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Genetic and Phenotypic Parameters of Body Weight in Ettawa Grade Goats

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ABSTRACT

The aim of this study was to estimate genetic and phenotypic parameters of growth traits consisting of birth weight (BW), weaning weight (WW), 6 mo body weight (6WM), 12 mo body weight (12WM), and 18 mo body weight (18WM) of Ettawa Grade goats. The number of goat used to determine growth traits of BW, WW, 6WM, 12WM, and 18WM were 316; 316; 259; 259 and 165 heads, respectively. Data were analyzed using *General Linear Model* (GLM) to identify non-genetic effect. Estimation of genetic and phenotypic parameters including heritability, repeatability, genetic and phenotypic correlation were calculated using *Restricted Maximum Likelihood* and GLM. Genetic trends were calculated using the regression of mean breeding values on birth year. The results showed that parity and type of birth had significant (P<0.05) influence on all growth traits. Estimated heritability of birth, weaning, 6WM, 12WM, and 18WM were 0.54±0.12; 0.35±0.07; 0.37±0.09; 0.68±0.16 and 0.63±0.19, respectively. Estimated repeatability of WW, 6WM, 12WM and 18WM, WW, 6WM, 12WM and 18WM were 0.98±0.01; 0.97±0.01; 0.94±0.03; 0.71±0.12 and 0.91±0.04, respectively. The genetic trends for traits of BW and 18MW were decreased fluctuatively. However, the WW, 6MW, 12MW were increased fluctuatively. The high and positive genetic correlations between all growth traits and 12WM traits in this study indicated that selection for high 12WM will improve genetic merit in Ettawa Grade goats.

Key words: body weight, EBV, Ettawa Grade goat, genetic and phenotypic parameters

ABSTRAK

Penelitian ini bertujuan untuk mengetahui parameter genetik dan fenotipik sifat pertumbuhan pada waktu lahir (BL), sapih (BS), 6 bulan (B6), 12 bulan (B12) dan 18 bulan (B12) pada kambing peranakan ettawa. Total data yang digunakan untuk menentukan BL, BS, B6, B12 dan B18 masing-masing 316; 316; 259; 259 dan 165 ekor. Analisis *general linear model* (GLM) digunakan untuk mengkaji pengaruh non-genetik. Parameter fenotipik dan genetik yang meliputi nilai heritabilitas, ripitabilitas dan korelasi genetik dihitung melalui analisis *restricted maximum likelihood* dan GLM. Selanjutnya untuk mengetahui pola genetik sifat pertumbuhan dihitung melalui analisis regresi rataan nilai pemuliaan terhadap tahun kelahiran. Hasil penelitian menunjukkan bahwa semua sifat pertumbuhan dipengaruhi (P<0,05) paritas dan tipe kelahiran. Nilai heritabilitas BL, BS, B6, B12 dan B18 yang diperoleh masing-masing adalah 0,54±0,12; 0,35±0,07; 0,37±0,09; 0,68±0,16 ;dan 0,63±0,19. Nilai ripitabilitas BL, BS, B6, B12 dan B18 yang diperoleh masing-masing adalah 0,98±0,01; 0,97±0,01; 0,94±0,03; 0,71±0,12; dan 0,91±0,04. Pola genetik sifat pertumbuhan bobot lahir dan 18 bulan menunjukkan fluktuasi yang cenderung menurun. Hal berbeda ditunjukkan BS, B6 dan B12 yang menunjukkan fluktuasi cenderung meningkat. Korelasi genetik dan fenotipik sifat pertumbuhan kecuali pada BS dengan B12 menunjukkan korelasi tertinggi dengan kisaran antara 0,65-0,92. Tingginya nilai parameter genetik dan fenotipik antara sifat pertumbuhan dengan B12 mengindikasikan bahwa seleksi terhadap B12 akan efektif dalam perbaikan mutu genetik pada kambing peranakan ettawa.

Kata kunci: bobot badan, EBV, kambing Peranakan Ettawa, parameter genetik dan fenotipik

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INTRODUCTION

Ettawa Grade goats are one of several Indonesian local goats that plays major role in meat and milk production (dual purpose). Ettawa Grade goats are descended originally from crossing between the Kacang and Ettawa goats (Sodiq, 2012). This breed has a larger body frame, long hanging ears, a convex face, larger horns and excellent body profile (Sodiq & Abidin, 2010). The population of goat in Indonesia was recorded 18.576.192 in 2013 (Direktorat Jenderal Peternakan, 2013). Most population of Ettawa Grade goats was concentrated in Kaligesing Purworejo Central Java Province. Faster *growth rate* is a very important *trait* while *meat production* is the target. In addition, growth traits are effectively affected program selection because of moderate to higher heritability (Zhang *et al*., 2009).

Genetic and phenotypic parameters estimation of growth traits of different goat breeds have been reported by several studies (Shrestha & Fahmy, 2007; Boujenane & El-Hazzab, 2008; Zhang *et al*., 2009; Al-Saef, 2013). Al Saef (2013) reported heritability of birth and weaning weight in Syrian Damascus and Boer goat were 0.41 and 0.21, respectively. Zhang *et al*. (2009) obtained heritability of birth weight and weaning weight in Boer goat were 0.30 and 0.23, respectively. The heritability estimated of 18 months of age weight (18WM) in Dwarft African goat was 0.63 (Bosso *et al*., 2007). Another factor has to be considered when selecting for growth traits were repeatability, genetic and phenotypic correlation (Mokhtari & Rashidi, 2010). Snyman & Olivier (1999) reported repeatability of body weight was 0.63. Bosso *et al*. (2007) reported genetic correlation between WW and W360 in Dwarft goat was 0.74. The high and positive genetic correlations implies that they are all being controlled by similar genes and thus selection for any one of these traits would lead to positive changes in the other. Apart from this part, annual genetic trend for growth traits should be monitored overtime to check the accuracy of the genetic prediction made and identification direction genetic change (Intaratham *et al*., 2008). That is why for designing local goat such as Ettawa Grade goats, improvement of genetic program are very important to realize. However, information of genetic parameter such as heritability related to growth trait for Indonesian local goat such as Ettawa Grade goat are very rare. Therefore, the estimation of genetic and phenotypic parameter for growth traits is important in designing breeding program aim at maximizing genetic improvement. The aim of this study was to estimate genetic analysis of growth trait of Ettawa Grade goat in Breeding Center at Pelaihari, South Kalimantan province.

MATERIALS AND METHODS

Data Collection

The data used in this study were collected between 2007 and 2011 from Breeding Center of Ettawa Grade goat in South Kalimantan Province. A total of 316 kids consisting of 138 males and 178 females were used in this research. The traits analyzed included: body weight growth traits at birth (BW), weaning (WW), 6 mo (6WM), 12 mo (12WM) and 18 mo (18WM). The records number of BW, WW, 6WM, 12WM and 18WM were 316; 316; 25; 259 and 165 heads, respectively.

Data Analyses

Non-genetic effect. Growth traits included for this study were BW, WW, 6WM, 12WM and 18WM. All traits were analyzed using *General Linear Model* (GLM) procedure (SAS 9.2) (Steel & Torrie, 2005).

$$Y = \mu + ri + si + pi + qi + ti + e$$

where:
Y = BW, WW, 6WM, 12WM and 18WM
μ = overall mean
ri = the effect sex of kid (male, female)
si = the effect of birth type (single, twins, triplets)
pi = the effect of parity (1, 2, 3)
qi = the effect of year birth (2007, 2008, 2009, 2010, 2011)
ti = the effect of season (dry, rainy)
e = random error

The same statistical model was used to analyze BW, WW, 6WM, 12WM, and 18WM including 2 way interactions such as year of birth, parity and season. In all statistical model there was no two way interaction, therefore, final models considered only the main effects (Hammoud *et al*., 2010).

Genetic effect. To evaluate genetic effect of heritability on BW, WW, 6WM, 12WM and 18WM, the data were analyzed by mixed model, sire and dam were included as a random effect in model. The total variance and covariance component were sorted into additive and non-additive components (Meyer, 1992).

$$Y_{ijk} = \mu + S_i + D_{ij} + E_{ijk}$$

where:
μ = overall mean
S_i = effect of the i[th] sire
D_{ij} = effect of the ij[th] dam within the i[th] sire
E_{ijk} = uncontrolled environmental deviations associated with each record which is assumed to be random independent and normally distributed with a mean 0 and a common variance.

Heritability was estimated from sire and dam variance component, according to Becker (1992) as follows:

$$h_d^2 = \frac{4\,\delta_d^2}{(\delta_s^2 + \delta_d^2 + \delta_w^2)}$$

where:
h_d^2 = heritability from dam component
δ_d^2 = dam variance component
δ_s^2 = sire variance component
δ_w^2 = within progeny variance component

To estimate standard errors for heritability were analyzed according to Becker (1992):

$$SE\,(h^2\,s+d) = \sqrt[4]{\frac{\frac{2}{K_3^2}\left[\frac{MS_s^2}{S-1+2}+\frac{MS_d^2}{d-s+2}\right]}{S^2T}}$$

$$K_3 = \frac{1}{S-1}\left[\frac{N-\sum n^2-1}{n1}\right]$$

where:

MS_d^2 = mean square dam
MS_s^2 = mean square sire
d_T^2 = total variance
d = number of dam
s = number of sire
K_3 = number of progeny per sire

Repeatability was estimated from sire variance component, according to Becker (1992) as follows:

$$R = \frac{\delta_w^2}{\delta_w^2 + \delta_e^2}$$

$$\delta_e^2 = MS_e \text{dan } \delta_w^2 = \frac{MS_w - MS_e}{k_1}$$

where:

δ_w^2 = with progeny variance component
δ_e^2 = within progeny variance componet
MS_w = mean square traits
MS_e = mean square individual
k_1 = number of progeny

Phenotypic and genetic correlations were estimated to know relationship among growth traits.

$$r_g = \frac{cov_0}{\sqrt{\delta_{ox}^2 \delta_{sy}^2}}$$

$$r_p = \frac{cov_0 + cov_e}{\sqrt{(\delta_{ox}^2 + \delta_{ex}^2) \times (\delta_{oy}^2 + \delta_{ey}^2)}}$$

where:

o = random effects
e = fixed effects
x or y = traits a given value refers to (BW, WW, 6WM, 12WM and 18WM)

Estimate Breeding Value (EBV) was estimated according to Becker (1992) as follows:

EBV = h^2 x DS

where:

h^2 = heritability
DS = differential selection

Genetic and phenotypic trends were obtained by regression means of predicted breeding values on year of birth and means of traits growth for each trait. Genetic and phenotypic trends analysis according to Filho *et al*. (2005).

Y = a + bX

where:

Y = BW, WW, 6WM, 12WM, 18WM or breeding value
a = Intercept
X = year of birth
b = the regression coefficient for Y on X

RESULTS AND DISCUSSION

Comparison of Growth Traits

Mean along with their standard error (SE) of BW, WW, 6WM, 12WM and 18WM are presented in Table 1. The mean and standard error of BW WW, 6WM, 12WM and 18WM were 3.78±0.03; 10.57±0.11; 17.02±0.25; 32.01±0.95 and 48.66±0.80 kg, respectively. The mean of BW in this study was higher than value obtained by Sodiq (2012 and 2005) which showed the mean of BW for Ettawa Grade goat in Kaligesing was 3.44 and 3.29 kg. The mean of BW in this study also was higher compared with other goat breed (Al-Shorepy *et al*., 2002; Rashidi *et al*., 2011). The mean of BW of Ettawa Grade goat was ranged between 2.63-4.29 kg (Atabany *et al*., 2001). In contrast with BW, the mean WW and 6WM in this study was lower than previous value reported by Sodiq (2012) in Ettawa Grade goat were 14.75 and 18.86 kg, respectively. However likely BW, the WW and 6WM values also lower compared to other result (Zhang *et al*., 2009; Rashidi *et al*., 2011; Al-Saef, 2013). Boujenane & El-Hazzab (2008) obtained WW value of Draa goat in Morocco was 9.13 kg. Al-Saef (2013) estimated 6WM value of Saudi Aradi goat and their crosses with Syrian Damascus goat was higher than in this study. The 12WM and 18WM mean of Ettawa Grade goat in this study was

Table 1. Number of animals, means, standard error, standard deviations, coefficient of variation, minimum and maximum for Ettawa Grade goat

Traits	Number	Mean	Standard error	Standard deviation	Coefficient of variation	Min	Max
BW	316	3.78	0.03	0.59	15.54	2.20	5.60
WW	316	10.57	0.11	1.89	17.93	5.60	15.30
6WM	259	17.02	0.25	4.06	23.86	7.00	25.00
12WM	259	32.01	0.95	15.34	36.92	11.00	58.00
18WM	165	48.66	0.80	10.27	21.11	24.00	65.00

Note: BW= growth traits at birth, WW= growth traits at weaning, 6WM= growth traits at 6 mo, 12WM= growth traits at 12 mo, 18WM= growth traits at 18 mo.

32.01 and 48.66 kg, respectively. The mean of 12WM in this study was higher than those reported by Bosso *et al.* (2007) who obtained mean 360 day of age weight in Dwarf goat was 8.04 kg. However, the BW value was lower compared with Boer goat (Zhang *et al.*, 2009). This may be due to the breed factor and effect of environment (Zhang *et al.*, 2009).

Non-Genetic Effect

Least square means (LSM) and standard errors (SE) for BW, WW, 6WM, 12WM, and 18 WM in various fixed effect are given in Table 2. Sex of kid birth had significant effect on BW, WW and 6WM (P<0.01) but no significant effect on 12WM and 18 WM. This result was in agreement which describing that sex had highly significant influence on pre-weaning and growth rate (Browning *et al.*, 2004; Vargas *et al.*, 2007; Wenzhong *et al.*, 2005; Mioč *et al.*, 2011). In the contrary, sex of kid birth had significant effect on 18 MW and 24 MW in Angora goats (Liu *et al.*, 2005). This might be attributed to different physiological processes in the two sexes. According to endocrine system, estrogen hormone has a limited effect for growth in females. That was one reason why females have smaller body than males (Baneh & Hafezian, 2009). The effect of parity had no significant on BW, but it had significant effect on WW, 6WM, 12WM and 18WM (P<0.01). Zhang *et al.* (2009) reported that the effect of parity had significant on BW (P<0.01). The effect of parity decreased on parity 1 to 2, but increased on parity 2 to 3 for BW. It effect increased with increasing parity for WW, 6WM, 12WM and 18WM on parity 1 to 2 and 3, respectively. The parity of dam effect may be explained by the better development of dam's uterus with increasing parity and age (Zhang *et al.*, 2009; Valencia *et al.*, 2007).

The effect of birth type was significant (P<0.01) effect on BW, 12WM and 18WM, but had no significant effect on WW and 6WM. Sodiq (2012) reported that birth type was significant effect on BW, 30WD, 60WD, 90WD and 120WD in Ettawa Grade goat. These result agree with previous studies in other breeds by several authors Zhang *et al.* (2009) on Boer goat, Mandal *et al.* (2006) on Muzaffarnagari sheep, Liu *et al.* (2005) on Angora goat, Zhou *et al.* (2003) on Mongolia cashmere goats in China, Al-Shorepy *et al.* (2002) on Emirati goat. Single born kids in this study was larger than twins and triplets on BW, but it was lower than twins and triplet on WW, 6WM, 12WM, and 18WM. Zhang *et al.* (2008) reported that single born was larger than twins and triplets in Boer goat. Growth advantage of single in early period might result from its lower competition for nutrition supply of dam in gestation period than the multiple birth ones (Zhang *et al.*, 2009). Liu *et al.* (2005) reported that twins and triplets born were lower than single affecting by decreased maternal effect including nursing and milk feeding of the kids by their mothers.

Table 2. Mean along with their standard error (SE) for BW, WW, 6WM, 12WM and 18WM (kg) for Ettawa Grade goat

	Trait				
	BW (n)	WW (n)	6WM (n)	12WM (n)	18WM (n)
Sex of kid:					
Male	3.87±0.05^{A} (138)	10.90± 0.16^{A} (138)	18.12±0.38^{A} (116)	33.20±1.42 (116)	50.41±1.09 (79)
Female	3.71±0.04^{B} (178)	10.30±0.14^{B} (178)	16.41±0.37^{B} (143)	30.43±1.31 (143)	47.20±1.13 (94)
Parity:					
1	3.79±0.04 (172)	11.50±0.12^{A} (172)	19.65±0.27^{A} (138)	44.27±1.07^{A} (138)	52.60±0.75^{A} (128)
2	3.75±0.06 (130)	9.40±0.14^{B} (130)	14.19±0.36^{B} (107)	17.15±0.42^{B} (107)	34.87±1.04^{B} (31)
3	3.99±0.19 (14)	9.30±0.37^{B} (14)	14.06±0.71^{B} (14)	17.56±0.92^{B} (14)	33.74±1.92^{B} (6)
Birth type:					
Single	4.18±0.09^{A} (44)	10.80±0.28 (44)	17.06±0.62 (37)	22.51±1.49^{C} (37)	40.62±2.52^{B} (17)
Twins	3.77±0.04^{B} (224)	10.50±0.13 (224)	17.01±0.34 (180)	31.08±1.22^{B} (180)	48.53±1.02^{A} (109)
Triplets	3.46±0.05^{C} (48)	10.90±0.24 (48)	18.35±0.51 (42)	42.25±1.87^{A} (42)	52.47±0.90^{A} (39)
Year:					
2007	3.72±0.03 (124)	11.90±0.13^{A} (124)	20.17±0.25^{A} (124)	46.68±0.89^{A} (124)	53.31±0.58^{A} (123)
2008	4.04±0.18 (29)	10.40±0.25^{B} (29)	15.00±0.65^{BC} (3)	22.28±0.98^{BC} (3)	37.53±6.26^{BC} (3)
2009	3.66±0.18 (16)	10.10±0.16^{BC} (16)	17.85±1.03^{AB} (6)	27.33±3.80^{B} (6)	-
2010	3.73±0.64 (35)	10.50±0.168^{B} (35)	16.62±1.08^{B} (17)	22.85±1.12^{B} (17)	40.16±0.91^{B} (15)
2011	3.81±0.06 (112)	9.20±0.14^{C} (112)	13.83±0.32^{C} (109)	16.27±0.33^{C} (109)	31.08±1.01^{C} (24)
Season:					
Dry	3.79±0.04 (237)	11.00±0.16^{A} (237)	18.32±0.30^{A} (189)	36.35±1.11^{A} (189)	52.10±0.77^{A} (130)
Rainy	3.73±0.68 (79)	9.20±0.21^{B} (79)	14.14±0.37^{B} (70)	18.80±0.98^{B} (70)	35.40±1.48^{B} (35)

Note: means in the same column with different superscript differ significantly (P<0.01); n= number of animal; BW= growth traits at birth; WW= growth traits at weaning; 6WM= growth traits at 6 mo; 12WM= growth traits at 12 mo; 18WM= growth traits at 18 mo.

Year of birth had no significant on BW, but it had significant effect on WW, 6WM, 12WM and 18WM (P<0.01). Year of birth significantly influenced at WW and 18WM with trend of 2007>2010>2008>2009>2011. Year of birth was significantly at 6WM and 12WM with trend of 2007>2009>2010>2008>2011. Differences result weight in this study between years may be a reflection of differences in feed availability among years due to by variation in total annual precipitation and the distribution of rainfall in breeding centre Ettawa Grade goat. The differences trend of year reflected the variations of natural environments, climate, feeding plane, body conditions of dams, and management for the animals (Zhou *et al*., 2003; Haile *et al*., 2009).

Season of birth had no significant on BW, but it had significant effect o WW, 6WM, 12WM and 18WM. Season of birth significantly (P<0.01) influenced at WW, 6WM, 12WM and 18WM with a trend was dry > rainy. Live weight (BW, WW, 6WM, 12WM and18WM) of Ettawa Grade goat was born during dry season were always heavier than born during rainy season. Thus, from the results of this study it is evident that kids born in the dry season perform better than in rainy season. Zhang *et al.* (2009) reported that kids born between May-September were larger than among those born in other season. This variation is due to the availability of pastures to the pregnant dams. Effect season on body weight also reflected management such as mating, housing and feeding for the animals in the local the flock was located (Gunawan & Noor, 2006). Al-Shorepy *et al.* (2002) reported that variations among different season might be explained by differences of rainfall which in turn influenced grass production and feed availability.

Genetic Effect

Heritability. Heritability estimation for BW, WW, 6WM, 12WM, and 18WM were 0.54±0.12; 0.35±0.07; 0.37±0.09; 0.68±0.16 and 0.63±0.19, respectively. The heritability estimated for body weight traits were moderate to high and range from 0.37 to 0.68, which indicated a relatively large contribution of additive genetic variance and potentiality for improving body weight in goats by selection. Heritability estimates for BW of Ettawa Grade goat were 0.54 higher than those usually found in literature for tropical goat. Al-Shorepy *et al.* (2002) reported in Emirati goat used DFREML program was 0.39. Bosso *et al.* (2007) reported 0.50 for BW of Dwarf goat in West African used ASREML analysis. Estimation heritability of BW was reported in Syrian Damascus goat and Boer goat to be 0.41 and 0.30, respectively (Zhang *et al.*, 2009; Al-Saef, 2013). The heritability estimates generally increased as the age increased from 6WM to 18WM of age. This indicated that gain due to selection in weights at later age could be obtained, as compared to that of earlier age. In the contrary, high estimate of heritability for BW of Aradi goat, Damascus and their crossbreed kids (Al-Saef, 2013).

Estimates of heritability obtained for WW in the present study was 0.35. This estimate heritability of WW in this study was lower than the value obtained by Zhang *et al.* (2009) which found that the heritability estimate of WW in Boer goat used *Derivative Free Restricted Maximum Likelihood* procedure (DFREML) analysis with range of 0.09 to 0.23. However, heritability values for WW of Ettawa Grade goat in this study was within the range of published values (Al-Shorepy *et al.*, 2002; Boujenane & El-Hazzab, 2008; Al-Saef, 2013). Estimation heritability of weaning weight was reported in Emirati and Syrian Damascus goat to be 0.45 and 0.21 respectively (Al-Shorepy *et al.*, 2002; Al-Saef, 2013). Boujenane & El-Hazzab *et al.* (2008) obtained heritability for weaning weight used single-trait analysis with range of 0.18-0.65. Genetic improvement for WW has also been attributed to affecting fertility, prolificacy, kid survival to weaning and dam viability from mating to weaning (Zhang *et al.*, 2009).

Estimated heritability in Ettawa Grade goat for 6 mo of age was 0.37 (Table 3). Heritability estimate for 6WM in the present study was higher than those usually in previous study. Boujenane & El-Hazzab (2008) reported heritability of 6WM used MTDFREML program with range of 0.11-0.23. However, this value of 6WM closely in agreement with data reported by Al Saef, (2013) for Syrian Damascus goat used *Multi Traits Derivative Free Restricted Maximum Likelihood* program (MTDFREML) was 0.36. The variations in these literatures may be due to the differences in goat breed, environment and management. Additionally, statistical methods, data structure and sampling error accord to Zhang *et al.* (2009).

The heritability estimates for 12WM and 18WM were 0.68 and 0.63 respectively. Heritability in this study was lower than the value obtained by Bosso *et al*. (2007) on Dwarf goat was 0.73. Nevertheless, these estimates are higher than the value obtained by several authors Zhang *et al.* (2009) on Boer goat, Ozcana *et al.* (2005) on Turkish Merino sheep, Safari *et al.* (2005) on sheep and Gizawa *et al.* (2007) on Menz sheep. Result of heritability 12WM in this study was high, it was expected that selection on growth trait was effective. High heritability value of 12WM and 18WM suggest that selection on the basis of individual performance will effective in achieving increased gain in 12WM and 18WM.

Repeatability. Estimates of repeatability of BW, WW, 6WM, 12WM, and 18WM were 0.98±0.01; 0.97±0.01; 0.94±0.03; 0.71±0.12 and 0.91±0.04, respectively. The re-

Table 3. Estimated heritability and standard errors for BW, WW, 6WM, 12WM and 18WM for Ettawa Grade goat

Traits	Number of animal	h^2±SE	VA	VE	VP
BW	316	0.54±0.12	0.022	0.175	0.197
WW	316	0.35±0.07	0.034	1.534	1.568
6WM	259	0.37±0.09	3.579	6.063	9.642
12WM	259	0.68±0.16	3.846	28.132	31.978
18WM	165	0.63±0.19	0.012	15.743	15.755

Note: BW= growth traits at birth, WW= growth traits at weaning, 6WM= growth traits at 6 mo, 12WM= growth traits at 12 mo, 18WM= growth traits at 18 mo.

peatability estimated for body weight traits were high range from 0.71 to 0.98 are presented in Table 4. Repeatability in this study was higher than the value obtained by several studies in diffrent goat breeds (Gifford *et al.*, 1991; Snyman & Olivier 1999). Gifford *et al.* (1991) reported repeatability of body weight were 0.62 and 0.18, respectively. High repeatability values of all growth traits in Ettawa grade goat suggest that a relatively large contribution of additive genetic variance and potentiality of improving body weight in goats by selection. Difference in reproductive status of the does could most probably have contributed to the low estimated repeatability of body weight (Snyman & Olivier, 1999).

Genetic and phenotypic correlations. Genetic and phenotypic correlations among the traits studies are presented in Table 5. Genetic correlations between all body weight traits in this study ranged from between 0.03 for BW and 12WM and 0.87 for 12WM and 18WM. Genetic correlations among weight measurements were low to high and range from 0.19 to 0.92 (Bosso *et al.*, 2007; Zhang *et al.*, 2008; Wang *et al.*, 2011). The genetic correlations between all traits of growth traits in this study were consistently low to high and positive. The positive genetic correlations existing between body weight traits indicate that genetic improvement in any one of the traits could be made through indirect selection for correlated traits (Boujenane & El-Hazzab, 2008). In this study, BW had low correlations with the remaining variables ranging from 0.03 to 0.35 for genetic correlations. This result corresponds well with Bosso *et al.* (2007) and Al-Saef (2013) who reported BW had lower genetic correlation. In the contrary, Boujenane & El-Hazzab (2008) reported that BW had higher genetic correlation on Draa goats. The estimate of genetic correlation between WW and 12WM in this study was high (0.71) and this implies that WW is a good indicator of subsequent development of the kid. The genetic correlation estimates in this study correspond well with Bosso *et al.* (2007) who reported genetic correlation for WW and W360 for Dwarf goat of 0.74. The reason of different estimates could be due to the fact that all estimates depend on the models that were utilized as well as the random factors (Zishiri *et al*., 2009). The high and positive genetic correlations between WW and 12WM traits in this study implies that they are all being controlled by similar genes and thus selection for any one of these traits would lead to positive changes in the other.

The phenotypic correlations ranging from 0.08 between BW and 12WM to 0.93 between 12WM and 18WM. The genetic correlations between all traits found same trend as the genetic correlations in accordance with previous stud in different goat breeds (Al-Shorepy *et al.*, 2002; Xu *et al.*, 2005; Han *et al.*, 2005; Maxa *et al.*, 2006). Al-Shorepy *et al.* (2002) obtained that genetic and phenotypic correlations between BW, 1WM and 3WM of age were positive (0.45-0.99). These low correlations between BW and 12WM are favourable because selection for traits like pre-weaning weight is not expected to have an effective correlated response in birth weight. Heavier kids at birth were not able to express their potential for growth (Mugambi *et al.*, 2007). However, the estimate of phenotypic correlation between WW and 12WM in this study was high (0.65) indicated a strong positive relationship between the two traits. These results were consistent with that reported by Bosso *et al.* (2002) were still positive indicating that selection for high WW will result in higher 12WM.

Table 4. Estimated repeatability and standard errors for BW, WW, 6WM, 12WM and 18WM for Ettawa Grade goat

Traits	Number of animal	R±SE
BW	28	0.98±0.01
WW	28	0.97±0.01
6WM	23	0.94±0.03
12WM	26	0.71±0.12
18WM	21	0.91±0.04

Note: BW= growth traits at birth, WW= growth traits at weaning, 6WM= growth traits at 6 mo, 12WM= growth traits at 12 mo, 18WM= growth traits at 18 mo.

Table 5. Estimated of genetic correlations (below diagonal) and phenotypic correlations (above diagonal) among body weights for Ettawa Grade goat

	BW	WW	6WM	12WM	18WM
BW		0.169	0.298	0.084	0.232
WW	0.349		0.689	0.653	0.642
6WM	0.044	0.644		0.83	0.744
12WM	0.033	0.708	0.766		0.926
18WM	0.149	0.547	0.590	0.872	

Note: BW= growth traits at birth, WW= growth traits at weaning, 6WM= growth traits at 6 mo, 12WM= growth traits at 12 mo, 18WM= growth traits at 18 mo.

Genetic and Phenotypic Trends

Genetic and phenotypic trends for growth trait including BW, WW, 6WM, 12WM, and 18WM are shown in Figure 1 and 2, respectively. The genetic trends for all growth traits were fluctuating from 2007 to 2011. As illustrated in Figure 1, the genetic trends, the BW rose from 2007 to 2008 and constant until 2009, and after 2009 declined until 2011. The weaning weight (WW) showed after the large decline in 2008, the trends rose considerably at 2009, but after 2009 the trends decline considerably until 2011. There were increased in the genetic trends of 6WM from 2007 to 2009 but declined from 2009 to 2011. The 12WM showed after the large rose in 2008, the trends decreased until 2009. In 2009 the trends decreased considerably at 2010 and decreased until 2011. There were constant in the genetic trends of 18WM from 2007 to 2008. After the large decline in 2009, the trends in 2010 constant and declined until 2011. This result was in agreement with Bosso *et al.* (2007) who reported that the fluctuation of genetic trends values were observed for BW, W120 and W360 in Dwarf goat. The genetic trend of BW, WW, 6WM, 12WM, and 18WM were -0.019; -0.02; 0.003; 0.009 and 0.005 kg/year, respectively (Table 6). Bosso *et al.* (2007) reported that genetic trend for

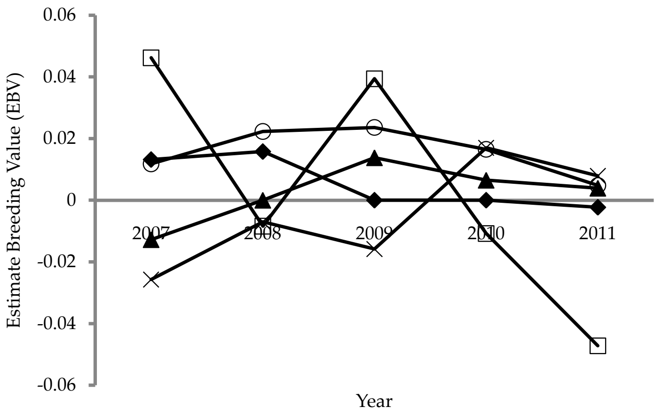

Figure 1. Genetic trend of BW (-○-), WW (-□-), 6WM (-▲-), 12WM (-×-) and 18WM (-♦-) for Ettawa Grade goat

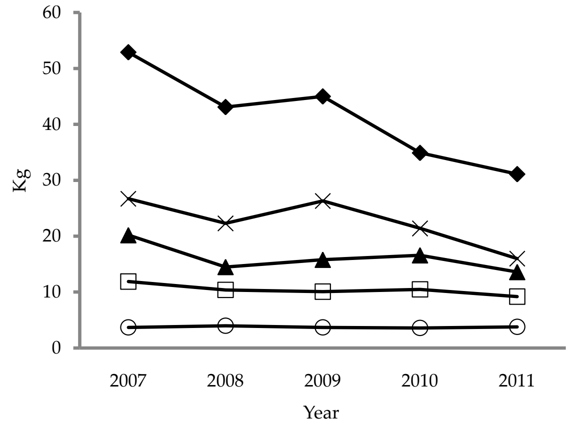

Figure 2. Phenotypic trend of BW (-○-), WW (-□-), 6WM (-▲-), 12WM (-×-) and 18WM (-♦-) for Ettawa Grade goat

BW, W120 and W180 were 0.01; 0.02 and 0.08 kg/year, respectively. Differences between estimated genetic values for these traits in comparison with other studies in general is due to difference in animal breeding standard and follow that different program selection, difference between models and calculation method and also effects of environmental, interaction between genetic and environmental, nutrition, climate conditions and breed factors (Shaat *et al*., 2004; Zhang *et al*., 2009; Yaeghoobi *et al*., 2011). Irregular fluctuations were observed in yearly mean predicted breeding values for WW, 12WM, and 18WM. The fluctuation of predicted breeding value mean was apparently due to selection sire with low breeding value. It seems that this low selection response implying that introduction of outside sire was base and phenotypic characteristics.

As illustrated in Figure 2, the phenotypic trends BW and WW traits generally showed a constant from 2007 to 2011. After the small declined in 2008, the trends for 6WM in 2009 to 2010 small rose and declined until 2011. The phenotypic trends of 12WM and 18WM traits decreased from 2007 to 2008, but in 2009 the trends were increased and in 2009 until 2011 decreased considerably. The phenotypic trends of all growth traits generally were negative for all studies trait. The phenotypic trend for BW, WW, 6WM, 12WM, and 18WM were -0.02; -0.53; -1.11; -2.23 and -5.18 kg/year, respectively (Table 6). The phenotypic 6WM, 12WM, and 18WM were fluctuating from 2007 to 2011. The trends of 6WM, 12WM, and 18WM in 2008 decreased and thereafter increased in 2008 to 2010; 2008 to 2009 and 2008 to 2009 respectively. The trends of 12WM and 18WM in 2009 to 2011 rose considerably. The reduction for calve born 6WM in 2008; 12WM and 18WM in 2008 and 2009 to 2011 were mainly due to a larger proportion of calves selected in previous years in order to increase the population for selected sire and dams. Phenotypic performance in 6WM, 12WM and 18WM could be improved also through management strategies. Changes in management such as grazing strategies, pasture improvement and culling procedures needed to be monitored in order to evaluate the benefit of change (Intaratham *et al*., 2008). Body weight showed no definite trend that indicated low degree of R^2 except

Table 6. Genetic and phenotypic trends of body weight for Ettawa grade goat

	Regression equation	R2
Genetic trend	EBV BW = 0.02 – 0.019x	16.3
	EBV WW = 0.06 – 0.02x	59.4
	EBV 6WM = -0.01 + 0.003x	41.3
	EBV 12WM = -0.03 + 0.009x	69.4
	EBV 18WM = 0.019 + 0.005x	78.7
Phenotypic trend	BW = 3.82 – 0.02x	15.3
	WW = 12.0 – 0.53x	74.2
	6WM = 19.5 – 1.11x	47.5
	12WM = 29.2 – 2.23x	65.8
	18WM = 56.9 – 5.18x	90.5

Note: BW= growth traits at birth, WW= growth traits at weaning, 6WM= growth traits at 6 mo, 12WM= growth traits at 12 mo, 18WM= growth traits at 18 mo.

18WM for genetic and phenotypic trend. The low degree of genetic progress for body weight can be explained mainly by selection program and this may slow down genetic progress (Gunawan *et al*., 2011).

CONCLUSION

High and positive genetic correlations between all growth traits and 12WM traits in this study indicated that selection for high 12WM will improve genetic merit in Ettawa Grade goats.

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