential for genetic enhancement of a trait is highly dependent on the genetic variation of the trait and its relationship with other traits. Genetic correlation provides information of genes that influence one trait also influence other traits, so that the effectiveness of selection and genetic progress can be measured when selection is made for more than one trait. Genetic correlation between two traits is desirable when evaluating the selection response of the correlated traits.

Knowledge on genetic parameters including heritability, genetic and phenotypic correlations are important for selection programs especially for correlated traits (Hardjosubroto, 1994; Sulastri et al., 2019). The estimates of heritability and genetic correlation between traits are helpful in determining the selection program to predict direct and correlated response to selection for future improvement of the traits (Jared et al., 2004). Kuthu et al. (2017) reported that there was a positive correlation between birth weight and weaning weight in Teddy goat in Pakistan, which is expected that selection program for birth weight will increase weaning weight of the goat.

Genetic evaluation and selection response for birth weight and weaning weight in Saburai goat have not been estimated. The current study was therefore conducted to estimate genetic parameters of birth and weaning weight and used these parameters to evaluate selection response and correlated response to selection for these two traits of Saburai goat.

MATERIALS AND METHODS

This research was conducted in Sumberejo district, one of the Saburai goat breeding center in Tanggamus regency, Lampung province using data recording of Saburai goat from 2017-2018. Birth weight and weaning weight (3 months of age) data of ninety male Saburai kid generated from nine bucks and 45 dams were used in this study. Data of birth weight and weaning weight were adjusted to single birth type and adult age of dam. The descriptive of birth weight and weaning weight data is shown in Figure 1.

Co(variance) components were estimated using paternal half-sib and genetic and phenotypic correlation were calculated using formulae suggested by Becker (1992), Hardjosubroto (1994), Sulastri et al. (2019), and Falconer & Mackay (1996) as shown in Table 1 and Table 2.
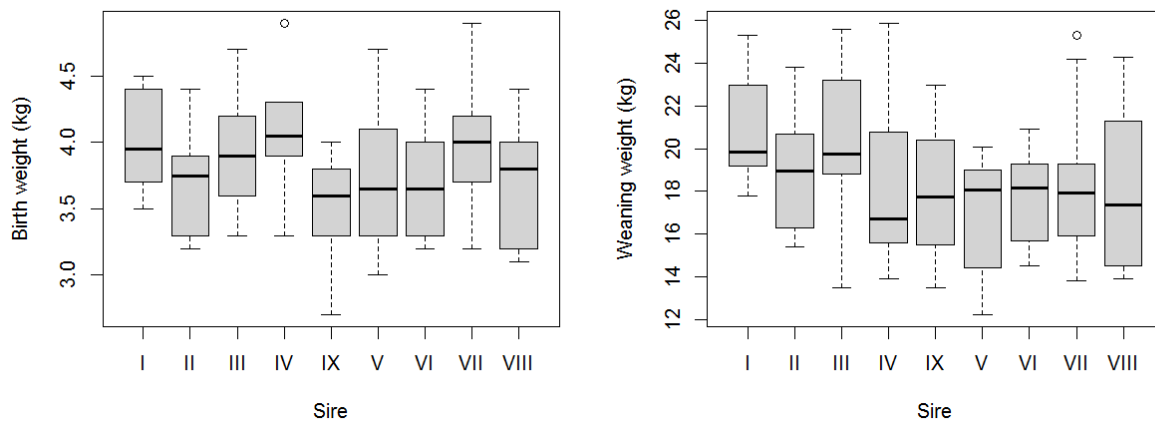

Figure 1. Boxplot of birth weight and weaning weight data of nine sires

Table 1. Analysis of variance of birth weight (X) and weaning weight (Y)

Source of variance	Degree of freedom	SS	MS	EMS
Sire	S - 1	SS_S	MS_S	$\sigma^2_w + k\ \sigma^2_S$
Progeny within sire	S(n-1)	SS_W	MS_W	σ^2_w
Total	Sn-1	SS_T		

Note: S = number of sire, n = k = number of progeny of each sire, SS = sum square, MS = mean square, EMS = Expected MS, σ^2_S = variance of sires, σ^2_w = variance of within sires.

k = (1/(S-1))(n. – ni^2/n.) with S is number of sire; n. is number of data; ni is number of progeny for each sire

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Table 2. Analysis of covariance (XY)

Source of covariance	Degree of freedom	SCP	MCP	EMCP
Sire	S - 1	SCP_S	MCP_S	$Cov_W + k\, Cov_S$
Progeny within sire	S(n-1)	SCP_W	MCP_W	Cov_W
Total	Sn-1	SCP_T		

Note: S = number of sire, n = k = number of progeny of each sire, SCP = sum cross product, MCP = mean cross product, EMCP = Expected MCP, Cov_S = covariance of sires, Cov_W = covariance of within sires. k = (1/(S-1))(n. – ni^2/n.) with S is number of sire; n. is number of data; ni is number of progeny for each sire

Based on the result of analysis of variance and covariance shown in Table 1 and Table 2, the heritability of birth and weaning weight, genetic, phenotypic, and environmental correlation between birth weight and weaning weight of Saburai goat were calculated as follows.

Heritability ($h^2 = 4t$), where t was calculated as follows:

$$t = \frac{(\sigma_s^2)}{(\sigma_w^2 + \sigma_s^2)}$$

with standard error as follows:

$$S.E.\,(h^2) = 4\sqrt{\frac{2(1-t)^2.\{1+(k-1)t\}^2}{k\,(k-1)\,(s-1)}}$$

Estimated breeding value (EBV) was calculated as follows:

$$EBV = h^2.\,(P - \bar{P})$$

Where
h^2 = heritability estimate for birth weight or weaning weight
P = kid birth or weaning weight
$\bar{P}$ = average of birth or weaning weight

Genetic correlation (r_G) between birth weight (x) and weaning weight (y):

$$r_G = \frac{4(Cov_s)}{\sqrt{4\sigma_{s(x)}^2 . 4\sigma_{s(y)}^2}}$$

with standard error as follows:

$$S.E.\,(r_G) = \frac{1-r_G^2}{\sqrt{2}}\sqrt{\frac{S.E.\,(h_1^2).\,S.E.\,(h_2^2)}{h_1^2.\,h_2^2}}$$

S.E. (h_1^2) and S.E. (h_2^2) are standard error for heritability of birth weight and weaning weight, respectively.

Environmental correlation (r_E):

$$r_E = \frac{Cov_W + Cov_s}{\sqrt{\{\sigma_{w(x)}^2 - 3\sigma_{s(x)}^2\}\{\sigma_{w(y)}^2 - 3\sigma_{s(y)}^2\}}}$$

Phenotypic correlation (r_P) :

$$r_p = \frac{Cov_W + Cov_s}{\sqrt{\{\sigma_{w(x)}^2 + \sigma_{s(x)}^2\}\{\sigma_{w(y)}^2 + \sigma_{s(y)}^2\}}}$$

Response to selection was calculated as follows:

$$R = i.h^2.\sigma_p$$

Where
R = selection response,
i = selection intensity,
h^2 = heritability estimate for birth weight or weaning weight
σ_p = Standard deviation of birth or weaning weight.

Correlated response to selection was calculated as follows:

$$CR_x = i.h_x.h_y.r_G.\sigma_y$$

Where
CR_x = correlated response obtained by trait y (weaning weight) due to the selection of trait x (birth weight)
i = selection intensity
h_x = accuracy of selection for birth weight
h_y = accuracy of selection for weaning weight
r_G = Genetic correlation between birth weight and weaning weight
σ_y = Standard deviation for weaning weight.

Selection intensity can be calculated as follows.

In R : intensity = dnorm(qnorm(1-p))/p

In Excel: = NORMDIST(NORMSINV(1-p) ,0,1,0)/p
where p is selection proportion

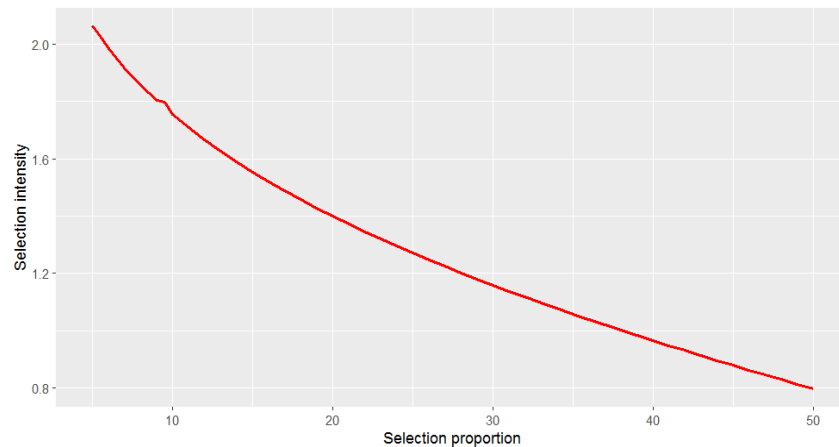Selection intensity with selection proportion from 5-50% (0.05-0.50) can be seen in Figure 2.

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Figure 2. Selection intensity with selection proportion

RESULTS AND DISCUSSION

Birth Weight and Weaning Weight of Saburai Goat

The results of this research showed that the birth weight and weaning weight of Saburai goat were 3.81 ± 0.46 kg and 18.85±4.28 kg, respectively. Birth weight and weaning weight of Saburai goat of this study were higher than those reported by Pratama et al. (2020) that birth weight of Saburai goat in Pesawaran regency at the first and second parity were 3.09 ± 0.42 kg and 3.28 ± 0.54 kg, respectively, while the weaning weight at the first and second parity were 17.20 ± 1.69 kg and 17.36 ± 2.24 kg, respectively. The result of this study was also higher than that reported by Adhianto et al. (2016) which birth weight of Saburai goat in Gisting and Sumberejo district were 3.42 ± 0.28 kg and 3.48 ± 0.41 kg, respectively. The different results might be influenced by several factors such as genetics and environment. According to Mahmalia et al. (2010), Bharathidhasan et al. (2009), Dakhlan et al. (2019), Anggraeni et al. (2020), Vázquez-Armijo et al. (2021), and Tesema et al. (2021) that differences in birth weight of kid in the same breed are influenced by birth type, season, maintenance management, differences in male genetic potential, and environmental conditions.

Parental genetics also affect the genetics of the offspring, a good sire when mated with a good dam will produce good offspring. Apart from genetic factors, birth weight is also influenced by the dam factor during pregnancy, adequate nutrition will meet the living needs of the mother and will also meet the growing needs of the kid during pregnancy. According to Kaunang et al. (2013) and Rout et al. (2018), birth weight is influenced by the genetic quality of sires. Sires that have high genetic potential in production

traits are expected to produce young goats with high birth weight as well.

A good birth weight will affect the weaning weight, this is due to the higher percentage of kid going through the growth period after birth. According to Gunawan & Noor (2006) and Hyera et al. (2018), kid with high birth weights (above the average of birth weight), generally will have a higher ability to live through a critical period, have fast growth and will have a higher weaning weight.

The results of this study indicated that the Saburai goat weaning weight was 18.85 ± 4.28 kg. The results obtained from this study (18.85 ± 4.28 kg) showed a higher weaning weight compared to the results of the study reported by Adhianto et al. (2016), namely 16.85 + 2.58 kg and research by Pratama et al. (2020), namely 17.36 ± 2.24 kg. The increase in the average value of the weaning weight could be influenced by the improvement of the genetic quality of the saburai goats in Sumberejo district, because some studies have been conducted to improve the genetic quality of the saburai goats. The results can be felt currently with the continuing improvement of the genetic quality of the Saburai goat. Factors that also influence the high weaning weight of the Saburai goat were environmental factors, for example feedstuff. The availability of feedstuff during maintenance greatly affects the weaning weight of goat.

Heritability Estimates of Birth Weight and Weaning Weight

The results showed that heritability estimates for birth weight and weaning weight of Saburai goat were 0.30±0.08 and 0.22±0.07, respectively. This moderate heritability of birth and weaning weight of Saburai goat kids indicated

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enough contribution of additive genetic variance and possibility for improving body weight of these goats with selection program although environmental factors still have more influence on birth weight and weaning of the goat. Heritability estimates for birth weight and weaning weight of Saburai goat observed in current study were higher than those reported by Baneh et al. (2012) that heritability estimates for birth and weaning weight of Naeini goats were 0.25±0.05 and 0.07±0.06, respectively. However, the result of present study were lower than those reported by those reported by Dakhlan & Sulastri (2006) that heritability estimates for birth and weaning weight of Boerawa goat (Boer x Ettawa Grade goat) were 0.327±0.036 and 0.255±0.112, respectively, Beyleto et al. (2010) in Boerawa goat with heritability estimates for birth and weaning weight were 0.80±0.40 and 0.30±0.17, respectively, and those reported by Bhattarai et al. (2017) that heritability estimates for birth and weaning weight of Khari goats were 0.37±0.12 and 0.42±0.13, respectively.

Genetic and Phenotypic Correlation between Birth Weight and Weaning Weight

The results of this study showed that the genetic correlation between birth weight and weaning weight of male saburai goats was 0.42 ± 0.06, the phenotypic correlation was 0.10 and the environmental correlation was 0.56. These results indicated that birth weight of male saburai goats has positive genetic, phenotypic and environmental correlation with weaning weight. The genetic and environmental correlation between birth weight and weaning weight were categorized as high positive correlation according to Warwick et al. (1990), while the phenotypic correlation was in the low category (0.1).

This high positive genetic correlation shows that improving the birth weight will improve the weaning weight of the Saburai goat. The value of genetic correlation between birth weight and weaning weight was in high category meaning that the higher the birth weight, the higher the weaning weight of the Saburai goat. The magnitude of genetic correlation between birth weight and weaning weight might be influenced by several factors such as genetic co(variance) of the two traits.

The phenotypic correlation between birth weight and weaning weight of male Saburai goats is categorized as low positive correlation (Warwick et al., 1990), meaning that when one trait (birth weight) increases then other trait

(weaning weight) also increase with low increase. Phenotype correlation is the total correlation of all traits possessed by livestock. It can also be interpreted as a correlation which is divided into genetic and environmental correlations. Phenotypic correlation value is useful for estimating the magnitude of productivity changes in the future so that it can be used to carry out a proper breeding system. According to Hardjosubroto (1994), the phenotypic correlation between growth performance is lower than the genetic correlation due to environmental influences that affect the phenotype of livestock.

Environmental correlation is a non-genetic correlation between two traits analyzed. The environmental correlation between birth weight and weaning weight was 0.56 which is high positive category. The environment is a factor that greatly affects livestock growth. For example, cleanliness of pen will affect the health of livestock. Environmental factors such as feedstuff is a factor that greatly influences the growth of livestock, if the feed given is not good enough, it will cause the livestock to release its potential less optimally. Conversely, if the feed given is good, it will maximize the potential of the livestock.

The result of genetic correlation of present study was similar to the result reported by Hamdani et al. (2020) that genetic correlation between birth weight and weaning weight of Saburai goat was 0.37. This little different of the genetic correlation was maybe because of different method applied of which the previous research used parent-offspring correlation, while in this current study used paternal half sib correlation. The genetic, phenotypic and environmental correlations estimates between birth weight and weaning weight of current study was also similar with the result reported by Kuthu et al. (2017) that genetic, phenotypic and environmental correlations estimates between birth weight and weaning weight of Teddy goat in Pakistan were 0.61, 0.20 and 0.19, respectively. This high genetic correlation indicated that between the two traits both of current and previous study are affected by similar genes meaning that higher birth weight selection will improve higher weaning weight because of correlated response. Similarly the environmental and phenotypic correlation between the two traits showed positive correlation between the traits.

Breeding Value and Response to Selection

Summary statistics of estimated breeding value (EBV) of birth and weaning weight are

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presented in Table 1 and Figure 3. It can be seen from Table 1 that variation of EBV both for birth and weaning weight was quite high. There were 45 kids with EBV based on birth weight higher than the average EBV (0.00, blue line in Figure 3)

and there were 23 kids with top 25% EBV (green line in Figure 3), while for weaning weight there were 46 kids with EBV higher than the average EBV (0.00) and there were 23 kids with top 25% EBV.

Table 1. Summary of estimated breeding value of birth and weaning weight of Saburai goat

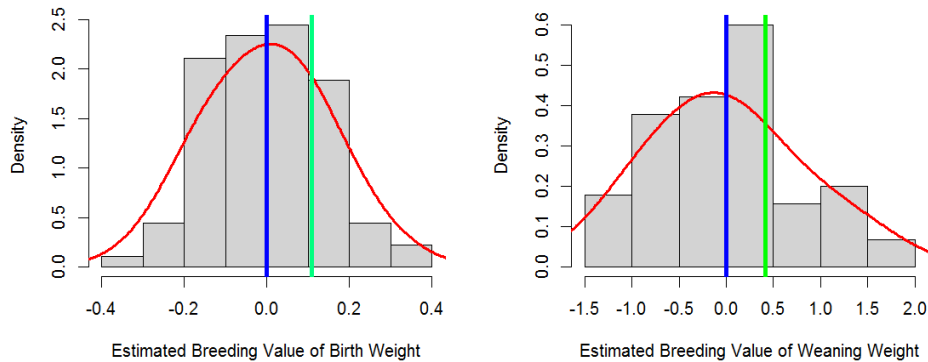| Traits	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Birth weight	-0.33019	-0.12175	0.01224	0	0.10902	0.3249
Weaning weight	-1.42915	-0.60079	0.02743	0	0.41103	1.61743

Figure 3. Histogram of estimated breeding value of birth and weaning weight of Saburai goat

This result indicated that selection program can be applied with quite high success because of high variation of EBV and moderate heritability estimate (0.30±0.08 and 0.22±0.07, respectively, for birth and weaning weight). In addition, selection program can be started from kid birth

weight selection because of positive genetic correlation between birth and weaning weight (0.42 ± 0.06) meaning that improving birth weight will impact on the increase of weaning weight simultaneously.
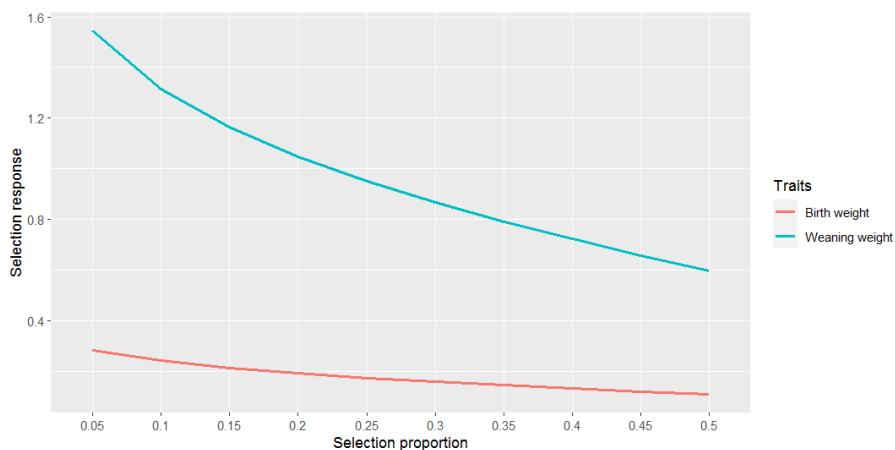

Figure 4. Response to selection of birth and weaning weight of Saburai goat with selection proportion from 5% to 50%

Response to selection of birth and weaning weight with selection proportion from 5% to 50% are shown in Figure 4. Response to selection of birth and weaning weight were increase with increasing selection intensity ranged from 0.11 kg to 0.28 kg and 0.60 kg to 1.54 kg for birth and

weaning weight, respectively, at 50% to 5% selection proportion or from the lowest to the highest selection intensity in this study. On the other hand, the estimated expected correlated response to selection for weaning weight (Figure 5) by directly selecting first for birth weight

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