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Original Article

Genetic parameter estimates for weaning weight and Kleiber ratio in goats

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Abstract

The research was conducted to evaluate the factors affecting on weaning weight (WW) and Kleiber ratio (KR) and to estimate genetic parameters for two traits in goats. The fixed factors affecting both traits indicated that year-season of birth, sex, birth type and regression of the Thai Native (TN), Boer (BO) and Saanen (SA) influenced on WW and KR ($P<0.05$). Males in this population were heavier ($P<0.05$) than females. Weaning weights and KR of single kid were significantly higher ($P<0.05$) than other birth rearing types. Bivariate analysis of three models (Model 1: without maternal genetic effect, Model 2: with maternal genetic effect and $\sigma_{am} = 0$, and Model 3: with maternal genetic effect and $\sigma_{am} \neq 0$) were used to estimate genetic parameters for this research. Estimated direct heritabilities from all models were 0.26 to 0.38 for WW, and 0.22 to 0.35 for KR. Estimated maternal heritabilities from Model 2 and 3 were 0.09 and 0.12 for WW and 0.08 and 0.11 for KR, respectively. The direct genetic and phenotypic correlations between WW and KR were positive and moderate values. Maternal genetic correlations between them were positive and of low values. An antagonistic direct-maternal correlations from Model 3 within traits and between traits indicated that offspring of does with superior maternal abilities probably may provide an inferior direct genetic effect in the same trait and between traits. It was therefore possible to rapidly improve WW and KR in this goat population through selection, while the adverse effects of direct-maternal correlation within and between traits should be considered. The best fit model would be a model including maternal genetic effect without a direct-maternal genetic covariance.

Keywords: genetic parameters, Thai goat, Kleiber ratio, weaning weight

1. Introduction

In Thailand, meat goat production is characterized as non-traditional alternative agricultural enterprise. The meat goat production is an emerging class of livestock offering southern Thai farmers an on-farm income. Major determinants of profitability in meat goat enterprise are the growth traits. Weight and daily gain are important components influencing the profitability of goat and they are the two essential objectives in selection strategies. Growth in live weight reflects the genes an animal has inherited from its parents, such as direct and maternal genetic effects. Moreover, a mix of seasonal and husbandry factors peculiar have been influenced on a production system or farm (Lewis and Beatson, 1999). As a part of phenotypic variance of growth trait is heritable. Genetic improvement in this trait through selection programs would be possible.

Promoting the growth potential of small ruminant animal is a possible alternative to increase meat production and improving breeding efficiency in any breeding enterprise (Miraei-Ashtiani *et al.*, 2007). In any selection program aimed at increasing growth performance in order to achieve maximum output, improving weaning weight (WW) is necessary. This is possible by including a trait such as Kleiber ratio (KR) in selection programs. Unlike the case of animal in feedlots, it is virtually impossible to determine feed intake of grazing goats. The relation of growth rate to metabolic weight or KR was developed as an alternative ratio to address this problem

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in rangeland animals (Arthur *et al.*, 2001). Kleiber ratio defined as growth rate divided by body mass$^{0.75}$. This ratio as an indication of efficiency of feed conversion is useful because it does not require individual intake to be measured and allows classify animals with high efficiency of growth relative to body size (Kleiber, 1947). Moreover, Köster *et al.* (1994) suggested that KR was a useful indicator of growth efficiency and an important selection criterion for efficiency of growth. Arthur *et al.* (2001) found a strong correlation between KR and feed conversion ratio in bull (-0.81). In addition, one way to increase this efficiency is the selection of animals with respect to efficiency of feed utilization. Since individual animal differs in their ability to efficiently utilize feed, selecting the most efficient animals result in a significantly lower production cost (Ghafouri-Kesbi *et al.*, 2011). Although direct selection for lower maintenance requirements is difficult, KR allows identifying efficient animals (Kleiber, 1947). Scholtz *et al.* (1990) supported that the KR could be used as an indirect selection parameter for feed conversion. Animals that have a high KR are considered efficient users of feed (Ghafouri-Kesbi *et al.*, 2011). Also, knowledge of genetic parameters such as heritability and genetic correlations between traits are required to construct efficient selection indexes to make genetic improvement in growth via a selection program.

Animals in the studied consisted of purebred and several kinds of crossbred. Moreover, not only purebreds but also crossbreds were selected as parents of the next generation. Characteristics of this population had similarities with commercial goat production. Due to the paucity of reliable information regarding (co)variance components for direct and maternal genetic effects of WW and KR and also given the fact that such estimates are vital for designing optimal selection programs. The present study was carried out to estimate genetic and phenotypic parameters for these decisive traits, attempting to separate direct and maternal genetic effects.

2. Materials and Methods

2.1 Data structure

Data for this research consisted of 1,623 records. Purebred and crossbred animals were born during 2005 through 2008 at a commercial farm in southern Thailand. Animals in this evaluation were composed of several types of breed groups. The goat population had four major breed compositions: Thai native (TN), Anglo-Nubian (AN), Boer (BO), and Saanen (SA). SA breed was applied in goat crossbreeding strategies for improve dam's milk yield and milk quality that could be influenced on WW. The purpose of this farm is to produce goats for meat. Both purebreds and crossbreds were selected as parents of the next generation. The investigated traits were WW and KR. The age at weaning of goats ranged from 150 to 155 days while KR was calculated as a ratio of ADG to metabolic weight at weaning (WW$^{0.75}$). Feeding and management including climate and type of roughage for this population was described by Supakorn and Pralomkarn (2009). All kids were vaccinated against other diseases and also were drenched to control internal and external parasites that were certified by Department of Livestock Development (DLD), Thailand. Details of data structures for the goat population are show in Table 1.

Table 1. Description of data structure.

	WW (kg)	KR
No. recordMaleFemale	1,623791832	1,623791832
Mean±SD	13.37±3.84	10.26±1.31
Range	3.00 to 27.50	3.58 to 13.61
CV (%)	28.72	12.76
No. of sires	35	35
No. of dams	563	563

WW = weaning weight and KR = Kleiber ratio

2.2 Estimation of (co)variances

Fixed effects were year-season of birth, birth type, sex, and regression of TN, AN, BO, and SA breed fractions. Seasons were considered and tested for significant difference in relative humidity, temperature, and quantity of rainfall in each month from the Thai Meteorological Department (2010). Birth type was composed of single, twins, triplets and quadruplets. Sex was male and female.

Direct and maternal genetic effects were set as random effects into the bivariate animal model. The maternal genetic effect was included in this model because this effect represented mainly the dam's milk production and mothering ability, although effects of the uterine environment and extra-chromosomal inheritance may contribute (Meyer, 1992). Twenty-five and 70% of goats were selected as sires and dams, respectively. Nevertheless, models with maternal permanent environmental effects, which were with and without direct and maternal genetic covariances were close to zero from the preliminary univariate analysis. Therefore, maternal permanent environmental effects were not included in the bivariate animal model.

The model is detailed as follows:

Model 1 : $y = X\beta + Z_1a + e$

Model 2 : $y = X\beta + Z_1a + Z_2m + e$ with $\mathrm{cov}(a,m) = 0$

Model 3 : $y = X\beta + Z_1a + Z_2m + e$ with $\mathrm{cov}(a,m) \neq 0$

The X, Z_1, and Z_2 were design matrices relating records of fixed, direct and maternal genetic effects, respectively. The symbols β, a, m, and e were the vectors of fixed, direct and maternal genetic effects, and residual effects for each individual, respectively. The first and second moments for above model were assumed as follows:

$$E\begin{bmatrix} y_{WW} \\ y_{KR} \end{bmatrix} = \begin{bmatrix} X\beta_{WW} \\ X\beta_{KR} \end{bmatrix}, \quad V\begin{bmatrix} a_{WW} \\ a_{KR} \\ m_{WW} \\ m_{KR} \\ e_{WW} \\ e_{KR} \end{bmatrix} = \begin{bmatrix} A\sigma^2_{a_{WW}} & A\sigma_{a_{WW}a_{KR}} & A\sigma_{a_{WW}m_{WW}} & A\sigma_{a_{WW}m_{KR}} & 0 & 0 \\ A\sigma_{a_{WW}a_{KR}} & A\sigma^2_{a_{KR}} & A\sigma_{a_{KR}m_{WW}} & A\sigma_{a_{KR}m_{KR}} & 0 & 0 \\ A\sigma_{a_{WW}m_{WW}} & A\sigma_{a_{KR}m_{WW}} & A\sigma^2_{m_{WW}} & A\sigma_{m_{WW}m_{KR}} & 0 & 0 \\ A\sigma_{a_{WW}m_{KR}} & A\sigma_{a_{KR}m_{KR}} & A\sigma_{m_{WW}m_{KR}} & A\sigma^2_{m_{KR}} & 0 & 0 \\ 0 & 0 & 0 & 0 & I\sigma^2_{e_{WW}} & I\sigma_{e_{WW}e_{KR}} \\ 0 & 0 & 0 & 0 & I\sigma_{e_{WW}e_{KR}} & I\sigma^2_{e_{KR}} \end{bmatrix}$$

It was assumed that direct, maternal genetic effects and residual effects were normal distributed with mean zero and variance $V(a) = A\sigma^2_a$, $V(m) = A\sigma^2_m$ and $V(e) = I_n\sigma^2_e$ where I_n was identity matrix of order equal to the number of records. The σ^2_a, σ^2_m and σ^2_e were direct genetic variance, maternal genetic variance and residual variance, respectively. The A represented a numerator relationship matrix that obtained from pedigree structure. Finally, σ_{am} was the covariance between direct and maternal genetic effects.

Covariance components were estimated by restriction maximum likelihood (REML) using the average information (AI) and fitting an animal model throughout using ASREML software (Gilmour *et al.*, 2001). The information or prior values for the estimation of the (co)variance in bivariate analysis values were those from univariate analysis of the same data set. The information criterion was computed to rank the models according to their power to fit the data. The most suitable model among three models was determined based on likelihood ratio tests for each trait (Meyer, 1992). Likelihood ratio was defined as $-2\log L_i$ which $\log L_i$ was the maximized log likelihood of model i at convergence. It was received from an animal model throughout using ASREML software (Gilmour *et al.*, 2001). A model with the lowest -2logL was chosen as the most appropriate model.

3. Results and Discussion

3.1 Least square means and standard error of fixed effects for WW and KR in goat

Least square means of year-season of birth, sex and birth type for WW and KR are presented in Table 2. These fixed effects were an important environmental source of variation. Overall means and standard deviation for both traits were 13.37±3.84 kg and 10.26±1.31 kg. The overall mean for WW was lower than Akkahart *et al.* (2011) who reported 16.05±0.06 kg for this trait at Chaiyaphum Livestock Research and Testing Station in Thailand. Weaned kids from multiparous dams were significantly higher WW than those of primiparous dams, probably because the maternal performance of mutiparous goats is high (Mourad, 1994). The result indicated that WW and KR of males were always higher and grew faster than females ($P<0.05$). Sex differences increased with growth rate indicating that males are more responsive to improvements in the environment and may be due to a higher birth weight compared with females (Hopkins, 1970; Amoah *et al.*, 1996). The levels of advantages of males recorded in this study are comparable to those reported for goat breeds (Blackburn and Field, 1990; Warmington and Kirton, 1990; Portolano *et al.*, 2002; Sangworakhan and Intachinda, 2006; Akkahart *et al.*, 2011). WW and KR of single kids were significantly heavier than the others ($P<0.05$). Similarity, Singh (1973) stated that the growth rate of a single kid in India was significantly better than twins and triplets ($P<0.01$). Portolano *et al.* (2002) confirmed that single kids were heavier compared with twins and twins compared with triplets because body weight traits were significantly affected by the kid's maternal litter size. In fact, maternal ability such as milk yield and its composition including milking ability could influence on these traits. Kids born in rainy season tended to be heavier at weaning than their counterparts from the summer except in 2007. The effect of season may be explained partly by the climatic conditions and epidemics in the periods. Important influence of season on kid live weights reported in several breeds (Malik *et al.*, 1986; Warmington and Kirton, 1990; Gebrelul *et al.*, 1994). Finally, regression of TN, BO and SA breed fractions were significant except for the regression of the AN breed fraction. However, this regression was taken into account for the estimation of genetic parameters because they probably could reduce some random errors.

3.2 Variance components and genetic parameters for WW and KR in goat

Models with maternal and maternal permanent environmental effects, which were with and without direct-maternal covariances, were considered in this study. Unfortunately,

Table 2. Least square means (±SE) of fixed effects for weaning weight (WW) and Kleiber ratio (KR).

Fixed effects	Traits	
	WW (kg)	KR
Year-season of birth	**	*
S2005	12.41±3.42^{a}	10.21±1.23^{ab}
R2005	14.09±2.99^{b}	10.45±1.24^{a}
S2006	13.97±4.28^{ab}	10.39±1.23^{a}
R2006	15.50±2.14^{b}	10.24±1.10^{ab}
S2007	14.60±4.21^{b}	10.47±1.31^{a}
R2007	13.14±3.50^{a}	10.26±1.28^{ab}
S2008	13.06±3.71^{a}	10.11±1.17^{b}
Sex	**	*
Male	14.10±0.93^{a}	10.43±1.30^{a}
Female	12.68±0.61^{b}	10.03±1.29^{b}
Birth Type	**	*
Single	15.04±0.84^{a}	10.99±0.90^{a}
Twins	12.33±0.45^{b}	10.72±1.12^{b}
Triplets	11.45±0.89^{b}	10.20±1.09^{b}
Quadruplets	12.75±0.35^{b}	9.97±1.34^{c}

S = summer and R = rainy season, * =$P<0.05$ and ** $P<0.01$, ^{a} and ^{b} within the same column values marked with the different letter are significantly different at $P < 0.05$.

maternal permanent environmental effect from model with only direct genetic effect was close to zero from the univariate analysis. The estimate of maternal permanent variance in this study from models with direct and maternal effects did not converge. It was shown that the models and maternal permanent environment effect were not fit with this data structure. In contrast with Mohammadi *et al.* (2010) who reported that maternal permanent environment effect influenced on KR in sheep and the variance of this effect was 0.24.

Estimates of variance components and heritabilities obtained from bivariate analysis based on three appropriate models and -2log likelihood values for the different models on both traits are presented in Table 3. The random residual variances of both traits were 55% to 65% for WW and 63% to 69% for KR, respectively, when compared with phenotypic variances. The maternal variances of WW and KR were 8% to 12%, respectively, when compared with total genetic variances. The direct additive variances (σ^2_a) and direct heritabilities (h^2_a) were larger than their corresponding maternal values for both traits. In fact, there were roughly more than three times for WW and KR when compared with maternal effects. It implies that variation of direct genetic effects of both traits were higher than variation of maternal genetic effects in this herd.

Selection depends upon knowledge of heritabilities for important characteristics together with genetic and phenotypic correlations among them (Pattie, 1991). The estimate direct heritabilities in this study (0.38 for Model 1; 0.26 for Model 2; 0.33 for Model 3) were lower than 0.48 for Common African and Alpine crossbred kids (Mourad and Anous, 1998). It was similar to Malik *et al.* (1986) for Bangal goats and Mavrogenis *et al.* (1984) for Damascus goats. Using a comparable model, Schoeman *et al.* (1997) estimated only direct heritability on WW in Boer breed was higher than this result. Compared to the estimates reported in sheep breeds, direct and maternal heritabilities in this study are within the range of reported values for WW (Al-Shorepy and Notter, 1996; Yazdi *et al.*, 1997; Saatci *et al.*, 1999).

KR is a measure of energetic efficiency of animals with economically importance (Kleiber, 1947) and provides a suitable indication of how economically an animal grows. Scholtz and Roux (1988) reported that KR has high relationship in phenotypic level with feed efficiency in beef cattle and has been purposed as an appropriate indirect selection criterion for feed efficiency under extensive breeding systems. Köster *et al.* (1994) recommended that KR could be a useful indicator of feed conversion and an important selection criterion for growth efficiency. The direct heritability for KR was moderate values (0.35 for Model 1; 0.22 for Model 2; 0.27 for Model 3). It was generally concordant with estimate of Schoeman *et al.* (1997) who reported direct heritability in Boer goats when compared model without maternal effect. Direct heritabilities from model without maternal effect were higher than some reported estimates in sheep (Matika *et al.*, 2003; Abegaz *et al.*, 2005; Rashidi *et al.*, 2008). Mohammadi *et al.* (2011) reported that Model 1 was the best fit for KR and estimates direct heritability of KR in Zandi sheep was lower than this study (0.01±0.02). According to these estimates for KR, it is concluded that growth efficiency in terms of the KR is moderately heritable and that the KR could be applied in selection for increasing the efficiency of growth. Therefore, this trait can be used effectively as a selection criterion in multi-trait selection programs that will lead to an improved biological efficiency of a herd (Ghafouri-Kesbi *et al.*, 2011). Mohammadi *et al.* (2011) pointed that the genetic potential of lambs for KR are restricted by poor nutritional conditions. Thus, improving nutritional management was of vital importance.

Maternal heritabilities (h^2_m) from Model 2 were 0.09 and 0.08 for WW and KR. The values from Model 3 were 0.12 and 0.11 for WW and KR. Low maternal heriatability values indicated that this goat population showed a low variation with characteristics for good mothering genetic ability. This result indicates that early growth rate and weight of an animal, in particular until weaning, was not determined only by its own genetic potential and the environment under which it was raised but also by maternal effect. Maternal effect arises when the phenotype of a mother or the environment it experiences has a phenotypic effect on her offspring (Ghafouri-Kesbi and Eskandarinasab, 2008). In the literature carry-over effect of the maternal genetic effect was shown to persist for longer periods, namely to the age of 18 months (Snyman *et al.*, 1996). Although, current estimates of maternal variance and maternal heritability were low, they were still within the range of other reports (Al-Shorepy *et al.*, 2002; Abegaz *et al.*, 2005; Ghafouri-Kesbi *et al.*, 2009). In the current study, the maternal permanent environmental effect on WW and KR was near to zero. Lewis and Beatson (1999) and Matika *et al.* (2003) observed that the permanent environmental effect was important for hogget weight which was taken between 8 and 12 months of age in sheep.

This study, direct heritabilities for WW and KR under Model 2 and 3 were higher than under Model 1, which ignored maternal effect. This upward bias was most likely the result of maternal effect being confounded with direct genetic effect. It has been frequently shown that when maternal genetic effect is present, but not accounted in the model, heritability estimate is bias upward and the realized efficiency of selection is reduced (Schoeman *et al.*, 1997; Abegaz *et al.*, 2005; Ghafouri-Kesbi and Eskandarinasab, 2008).

The lower estimates direct and maternal heritabilities for WW from Model 3 in the present study for WW were compared to Supakorn and Pralomkarn (2009). There were alternate hypotheses that might be due to unfavorable environmental conditions during pre-weaning period. Moreover, the producer judged animals to be a parent stock by using estimated breeding values corresponding phenotypic expression. For this data set, the connectedness of the data was of importance before preliminary analysis. It is well known that heritabilities are not constant but they can vary with environmental conditions because the harsh rearing environment inflates the error variance and results in lower heritability estimates (Ghafouri-Kesbi *et al*., 2009). Moreover, the direct heritability in this study for WW was lower than shown by Sookras *et al*. (2008) who only reported a direct heritability for WW (0.52) at the Trang Livestock Research Station in Thailand by REML software. The direct and maternal heritabilities of both traits in this study were different from other publications because of data structure of the records (i.e. number of records per dam and the proportion of dams with their own record), modeling for analysis and selection criteria. Maniatis and Pollott (2003) reported that it affect the accuracy of partition of maternal genetic and environmental effects. In fact, the total weight of offspring weaned per dam is determined by litter size and survival rate, as well as several other factors such as mothering ability, milk production of dam and growth potential of the offspring (Snyman *et al*., 1996). Increasing litter size is of economic importance and deserves more attention. Although in this study our immediate objective was not reproductive traits under the adverse conditions where the animal lives, pre-weaning growth rate and survival rates are definitely traits of high interest and are important traits to be considered in the selection index.

The direct-maternal, direct genetic, maternal genetic and phenotypic correlations from Model 3 are presented in Table 3. In this population, the direct-maternal correlation of WW and KR were negative and moderate values (-0.27 for WW and -0.16 for KR). It demonstrated that the genetic improvement would be difficult since an increase in one genetic component would result in a decline in the other. Genetic progress in both traits was expected to be slow owing to negative correlation between direct-maternal genetic effects. The same results in WW were obtained by Schoeman *et al*. (1997) in Boer goats but direct-maternal genetic correlation of KR was disagreement. Schoeman *et al*. (1997) used a model for KR that included litter effect as a random effect. It was not confounded with the direct or maternal genetic effect. Swalwe (1993) pointed out that negative direct-maternal correlations may be the result of the management system. He concluded that these correlations are more negative in field data compared with experimental data.

The direct genetic correlations between WW and KR in all models were high and moderate values. The pattern of direct genetic correlations between WW and KR showed the possibility of indirect selection for efficiency of growth by selecting WW in order to improve the marketable weight. The estimates of maternal and phenotypic correlations were all positive and similar to the genetic correlation. In general, it showed the same trend as the direct genetic correlations. The results suggest that the breeders could probably improve KR by selecting high WW animals. Therefore, an improvement in KR of feed efficiency is possible through the selection on WW. This result was in agreement with Mohammadi *et al*. (2011) who reported the positive direct genetic and phenotypic correlations between WW and KR in Zandi sheep.

Negative relationships with moderate values were achieved between direct genetic effect for WW and maternal genetic effect for KR and vice versa. It implies that further selection to increase WW could not potentially increase KR or feed efficiency while selection of direct genetic effect for one trait may result in a declined in maternal ability for other traits. As a result, the breeders should consider the antagonistic relationship between direct-maternal genetic effects within and between traits or select other traits which were favorable for WW or KR in a selection index for selection of the parent stock in order to increase the economical efficiency of this herd.

Table 3 shows the -2logL values for each model of bivariate analysis. Inclusion of direct and maternal genetic effects and with covariances between direct-maternal genetic effects (Model 3) did not improve the model-tested against as shown by the values of -2LogL. However, maternal effect constitutes a sizeable source of variation in growth traits of mammalian species, particularly in the early stages of growth. Such effect mainly denotes the mothering milk production ability of dams as well as intrauterine circumstances and may be affected by both genetic and environment factors (Ligda *et al*., 2000; Maniatis and Pallott, 2003). Also, considering maternal genetic was needed in order to obtain accurate direct heritability estimate. The differences of -2logL between model with and without maternal effect were 237.86 for between Model 1 and Model 2 and 78.89 for between Model 1 and Model 3 and were significant from χ^2 test. Based upon the lowest logarithm of the likelihood function, model with maternal genetic effect without a direct-maternal covariance resulted in a significantly better fit when compared with the other models. Likewise, Mohammadi *et al*. (2011) reported a model which included maternal genetic effect as well as direct genetic ones, without taking covariance between them into account, which was determined as the best model for KR in sheep. However, Al-Shorepy and Notter (1996) and Al-Shorepy *et al*. (2002) reported fitting maternal effect and non-zero direct-maternal covariances affected in a significantly better fit compared with models which ignored maternal effects or permanent environment.

4. Conclusions

WW is routinely recorded to be a useful for pre-weaning growth improvement. KR gives a good indication of how economically an animal grows that is one of the indices that have been proposed and used to determine the energetic efficiency of goats. Also, KR could be applied in selection index as an indication of feed efficiency for pre-weaning growth traits. From the study, it is understood that year-season of birth, sex and birth type have an influence on WW and KR in this goat population. Moreover, direct heritabilities, maternal heritabilities and correlations from three models (Model 1: without maternal effect; Model 2: with maternal effect and $\sigma_{am} = 0$, and Model 3: with maternal effect and $\sigma_{am} \neq 0$) were carried out in this research. WW and KR of males were found higher than females. WW and KR of single kids were also higher than those of other birth types. Direct heritabilities for WW and KR were moderate values. Maternal heritabilities

Table 3. Estimates of variance components, genetic parameters and -2logL values from bivariate analysis.

	Model 1		Model 2		Model 3	
	WW	KR	WW	KR	WW	KR
σ^2_a	9.36	9.20	5.78	5.15	6.66	5.62
σ^2_m	-	-	1.96	1.86	2.36	2.53
σ^2_e	15.04	16.94	14.26	15.93	11.03	13.79
σ^2_p	24.41±0.92	26.14±0.99	22.00±0.67	22.94±0.72	20.05±1.64	21.94±1.65
h^2_a	0.38±0.06	0.35±0.04	0.26±0.01	0.22±0.01	0.33±0.07	0.27±0.08
h^2_m	-	-	0.09±0.01	0.08±0.01	0.12±0.03	0.11±0.04
$r_{a(WW),a(KR)}$	0.19±0.02		0.17±0.01		0.24±0.02	
$r_{m(WW),m(KR)}$	-		0.04±0.01		0.03±0.04	
$r_{p(WW),p(KR)}$	0.12±0.01		0.11±0.01		0.13±0.01	
$r_{a(WW),m(WW)}$	-		-		-0.27±0.08	
$r_{a(KR),m(KR)}$	-		-		-0.16±0.05	
$r_{a(WW),m(KR)}$	-		-		-0.14±0.10	
$r_{m(WW),a(KR)}$	-		-		-0.15±0.14	
-2log L	-13166.44[a]		-13404.30[b]		-13245.26[c]	

σ^2_a = direct genetic variance; σ^2_m = maternal genetic variance σ^2_e = random residual variance; σ^2_p = phenotypic variance; h^2_a = direct heritability; h^2_m = maternal heritability; $r_{a(WW),a(KR)}$ = direct genetic correlation between weaning weight and Kleiber ratio; $r_{m(WW),m(KR)}$ = maternal genetic correlation between weaning weight and Kleiber ratio; $r_{p(WW),p(KR)}$ = phenotypic correlation between weaning weight and Kleiber ratio; $r_{a(WW)m(WW)}$ = direct-maternal genetic correlation for weaning weight; $r_{a(KR),m(KR)}$ = direct-maternal genetic correlation for Kleiber ratio; $r_{a(WW),m(KR)}$ = correlation between direct genetic effect for weaning weight and maternal genetic effect for Kleiber ratio; $r_{m(WW),a(KR)}$ = correlation between maternal genetic effect for weaning weight and direct genetic effect for Kleiber ratio and [a], [b] and [c] within the same row values marked with the different letter are significantly different at $P < 0.05$.

for both traits were low. The results illustrated that genetic improvement can be obtained by selection using both direct and maternal breeding values. Maternal effect constituted a considerable part of the phenotype variance for pre-weaning traits. This effect should be taken into account in genetic evaluation of these traits because ignoring it caused biases in the genetic parameter estimates. The antagonism correlations of direct-maternal genetic values within traits and between traits pose some limitations on total response of selection that can be expected. Differences between heritabilities among models clearly suggest bias in the model without maternal genetic effect. The direct, maternal genetic and phenotypic correlations between WW and KR were positive. The best fit model would be a model including maternal genetic effect that no allowed for a direct-maternal genetic covariances. Genetic parameters demonstrated that there is a genetic potential in the herd for the improvement of the growth traits. Therefore it is feasible to implement a breeding program in the herd. It could be as basic knowledge and benefits for accurate recording data for village circumstances. Accuracy of recording data, appropriate model and precision of analysis leads clearly genetic values. The genetic values and genetic parameters estimates can be used for further improvement of selection strategy in the future.

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