Genetic and non-genetic factors estimation for growth parameters of Abergelle and Boer goat crossbred kidsin Tigray Region, Ethiopia

Comment [H1]: Which blood level kid? 50%....? F1....?

Abstract

A total of 787 records on each growth traits and average daily gains kept on a semi intensive management system for a period of 10 years were assessed to determine the effects of genetic and environmental factors on the growth performance of Abergelle and Boer crossed kids. General Linear Model procedures of SAS and paternal half sib analysis was used to analyze the fixed effects andgenetic parameters respectively. The study revealed that genetic groups,birth type, season of birth, sex, parity and year of birth and dam weight at kidding significantly (p<0.01) affect birth weight of kids. The overall mean birth weight was 2.29±0.01and 2.98±0.03 kg for both genetic groups respectively. Single born kids, kids born in the major wet season and male were heavier than their counterparts. The heritability values for birth weight (0.14±0.05 and 0.20±0.06) for the local and the crossbred were moderate, and show significance difference (P<0.05).The genotypic and phenotypic correlations between the studied growth traits showed positive values for both Abergelle and Boer cross kids.It was also observed that the highest growth parameters were ~~occurred~~ observedin crossbred kids, and crossing of local breeds with exotic is appreciated to improve the production and productivity of local goats.

Key words:Abergelle goat, Correlation, Genetic parameter, Heritability, Non genetic effect, Repeatability

Introduction

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Ethiopiaowned about 30 million goats, of which 71.6and 28.4% are female and male respectively(CSA, 2016; Abraham *et al.*, 2017). The goat population in Ethiopia showed an increasing trend (1.4%) from year to year (FAO, 2014). Increasing population pressure, land scarcity and diminishing production resources are some of the causes for the higher interest of the community for goat husbandry in comparison to other species in the tropics (Temesgen, 2016). In addition to that goats are relatively tolerant to drought and widely adapted to different climates, they can survive on woody browse and infrequent watering and their fast reproduction rate enables their owners to recover quickly, following a drought.

Comment [H3]: Old reference. 2022 CSA is violable.

Though, goats play great role in the livelihood of the producers and the economy of the country at large, production and productivity of indigenous goats is very low. This may due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breed and breeding strategies. Thus, intensification of livestock production system by using improved exotic breeds and crossing them with local breeds is an option and advocated for the past many decades in Ethiopia.

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Combining the adaptability (harsh climates, disease resistance, heat tolerance, ability to utilize poor quality feeds) of native goat with the high milk and meat production potential and fast growth rates of temperate goat through cross breeding lead to good adaptability, improve fertility, reduce mortality, efficient growth, feed conversion, milk and meat improvement and this has been practiced as a more sustainable way to improve productivity (Kefena*et al.*, 2011).

Crossing of Boer bucks with Abergelledoes, one of the genetic improvement programshad been implemented at Abergelle Agricultural Research Center to evaluate the growth performance and associated factors for the crossbred kids. Though the research had been conducted since 2009,the genetic parameters (heritability, repeatability and genetic and phenotypic correlations) and impact of non-genetic factors on crossbred goats was not yet estimated. With the above background, the study was undertaken with the objectivesof estimating the genetic and non-geneticfactors and evaluating growth performance of Abergelle goats and their crosses with Boer

Materials and methods

Study Area

The study was conducted at Abergelle Agricultural Research station, TanquaAbergelle district,Central Zone of Tigray.The area found at 110 km from Mekelle (the capital city of the National Regional State) and 893 km from Addis Ababawith a latitude and longitude of $13^{o} 14^{'} 06^{''}$ N and $38^{o} 58^{'} 50''$ E respectively. It is categorized as hot to warm sub-moist lowland (SML-4) sub-agro ecological zone of the region with an altitude of 1300-1800 m above sea level. The main rainy season is June to August with mean annual rainfall ranges from 299 to 650 mm and is characterized by low, erratic and variable rainfall. A little amount of rain is found in the short rain season from March to April. The mean annual temperature ranges from 2/8 to 40^{o}c.

Comment [H5]: Sources?

The district has a total population of 92,844 with an annual growth rate of 2.7% and a population density of 64.22 persons per kilometer square (CSA, 2007). Of the total population, 92.43% lives in rural areas, while the rest lives in the urban. The area is known for its large livestock population especially goats. The main crops are sorghum, maize, sesame, teff (*Eragrostistef*), cow pea, check pea, lentil, and limited amounts of barley and oil seed crops (TanquaAbergelle BOARD,2018).

Comment [H6]: No recent reference yet?

Breed Description

The key identifying features of Abergelle breed is that it is found in mixed farming and agro pastoral areas with average flock size of 20±16 and flock structure 84% female and 16% male (14% intact and 2% castrated). Facial profile of the goats is 44% straight and 56% concave and almost all males have horn (89% spiral, 11% straight), in which all directed backwards. Ruffs and wattles are present in both sexes (FARM Africa, 1996; Halima *et al*., 2012).The common coat colors are plain, patchy, and spotted 56, 33 and 11% respectively. The height at wither (cm), mature body weight (kg), chest girth (cm), ear length (cm) and horn length (cm) are 71.4±3.5, 33.6±5.9, 79.5±2.9, 13.0±0.8 and 37.07±9.1 for males and 65.0±2.8, 28.4±3.5, 71.2±3.8, 12.7±0.8 and 19.6±5.7 for females respectively. The common birth type is single (98.7%) and rare twinning (1.3%) (Minister, 2017; Alubel, 2015).

The Boer breed is known for its good-quality meat and fast growth rate. Boer goats have earned popularity in many parts of the world. These goats are characterized by their large white bodies and brown heads. The brown color extending or covering the neck and part of the chest regions may be observed in a few. However, some may be completely brown or white in color. Boer goats are known for their rapid growth, high fertility, and adaptability. They are sturdy animals and can be taken care of and managed easily and are also capable of surviving droughts, in the absence of any supplementary feed. The does in this breed have strong maternal skills when compared to other goats. A mature buck has a weight of around 110 to 135 kg, while a mature doe is around 90 to 100 kg. The weights of their young ones at birth are around 3 to 4 kg. Also, the male kids are about 0.5 kg heavier than the female kids.According to the South African Breeders' Association; there are five types of Boer goats, namely, the ordinary Boer goats, the long hair Boer goats, the polled Boer goats, the indigenous Boer goats, and the improved Boer goats (Lu and Potcoiba, 1988). A 50% blood level cross bred kids were used for the study.

Comment [H7]: Incorporate updates

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Animal Management

A semi-intensive management system was practiced at the center with the herd grazing and browsing outdoors during the day (7:30 - 11:30 AM and 2:00 - 5:30 PM) and housed in pens at night. The house was constructed as half concrete building walls with mesh wire and corrugated metal sheet roofs. Hay and water were freely availablebut supplementary feed (composition of 59% wheat bran, 33% “nug” cake,4% molasses, 3% lime and 1% salt and nutrient content of CP 20% and ME (Mcal/kg) 2.18) was provided depending on the age and physiological status of the animal.

Does and bucks were herded and housed separately except during the mating periods. Bucks were selected for general health and absence of observable defects (small testes, hocked joint) before randomly assigned to doe groups. In addition, a few bucks were kept in reserve and used to replace if there was sudden death and those with poor libido. The pedigree of each buck was checked for close relationships with the does in their respective groups and when such relationships exist, does were exchanged between groups taking similarity in age and weight into consideration.

Mating groups were assigned twice a year (June and December) and 15 to 20 does were assigned to a single buck. The mating period usually lasts for about 42 days (minimum of two oestrous cycles) and controlled single sire mating was practiced. Beginning from date of mating assignment and following the kidding, all necessary information (sire and dam breed and id, birth weight, date of birth, birth type, sex of kid, parity, year, season of birth and dam weight at kidding, etc.) were recorded in the herd book. Then after, data on weaning weight, six month weight, nine month weight, and yearling weight, and others (death and other health problems) were recorded. Finally, those kids of both sexes with better performance were selected for future parent stock based on own and parent performance.

Data for Statistical Analysis

The data for this study were collected at Abergelle Agricultural Research Center from 2009 to 2018. A total of 787 records (339 crosses and 448 pure) from 21 sire bucks (12 local and 9 Boer blood) and 225 does were collected. Each kid was weighed at birth and then monthly up to yearling using a hanging balance that has 200 g precision. The data were tested for normality, homogeneity, duplications and omissions.Then after checking, the following growth traits were evaluated; Birth weight (BW), weaning weight (WW) and six month weight (SMW) as well as average daily gain during different growth stages i.e. from birth to weaning (ADG_1), from weaning to six months (ADG_2) and from birth to six months of age (ADG_3) of all animals at the two seasons (wet and dry) and birth years from 2009 to 2018. Weaning weight and six month weight was adjusted to 90 and 180 days of age, using a linear regression calculated for that cohort. The pre- and post-weaning daily gains were calculated as total gain divided by the number of days in the period.That is;

ADG_1 (Birth to weaning) = [(WW – BW)/ 90]*1000 g……………………………….1
ADG_2 (Weaning to Six month) = [(SMW –WW) /90]*1000 g……………………….2
ADG_3 (Birth to Six month) = [SMW – BW)/180]*1000 g…………………………….3

The recorded data was classified with the fixed effects of parity, sex, season, year, type of birth, and dam weight at birth. Data was analyzed using PROC GLM procedure of SAS, 2008 for the least-squares means and standard errors of the fixed factors. Genetic parameters (heritability (h^2), Repeatability, and genetic and phenotypic correlations) were computed by the method of paternal half-sib analysis using VARCOMP procedures of SAS 2008.

Heritability

Comment [H9]: How many % kept anually?

Comment [H10]: Why twice? What factors forced to do so?

Comment [H11]: Pure Boar bucks or not?

Comment [H12]: Why live weight is not measured until yearling or mature stages?

Comment [H13]: From which source?

Estimates of heritability for birth, weaning, six month weight and average daily gains for both breeding groups were determined from sire by using the following formula (Becker, 1993): Heritability from sire component:

$$h^2 s = 4*\sigma^2 s / \sigma^2 p \quad \sigma^2 s = (\text{mean square model - mean square error}) / k \quad \ldots\ldots\ldots\ldots 4$$

k=number of progenies produced per sire

Repeatability

Repeatability estimates were made for traits with repeated records and was calculated by using the formula of Fowler and Cohen, (1986) from variances partitioned using single factor (one way) ANOVA, with both "within and across context consistency" and considering the confounding factors that may be especially problematic when attempting to measure repeatability in goats. Environmental contexts like temperature, feed availability, aging, habituation, physiological states, time, source of animals for study and collection bias and biotic factors like parasitic infestation were potential confounding factors that cause the variations in the repeatability values. Because, repeatability introduces time dimension, it was tried to minimize time dependent changes in sources of measurement error.

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$$\text{Repeatability (R)} = \frac{B - W}{[B + (N-1) W]}$$

Where, **B** is variance between individuals and **W** variance within individuals. **N** is simply the size of each sample and for variable sample size it is calculated as $N = [M - (\sum n^2/M)/ k-1]$ Where **k**, is individuals measured at least twice and **M**, is the total number of measurements which is number of individuals '**k**' plus number of records (**R**), ∑ means 'the sum of and ***n*** is the number of measurements for an individual.

Genetic and Phenotypic Correlations

The genetic cause of correlation between characters is largely due to pleiotropy, although linkage of genes on the same chromosome is a transient cause of correlation. Genetic (rG) and phenotypic (rP) correlations between traits were estimated from variance and covariance components using the following formulae (Becker, 1984).

Genetic Correlation: $rG = \sigma^2 s_{XY} / \sqrt{\sigma^2 s_{XX} \times \sigma^2 s_{YY}}$

Phenotypic Correlations $rP = \sigma^2 P_{XY} / \sqrt{\sigma^2 P_{XX} \times \sigma^2 P_{YY}}$

Where: $\sigma^2 s$ = sire variance component $\sigma^2 s_{XY}$= sire covariance of traits x and y $\sigma^2 s_{XX}$ = sire variance of trait x $\sigma^2 s_{YY}$ = sire variance of trait y $\sigma^2 P_{XY}$ = phenotypic covariance of traits x and y $\sigma^2 P_{XX}$= phenotypic variance of trait x $\sigma^2 P_{YY}$ = phenotypic variance of trait y

Statistical Models

Least square means analysis was carried out to examine the influence of fixed effects using the General Linear Model (GLM) procedures of SAS (2008). The following models were used to estimate the growth traits;

Model 1

$$Y_{ijklmno} = \mu + BT_i + P_j + X_k + S_l + Y_m + G_n + Wo + e_{ijklmno}$$

Where ;$Y_{ijklmno}$: The record of BW, 6MW, YW, ADG1, ADG2 or ADG3 measured on n^{th} kid born at m^{th} year of birth, i^{th} birth type, j^{th} parity, k^{th} sex and l^{th}season.
μ: Overall mean
BT_i: effect of i^{th} birth type (i, 1=single, 2= twin);
P_j: effect of j^{th} parity (J, 1= parity1, 2= parity 2, 3= parity 3 and 4= parity 4);
X_k: effect of k^{th} sex (k, 1= male and 2= female);
S_l: effect of l^{th} season (l, 1= wet season and 2= dry season);
Y_m: effect of m^{th} year (m, 2009- 2018);
G_n = effect of n^{th} genetic group (Abergelle and Abergelle x Boer)
Wo= effect of o^{th} weight of dam
$e_{ijklmno}$: Random error particular to the ijklmnoth observation

Model 2

The (co)variance components and genetic parameters (heritabilities, direct genetic parameter correlations) was estimated by fitting an animal model which fits direct additive effect as random effect and the significant fixed effects. The representation of the animal model was:

$$\mathbf{Y = Xb + Z_1a + e}$$

Where Y is the vector of records, b is a vector of an overall mean and fixed effects with incidence matrix X; a, is vector of random additive direct genetic, Z1 incidence matrix of the random effects and e is a vector of random errors.

Results and D~~d~~iscussion

~~Overall mean~~Growth and weight gain comparison of the genotypes

The Least square means of all traits shows high significance difference (p<0.001) between the genetic groups (Table1).

Table1. Mean comparison between the genetic groups

Traits	Genetic group	N	Mean ± SEM	CV %	Minimum	Maximum	P value
BW (kg)	Abergelle	448	2.29^b ±0.01	10.2	1.2	3.2	P<0.001
	Abergelle x Boer	339	2.98^a± 0.03	16.1	1.5	4.4	
WW (kg)	Abergelle	379	7.12^b ± 0.07	19.2	4.2	12	P<0.001
	Abergelle x Boer	309	8.30^a± 0.11	20.5	4	14	
SMW	Abergelle	343	9.98^b ± 0.11	18.1	4.2	14.8	P<0.001

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(kg)	Abergelle x Boer	278	10.69^{a}±0.13	19.4	5.2	20	
ADG1 (g)	Abergelle	379	53.21^{b} ±0.86	31.4	17.8	111	P<0.001
	Abergelle x Boer	309	59.57^{a} ±1.06	27.9	16.7	111.1	
ADG2 (g)	Abergelle	343	44.02^{b} ±1.4	27.5	17.8	128.9	P<0.001
	Abergelle x Boer	278	59.15^{a} ±0.79	22.6	11.11	117.8	
ADG3 (g)	Abergelle	343	32.73^{b} ±1.0	23.7	9	74.4	P<0.001
	Abergelle x Boer	278	42.82^{a} ±0.66	24.2	12.2	88.9	

ADG1 = Average Daily Gain from birth to weaning, ADG2= Average Daily Gain from weaning to six month, ADG3= Average Daily Gain from birth to six month, BW = Birth Weight, CV = Coefficient of Variation, SEM = Standard Error of Mean, SMW = Six Month Weight, WW = Weaning Weight, Means on the same column for a given trait with different superscripts (a,b,) are significantly different (P<0.001).

When compared with the Abergelle(AB) kids, Abergelle × Boer(AB x BO) kids had higher birth weights and live weights in the different growth periods, as well as increased Average Daily Gains (ADG) in the pre-weaning and post-weaning periods (P<0.001). This difference between the two genotypes is due to the effect of heterosis exploited from epistatic and dominant gene effect during cross breeding. Heterosis has a positive effect because in the crossbreds many genes are heterozygous that were homozygous in the parent breeds. Alleles with a negative effect are often recessive. In the cross breeds these negative alleles are ruled out and hybrid vigor could be exploited. The results of the present study on the Boer and Abergelle crosses was in agreement with reports on Boer and Spanish and Boer and Angora crosses which was reported as they had higher dry matter intake, average daily gain than pure Spanish and Angora goats (Cameron *et al.*, 2001). The birth and weaning weights of the local breeds in this study were in contrast with the results reported by Khadiga*et al.* (2008) on Sudanese Nubian goats (2.93 ± 0.18), Tatek*et al.* (2004) on Arsi-Bale goats (2.8 kg and 8.39 kg), Belete (2009) on Keffa goats (2.78 and 9 kg), which were traditionally managed and Zeleke (2017) on Somali goats (3.19 and 11.67 kg) and Teddy kids in Pakistan (8.50±2.18). However, the BW and WW in this study were in agreement with the study Tsegaye, (2009) on Western lowland goats (2.28 kg) and Tesfaye*et al.* (2006) on Central High land goats (7.17 kg) respectively. The lower BW and WW in the Abergelle goats may be related with the genetic performance and environment on which Abergelle goats is reared.

Comment [H14]: Although there are a number of references used for local breeds, there are shallow comparisons for Boer crossbreds. There are many recent findings reported by different scholars even in Ethiopia compatible for both genetic groups to refer (for instance: Konso goat, Woyto-Guji goat and their crossbreds....).

Weight gains of local breeds in this study were in agreement with the study Ameha*et al.* (2007) conducted on long eared Somali, Central Highland, and Afar goat breeds supplemented with low and high proportion of concentrate with a weight gain of 37 - 44 g/day. In the contrary the result of average daily weight gain in this study was lower than the study Tesfaye*et al.* (2008) on Arsi Bale goats with average daily body weight gain reported between 63 and 68 g/day. The reasons for these variations may be due to scarcity of feed in terms of quality and quantity, overall managemental and husbandry practices in the study area and feed conversion efficiency of the breeds. This result indicates that cross breeding could be one of the options to improve productivity of local breeds.

Factors affectgrowth parameters

Birth type

Majority (N=729) of the kids were born as single. No triple birth was observed in this study. All traits except ADG_3 in twin birth show high significance (p<0.001) difference between the genotypes. Butthere was no significance difference (p>0.05) on weaning weight, six month weight, ADG_2 and ADG_3 for the pure breeds (Table 2).

Table2. Least square means of birth type for the Abergelle goats and their crosses with Boer.

Traits	Genetic group	N	Mean ± SEM		P-value (within)
			Single	Twin	
BW (kg)	AB	448	2.30^{a} ±0.01 (N=418)	2.10^{b} ±0.02 (N=30)	P<0.000
	ABxBO	339	3.03^{b} ±0.30 (N=311)	2.43^{a} ±0.06 (N=28)	P<0.000
p-value (between)			***	***	
WW (kg)	AB	379	7.08^{a} ±0.07 (N=353)	7.59^{b} ± 0.29 (N=26)	P<0.072
	ABxBO	309	8.5^{b} ±0.11 (N=288)	6.30^{a} ±0.22 (N=21)	P<0.000
p-value (between)			***	***	
SMW (kg)	AB	343	9.95^{a} ±0.11 (N=322)	10.53^{b} ±0.48 (N=21)	P<0.210
	ABxBO	278	10.90^{b} ±0.13 (N=263)	8.14^{a} ±0.22 (N=15)	P<0.000
p-value (between)			***	***	
ADG_1 (g)	AB	379	52.64^{a} ±0.9 (N=353)	61.07^{b} ±3.4 (N=26)	P<0.013
	ABxBO	309	60.6^{b} ±1.1 (N=288)	42.98^{a} ±2.14(N=21)	P<0.000
p-value (between)			*	***	
ADG_2 (g)	AB	343	44.41^{a} ±1.4 (N=322)	38.59^{a} ±0.4 (N=21)	P<0.290
	ABxBO	278	60.65^{b} ±0.8 (N=263)	47.54^{a} ±1.7 (N=15)	P<0.000
p-value (between)			***	*	

Comment [H15]: Why superscript 'b' put for lower values which is not followed for others?

Comment [H16]: How similar superscript for different values?

Comment [H17]: How similar superscript for high variants?

ADG_3 (g)	AB	343	32.72[a] ±1.1 (N=322)	32.78[a] ±0.99 (N=21)	P<0.985
	ABxBO	278	43.82[b] ±0.7 (N=263)	31.77[a] ±1.09 (N=15)	P<0.000
p-value (between)			***	NS	

AB = Abergelle BO = Boer, ADG1 = Average Daily Gain from birth to weaning, ADG2= Average Daily Gain from weaning to six month, ADG3= Average Daily Gain from birth to six month, BW = Birth Weight, N= Number of observations SEM = Standard Error of Mean, SMW = Six Month Weight, WW = Weaning Weight, Superscripts down column = comparison between genetic groups, p values are within breed comparison. * Significant at p<0.05 ** significant at p<0.01 ***significant at p<0.001 NS= Non Significant and are between breed comparison.

All body weight traits and pre and post weaning daily gains of the crossbred kids had shown high significance (p<0.001) variation between single and twin births. The present result was in consistent with that of Zeleke*et al*. (2017) studied on Boer and Central Highland and found significant differences between single and twins of cross breeds in all growth traits. The higher BW of single than twins in this study was in compatible with the findings of (Alula *et al*., 2013; Belay and Mengistie 2013; Mohammed *et al.*, 2018). This may be the fierce competition of twins on the scarce feed (browse plant or supplements) than single born kid. This difference between the single and twin at birth weight is probably due to the intrauterine environment, where a higher availability of nutrients to the single kid, lack of competition as well as more space may facilitate growth.In this regard, Hagan*et al.* (2014) reported that as the number of foetus increases, the number of caruncles attached to each foetus decreases, thus reducing the feed supply to the foetus and consequently resulted into lowerbirth weight. In a comprehensive analysis of factors associated with low kid birth weight, Gardner *et al*. (2007) identified that litter size had the greatest influence on increasing or decreasing birth weight, while year of birth, maternal birth weight, maternal nutrition, and maternal body composition at mating were also important.

Season

Season of birth had significant effect (p<0.001) on all growth traits between the genetic groups. But there is no significance difference for the weaning weight; six month weight and the average daily gains within the genetic groups (Table3).

Table3. Effect of season on growth traits of Abergelle goats and their crosses with Boer

Traits	Genetic group	Season (Mean ±SEM)		P value(within)
		Wet	Dry	
BW	AB	2.31±0.02[b] (N=332)	2.21±0.03[a] (N=116)	P< 0.000
	AB x BO	3.01±0.03[a]	2.78±0.07[b]	P<0.010

		(N=296)	(N=43)	
WW	AB	7.10±0.08^b (N=282)	7.14±0.14^b (N=97)	P< 0.072
	AB x BO	8.37±0.12^a (N=273)	7.87 ±0.29^a (N=36)	P<0.134
SMW	AB	9.90±0.13^b (257)	10..23±0.23^b (86)	P< 0.210
	AB x BO	10.74±0.14^a (N=249)	10.32±0.37^a (N=29)	P<0.286
ADG_1	AB	53.05±0.95^b (N=282)	53.69±1.89^b (N=97)	P< 0.013
	AB x BO	59.52±1.15^a (N=273)	56.62±2.79^a (36)	P<0.363
ADG_2	AB	44.20±1.58^b (N=257)	43.49±2.77^b (N=86)	P< 0.585
	AB x BO	59.79±0.84^a (N=249)	58.04±2.29^a (N=29)	P<0.458
ADG_3	AB	32.66±1.11^b (N=257)	32.94±2.10^b (N=86)	P< 0.101
	AB x BO	42.96±0.71^a (N=249)	41.88±1.84^a (N=29)	P<0.591

AB = Abergelle BO = Boer, ADG1 = Average Daily Gain from birth to weaning, ADG2= Average Daily Gain from weaning to six month, ADG3= Average Daily Gain from birth to six month, BW = Birth Weight, SEM = Standard Error of Mean, SMW = Six Month Weight, WW = Weaning Weight, Superscripts down column = comparison between genetic groups, p values are within breed comparison

Kids born in the wet season were heavier than the kids born in the dry season. Generally, under extensive and semi-intensive system of management where animals spend some time outdoors to graze, season has appreciable influence on a number of economic traits of farm animals. In this study, season of birth had significant effect on birth weight. The birth weight of kids born in the rainy season of both genotypes were significantly (p<0.001) heavier than those of the dry season (Table3). The availability of green and high-quality forage during the late pregnancy period could have contributed to this observation. This result is in conformity with Zeleke *et al*., (2017), and Baiden (2007) who were reported heavier birth weight for kids born in the major wet season. Similar reasons were given by Boujenane and El Hazzab (2008) and Ahuya*et al*. (2009) for the similar traits studied. According to these reports, influence of season on growth traits can be explained by variability of feeds in different seasons. Kidding season may well affect kids' growth, because the season could affect the climate thereby feed supply and animal health.

Birth year

Year of birth had significant effect (p<0.01) on all growth parameters and average daily gains at different growth stages between the two genotypes.

Table4. The effect of Birth year on the growth parameters of Abergelle goats and their crosses

Comment [H18]: Check superscripts utilization throughout tables.

Comment [H19]: Have you given 'a' superscript as lower value or not? Make it clear and unique throughout table again.

Year	N	Traits (Abergelle)					
		BW	WW	SMW	ADG1	ADG2	ADG3
2009	14	2.31±0.2^{b}	7.14±0.12^{b}	9.71±0.24^{b}	53.7±2.14^{b}	54.22±2.34^{b}	41.11±1.60^{b}
2010	18	2.26±0.01^{b}	6.84±0.23^{b}	10.12±0.43^{a}	50.89±1.8^{b}	61.56±2.14^{a}	43.66±1.12^{a}
2011	17	2.40±0.03^{b}	7.04±0.04^{b}	9.70±0.27^{b}	51.6±2.12^{b}	55.89±2.21^{b}	40.56±1.67^{b}
2012	24	2.5±0.04^{b}	7.21±0.24^{b}	9.86±0.27^{b}	52.17±2.5^{b}	57.37±2.57^{b}	40.83±1.48^{b}
2013	67	2.30±0.04^{b}	7.17±0.20^{b}	11.3±0.26^{a}	54.4±2.29^{b}	72.78±3.07^{a}	50.21±1.49^{a}
2014	42	2.25±0.05^{b}	6.87±0.21^{b}	9.3±0.38^{ns}	51.8±2.3^{ns}	52.85±2.8^{b}	39.46±2.08^{a}
2015	61	2.23±0.04^{b}	6.70±0.15^{b}	8.66±0.21^{b}	49.7±1.55^{a}	47.86±1.6^{b}	35.92±1.15^{ns}
2016	70	2.30±0.03^{b}	7.13±0.13^{a}	10.9±0.24^{a}	53.78±1.5^{a}	67.28±2.17^{a}	48.05±1.38^{a}
2017	82	2.23±0.03^{b}	7.47±0.19^{a}	9.68±0.25^{a}	58.28±2.2^{a}	48.66±1.6^{b}	41.43±1.42^{a}
2018	53	2.33±0.04^{b}	7.16±0.21	9.21±0.21^{b}	53.89±2.2^{b}	47.79±1.2^{b}	38.34±1.14^{b}
Abergelle x Boer							
2009	71	2.87±0.06^{a}	9.61±0.22^{a}	12.37±0.29^{a}	74.79±2.19^{a}	62.54±1.80^{a}	52.73±1.47^{a}
2010	65	2.87±0.06^{a}	7.58±0.23^{a}	9.92±0.26^{b}	52.32±2.27^{a}	57.91±1.57^{b}	39.19±1.26^{b}
2011	42	3.03±0.09^{a}	8.04±0.32^{a}	10.63±0.37^{a}	55.69±2.89^{a}	62.38±2.19^{a}	42.22±1.73^{a}
2012	48	3.15±0.08^{a}	8.7±0.26^{a}	11.44±0.33^{a}	61.64±2.36^{a}	65.48±1.95^{b}	46.06±1.53^{a}
2013	37	3.23±0.09^{a}	9.12±0.33^{a}	10.51±0.38^{b}	65.44±2.98^{a}	51.38±2.49^{b}	40.45±1.81^{b}
2014	20	3.02±0.14^{a}	7.68±0.31^{a}	9.57±0.37^{ns}	51.8±2.65^{ns}	54.50±2.79^{a}	36.42±1.71^{b}
2015	14	2.96±0.12^{a}	7.15±0.39^{a}	9.12±0.38^{a}	46.59±3.14^{b}	54.76±3.09^{a}	34.21±1.53^{ns}
2016	13	2.83±0.13^{a}	6.50±0.16^{b}	8.78±0.20^{b}	40.77±2.11^{b}	56.75±2.32^{b}	33.03±1.37^{b}
2017	18	2.98±0.08^{a}	6.96±0.35^{b}	9.26±0.45^{b}	44.19±3.49^{b}	58.64±3.07^{a}	34.88±2.36^{b}
2018	11	2.66±0.18^{a}	7.65±0.43^{a}	10.52±0.84^{a}	55.35±4.08^{a}	61.52±6.78^{a}	43.64±4.12^{a}

ADG1 = Average Daily Gain birth to weaning, ADG2 = Average Daily Gain from weaning to Six month, ADG3 = Average Daily Gain from birth to six month, BW = Birth Weight, N = Number of observations, SEM = Standard Error of Mean, SMW = Six Month Weight, Super scripts down column for a given trait shows the variation between genetic group, WW = Weaning Weight

Maximum and minimum birth weights were obtained in the years 2013 and 2018 (3.23±0.55 vs 2.66 ±0.60) respectively. Highest weaning and six month weights were found in the birth years of 2009 while lowest weights were recorded in the year 2016. This difference might be due to critical environmental and managemental problems at the farm in 2016 and 2018 which might have caused nutritional stress that might have resulted in loss of dams' body weight, induced retardation of fetal growth and reduced birth weight

The results in the present research were in agreement with Yadav *et al*. (2008) observed the si gnificant variation in the growth rate of Kutchi kids due to year of birth and Thiruvenkadan *et. al.* (2009) found significant differences associated with the year of kidding in body weights at birth, weight gain and efficiency in weight gain at different stages of growth. But no significant variation was found in Boer and Turkish hair goats because of year of birth (Memis*et al.*, 2017). It is worthwhile to mention, that the level of management is bound to vary according to the ability of the farm manager, the system of crop husbandry, the methods and criteria of culling and his overall supervision at the farm, availability of farm resources and their mobilization in different years.

Sex of kids

Out of the total kids (787) born, about 44% were male 56% were female. Sex of kids had highly significant effect (p<0.001) on birth weight of Abergelle kids. (Table 5).

Table5. The effect of sex on the growth performance of local and cross breed goats

		Sex (Mean ±SEM)				
Traits	Genetic group	Male	N	Female	N	P value (within)
BW	Abergelle	2.42^{a}±0.02	219	2.16^{b}±0.02	229	P<0.000
	Abergelle x Boer	3.06^{b}±0.04	150	2.91^{a}±0.04	189	P<0.015
WW	Abergelle	7.19^{a}±0.09	181	7.06^{b}±0.10	198	P<0.374
	Abergelle x Boer	8.29^{b}±0.15	131	8.31^{a}±0.15	178	P<0.972
SMW	Abergelle	10.09^{a}±0.17	159	9.89^{b}±0.15	184	P<0.372
	Abergelle x Boer	10.75^{b}±0.19	122	10.64^{a}±0.17	156	P<0.670
ADG1	Abergelle	52.57^{a}±1.16	181	53.79^{b}±1.26	198	P<0.477
	Abergelle x Boer	58.21^{b}±1.56	131	59.91^{a}±1.46	178	P<0.428
ADG2	Abergelle	42.94^{a}±2.07	159	45.05^{b}±1.82	184	P<0.443
	Abergelle x Boer	61.20^{b}±1.21	122	58.28^{a}±1.03	156	P<0.066
ADG3	Abergelle	30.92^{a}±1.47	159	34.46^{b}±1.32	184	P<0.074
	Abergelle x Boer	42.72^{b}±1.01	122	42.90^{a}±0.88	156	P<0.894

ADG1 = Average Daily Gain birth to weaning, ADG2 = Average Daily Gain from weaning to Six month, ADG3 = Average Daily Gain from birth to six month, BW = Birth Weight, SEM = Standard Error of Mean, SMW = Six Month Weight, WW = Weaning Weight, Superscripts down column = comparison between genetic groups, Superscripts on overall mean are only between the genetic groups.

The male kids were heavier than females at birth. Similar results were reported by Memis *et al* . (2017) on the crosses of Turkish indigenous with that of Boer. This finding is also similar with Talekar, (2015) who studied the effect of sex on the growth parameters of Sangamneri kids, but contradicted with that of Mia *et al*. (2013) in Black Bengal goat observed significant effect of sex on all body weight. The superiority of males to female at BW could be due to hormonal differences that enhance growth. In addition, goat belongs to the most dimorphic mammals and other domestic animals, which exists along the life of animals from fertility until adult age. Rensch (1960) described that in many taxa, sexual size dimorphism (SSD) varies with body size and larger species generally exhibits higher male to female body size ratio, which is known as “Ranch’s rule”. The cause of sexual dimorphism is described by the study of Vitousek*et al.* (2007) in that, resource availability may influence the body size of one sex to a greater degree than the other when relative energy expenditure on mating and reproduction is greater for that sex. In addition, ecological factors may select for small body size in both sexes but female body size may be constrained by fecundity selection.

Parity

Parity of dam in this study had significant effect ($p<0.01$) on least square mean of the growth parameters of kids between the genotypes. But parity had significant effect only on birth weight of local Abergelle goats (Table 6).

Table6. Least square means of parity in Abergelle local and crossbred goats

Traits	Genetic group	Parity (Mean ± SEM)							
		N	1	N	2	N	3	N	4
BW (kg)	AB	105	2.15±0.02^{b}	131	2.26±0.02^{b}	123	2.32±0.02^{ab}	89	2.44±0.03^{a}
	AB x BO	78	2.87±0.05^{a}	90	2.92±0.48^{a}	103	3.09±0.06^{ab}	68	3.14±0.09^{b}
			***		***		***		***
WW (kg)	AB	90	7.04±0.12^{b}	114	7.09±0.13^{b}	98	7.09±0.13^{b}	77	7.29±0.16^{b}
	AB x BO	71	8.77±0.19^{a}	85	8.14±0.21^{a}	94	8.13±0.21^{a}	59	8.05±0.26^{a}
			***		**		**		**
SMW (kg)	AB	77	10.39±0.24^{b}	101	9.70±0.22^{b}	91	9.95±0.21^{b}	74	9.99±0.21^{b}
	AB x BO	66	11.45±0.24^{a}	74	10.57±0.24^{a}	86	10.29±0.24^{a}	52	10.15±0.32^{a}
			**		**		*		NS
ADG1 (g)	AB	90	54.58±1.61^{b}	114	53.87±1.46^{b}	98	50.71±1.94^{b}	77	53.93±1.85^{b}
	AB x	71	65.54±2.0	85	58.02±1.9	94	56.03±1.9	59	54.54±2.28^{a}

	BO		4^{a}		8^{a}		1^{a}		
			**		*		*		NS
ADG2 (g)	AB	77	44.29±3.08^{b}	101	42.44±3.08^{b}	91	53.93±1.85^{b}	74	47.30±2.69^{b}
	AB x BO	66	61.61±1.47^{a}	74	59.39±1.41^{a}	86	58.24±1.49^{a}	52	58.29±2.23^{a}
	AB		**		**		NS		*
ADG3 (g)	AB	77	33.80±2.20^{b}	101	31.91±1.80^{b}	91	53.21±0.9^{b}	74	34.94±1.9^{b}
	AB x BO	66	47.68±1.30^{a}	74	42.47±1.2^{a}	86	39.97±1.20^{a}	52	38.95±1.50^{a}
			*		*		*		NS

AB = Abergelle, BO = Boer, ADG1 = Average Daily Gain birth to weaning, ADG2 = Average Daily Gain from weaning to Six month, ADG3 = Average Daily Gain from birth to six-month, BW = Birth Weight, SEM = Standard Error of Mean, SMW = Six Month Weight, T = Total, WW = Weaning Weight. Superscripts (a,b) down column represent differences between the genetic groups. P values show differences within genotypes.

Average BW of Kids of the crosses from fourth parity dams exceed by about 27% (3.14±0.09) than the kids form first parity (2.87±0.05). The increment in birth weight as parity increase is related with utilization of more feed for production and reproduction than for growth in older age doe and provide more feed for the fetus than young age does. Hence, as parity increases mothering ability and milk production increases and this is observed in kid growth. Effect of parity on weight is reported in different studies (Hailu *et al*., 2008; Jimenez-Badillo *et al*., 2009). The result of this study was in line with the results reported by Sodiq, (2012) and Bemji*et al*. (2006). This indicates the influence of mothering ability on birth weight of kids.

Comment [H20]: Source?

Dams weight at kidding

Differences due to dams' weight at kidding were found to be significant (p<0.05) to kid's body weight at birth (Table 7).

Table7. The effect of dam weight at kidding on growth traits of local and cross breed goats in the study area

Factor	Abergelle (Mean ± SEM)					
	BW(kg)	WW(kg)	SMW(kg)	ADG1(g)	ADG2(g)	ADG3(g)
Dam weight(kg)	*	NS	NS	NS	NS	NS
15-25	2.27±0.02	7.04±0.11	10.11±0.17	52.72±1.21	60.43±1.69	43.36±0.96
26-35	2.31±0.02	7.22±0.11	9.84±0.15	53.80±1.41	52.98±1.23	42.11±0.87
Total	2.29±0.01	7.12±0.07	9.98±0.11	53.21±0.86	44.02±1.37	32.73±0.99
p-value	0.043	0.969	0.864	0.965	0.354	0.602
Abergelle X Boer (Mean ±SEM)						
15-25	2.88±0.04	8.84±0.18	11.43±0.22	66.26±1.84	60.65±1.29	42.82±0.66
26-35	3.04±0.04	7.98±0.13	10.25±0.16	54.95±1.23	58.93±0.99	40.04±0.75
Total	2.98±0.03	8.30±0.11	10.69±0.13	59.15±1.06	59.57±0.79	42.82±0.66

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Comment [H22]: Using p-value with * and NS at once mandatory?

p-value	0.049	0.437	0.357	0.442	0.381	0.356

ADG1 = Average Daily Gain from birth to weaning ADG2= Average Daily Gain from weaning to six month, ADG3= Average Daily Gain from birth to six- month weight, BW = Birth Weight, SEM = Standard Error of Mean, SMW = Six Month Weight, WW = Weaning Weight. NS = Non significant * = significant at 0.05.

The minimum and maximum body weights of does at kidding were 18 and 34 with an average of 25.78. The mean values of this study confirmed to that of Minister (2017), Alubel (2015) and Belay and Mengstie (2013) who reported the weight of Abergelle does at different production and management systems.The most important influences on birth weight in small ruminants are the number of newborns, followed by number of parturitions, body weight and condition of female around the time of parturition, nutrition and gender of newborns (Gardner *et al.*, 2007). This finding was related with the findings of Memis*et al*., (2017) on weight of Boer and Turkish hair goat. However, (Sharma *et al.*, 2010; Kharkar *et al.*, 2014) reported non-significant effect of dam's weight at kidding on all morphometric traits at birth and 3 months of age in India goats and at 6, 9, and 12 months of ages in Jamunapari goats respectively.

Estimation of genetic and phenotypic parameters

Heritability

Heritability of the growth traits and pre and post weaning daily gains revealed significance variation ($p<0.05$) between Abergelle goats and their crosses with Boer(Table 8)**.**

Table8. Estimates of heritability for the growth parameters of local and cross breed goat populations

Traits	Genetic group	Heritability (h^2s)	Repeatability
Birth Weight (BW)	Abergelle	$0.14^b \pm 0.01$	$0.24^a \pm 0.05$
	Abergelle x Boer	$0.20^a \pm 0.06$	$0.20^b \pm 0.08$
Weaning Weight (WW)	Abergelle	$0.08^b \pm 0.01$	$0.19^{ns} \pm 0.06$
	Abergelle x Boer	$0.14^a \pm 0.05$	$0.17^{ns} \pm 0.04$
Six Month Weight (SMW)	Abergelle	$0.04^b \pm 0.02$	$0.14^b \pm 0.03$
	Abergelle x Boer	$0.10^a \pm 0.04$	$0.26^a \pm 0.12$
Average Daily Gain 1 (ADG1)	Abergelle	$0.11^b \pm 0.03$	$0.08^b \pm 0.02$
	Abergelle x Boer	$0.16^a \pm 0.07$	$0.18^a \pm 0.04$
Average Daily Gain 2 (ADG2)	Abergelle	$0.09^b \pm 0.02$	$0.10^{ns} \pm 0.07$
	Abergelle x Boer	$0.13^a \pm 0.06$	$0.09^{ns} \pm 0.03$
Average Daily Gain 3 (ADG3)	Abergelle	$0.07^{ns} \pm 0.02$	$0.24^a \pm 0.05$
	Abergelle x Boer	$0.09^{ns} \pm 0.01$	$0.20^b \pm 0.08$

ADG1 = Average Daily Gain from birth to weaning, ADG2 = Average Daily Gain from weaning to Six month, ADG3= Average Daily Gain from birth to six- month BW = Birth Weight, h2s = Heritability of sire, SMW = Six Month Weight, WW = Weaning Weight $p<0.05$.

The heritability value of local breed was in a decreasing trend as it goes from BW up to six-month weight. This may indicate the higher impact of environment and management at later age in comparison to earlier age and it may be due to absence of appropriate husbandry practices in the study area. This study result was different from Thiruvenkadan*et al*. (2009) who studied the heritability of body weight tended to increase with increasing age from birth to six months.

The heritability value of birth weight in the present study of both genotypes were lower than the studies ofBosso*et al.* (2007) working in West African Dwarf goats and Al-Shorepy*et al*. (2002) working in Emirati goat reported the heritability estimates of 0.50 and 0.39, respectively. Zhang *et al*. (2009) and Al-Saef (2013) also reported the heritability estimates of birth weight in Syrian Damascus goat and Boer goat as 0.41 and 0.30, respectively. The lower heritability value of BW in this study than other previous studies in various part of the world may indicate the poor husbandry practices of goat in Abergelle research station. Lower heritability estimates for body weight was reported by Mohammed *et al.,* (2013) on birth, weaning, six month and yearling weights of Arsi Bale goats of Ethiopia with the value of 0.09±0.08, 0.03±0.08, 0.04±0.08, 0.02±0.10 respectively.

The heritability values for birth weight and average daily gain 2 of the pure breed were moderate, while the weaning weight, six- month weight, ADG1 and ADG3 were low. Results given in Table8 showed a range of the heritability estimates for body weight from birth to six months of age between the genetic groups. Heritability estimate of body weight and weight gain decreased over age. But the heritability of birth weight of this study was similar to that of Mohammed *et al*. (2013). The findings in this study were lower than Draa goats of Morocco 0.16±0.07, 0.11±0.06, 0.01±0.08, 0.50±0.05(Boujenane and Hazzab, 2012) and West Africa Dwarf goats of Gambia, 0.43±0.07, 0.30±0.07, 0.54±0.05 and 0.16±0.12 (Bosso*et al.*, 2007; Balla*let al*., 2008). Heritability estimates for weaning weight of Ardi, Angora, Black Bengal, Boer, Damascus and Jamnapari goats, 0.26, 0.45, 0.16, 0.60, 0.35 and 0.43, respectively (Rashidi*et al*., 2008) were higher than the heritability of weaning weight at this study (0.14±.0.03). Birth weight and weaning weight heritabilities of Red sokoto Goats (RSG) and their crosses with West African Dwarf (RSG x WAD) were higher than the crosses of Boer and Abergelle (0.41, 0.55, 0.65 and 0.25) respectively (Yusuff*et al.*, 2015).

This difference in the heritability of traits could be due to genetic and non genetic variations of the breeds and production environment. The difference in estimates may also arise from sample size, method of data analysis and the model used by each investigator. Biologically, it can be explained by genetic variation among breeds or type of goats and temporary environmental effects. According to Bhattarai*et al. (*2017) weight at birth is of low heritability (0.062 ± 0.069) and the heritability's of the body weights at three, six, nine and twelve months of age were medium to highly heritable. However, heritability of most traits in the current study was low to moderate for both local and crossbred,which show most variations are due to environmental and management variations.

Repeatability

The repeatability values of birth weight, six-month weight, pre weaning daily gain and daily gain from birth to six month showed significance difference ($p<0.05$) between the genotypes while, there was non-significant variation ($p>0.05$) in the post weaning daily gain (ADG2) (Table 8). The repeatability values generally were higher than the corresponding heritability estimates. This is in agreement with the theory that repeatability sets the upper limit to heritability estimates. The maximum (0.26 ± 0.12) and minimum (0.06 ± 0.04) repeatability values were observed on birth weight and six-month weight respectively. The repeatability values of the crosses were agreed with report of Das *et al.* (2013) of Tanzanian blended goats but they were by far lower than the results of Aladee*t al.* (2010) repeatability on Birth weight, Pre weaning weight, Weaning weight, Post weaning gain and 9 month body weight were 0.61 ±0.15, 0.37±0.11, 0.52±0.12, 0.24±0.08 and 0.40±0.04 respectively.

The variations in the repeatability values between the studied breeds and among other breeds were due to the continuous physiological changes of the dams and variations on the individual progeny performance. Repeatability value is greater than heritability value since repeatability estimates include the permanent environmental variance in addition to the additive genetic variance component. When repeatability is high, it indicates that a single record of performance on an animal is, on average, a good indicator of that animal's producing ability. When repeatability is low, a single phenotypic value tells very little about producing ability. Lower repeatability estimate for traits could be also due to higher influence of specific environmental effects on a given record that may inflate within animal records variability (Aynalem*et al*., 2014).

Understanding the concept and knowing the repeatability values of growth traits help considerably in deciding which does to cull since to make the best possible decision at how well the doe would perform in the next parity from the observation in the previous parity.

Genetic and Phenotypic Correlation

Genetic correlations of all traits of the cross breeds had high significant difference ($p<0.01$). High genetic correlations ($p<0.001$) were observed in the correlation between six month weight and ADG3 in both genetic groups (Table 9).

Table9. Genetic (below diagonal) and phenotypic (above diagonal) diagonal (number of observations) correlations of body weights and average daily gains.

Genetic group		BW	WW	SMW	ADG1	ADG2	ADG3
Abergelle	BW	**448**	0.08^{a}	0.01^{a}	0.1^{a}	0.12^{b}	0.12^{a}
	WW	0.12^{a}	**379**	0.59^{a}	0.98^{ns}	0.07^{a}	0.58^{a}
	SMW	0.25^{ns}	0.51^{a}	**343**	0.59^{a}	0.75^{a}	0.99^{ns}
	ADG1	0.31^{ns}	0.49^{a}	0.41^{a}	**379**	0.01^{a}	0.60^{a}
	ADG2	0.15^{a}	0.07^{a}	0.75^{a}	0.01^{a}	**343**	0.73^{a}
	ADG3	0.17^{a}	0.58^{ns}	0.29^{a}	0.06^{a}	0.29^{a}	**343**
Abergelle x Boer	BW	**339**	0.55^{b}	0.50^{b}	0.32^{b}	0.50^{b}	0.31^{b}
	WW	0.35^{b}	**309**	0.88^{b}	0.97^{ns}	0.33^{b}	0.84^{b}
	SMW	0.20^{ns}	0.18^{b}	**278**	0.85^{b}	0.70^{b}	0.98^{ns}

ADG1	0.32^{ns}	0.29^{b}	0.55^{b}	**309**	0.22^{b}	0.86^{b}
ADG2	0.50^{b}	0.23^{b}	0.40^{b}	0.20^{b}	**278**	0.65^{b}
ADG3	0.31^{b}	0.54^{ns}	0.68^{b}	0.56^{b}	0.45^{b}	**278**

ADG1 = Average Daily Gain from birth to weaning, ADG2 = Average Daily Gain from weaning to Six month, ADG3= Average Daily Gain from birth to six-month BW = Birth Weight, SMW = Six Month Weight, WW = Weaning Weight $p<0.05$.[a,b] Significantly difference between the genetic groups ns = Non significant

Almost all genetic correlations in the cross breeds were ranged from moderate to high and positive while in the pure breeds all(low, medium and high) correlations were observed. The genetic and phenotypic correlations between birth weight and weaning weight, birth weight and six month weight and weaning weight and six month of the pure Abergelle were almost similar to that of Arsi- Bale goats which was numerically reported as 0.70±0.55 and 0.17, 0.64±0.47 and 0.19 and 0.57±0.43 and 0.65 respectively (Mohammed *et al*., 2013). The results also agreed to Boujenane and Hazab, (2012), and Bosso*et al.* (2007) studied genetic and phenotypic correlation of Draa WAD goats respectively and reported BW vs. WW, 0.58 and 0.27, BW vs SMW, 0.28 and 0.15, WW vs. SMW, 0.43 and 0.51 and BW vs. WW, 0.74 ± 0.08 and 0.30 for genetic and phenotypic correlations respectively. Hasan*et al.* (2014) working in Etawa Grade goats reported the phenotypic correlations ranging from 0.08 between birth weight and twelve month weight to 0.93 between twelve months weight and eighteen months weight of kids.

The phenotypic correlations between all traits found same trend as the genetic correlations in accordance with previous studies in different goat breeds as reported by Al Shorepy*et al.* (2002), Xu*et al.* (2005) and Han *et al.* (2005). Phenotypic correlation between birth weight, one month weight and three months weight of kids were ranging from 0.45 to 0.99 Al Shorepy*et al.*, (2002) which was within the range of the current study findings.The high genetic correlation in the cross breeds between the two traits in present study indicated that both traits are under the influence of similar genes and selection for higher birth weight will result in higher weaning weight as a correlated response. Similarly, the phenotypic correlation between the two traits indicated a positive relationship between the traits.

The genotypic and phenotypic correlations between the studied growth traits at different stages showed positive values for both Abergelle and crossbred goats. Similarly, Rashidi *et al.* (2008) and Xiong *et al*. (2016) 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 kid had a fast growth rate during the pre-weaning stage which resulted in heavy weaning weight.

6. REFERENCES

Comment [H23]: Strictly follow AJRRA referencing guidelines.

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