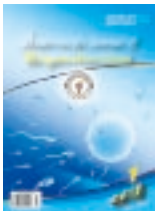

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Heritability and variance components estimates for growth traits in Saudi Ardi goat and Damascus goat and their crosses

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ABSTRACT

Objective: To study the genetic and non-genetic factors and their interactions affecting growth rate and body weights at birth, weaning and at 6 months of age in Saudi Ardi, Damascus goats and their crosses. **Methods:** Crossbreeding program between Saudi Ardi(A) goats with Damascus(D) was carried out to improve the meat productivity of Ardi goats through crossbreeding. The pedigree records of the body weights were obtained from 754 kids (397 males and 357 females) produced from 46 Sires and 279 Dams. Birth weight, weaning weigh and 6 months weight as well as average daily gain during different growth stages from birth to weaning (D1), weaning to 6 months (D2) and from birth to 6 months of age (D3) were recorded during winter/autumn and summer/spring. Data were classified according to breed, generation, sex, season, year, and type of birth. Data were analyzed using GLM procedure for the least-squares means of the fixed factors. Heritability and genetic parameters were estimated with derivative-free restricted maximum likelihood procedures using the MTDFREML program. **Results:** The percentages of variations were moderate for body weights and high for daily gains. Genetic groups had a highly significant (P<0.01) effect on the body weights traits. Damascus goats had higher (P<0.01) birth and weaning weights, but ½D½A group kids had a higher (P<0.01) body weight at 6 months. The genetic groups had a significant effects on the daily weight gains for D1 (P<0.01) and D3 (P<0.05) periods, whereas, it had no effects on D2 period. The fixed effects of sex, season, year and type of birth were significant differences for body weights. Male kids were heavier (P<0.01) than females for different growth stages. Body weights and daily gains during winter/autumn were significantly higher (P<0.01) than summer/spring. Kids born and raised as singles were significantly (P<0.01) heavier than those were born as twins or triplets. The genetic and phenotypic correlations between birth and weaning weights were positive for both Damascus and Ardi goats. **Conclusions:** Genetic program for Ardi goats through upgrading with Damascus is possible to improve meat production.

1. Introduction

The most common indigenous breeds of goats raised in Saudi Arabia are Ardi, Hibsi and Zumri[1]. These local breeds have a considerable additive genetic variance and this concept is attributed to the fact that intensive selection was not practiced in these breeds. Therefore, high variability in local breeds shows that improving of these local breeds through selection is quite possible. However,

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comparing to other breeds under the same conditions, Ardi goat has the highest kidding percent ranging from 147.7% to 166.7% with the highest litter size (1.67). The mean feedlot gain of all breeds is 115 g/d, where Ardi kids expressed the fastest rate of gain (149 g/d). Furthermore, it has a satisfactory more milk yield [(160.3±6.37) kg/lactation] than other breeds and well-adapted to a wide range of farming environments, so more attention should be paid to this breed. Goat productivity can be improved through the selection of the distinguished individuals within herds of the same breeds to be used for breeding or through crossbreeding systems between different breeds to synthesis a new sophisticated improved breed of multipurpose[2-4]. The Damascus goats are considered a dual purpose animal for meat and milk production with high genetic level, therefore, they are used at large scale for production improvement of other breeds[5]. There is a great deal of interest to increase productivity of native goat breeds with more utilization of the genetic resources of Saudi Arabia goats through crossbreeding with Damascus breed. The upgrading programs are required to characterize genetically these local goat breeds as well as of the exotic breed (Damascus) that could be used for genetic improvement. The potential genetic changes in the economic traits are depending on the genetic variance, the heritability of the traits measured and its relationship with others. Breeding programs depend on the identification of various useful traits of high heritability and ease to measure for breeding improvement[6]. Estimation of heritability for early growth traits including birth weight and their linking to each other are hugely base for the selection progress which is ultimately dependent on maternal influences besides the additive genetic variance effects[7-10]. This does not make us forget the importance of environmental factors representing the identification of the genetic differences is realistic and truth between individual animals within herd[11-13]. So, such traits are considered as an early indicator for the late growth of economic interest[14,15]. Whereas, the existence of correlation between phenotypic and genotypic particularly the growth traits in early stages of ages allows early selection and exclusion of the unwanted animals[14-17]. The present study aimed to study the genetic and non-genetic factors and their interactions affecting body weights at birth, weaning and at 6 months of age, and average daily gains from birth to weaning, birth to 6 months and weaning to 6 months in Saudi Ardi, Damascus goats and their crosses. The study also aimed to estimate the heritability and variance components for the previous traits parameters in Ardi and Damascus goats.

2. Materials and methods

2.1. Location of study and animal management

A crossbreeding program between Saudi goats (Ardi, AA) as a native breed with Syrian goats (Damascus, DD) was carried out at Camel and Range Research Center (Al-Jouf province, Northern region of Saudi Arabia located at latitude of 29.97 °N and longitude of 40.21 °W and at 684 meters above sea level) to improve the meat productivity through crossbreeding and selection. Genetically selected and improved bucks were used to disperse these valuable genes throughout the goat herds in Saudi Arabia. All animals were raised under similar environmental, nutritional, and management conditions. The animals were housed in semi-shaded/open front barn and fed on a commercial concentrate and alfalfa hay. The amount of concentrate and hay were calculated according to the nutritional requirements for goats[18] which were dependent on animal ages and production status. Water, straw, salt and minerals supplemented in blocks were freely available to all animals.

2.2. Breeding plan of the genetic groups

A crossbreeding program between Ardi Saudi goats (A) as a native breed with Syrian Damascus goats (D) was started in 2006 to develop local breed through selection program. At the beginning of the base generation, breeding does of Ardi goats (A) were randomly divided into two groups. The first group of Ardi goats (A) was inseminated by elite bucks of the same breed to produce purebred litters and progenies. The second group of Ardi goats (A) was inseminated by Damascus sire (D) to produce crossbred of ½D½A. The latter crossbred (½D½A) was inseminated by Damascus sire to produce crossbred of ¾D¼A. At the same time, does of Damascus breed were inseminated from bucks of the same breed to produce purebred litters and progenies. Accordingly, the breeding plan was permitted to produce four genetic groups of AA, DD, ½D½A and ¾D¼A. The pedigree records of the body weights were obtained from a total number of 754 kids (397 males and 357 females) resulting from 46 Sires and 279 Dams during the time period from 2006 to 2010 of the study.

2.3. Data collection for statistical analysis

Birth weight (BW), weaning weigh (WW) and 6 months weight (6MW) as well as average daily gain during different growth stages from birth to weaning (D1), from weaning to 6 months (D2) and from birth to 6 months of age (D3) were recorded for all animals during season 1 (winter and Autumn) and season 2 (summer and spring) and years from 2006 to 2010.They were classified according to breed, generation, sex, season, year, and type of birth. Data were analyzed using PROC GLM procedure[19] for the least-squares means and standard errors of the fixed factors. Heritability and genetic parameters were estimated with derivative-free restricted maximum likelihood (REML) procedures using the MTDFREML program of Boldman *et al*[20].

2.4. Statistical model used for data analysis

$Y_{ijklmno} = \mu + B_i + G_j + X_k + S_l + Y_m + T_n + e_{ijklmno}$

Where;

$Y_{ijklmno}$: The record of BW, 6MW, YW, D1, D2 or D3 measured on o^{th} lamb born at m^{th} year of birth, i^{th} breed, j^{th} generation, k^{th} sex, l^{th} season and n^{th} type of birth;

μ: Overall mean when equal subclass numbers exists;

B_i: Fixed effect of i^{th} breed (i = 1, 2, 3 and 4);

G_j: Fixed effect of j^{th} generation (j = 1 and 2);

X_k: Fixed effect of k^{th} sex (k = 1 and 2);

S_l: Fixed effect of l^{th} season (l = 1 and 2);

Y_m: Fixed effect of m^{th} year (m = 1, 2, 3, 4 and 5);

T_n: Fixed effect of n^{th} type of birth (n = 1, 2, and 3);

$e_{ijklmno}$: Random error particular to the ijklmnoth observation assumed to be independently and normally distributed with mean zero and variance of $\delta^2 e$.

The assumed model for heritability, genetic correlations and breeding values was:

y = Xb + Zu + e

Where;

y: a vector of observations, b: a vector of fixed effects with an incidence matrix X;

u: a vector ofrandom animal effects with incidence matrix Z;

e: a vector of random residual effects with meanequals zero and variance $\delta^2 e$.

3. Results

The obtained results articulated wide phenotypic variations in all traits of the body weight and daily gain. The percentages of variation for body weights traits were moderate and ranged from 20.960% to 26.250%, while these variations were high and ranged from 24.070% to 39.990% for daily gains (Table 1).

Table 1

Actual means standard error (SE), standard deviations (SD) and ranges for kids growth traits.

Variables	Mean	SE	CV%	SD	Minimum	Maximum
BW	3.960	0.030	21.370	0.840	1.600	6.750
WW	15.440	0.147	26.250	4.050	5.550	27.200
6MW	24.210	0.184	20.960	5.070	8.600	43.000
D1	0.136	0.001	33.660	0.040	0.030	0.260
D2	0.104	0.001	39.990	0.040	0.002	0.290
D3	0.120	0.001	24.070	0.020	0.032	0.220

The genetic groups had a highly significant (P<0.01) effect on the body weights traits and daily weight gains for D1 (P<0.01) and D3 (P<0.05). Damascus and ½D½A goat groups had higher body weights (P<0.01) than Ardi and ¾D¼A groups at birth, weaning and at 6 months (Table 2).

Table 2

Least squares for weights (kg) at birth, weaning and 6 months of age.

Items	No.	BW	WW	6MW
Overall mean	754	3.737	15.077	23.593
Genetic groups				
AA	314	3.653 ± 0.053	14.464 ± 0.258	23.313 ± 0.335
DD	175	3.912 ± 0.076**	15.960 ± 0.366**	24.774 ± 0.475**
½D½A	87	3.823 ± 0.096**	15.270 ± 0.462**	24.841 ± 0.599**
¾D¼A	178	3.560 ± 0.075	14.615 ± 0.365	23.446 ± 0.473
Generation				
F1	432	3.860 ± 0.052**	14.936 ± 0.252	23.541 ± 0.326
F2	322	3.614 ± 0.077	15.218 ± 0.372*	24.646 ± 0.482*
Sex of kids				
Male	397	3.898 ± 0.054**	15.947 ± 0.264**	25.307 ± 0.342**
Female	357	3.576 ± 0.055	14.207 ± 0.266	22.879 ± 0.345
Seasons				
Winter-Autumn (S1)	456	3.629 ± 0.057	14.969 ± 0.276	23.487 ± 0.358
Summer-Spring (S2)	298	3.845 ± 0.055**	15.185 ± 0.268	24.700 ± 0.348**
Years				
2006	37	3.213 ± 0.137	13.607 ± 0.664	22.349 ± 0.860
2007	188	3.548 ± 0.073	13.733 ± 0.356	22.893 ± 0.461
2008	120	3.868 ± 0.076	15.546 ± 0.367	26.087 ± 0.476**
2009	139	4.086 ± 0.071**	15.437 ± 0.343	23.580 ± 0.445
2010	270	3.970 ± 0.054	17.063 ± 0.264**	25.556 ± 0.342
Type of births				
Single	216	4.278 ± 0.058**	17.146 ± 0.279**	25.646 ± 0.362**
Twins	470	3.827 ± 0.046	14.410 ± 0.225	23.779 ± 0.291
Triplets	68	3.107 ± 0.097	13.675 ± 0.467	22.854 ± 0.605

* = P < 0.05; ** = P < 0.01.

Also, Damascus and ½D½A goat groups had higher daily gain during D1 ($P<0.01$) and D3 ($P<0.05$) periods than Ardi and ¾D¼A groups (Table 3). However, no significant differences between the genetic goats groups in the daily gain during D2 period (Table 3). Generally, F2 generation had a higher body weights than F1 at weaning and at 6 months, as well as the daily body gain during D1, D2 and D3 periods (Table 2 and Table 3). However, F1 had a significantly higher ($P<0.01$) birth body weights than F2 and no significant effect on daily gain during D2 period.

Analyses of variance showed that the fixed effects of sex, season, year and type of birth were significantly different for most body weights and daily gains (Tables 2 and 3). Male kids had a significant ($P<0.01$) heavier body weights than female at birth, weaning and at 6 months of ages. Subsequently, the daily body gains for male kids were significantly higher ($P<0.01$) than females during D1, D2 and D3 periods.

Kids born during Summer/Spring season (S2) had a significant heavier ($P<0.01$) body weights than at birth and 6 months of ages, as well as higher daily gain during D2 and D3 periods than those born during Winter/Autumn (S1). Anyways, no significant differences between seasons for body weight and daily gain were observed at weaning and D1 period.

Project years had highly significant ($P<0.01$) effect on the body weights and daily gain during various growth stages (Table 2 and 3). As shown in Table 3, the highest body weight ($P<0.01$) at birth, weaning and at 6 months of age were recorded for kids born in years 2009, 2010 and 2008, respectively. Conversely, the lowest body weight at birth, weaning and at 6 months were recorded in the first and second years of the project (2006 and 2007). The highest ($P<0.01$) daily body gain during D1 period was observed for kids born in 2010, whereas kids born in 2008 recorded highest daily gain during D2 and D3 periods (Table 3).

Kids born as single had heavier ($P<0.01$) body weights at birth, weaning and at 6 months of ages than those born as twins or triplets (Table 2). Similarly, they had higher ($P<0.01$) daily body gain during D1 and D3 periods. However, there were no significant differences between type of births for daily gain during D2 period (Table 3).

The estimates of heritability and variance components for body weights at different stages in Ardi and Damascus goats are presented in Table 4. Damascus goats had higher heritability estimates than

Table 3

Least squares for daily weights (kg) gains at different ages.

Items	No.	D1	D2	D3
Overall mean	754	0.135	0.107	0.121
Genetic groups				
AA	314	0.128 ± 0.003	0.105 ± 0.002	0.117 ± 0.001
DD	175	0.144 ± 0.004**	0.104 ± 0.004	0.124 ± 0.002*
½D½A	87	0.136 ± 0.005**	0.113 ± 0.005	0.125 ± 0.003*
¾D¼A	178	0.131 ± 0.004	0.105 ± 0.004	0.118 ± 0.002
Generation				
F1	432	0.131 ± 0.002	0.102 ± 0.002	0.117 ± 0.001
F2	322	0.138 ± 0.004*	0.112 ± 0.004	0.125 ± 0.002*
Sex of kids				
Male	397	0.143 ± 0.003**	0.111 ± 0.003**	0.127 ± 0.001**
Female	357	0.126 ± 0.003	0.103 ± 0.003	0.114 ± 0.002
Seasons				
Winter-Autumn (S1)	456	0.135 ± 0.003	0.101 ± 0.003	0.118 ± 0.002
Summer-Spring (S2)	298	0.135 ± 0.003	0.113 ± 0.003**	0.124 ± 0.002**
Years				
2006	37	0.123 ± 0.007	0.104 ± 0.007	0.113 ± 0.004
2007	188	0.121 ± 0.004	0.109 ± 0.004	0.115 ± 0.002
2008	120	0.139 ± 0.004	0.125 ± 0.004**	0.132 ± 0.002**
2009	139	0.135 ± 0.004	0.096 ± 0.003	0.116 ± 0.002
2010	270	0.156 ± 0.003**	0.101 ± 0.003	0.128 ± 0.001
Type of births				
Single	216	0.153 ± 0.003**	0.101 ± 0.003	0.127 ± 0.002**
Twins	470	0.125 ± 0.002	0.111 ± 0.002	0.118 ± 0.001
Triplets	68	0.125 ± 0.005	0.109 ± 0.005	0.117 ± 0.003

D1 = daily weight gain from Birth to weaning; D2 = from weaning weight to 6 month; D3 = Birth to 6 month weights; * = $P < 0.05$; ** = $P < 0.01$.

Table 4

Estimates of heritability (h^2) and variance components for body weights at birth, weaning and 6 months of ages in Ardi goat (AA) and Damascus goat (DD).

Breed	Body weight	h^2	$\delta^2 p$	$\delta^2 g$	$\delta^2 e$
AA	BW	0.150	0.513	0.079	0.434
	WW	0.260	12.080	3.11	8.97
	6MW	0.450	23.264	10.385	12.88
DD	BW	0.410	0.564	0.232	0.332
	WW	0.350	15.561	5.451	10.11
	6MW	0.180	20.319	3.649	16.67

Ardi for birth (0.41 *vs* 0.15) and weaning (0.35 *vs* 0.26) weights, while, Ardi goats had higher heritability estimates than Damascus for body weights at 6 months of ages (0.45 *vs* 0.18).

The values of phenotypic correlation between BW and WW; BW and 6MW; WW and 6MW were 0.32, 0.32 and 0.73 for Damascus goats and were 0.18, 0.10 and 0.72 for Ardi goats, respectively. The corresponding values for genotypic correlations were 0.56, 0.05 and 0.81 for Damascus, and 0.22, 0.23 and 1.00 for Ardi goats, respectively.

4. Discussion

The genetic groups had a highly effect on the body weights traits and daily weight gains. Crossbred kids of ½D½A and ¾D¼A groups were heavier in all body weights compared to Ardi kids, which means the body weights and growth rates in the local goats breed were improved and associated in crossbred with Damascus sire bucks; and the variation in the growth performance in the crossbreeding attributed to Damascus genes. Therefore, the Damascus goat is the best breed to be raised in Saudi Arabia, and could be used in upgrading programs as well as improving meat production of local breeds in the Arabic countries. This result is consistent with those reported by Al-Saef[21] who reported that genetic groups of Ardi (A), Damascus (D), ½D½A and ¾D¼A goats were the main source of variations for the most body weights.

Compared to ½D½A group, the lower values in all stages of the body weights were observed in ¾D¼A kids group. This result would be expected under this model of crossbreeding where the estimates of direct heterosis were positive. This fact was confirmed by Khalil *et al*[22], since the estimates of direct heterosis were positive for the plurality of the weights. However, non-significant differences in post weaning body weights of kids related to different genetic groups were reported by other authors[23,24].

In the same context, Khadiga *et al*[25] and Browning *et al*[26] found that sire breeds were the main source for weight differences at various stages of growth. Similarly, the early live body weights in Boer crossbreds with Spanish purebred goats (Boer-Spanish) were slightly heavier (P<0.05) than Spanish goat breeds[27–29]. Similarly, Waldron *et al*[30] noted differences between Boer crossbreds with Spanish and Spanish pure breeds of 630 g in 90 days (weaning weight) and by 40 g in final body weight as a difference in favor of Boer crossbreds. In the same line Mourad and Anous[31] found that French Alpine-sire crossbred kids (½ Alpine × ½ African goat) were heavier (P<0.05) than kids of the common African breed at birth and 30 days of age. Not only the genetic potentiality can influence the initial growth rate, including birth weight, but also the maternal status and environmental conditions have a reasonable share of this[10].

The analyses of variance in this study showed that the fixed effects of sex, season, year and type of birth were significant differences for studying body weights. These results confirmed with those reported by many authors[21,26,31–35]. Sex of kids had a highly effect on daily weights gains for different growth stages in this study. During the different stages of growth periods, the daily weight gain was higher for male kids compared to females. So, male kids were significant heavier than females at all studied ages. This indicates that male kids can grow faster than female ones during the first six months of age. The differences in the chromosomal structure between males and females are associated with differences in the sex hormones which influence the skeletal growth and fetal development during pre and postnatal periods and subsequently affect the growth rate which attributed to the differences in the live body weights at birth, weaning and the following growth stages of age[36].

The present study showed that the kidding years of the project had highly significant effects on the daily weight gains during various growth stages in the study. The highest gain was observed for kids born in 2010, while the lowest gain was recorded for those born in 2006 and 2007. The average daily gains were varies with the stage of growth, but generally increased as the project progresses. The effects of kidding years of birth on the live body weights may be attributed to the climatic conditions which are varying from year to another and accompanied with nutritional changes and accordingly changes in the management of the herd[37–39].

The daily weight gains during summer/spring seasons were significantly higher than winter/autumn for both D2 and D3 periods. This means the kids which were born during winter/autumn seasons were grow up better during summer/spring seasons when the better quality green fodder is prevailing and available for dams and post-weaning kids. Similarly, Zhang *et al*[35] drew his attention; the kids born in summer had powerful growth rate during post-weaning period although they were of lowest rank in pre-weaning compared to others. Whatever the case, the influences of seasons on kids initial weights and growth rate are important and have been reported in different studies[17,38]. These variations between seasons among different years might be accompanied by differences of rainfall and have a great impact on the intensity of green fodder production and consequently its availability during the years and seasons[17]. Also, the variation values of weights and growth rates among different seasons and years of kidding may result from changes in management and herd size[35].

Kids born and raised as singles were significantly heavier than those raised as twins or triplets which reflected the fact that single kids had more milk from their dams than other types of birth. During pre-weaning, single born kids are luckier and get their food needs from his dam without competition from other kids. Contrary, multiple birth kids have a fierce competition for getting nutrition needs from their dam and this reflected in the growth rates and consequently weaning weights. However, after weaning, twins can adapt themselves to the environmental conditions and vigorously as usual compete the individuals of single births to get their food needs and this explains the lack of significant for daily weight gains during

period D2. So, rather than suckling period, the growth, dominance during D2 period, mainly depend on the viability of balanced ration and the adaptation to the environmental variations[35].

Heritability estimates for birth weights and weaning weights for Damascus goat were higher than Ardi goats. However, the heritability of weaning weights for Ardi goat (0.26) is similar to Damascus goat (0.27) in other study reported by Mavrogenis *et al*[40], furthermore, it was higher than Damascus (0.17) in other study[41]. Also, in the current study, Ardi goats recorded higher heritability estimates for weights at 6 months of age than Damascus goats (0.45 *vs* 0.18). In any case, the heritability estimates for weaning weight (0.26) of Ardi goat were higher than the estimate for birth weight (0.15) and this result was in consistency with Menezes *et al*[8]. Contrary, Rashidi *et al*[42] recorded higher heritability estimates for birth weight than weaning weight in Markhoz goats (0.22 *vs* 0.16).

Heritability estimate for birth weight of Ardi goat is similar to that was estimated (0.11 to 0.15) for Angora, Alpine and Blended goat breeds[43–46], whereas, it was higher than that recorded for Black Bengal[47] and Iranian Cashmere goats[48], and lower than that reported for Black Bengal[49,50], Boer[35,51,52], Ganjam[53], and Draa[32] goat breeds. On other side, the heritability estimate of the birth weight for Damascus goats herein (0.41) is similar (0.39-0.43) to Draa, Black Bengal and Boer goat breeds[32,49,52]. In any case, it was lower than that reported by Portolano *et al*[14] for Sicilian Girgentana goats (0.49), Bosso *et al*[54] for West African Dwarf goats (0.50), Khadiga *et al*[25] and Neopane for Nubian Goat (0.54)[55].

Generally, the trait of the low percentage of the genetic variance component indicates that these traits are highly affected by environmental conditions (management system, feeding regime, climatic conditions and diseases stability, *etc*). However, the moderate or high percentage of genotypic variance gives hope for the possibility to improving the traits through selection programs. In this study, the percentage of genetic variance component in Ardi goat is low in both birth weight and weaning weight so that the best programs for genetic improvement of Ardi goat is possible through upgrading with Damascus goats.

Heritability estimate for weaning weight of Ardi goat (0.26) is similar (0.23-0.30) to those estimated for Alpine, Jamunapari and Boer goats[35,44,56] and higher than those estimated for Angora (0.04), Sirohi (0.11), Black Bengal (0.16) and Draa goats (0.19) [32,50,57,58]. However, it was lower than those recorded for Angora (0.59) and Boer goats (0.60)[59,60]. On the one side, the heritability estimate for weaning weight of Damascus goats (0.35) in herein study is similar to that estimated (0.35-0.37) for the same breed in other studies[61,62]. Similarly, Singh *et al*[50] and Misra[63] in different two studies were recorded; the heritability estimates for weaning weight for Jamunapari goats were similar (0.42 and 0.43). However, the heritability for Damascus weaning weight was higher than those reported (0.16) for this breed in other study[41]. Different goat breeds as Sicilian Girgentana[14] and Angora goats[64] had similar heritability estimates as Damascus goats. Whereas, Black Bengal, Boer, Sirohi, Draa and Jamunapari goats recorded lower (0.11-0.30) heritability for weaning weights[32,35,50,56,57] than Damascus goats which were considered in this study. On the other side, it was lower than those reported by Ricordeau *et al*[65] for Saanen goats (0.48); Khadiga *et al*[25] for Nubian Goat (0.77); and Siddiqui *et al*[66] for Osmanabadi goats (0.75).

The heritability estimates for Ardiand Damascus weights at 6 months of ages were 0.45 and 0.18 respectively. These estimates are similar and differ (lower or higher) from various goat breeds. The heritability estimates for Ardi goats weights at 6 months of ages were higher than Damascus (0.45 *vs* 0.18) goats in this study and similar to Beetal goats (0.43) in other study[67]. However, these estimates were lower than those reported in Jamunapari[56], Boer[37], and Osmanabadi goats[66] where it were recorded 0.51, 0.59 and 0.66, respectively.

The genotypic and phenotypic correlations between the studied growth traits at different stages showed positive values for both Damascus and Ardi goats. Similarly, Hermiz[24], Mourad and Anous[31], Mavrogenis *et al*[40], and Xiong *et al*[68] found positive genotypic and phenotypic correlations between body weights at different ages. Therefore, these estimates suggest that there is no genetic contradiction between these traits and their assigned genes which were responsible for phenotypic expression. Accordingly, the selection of one trait will have an expected positive impact on the others related traits. The selection for birth weight would have a considerable positive impact on weaning weight. However, the efforts should be made to focus the high heritability, which incidentally are expressed early in life. Positive correlations between birth weight and weaning weight is an indication that a heavy kids had a fast growth rate during the pre-weaning stage which resulted in heavy weaning weight[17,55,69].

Since the estimates of direct heterosis were positive for the studied growth rates, the genetic program for Ardi goat meat production improvement through upgrading with Damascus goats is possible to this local goats breed in Saudi Arabia. Genetic and phenotypic correlations for growth traits are positive for Damascus and Ardi goats and consequently the selection for birth weight can have a considerable positive effect on weaning weight.

Conflict of interest statement

We declare that we have no conflict of interest.

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References

[1] Dosari MN, Al-Hazab AA, Al-Haj GA. Nutritional and physiological studies to native goat breeds in Saudi Arabia. King Abdul Aziz City for Science Technology Project No. AT-13-43, 1996.

[2] Mbuku SM, Okeyo AM, Kosgey IS, Kahi AK. Optimum crossbreeding systems for goats in low-input livestock production system in Kenya. *Small Rumin Res* 2015; **123**(1): 55-61.

[3] Babayan N. Goat industry development project in Armenia. European Regional Conference on Goats; 7-13 April 2014; 51-55.

[4] Ajay K, Lesile LP, Seiko J. Sustainable wool production in India. *Sustain Fibr Textil* 2017; 87-115.

[5] Mavrogenis NY, Antoniades RWH. The Damascus (Shami) goat of Cyprus. *Anim Genet Resources Inform* 2006; **38**: 57-65.

[6] Sonja D, Jennifer LS, Joanne C, Hans DD, Kim LB. Genetic solutions. *Adv Sheep Welfare* 2017; 107-130.

[7] Mandal A, Karunakaran M, Sharma DK, Hasan Baneh H, Rout PK. Variance components and genetic parameters of growth traits and Kleiber ratio in Muzaffarnagari sheep. *Small Rumin Res* 2015; **132**: 79-85.

[8] Menezes LM, Sousa WH, Cavalcanti EP, Gama LT. Genetic parameters for reproduction and growth traits in Boer goats in Brazil. *Small Rumin Res* 2016; **136**: 247-256.

[9] Al-Shorepy SA. Estimates of genetic parameters for direct and maternal effects on birth weight of local sheep in United Arab Emirates. *Small Rumin Res* 2001; **39**: 219-224.

[10]Mandal A, Neser FW, Rout PK, Roy R, Notter DR. Estimation of direct and maternal (co)variance components for pre-weaning growth traits in Muzaffarnagari sheep. *Livest Sci* 2006; **99**: 79-89.

[11]Samson TI, Olajumoke OA. Genetic and non-genetic factors affecting yield and milk composition in goats. *J Adv Dairy Res* 2017; **5**: 2.

[12]Mdladla K, Dzomba EF, Muchadeyi FC. The potential of landscape genomics approach in the characterization of adaptive genetic diversity in indigenous goat genetic resources: A South African perspective. *Small Rum Res* 2017; 87-92.

[13]Schaeffer LR. Multiple trait international bull comparisons. *Livest Prod Sci* 2001; **69**: 145-153.

[14]Portolano M, Todaro R, Finocchiaro JH, van Kaam CM. Estimation of the genetic and phenotypic variance of several growth traits of the Sicilian Girgentana goat. *Small Rumin Res* 2002; **45**: 247-253.

[15]Hanford KJ, Van Vleck LD, Snowder GD. Estimates of genetic parameters and genetic trend for reproduction, weight, and wool characteristics of Polypay sheep. *Livest Sci* 2006; **102**: 72-82.

[16]El-Fadili M, Michaux C, Detilleux J, Leroy PL. Genetic parameters for growth traits of the Moroccan Timahdit breed of sheep. *Small Rumin Res* 2000; **37**: 203-208.

[17]Al-Shorepy SA, Alhadranu GA, Abdul Wahab K. Genetic and phenotypic parameters for early growth traits in Emirati goat. *Small Rumin Res* 2002; **45**: 217-223.

[18]NRC. *Nutrient requirements of goats*. Washington DC: National Academy Press; 1981.

[19]SAS. *Procedure guide*. Version 6.12 Edition. Cary, NC, USA: SAS Institute, INC; 1999.

[20]Boldman KG, Kriese LA, van Tassell CP, Kachman SD. A manual for use of MTDFREML. A set programs to obtain estimates of variances and covariance [DRAFT]. U.S. Department of Agriculture, Agricultural Research Service; 1995.

[21]Al-Saef AM. Genetic and phenotypic parameters of body weights in Saudi Aradi goat and their crosses with Syrian Damascus goat. *Small Rumin Res* 2013; **112**: 35-38.

[22]Khalil MH, Mohammed KM, Al-Saef AM, Zeitoun MM, El-Zarei MF. Crossbreeding components for growth, carcass and meat composition traits in crossing Saudi Aradi with Damascus goats. *Small Rumin Res* 2010; **94**(1): 10-16.

[23]Gebrelul S, Sartin I, Iheanacho M. Genetic and non-genetic effects on growth and mortality of Alpine, Nubian and crossbred kids. *Small Rumin Res* 1994; **13**: 169-176.

[24]Hermiz HN. Genetic evaluation of local goats and their crosses using some productive traits [dissertation]. Iraq: University of Baghdad; 2001.

[25]Khadiga ME, Ballal Mohamed Khair A, Ahmed Lutfi MA. Estimates of phenotypic and genetic parameters of growth traits in the Sudanese Nubian goat. *Res J Anim Vet Sci* 2008; **3**: 9-14.

[26]Browning Jr, Leite-Browning ML. Birth to weaning kid traits from a complete diallel of Boer, Kiko and Spanish meat goat breeds semi-intensively managed on humid subtropical pasture. *J Anim Sci* 2011; **89**: 2696-2707.

[27]Luo J, Sahlu T, Cameron M, Goetsch AL. Growth of Spanish, Boer Angora, and Boer Spanish goat kids fed milk replacer. *Small Rumin Res* 2000; 36: 189-194.

[28]Oman JS, Waldron DF, Griffin DB, Savell JW. Carcass traits and retail display-life of chops from different goat breed types. *J Anim Sci* 2000; **78**: 1262-1266.

[29]Cameron MR, Luo J, Sahlu T, Hart SP, Coleman SW, Goetsch LA. Growth and slaughter traits of Boer × Spanish, Boer × Angora, and Spanish goats consuming a concentrate-based diet. *J Anim Sci* 2001; **79**:1423-1430.

[30]Waldron DF, Huston JE, Thompson P, Willingham TD, Oman JS, Savell JW. Growth rate, feed consumption and carcass measurements of Spanish and Boer Spanish goats. *J Anim Sci* 1995; **73**(suppl 1): 253 (Abstr.).

[31]Mourad M, Anous MR. Estimates of genetic and phenotypic parameters of some growth traits in common African and Alpine crossbred goats. *Small Rumin Res* 1998; **27**: 197-202.

[32]Boujenane I, El Hazzab A. Genetic parameters for direct and maternal effects on body weights of Draa goats. *Small Rumin Res* 2008; **80**: 16-21.

[33]Zhang CY, Yang LG, Shen Z. Variance components and genetic parameters for weight and size at birth in the Boer goat. *Livestock Sci* 2008; **115**: 73-79.

[34]Hermiz HN, Alkass JE, Hobi AA, Asofi MK. Genetic and phenotypic parameters of body weights in Iraqi local goat and their crosses with Damascus. *J Duhok Univ* 2009; **12**(1)(Special issue): 189-194.

[35]Zhang CY, Zhang Y, Xu DQ, Lia X, Sua J, Yang LG. Genetic and phenotypic parameter estimates for growth traits in Boer goat. *Livestock Sci* 2009; **124**: 66-71.

[36]Miroslav S, Nikolai T, Krym N, Atanas K, David LH. Influence of live weight, sex and type of birth on growth and slaughter characteristics in early weaned lambs. *Small Rumin Res* 2014; **121**(2-3): 188-192.

[37]Schoeman JF, Els B, Niekerk MM. Variance components of early growth traits in the Boer goat. *Small Rumin Res* 1997; **26**: 15-20.

[38]Zhang HP, Li L, Xu GY, Zhu XD, Li GQ, Hang HQ. Estimation of genetic parameters of reproduction traits in Boer goat. *Anim Husb Vet Med* 2002; **34**: 1-2.

[39]Shrestha JNB, Fahmy MH. Breeding goats for meat production: a review (2) Crossbreeding and formation of composite population. *Small Rumin Res* 2007; **67**: 93-112.

[40]Mavrogenis A, Constantinou, Louca A. Environmental and genetic causes of variation in production traits of Damascus goats. *Anim Prod* 1984; **38**: 99-104.

[41]Taskin T, Kosum N. Akbas Y, Kaymakc M. A study on some growth traits and their heritability estimates of Damascus kids. *Ege Universitesi Ziraat Fakultesi Dergisi* 2000; **37**(1): 137-144.

[42]Rashidi A, Bishop SC, Matika O. Genetic parameter estimates for pre-weaning performance and reproduction traits in Markhoz goats. *Small Rumin Res* 2011; **100**(2-3): 100-106.

[43]Das SM. Reporductivity parameters and productivity indices of Blended goats in Malya Tanzania. International Foundation for science Workshop: Animal production scientific Workshop for East Afircan IFS Grantees 1993; Kampala, Uganda.

[44]Nadarajah K, Burnside EB, Kennedy D. Estimation of phenotypic and genetic parameters for growth of goats enrolled in the Ontario goat. Herd Improvement Program (GHIP), Annual Report; 1995.

[45]Podisi B, Waldron DF, Shelton M, Lupton CJ. Relationships among production traits in Angora goats. *Anim Breeding Abst* 1997; **43**:1234.

[46]Mugambi JW, Wakhungu BO, Inyangala WB, Muhuyic Muasya T. Evaluation of the performance of the Kenya Dual Purpose Goat composites: Additive and non-additive genetic parameters. *Small Rumin Res* 2007; **72**: 149-156.

[47]Guha H, Gupta S, Mukherjee AK, Moulick SK, Bhattacharya S. Some causes of variation in growth rates of Black Bengal goats. *Indian J Vet Sci* 1968; **38**: 269-278.

[48]Maghsoudi R, Vaez Torshizi, Safi Jahanshahi A. Estimates of (co) variance components for productive and composite reproductive traits in Iranian Cashmere goats. *Livestock Sci* 2009; **126**: 162-167.

[49]Ali SZ. Heritability estimates for birth weight, 4-week weight, weaning weight and multiple birth in Black Bengal goats of Bangladesh. *Indian Vet J* 1983; **60**: 118-121.

[50]Singh DK, Singh CS, Mishra HR. Factors affecting growth of Black Bengal and its crossbreds with Jamunapari and Beetal goats. *Indian J Anim Sci* 1991; **61**: 1101-1105.

[51]Niekerk MM, van Schoeman SJ, Botha M.E, Casey N, van Niekerk MM. Heritability estimates for preweaning growth traits in the Adelaide Boer goat flock. *S Afr J Anim Sci* 1996; **26**: 6-10.

[52]Hongping Z. Estimation of genetic parameters of Boer goat reproductive traits. Proceedings of the 2001 Conference on Boer goats, International Goat Association. Beijing, China; 2001.

[53]Madeli UC, Patro BN. Heritability and correlations among body weights at different ages in Ganjam goats. *Indian Vet J* 1984; **61**: 233-235.

[54]Bosso NA, Cisse MF, van der Waaij EH, Fall A, van Arendonk JAM. Genetic and phenotypic parameters of body weight in West African Dwarf goat and Djallonke sheep. *Small Rumin Res* 2007; **67**: 271-278.

[55]Neopane SP. Selection for improvement of the productivity of Hill Goats in Nepal. Proceedings of the 7th International conference on Goats. International Goat Association. France; 2000, p. 206-208.

[56]Roy R, Saxena VK, Singh SK, Khan BU. Genetic analysis of body weights at different ages in Jamunapari goats. *Indian J Anim Sci* 1997; **67**: 337-339.

[57]Misra RK. Genetic analysis of growth, efficiency of feed conversion and carcass yield and composition in Sirohi (goat) and is crosses with Beetal [dissertation]. Haryana, India: Kurukshetra University; 1983.

[58]Gerstmayer S, Haussmann H, Schlote W. Estimation of variance components for filial and maternal effects in Turkish Angora goats. *J Anim Breed Genet* 1992; **109**: 252-263.

[59]Nicoll GB. Estimates of environmental effects and some genetic parameters for weaning weight and fleece weights of young Angora goats. *Proc N Z Soc Anim Prod* 1985; **45**: 217-219.

[60]Els JF. Heritability estimates for growth traits in the improved Boer goat. The 6th World Congress on Genetics Applied to Livestock Production. Armidale: NSWAustralia; 1998 Jan 12-16; **24**: 193-196.

[61]Mavrogenis AP. Relationships among criteria of selection for growth and mature body weight in the Damascus goat. *Tech Bull* 1985; 2-6.

[62]Jawasreh KIZ, S'oob M, Darweesh A. Estimation of some genetic and non-genetic parameters for some growth traits of Damascus goats in Jordan Dirasat. *Agric Sci* 2004; **31**(3): 317-322.

[63]Misra RK. Genetic improvement of feed-lot traits in goat. *Int J Anim Sci* 1995; **10**: 331-335.

[64]Taddeo HR, Allain D, Mueller J, Rochambeau H, Manfredi E. Genetic parameter estimates of production traits of Angora. *Small Rumin Res* 1998; **28**: 217-223.

[65]Ricordeau G, Poujardieu B, Bouillon J, Lajous A. Genetic parameters of growth in young Saanen female goats in a testing station. *Ann Genet Sel Anim* 1972; **4**(3): 477-480.

[66]Siddiqui MF, Bonde HS, Rotte SG, Deshpande KS. Studies on some growth attributes of Osmanabadi goat kids. *J Agric Sci Camb* 1981; **97**: 747-749.

[67]Nagpal S, Chawla DS. Genetic estimates of body weights of Beetal goats. In: Proceedings of 4th International Conference on Goats, Brasilia, Brazil, Empresa Braileira de Tequisa Agropecuaria. Brasilia, Brazil; 1987, p. 1313.

[68]Xiong Q, Chai J, Li XF, Suo XJ, Chen MX. Two tagSNPs in the prolactin receptor gene are associated with growth and litter traits in Boer and Macheng Black crossbred goats. *Livestock Sci* 2016; **193**: 71-77.

[69]Concepta M, Guilherma SF, Helde L, Laila TD, Rodrigo DT, Luci SM. Growth of Saanen, Alpine and Toggenburg goats in the Federal District, Brazil. Genetic and environmental factors. *Cienc Anim Brasil* 2008; **9**(1): 68-75.