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Environmental and Genetic Factors Affecting Early Growth Traits in Three Yemeni Indigenous Sheep Breeds

Research Article

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ABSTRACT

The data were collected from 1992 to 2009 in Burri, White Boni and Black Boni sheep maintained at the Regional Research Station in the Central Highlands of Yemen. Data were analyzed to study the effects of environmental and genetic factors on body weight and growth rate from birth to weaning. The least square means for body weights (BW) were 2.54, 2.18 and 2.26 kg for birth; 12.49, 10.58 and 11.14 kg for weaning weight (WW) and 114.91, 98.68 and 106.04 g for growth rate in Barri, Black Boni and White Boni sheep, respectively. Year of birth effects were significant ($P<0.05$) on BW, WW and growth rate in all the breeds. Also, analysis of variance showed that the sex of the lambs and the type of birth were important sources of variation ($P<0.05$) in the three breeds for all traits. The size of the ewe during lambing had also significant effect ($P<0.01$) on birth in all the breeds. The results show direct heritability for all traits, it was varied between 0.36 and 0.38 for BW, 0.30 and 0.35 for WW, 0.26 and 0.36 for growth rate in all breeds. Higher estimates of heritability for growth performance traits are refers to the presence of more additive genetic variance.

KEY WORDS environmental effect, genetic parameters, growth traits, yemeni indigenous sheep.

INTRODUCTION

Sheep husbandry in Yemen has been a historically important component of rural development and it still fulfills a sustainable role in the livelihood of farmers. The country has a tradition in the consumption of sheep products, especially lambs and mutton. The production of lamb is favored by a growing demand and favorable price. Sheep population of Yemen was estimated in 9.08 million head in 2009 (Yemen Agricultural Statistics, 2009). There are 11 traditional recognized sheep breed in Yemen of which five are wool and six are hair types (Wilson, 2003). All sheep breeds in the country are indigenous and it has fat tail although the conformation of the tail varies considerably (Hasanain *et al.* 1994).

Barri, White Boni and Black Boni breeds are the local breeds of sheep distributed over a wide area in the central and northern highlands region of Yemen. These local breeds, despite their lower growth rates and less prolificacy, they are characterized by the ability to survive and reproduce normally in the range without supplementary feeding.

The early growth traits (birth weight and weaning weight) are an important role in productivity and they are one of the major selection traits in sheep breeds which are known to be influenced by genetics and environmental factors (Rajab *et al.* 1992; Mandal *et al.* 2003; Gbangboche *et al.* 2006; Behzadi *et al.* 2007).

Information on the relative performance of indigenous sheep breeds in Yemen may vary from year to year. It is, therefore, important to investigate the effects of various factors on the variation among animals in order to find efficient breeding plans to improve production. Very little information is available on the genetic and environmental aspects of productive and reproductive performance of sheep in Yemen.

Therefore, the objective of this study was to evaluate the environmental and genetic effects on growth traits for three Yemeni indigenous sheep breeds (Barri, White Boni and Black Boni) in the central and northern highlands region of Yemen.

MATERIALS AND METHODS

Location

The breeds of sheep involved in this study were Barri, White Boni and Black Boni sheep. These breeds were raised at Regional Research Station in the central highlands, Dhamar, Yemen. The station is located at 14˚ 38 north by 44˚ 21east and a latitude of over 2400 meters. It is about 10 kilometres north of the Dhamar town, directly west of the Sana'a-Taiz road. The region is semi-arid with an annual rain full between 350 to 400 mm and temperature varying 29 ˚C and -4 ˚C.

Animal management

The management system used at the station was intended to be similar to the traditional system of sheep husbandry in the area, in terms of grazing and supplementation. A controlled mating scheme was used with three mating periods over two years.

The ewes were mated with unrelated rams, with each ram mated to a group of 30 to 40 ewes; mating continued for 54 days. After lambing each ewe was put separately with their lamb into a lambing pen for about 2 to 7 days. Ewes and their lambs were weighed and ear-tagged.

All the lambs were tattooed on the fat tail after weaning. Male and female lambs were allowed to remain with their mother until weaning. The weaning of lambs took place at an average of 91 days of age with a range in age from 79 to 98 days.

All ewes were grazed together during the day for about 6-8 hours. Then, they were housed in covered pens with free access to grass hay, water and mineral lick blocks. During the mating season ewes were supplemented with fresh alfalfa, alfalfa hay or with fresh barley or barley hay and occasionally sorghum stover.

Also a supplementary concentrate ration of 250-500 g/head/day, depending on season and physiological status, was fed to animals in the morning before grazing. The sheep shed was cleaned every two to three days.

Sick animals were removed from their pens and treated separately.

All animals were dipped for external parasite control once per year; animals were vaccinated once against rinderpest and sheep pox and drenched twice against internal parasites.

Statistical analysis

The data utilized in this study were obtained from weights of 2647 and 2371 records of lambs at birth and at weaning, respectively, through eighteen years period (1992-2009). Data were first analysed using the General Linear Models Procedures of the Statistical Analysis Systems (SAS, 2004) to identify the environmental factors affecting lambs weights and growth rate from birth to weaning in the three breeds.

Statistical model included lamb's gender in 2 class (male and female), birth type in 2 class (single and twin), dam weight at lambing in 3 class (≤24, 25-33 and >33), season of birth in 3 class (summer from March to June, autumn from July to October and winter from November to February), year of lambing has been divided into six period each comprising 3 years and parity with six levels.

In view of the difference in actual age at which weights were taken, the weight at weaning was pre-adjusted as follows: Adjusted 90-day weaning weight (WW)= growth rate x 90 + birth weight. Analysis was conducted according to the following model for each breed:

$$Y_{inkpmrs}= \mu + A_n + S_k + T_p + X_m + W_r + D_s + E_{inkpmrs}$$

Where:

$Y_{inkpmrs}$: the observation on the trait.

μ: the overall mean.

A_n: effects of the n^{th} period of lambing (n=1 to 6).

S_k: the effects of the k^{th} season of lambing (k=summer, autumn and winter).

T_p: the effects of the p^{th} type of birth (p=single and twin).

X_m: the effects of the m^{th} sex of lamb (m= male and female).

W_r: the effects of the r^{th} dam of weight during lambing (r=≤24 kg and 25-33 kg ≥31 kg).

D_s: the effects of the s^{th} parity number of dam (s=1 to 6).

$E_{inkpmrs}$ represents the random error associated with each observation.

(Co) variance components were estimated by restricted maximum likelihood procedures using MTDFREML program (Boldman, 1993). Single trait animal models were fitted for all traits to obtain heritability estimates. The general representation of the animal model used was as follows:

$$y= Xb + Z_a a + e$$

Where:

y is a N × 1 vector of records.

b denotes the fixed effects in the model with association matrix.

X, **a** is the vector of direct genetic effects with association matrix **Za**.

Additive direct effects were assumed to be normally distributed with mean **0** and variance $\mathbf{A}\sigma^2_a$ where **A** is the additive numerator relationship matrix and σ^2_a is the additive direct variance. Residual effects were assumed to be normally distributed with mean **0** and variances $\mathbf{I}_n\sigma^2_e$, respectively, $\mathbf{I}_n$ are identity matrices with orders equal to the number individual records and σ^2_e are residual variances.

Estimates of heritabilities were calculated as ratios of estimates from additive direct (σ^2_a) to the phenotypic variance (σ^2_p).

RESULTS AND DISCUSSION

Environmental effects

Birth weight (BW) The overall least squares means for lamb at birth weight were 2.54, 2.18, 2.56 kg for Barri, black Boni and White Boni breeds, respectively (Table 1).

The value of birth weight observed for period/year ranged from 2.24 to 2.36 kg in Barri breed, 1.92 to 2.22 kg in Black Boni breed and 1.98 to 2.15 kg in Whit Boni breed, and the differences between periods/years were statistically significant (P<0.01).

Differences in BW from year to year is mostly due to variation in climatic, feeding and management conditions, which either affects the lambs directly or indirectly through their effects on dams. The results of this study are similar to the results of Alnohkaif (1999) for Albial *et al.* (2010) for White Boni sheep.

Table 1 Number of records and least square means (±SE) for factors affecting birth weight in three Yemeni indigenous breeds

Breed	Barri		Black Boni		White Boni	
Items	**n**	**Mean±SE**	**n**	**Mean±SE**	**n**	**Mean±SE**
Overall	978	2.54±0.065	812	2.18±0.051	857	2.26±0.0.067
Period (year of birth)						
P1 (1992-1994)	84	2.36^{a}±0.06	169	1.92^{d}±0.04	136	2.15^{a}±0.05
P2 (1995-1997)	233	2.24^{c}±0.04	140	2.02^{c}±0.04	204	1.99^{ab}±0.04
P3 (1998-2000)	266	2.27^{bc}±0.04	219	2.18^{b}± 0.03	208	1.98^{b}±0.04
P4 (2001-2003)	170	2.33^{b}±0.05	159	2,21^{b}± 0.03	169	2.10^{a}±0.05
P5 (2004-2006)	138	2.47^{a}±0.05	93	2.18 ^{b}±0.05	111	2.07^{ab}±0.05
P6 (2007-2009)	87	2.29^{bc}±0.05	35	2.22 ^{a}±0.07	29	2.10^{a}±0.08
		***		**		**
Season						
Autumn	343	2.42^{a}±0.05	329	2.18^{a}±0.03	300	2.08±0.04
Summer	308	2.31^{b}±0.04	229	2.09^{b}±0.03	350	2.05±0.04
Winter	327	2.25^{b}±0.05	254	2.11^{b}±0.03	207	2.09±0.04
		***		*		n.s
Sex						
Female	485	2.29^{b}±0.04	396	2. 28^{b}±0.03	426	2.09^{b}±0.04
Male	493	2.36^{a}±0.04	416	2.34^{a}±0.03	431	2.14^{a}±0.04
		**		**		**
Type of birth						
Single	869	2.56^{a}±0.03	628	2.31^{a}±0.02	821	2.29^{a}±0.03
Twin	109	2.09^{b}±0.05	184	1.94^{b}±0.03	36	1.85^{b}±0.07
		***				***
Weight of dam						
<24	21	2.24^{c}±0.06	155	1.92^{c}=0.04	80	1.85^{c}=0.06
25-33	554	2.30^{b}±0.02	602	2.12^{b}=0.02	735	2.10^{b}=0.03
>33	403	2.43^{a}±0.02	56	2.34^{a}=0.05	42	2.26^{a}=0.07
		***		***		***
Parity						
1	360	2.32±0.04	315	2.07±0.031	328	2.02±0.04
2	238	2.36±0.05	196	2.19±0.037	190	2.07±0.04
3	160	2.38±0.05	133	2.14±0.04	120	2.09±0.05
4	103	2.34±0.05	90	2,11±0.05	82	2.08±0.06
5	62	2.37±0.06	44	2,15±0.06	58	2.08±0.06
6	55	2.19±0.06	34	2.09±0.07	79	2.07±0.07
		NS		NS		NS

The means within the same column with at least one common letter, do not have significant difference (P>0.05).

** Significant effect at P<0.01; * Significant effect at P<0.05 and NS: non significant.

Also similar results were found by Mandal *et al.* (2003), Thiruvenkadan *et al.* (2009), Abbas *et al.* (2010) and Petrovic *et al.* (2011).

Season of lambing in this study had significantly effect on BW for Barri and Black Boni only. Lambs born in autumn had higher BW than those born in winter and summer. The significance of BW at birth between these seasons can be interpreted as the influence of moderate weather conditions and a viability of green forage during pregnancy and growth stages for lambs. Similar results were found by Dixit *et al.* (2001), Mandal *et al.* (2003) and Albial *et al.* (2010). Analysis of variance showed that the sex of the lambs and the type of birth were important sources of variation (P<0.05) in the three breeds. Male lambs were heavier (P<0.05) than female lambs. The levels of advantages in male over female lambs were similar (3%) in the three breeds. The differences may by attributed to difference in metabolic rate during embryonic stage of life (Mishra *et al.* 2007) and to difference in the endocrine profile of the two sexes (Gamasaee *et al.* 2010). This significant difference was confirmed by many authors (Rajab *et al.* 1992; Dixit *et al.* 2001; Mandal *et al.* 2003; Mishra *et al.* 2007).

The birth weight of single born lambs was significantly heavier (P<0.01) than twins in the three breeds. The levels of advantages in single lambs have been reported in almost all studies (Dixit *et al.* 2001; Mishra *et al.* 2007; Thiruvenkadan *et al.* 2009; Abbas *et al.* 2010; Albial *et al.* 2010). Gamasaee *et al.* (2010) stated that the effect of birth type was significant on birth weight of lambs and it can be explained by limited uterine space and nutrition of lamb during pregnancy. The size of the ewe was reflected by dam weight during lambing and it also had a significant effect (P<0.01) on birth weight of the lamb born in all the three breeds. Similar positive relationships have been reported by Alnokhif (1999), Dixit *et al.* (2001) and Albial *et al.* (2010). Ewe parity did not influence (P>0.05) on lamb birth weight in the three breeds. The variation within breed and between breeds was very small. The interpretation of parity effects seems to be complicated by external confounding factors such as feeding during pregnancy, and selection and culling strategies that may influence birth weight. Similar results were reported by Thiruvenkadan *et al.* (2009).

Weaning weight (WW) Factors affecting WW for the three breeds are shown in Table 2. Weaning weight ranged from 10.33 kg to 12.47 kg, 9.28 kg to 10.58 kg and 9.28 kg to 10.58 kg in Barri breed, Black Boni and White Boni, respectively. Period/year of birth effects were significant (P<0.05) for weaning weights in the three breeds. Our results are in accordance with those reported by Mandal *et al.* (2003) and Thiruvenkadan *et al.* (2009).

Season of lambing in this study had significant effect (P<0.05) on WW in the three breeds as shown in Table 2. Lambs born in the autumn lambing season revealed the heaviest body weight at weaning as compared to those lambs born in summer and winter seasons.

This finding was in agreement with those reported by Thiruvenkadan *et al.* (2009) for Mecheri and their crossbred lambs and by Albial *et al.* (2010) for White Boni sheep. The higher weaning weight of lambs born during autumn might be due to the carryover effect of birth weight, because they were heavier at birth. Similar seasonal effects on weaning weight were also observed by Dixit *et al.* (2001) and Abbas *et al.* (2010).

Sex of lambs effects were not significant (P>0.05) for the three breeds (Table 2). The average weight of the both sexes was similar. Such results are in accordance with those reported by Petrovic *et al.* (2011). Type of birth also has significant effect (P<0.05) on body weight of lambs at weaning in the three breeds. The variation in weaning weight ranged from 9.68 kg (twin) to 12.59 kg (single) in Barri breed, 9.29 kg (twin) to 10.97 kg (single) in Black Boni and 9.96 kg (twin) to 11.13 kg (single) in White Boni, respectively. Similar results were reported by Rajab *et al.* (1992), Dixit *et al.* (2001) and Abbas *et al.* (2010). This indicates that lower of twin lambs at weaning may be due to low birth weights and the competition between the twins for limited quantity of milk available from the dam. The effect of dam weight at lambing on live weight of lambs at weaning were significantly higher (P<0.01) in all the breeds (Table 2).

These results were similar to those reported by Alnohkaif (1999) and Dixit *et al.* (2001). Weight of dam reflects the size of dam and its nutritional condition on prenatal lamb growth (Gamasaee *et al.* 2010). The effect of parity had consistently showed no significant effect (P>0.05) on weaning weight in the three breeds of the study (Table 2). It is in accordance with the reports of Thiruvenkadan *et al.* (2009) in Mecheri sheep.

Growth rate Period/year had a significant (P<0.01) effect on growth rate in the three breeds (Table 3). The effects of years of lambing on growth rate of these breeds were reported by Alnokhaif (1999) for Barri sheep and Albial *et al.* (2010) for White Boni sheep. The significant differences in growth rate of lambs in different periods maybe attributed to alterations in management, selection of rams and environmental condition such as ambient temperature, humidity, rainfall and other factors. Results also showed that season of lambing had effect (P<0.05) on growth rate of lambs in the three breeds.

Lambs born in the autumn season were faster in growth rate than lambs born in summer and winter seasons. These results are in agreement with the finding of other authors as Gbangboche *et al.* (2006) and Thiruvenkadan *et al.* (2009), who obtained a significant effect of season on this trait.

Table 2 Number of records and least square means (±SE) for factors affecting weaning weight in three Yemeni indigenous breeds

Breed	**Barri**		**Black Boni**		**White Boni**	
Items	**n**	**Mean±SE**	**n**	**Mean±SE**	**n**	**Mean±SE**
Overall	888	12.49 ±0.58	710	10.58±0.44	773	11.14±0.46
Period (year of birth)						
P1 (1992-1994)	76	12.47^{a}±0.48	144	9.95^{c}±0.26	130	12.18^{a}±0.30
P2 (1995-1997)	222	10.81^{bc}±0.35	127	10.08^{bc}±0.27	180	11.31^{a}±0.28
P3 (1998-2000)	236	11.63^{b}±0.33	194	10.44^{ab}±0.24	179	9.83^{c}±0.27
P4 (2001-2003)	146	1084^{bc}±0.37	140	10.58^{ab}±0.24	156	10.28^{b}±0.29
P5 (2004-2006)	127	10.71^{c}±0.39	74	10.46^{a}±0.34	103	10.48^{b}±0.32
P6 (2007-2009)	81	10.33^{c}±0.42	31	9.28^{bc}±0.47	25	9.15^{c}±0.47
		***		*		**
Season						
Autumn	322	11.94^{a}±0.34	289	11.01^{a}±0.21	273	11.24^{a}±0.27
Summer	270	11.39^{b}±0.33	200	10.02^{b}±0.25	183	10.61^{b}±0.28
Winter	296	10.6^{c}±0.34	221	9.28^{c}±0.23	317	9.79^{c}±0.27
		***		***		**
Sex						
Female	441	10.96±0.32	341	10.02±0.21	388	10.49^{b}±0.27
Male	447	11.31±0.32	369	10.24±0.21	385	10.59^{a}±0.26
		NS		NS		NS
Type of birth						
Single	796	12.59^{a}±0.27	571	10.97^{a}±0.19	746	11.13^{a}±0.16
Twin	92	9.68^{b}=0.41	139	9.29^{b}±0.26	27	9.96^{b}±0.43
		***		***		*
Weight of dam						
<24	15	10.49^{a}±0.77	128	8.75^{c}±0.27	65	8.88^{c}±0.33
25-33	499	10.85^{b}±0.21	534	10.02^{b}±0.16	671	10.66^{b}±0.22
>33	374	12.06^{b}±0.20	48	11.64^{a}±0.37	37	12.09^{a}±0.39
		***		***		**
Parity						
1	320	10.85±0.31	277	9.97±0.20	292	10.12±0.27
2	218	11.12±0.34	178	10.26±.24	173	10.59±0.28
3	149	11.57±0.38	117	10.12±0.25	108	10.46±0.31
4	92	11.33±0.42	71	10.10±0.33	74	10.80±0.33
5	60	11.42±0.51	40	10.29±0.41	53	10.80±0.37
6	49	10.50±0.53	27	10.08±0.50	73	10.48±0.33
		NS		NS		NS

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
** Significant effect at P<0.01; * Significant effect at P<0.05 and NS: non significant.

There were significant differences (P<0.05) on growth rate of lambs from different sexes in the three breeds considered (Table 3).

Male lambs had growth rate faster than female lambs. Several authors have also reported that male lambs grow faster than female from birth to weaning (Rajab *et al.* 1992; Dixit *et al.* 2001; Gbangboche *et al.* 2006; Mishra *et al.* 2007; Abbas *et al.* 2010).

Single born lambs were superior to lambs born as twins in growth rate and the different between them was highly significant (P<0.01). The values were 113.58±3.64 *vs.* 83.70±5.74 g/day for Barri breed, 101.69±2.57 *vs.* 84.64±3.52 g/day for Black Boni breed and 100.19±3.64 *vs.* 94.87±6.82 g/day for White Boni breed, respectively. This finding is in agreement with those reported by some authors (Mandal *et al.* 2003; Gbangboche *et al.* 2006; Abbas *et al.* 2010).

Growth rate was significantly (P<0.01) affected by weight of dam at lambing in the three breeds (Table 3). Similar positive relationships have been reported by Alnohkaif (1999) and Dixit *et al.* (2001). Parity of the ewe revealed a significant effect (P<0.05) on average growth rate of lambs only in the breed of White Boni. These results are in agreement with the reports by Mishra *et al.* (2007) who found a significant effect of parity on this trait.

Genetic Parameters

Variance component ratios and genetic parameter estimates for the three breeds are showed in Table 3. White Boni lambs had lower heritability for birth weight than other lambs.

Hence, heritability for White Boni lambs was 0.19 compared with 0.38 and 0.36 for Black Boni and Barri lambs, respectively.

Table 3 Number of records and least square means (±SE) for factors affecting growth rate from birth to weaning in three Yemeni indigenous breeds

Breed	Barri		Black Boni		White Boni	
Items	**n**	**Mean±SE**	**n**	**Mean±SE**	**n**	**Mean±SE**
Overall	862	114.91±5.88	706	98.68±5.43	761	10.6.04±4.98
Period (year of birth)						
P1 (1992-1994)	76	108.07^{a}±5.92	143	89.02^{c}±3.61	130	114.58^{a}±4.71
P2 (1995-1997)	207	90.50^{c}±4.35	125	91.49^{bc}±3.65	170	102.67^{a}±4.53
P3 (1998-2000)	234	109.87^{b}±4.19	194	96.32^{ab}±3.32	177	91.47^{b}±4.34
P4 (2001-2003)	143	105.41^{b}±4.64	140	105.24^{a}±4.60	156	106.16^{a}±4.63
P5 (2004-2006)	125	92.71^{c}±4.91	74	92.03^{ab}±4.60	103	106.76^{a}±5.01
P6 (2007-2009)	77	85.28^{c}±5.37	30	84.88^{abc}±6.51	25	78.56^{b}±7.48
		***		**		***
Season						
Autumn	126	107.09^{a}±4.26	288	101.44^{a}±2.95	272	110.77^{a}±4.31
Summer	263	105.17^{b}±4.21	198	94.86^{a}±3.46	174	102.36^{b}±4.45
Winter	291	83.67^{c}±4.33	220	83.20^{b}±3.21	315	86.98^{c}±4.28
		***		***		***
Sex						
Female	427	96.25^{b}±4.06	340	91.90±2.89	380	100.29±4.15
Male	435	101.03^{a}±3.97	366	94.43±2.92	381	99.77±4.16
		***		**		**
Type of birth						
Single	773	113.58^{a}±3.43	567	101.69±2.57	735	100.19±2.61
Twin	89	83.70^{b}±5.07	139	84.64±3.52	26	94.87±6.82
		***		***		
Weight of dam						
< 24	15	89.49^{b}±9.52	128	82.00^{b}±3.74	64	83.65^{b}±5.31
25-33	480	96.64^{ab}±2.65	530	93.72^{a}±2.23	660	102.92^{a}±3.49
>33	367	109.79^{a}±2.61	48	103.77^{a}±5.03	37	113.52^{a}±6.23
		***		**		***
Parity						
1	313	95.90±3.85	277	90.52±2.79	288	93.81^{b}±4.25
2	212	99.1±4.28	175	93.23±3.25	172	98.91^{ab}±4.48
3	141	105.42±4.74	117	91.89±3.47	104	97.83^{ab}±5.04
4	90	97.97±5.14	70	91.43±4.47	71	104.54^{a}±5.39
5	59	100.20±5.79	40	92.03±5.57	53	103.46^{a}±5.91
6	47	93.25±6.36	27	99.88±6.81	73	101.64^{ab}±5.23
		NS		NS		*

The means within the same column with at least one common letter, do not have significant difference (P>0.05).
** Significant effect at P<0.01; * Significant effect at P<0.05 and NS: non significant.

Heritability estimates for birth weight in various sheep breeds have ranged from 0.04 to 0.49 (Mandal *et al.* 2003; Behzadi *et al.* 2007; Thiruvenkadan *et al.* 2009). Heritability estimates for Barri and Black Boni resulted from Model 1 corresponded well with those reported by Rashidi *et al.* (2008) for Kermani sheep. Higher heritability estimates were reported by Al-Shorepy (2001) who found an estimate of 0.48 for crossbred lambs fitting similar model. The current h^2 estimates for White Boni lambs agreed well with those observed by Albial *et al.* (2010) for White Boni sheep and Dixit *et al.* (2001) for Bharat Merino lambs, whose estimate of h^2 was 0.18 and 0.23 for both breeds, respectively.

The moderate to high additive heritability estimates found in this study can be explained by uniformity of management at the sheep breeding station, creating small environmental variations.

The estimates of heritability in WW were 0.35, 0.43 and 0.30 for Barri, White Boni and Black Boni, respectively. In general, estimates of heritability in the current study were comparatively higher than those reported values for weaning weight using comparable model (Al-Shorepy and Notter, 1996; El Fadili *et al.* 2000; Albial *et al.* 2010). Higher estimates reported by several authors (Ghafouri Kesbi *et al.* 2008; Rashidi *et al.* 2008).

Moreover, Behzadi *et al.* (2007) working with Kermani sheep reported estimates of h^2 to be between 0.22 and 0.62 for WW. In most studies on growth traits, it has been frequently reported that heritability for body weights have a tendency to increase with age (Behzadi *et al.* 2007). Parameter estimates for growth rate from birth to weaning for each of the three breeds are shown in Table 4. Heritability estimates were 0.35, 0.30 and 0.26 for Barri, White Boni and Black Boni lambs, respectively.

Table 4 Variance component ratios for lamb birth weight, weaning weight and average daily gain in three Yemen indigenous breeds

Trait	Item[a]	Data set		
		Barri	Black Boni	White Boni
BW[b]				
	σ^2_a	0.06512	0.06631	0.02991
	σ^2_e	0.11671	0.10714	0.12847
	σ^2_p	0.18183	0.17345	0.15838
	h^2	0.36 (0.095)	0.38 (0.103)	0.19 (0 .070)
WW				
	σ^2_a	3.50878	2.06175	2.30520
	σ^2_e	6.51335	4.85173	3.07653
	σ^2_p	10.02213	6.91348	5.38173
	h^2	0.35 (0 .081)	0.30 (0.108)	0.43 (0 .090)
Growth rate				
	σ^2_a	499.99530	283.79538	348.61534
	σ^2_e	949.00611	812.90632	804.88022
	σ^2_p	1449.00141	1096.70170	1153.49555
	h^2	0.35 (0.081)	0.26 (.092)	0.30 (0 .084)

[a] σ^2_a, σ^2_e, σ^2_p are additive direct, residual variance and phenotypic variance, respectively; h^2 is heritability.
[b] BW: birth weight; WW: weaning weight; Growth rate: at pre-weaning.

Heritability estimates in the present study for growth rate gain in three breeds were similar to those observed by Dixit *et al.* (2001) in Bharat Merino. Estimate of heritability in White Boni lambs was similar to the estimate of 0.28 reported by Albial *et al.* (2010) in White Boni lambs.

CONCLUSION

From the current study it can be concluded that environmental and genetic factors cause differences on the expression of economically important traits like birth weight, weaning weight and growth rate from birth to weaning. The genetic parameters estimated for growth traits indicated that there is a genetic variation among the animals that it can be utilized for genetic change in these traits by selection in the breeds of sheep raised under their specific harsh environmental conditions.

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