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Genetic Analysis of Growth Traits in White Boni Sheep Under the Central Highlands Region of Yemen

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Abstract: The data were collected from 1992 to 2009 of White Boni sheep maintained at the Regional Research Station in the Central Highlands of Yemen. Data were analyzed to study the growth related traits and their genetic control. The least square means for body weights were 2.26±0.67, 11.14±0.46 and 19.21±1.25 kg for birth weight (BW), weaning weight (WW), six-month weight (WM6), respectively. The pre-and post-weaning average daily weight gains (ADG1 and ADG2) were 106.04±4.98g and 46.21±8.36 g/ day. Significant differences associated with the year of lambing were observed in body weight and weight gain at different stages of growth. Males were heavier and had a higher weight gain than females at almost all stages of growth and differences tended to increase with age. Single-born lambs had a distinct advantage over those born in twin birth at all stages of growth. The lambs in the dam's second to fourth parities were generally of heavier weight and higher daily weight gain than those in other parities. The heritabilities of all body weights, weight gains at different stages of growth were moderate (0.11-0.43). The phenotypic and genetic correlation among the different body weights were positive and high. The genetic correlations of the pre- and post-weaning average daily gains with body weights were hight to moderate, except BW with ADG2.

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INTRODUCTION

Important traits for genetic improvement in lamb breeding enterprises include the growth characteristics of the animal. A number of non-genetic factors affect these growth traits and directly obscure recognition of the genetic potential. Adjustment of the data for non-genetic factors and estimation of genetic parameters for the various traits are necessary for obtaining reliable estimates for important economic traits and increasing the accuracy of selection of breeding animals. The growth traits (birth weight, weaning weight and six-month weight) are an important role in productivity and are one of the major selection economic 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). An effective breeding plan can only be devised after through knowledge has been obtained about inheritance of economically important traits. Estimates of heritability and genetic and phenotypic correlations from the basis of such information. This knowledge is required to formulate optimum breeding objectives and effective genetic improvement program. The White Boni sheep is one of mutton breeds in Yemen and is widely distributed in the semi-arid region of the Central highlands regional and Northern highlands regional (Sanaa, Thamar, Elmohuit, Amranm, and part of Ibb). This breed is considered a less-known unique genotype exhibiting better growth, very good adaptability and a somewhat higher prolificacy. The breed has better potential for meat and wool production than other Yemeni sheep breeds. Data on the production performance of this breed over a good number of years on a semi-intensive system of management, which is similar to the management of the flock by the farmers, will indicate the most important environmental factors influencing the genetic potential of the animals, help in formulating a breeding program and in genetic evaluation of the breed, and should ultimately be useful for breed improvement programs at the farmer and institutional levels.

The previous reports about productive of White Boni sheep were based on short term observations, so the information available was very limited and difficult to arrive at anything other than very general conclusions. Therefore, the present study was undertaken to identify various factors (the period of lambing, season of lambing, sex and type of birth, weight of dam and parity of dam) influencing the growth traits and gain weight at different stages of development and to estimate the genetic and phenotypic parameters of these traits in White Boni sheep.

MATERIAL AND METHODS

Location

The breed of sheep in this study was 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 2,400 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 29C° and -4C°.

Animal management

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 857 records of lambs at birth 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 factors affecting growth traits at different stages of development.

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 $\leq$ 24, 25-33 and > 33), season of birth 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 were pre-adjusted as follows:

Adjusted 90-day weaning weight (WW) = growth rate x 90 + birth weight

Analysis was conducted according the following model for each breed.

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

Where Y_{nkpmrs} is the observation on the trait, μ is the overall mean, A_n is effects of the n^{th} period of lambing (n= 1 to 6), S_k is the effects of the k^{th} season of lambing (k= summer, autumn ,winter), T_p is the effects of the p^{th} type of birth (p= single , twin), X_m is the effects of the m^{th} sex of lamb (m= male , female), W_r is the effects of the r^{th} dam of weight during lambing (r = ≤ 24kg, 25-33 kg, ≥ 31kg), D_s is the effects of the s^{th} parity number of dam (s=1 to 6), E_{nkpmrs} represent the random error associated with each observation.

The genetic parameters of the various traits were estimated by the paternal half-sib method. The comparison of the means of the different subgroups was made by Duncan's multiple range tests as described by Kramer (1957).

RESULT AND DISCUSSION

1. Environmental effects

1.1 Birth weight

The leas-square means and standard error for the various traits (birth weight, weaning weight, six-month weight) are presented in Table 1. The number of individuals observed at the age of six-month was 61% lower than the number of lambs observed at birth. The reasons for this reduction were mortality, culling unproductive animals, sale or transfer of animals and transfer of animals within the experimental unit. The average live weights at birth (WB), weaning (WW) and six-month (WM6) of age were 2.26±0.0.067, 11.14±0.46 and 19.21±1.25kg, respectively. These result obtained in this study are in agreement with reported by Alazazi et al. (2005). The year of lambing was highly significant (P<0.01) in respect of the weights of the lambs at all developmental stages. The growth rate tended to increase during the first nine years of the study, than declined during the next nine years. The maximum growth from birth to six-month was observed in the year 1992 to 1994). Differences in body weight from year to year is mostly due to variation in climatic, feeding and management condition, which either affects the lambs directly or indirectly through their effects on dams. The result of this study are similar to the result of Al-Bial et al., (2010) for White Boni sheep. Also similar results were found by Abbas et al. (2010), Thiruvenkadan et al. (2009) and Mandal et al. (2003).

Season of lambing in this study had non-significantly effect on BW but, it had significant effects on weaning weight and six-month weight. Lambs born in the autumn lambing season revealed the heaviest body weight at weaning and six-month weight as compared by those lambs born in summer and winter seasons. This finding was in agreement with those reported by Al-Bial et al. (2010) for White Boni sheep and by Thiruvenkadan et al. (2009) for Mecheri and their crossbred lambs. 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 effect on weaning weight was also observed by Dixit et al. (2001) and Abbas et al. (2010).

Analysis of variance showed that the sex of the lambs and type of birth were important sources of variation ($P < 0.05$). Male lambs were heavier ($P < 0.05$) than female lambs. The levels of advantages of male over female lambs were similar (3%). 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 body weight at BW, WW WM6 of single born lambs was significantly heavier ($P < 0.01$) than twins. Gamasaee et al., (2010) stated that the effect of birth type was significant on birth weight of lambs and can be explained by limited uterine space and nutrition of lamb during pregnancy. The variation in weaning weight ranged from 9.96 kg (twin) to 11.13kg (single). Similar results were reported by Abbas et al. (2010), Dixit et al. (2001) and Rajab et al. (1992). 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 size of the ewe which was reflected by dam weight during lambing had also significant effect ($P < 0.01$) on BW and WW but it was not significant on WM6. Similar positive relationships have been reported by (Dixit et al., 2001; Alazazi et al. 2005; Al-Bial et al. 2010). 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 all traits (Table 2). 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. It is in accordance with the reports of Thiruvenkadan et al.,(2009) in Mecheri sheep.

1.2 Weight gain

The pre-and post-weaning average daily weight gains were observed as 106.04±4.98 and 46.21±8.36g/day, respectively. The effect of year, season of lambing sex and type of birth, weight of dam and parity of dam had significant ($P<0.01$) on the pre- and post-weaning average daily gain(Table 2). The highest per and post-weaning average daily weight gain was observed in 1992-1994 and 1995-1997, respectively. Results also show that season of lambing had effect ($P<0.05$) on weight gain of lambs. Lambs born in the autumn season were faster in growth rate than lambs born in summer and winter seasons. Similar results obtained by Alazazi et al. (2005) and Albial et al., (2010) for White Boni sheep and Thiruvenkadan et al. (2009) for Mecheri sheep.

The difference in average daily weight gain between male and female lambs increased from 9g to 11g/day at six-month of age. 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).

The difference in the rate of weight gain per day for single-born lambs compared to twin-born lambs was 14g up to weaning. The values were 100.19±3.64 vs. 94.87±6.82 g/ day. This finding is in agreement with those reported by some authors (Mandal et al., 2003; Gbangboche et al., 2006; Abbas et al., 2010).

The pre-and post-weaning average daily weight gains were observed significantly ($P<0.01$) affected by weight of dam at lambing (Table2). Similar positive relationships have been reported by Dixit et al., (2001).

The daily weight gain of lambs born to ewes in their second and fourth parities were higher than that of lambs from younger or older ewes during per-weaning stage. These results are in agreement with the reports by Mishra et al., (2007) and Gbangboche et al., (2006) who found a significant effect of parity on this trait.

2. Genetic and phenotypic parameters

2.1 Heritability

Variance component ratios and the genetic parameter estimates are given in Table 3. Heritability for birth weight had lower (0.19). 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).The current h^2 estimates for birth weight in this breed agreed well with those observed by Al-Bial et al., (2010) for White Boni sheep and Dixit al. (2001) for Bharat Merino lambs, whose estimate of h^2 was 0.18 and 0.23 respectively for both breeds.

Table 1: Least Squares Means (LSM) and Standard Errors (±SE) of factors affecting birth weight, weaning weight and six-month weight (kg) in White Boni sheep.

Fixed effect	BW (kg)		WW (kg)		WM6 (kg)	
	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE
Overall	857	2.26±0.67	773	11.14±0.46	336	19.21±1.25
Period (Year of birth)		**		**		
P1(1992-1994)	136	2.15[a]±0.05	130	12.18[a]±0.30	50	19.22[a]±1.18
P2(1995-1997)	204	1.99[ab]±0.04	180	11.31[a]±0.28	54	18.74[b]±1.25
P3(1998-2000)	208	1.98[b]±0.04	179	9.83[c]±0.27	60	17.70[b]±1.11
P4(2001-2003)	169	2.10[a]±0.05	156	10.28[b]±0.29	53	18.24[b]±1.07
P5(2004-2006)	111	2.07[ab]±0.05	103	10.48[b]±0.32	40	16.01[a]±1.03
P6(2007-2009)	29	2.10[a]±0.08	25	9.15[c]±0.47	79	16.85 [bc]±1.14
Season of lambing		n.s		**		**
Autumn	300	2.08±0.04	273	11.24[a]±0.27	117	18.85[ab] ±1.10
Summer	350	2.05±0.04	183	10.61[b]±0.28	95	18.11[b] ±1.02
Winter	207	2.09±0.04	317	9.79[c]±0.27	124	16.45[a] ±1.08
Sex of lamb		**		n.s		*
Female	426	2.09[b]±0.04	388	10.49[a]±0.27	166	19.04[b] ±1.03
Male	431	2.14[a]±0.04	385	10.59[a]±0.26	170	19.80[a] ±1.03
Type of Birth		***		*		*
Single	821	2.29[a]±0.03	746	11.13[a]±0.16	309	19.84[a] ± 0.75
Twin	36	1.85[b]±0.07	27	9.96[b]±0.43	27	18.10[b] ± 1.55
Weight of Dam		***		**		n.s
< 24	80	1.85[c]=0.06	65	8.88[c]±0.33	104	19.71[a] ±1.35
25-33	735	2.10[b]=0.03	671	10.66[b]±0.22	110	19.88[a] ±0.94
>33	42	2.26[a]=0.07	37	12.09[a]±0.39	124	19.83[a] ±1.32
Parity of dam		n.s		n.s		n.s
1	328	2.02±0.04	292	10.12±0.27	55	16.86 ± 1.04
2	190	2.07±0.04	173	10.59±0.28	49	19.15 ± 1.11
3	120	2.09±0.05	108	10.46±0.31	50	19.22 ± 1.25
4	82	2.08±0.06	74	10.80±0.33	63	20.25 ± 1.49
5	58	2.08±0.06	53	10.80±0.37	50	18.83 ± 1.53
6	79	2.07±0.07	73	10.48±0.33	69	19.51± 1.15

[a] means with different letters in each subclass within a column differ significantly at ($P < 0.05$). ** Significant effect at $P<0.01$; * Significant effect at $P < 0.05$; ns: not significant

Table 2. Least Squares Means (LSM) and Standard Errors (±SE) of factors daily weight gain during pre-and post-weaning in White Boni sheep

Fixed effect	Pre-weaning ADG1(g)		Post-weaning ADG2 (g)	
	n	Mean ± SE	n	Mean ± SE
Overall	761	106.04±4.98	336	46.21±8.36
Period (Year of birth)		***		*
P1(1992-1994)	130	114.58[a]±4.71	50	46.91[b]±9.65
P2(1995-1997)	170	102.67[a]±4.53	54	48.30[a]±0.67
P3(1998-2000)	177	91.47[b]±4.34	60	47.20a[b]±12.14
P4(2001-2003)	156	106.16[a]±4.63	53	55.66[a]±13.27
P5(2004-2006)	103	106.76[a]±5.01	40	39.96[c]±11.39
P6(2007-2009)	25	78.56[b]±7.48	79	40.42[b]±12.48
Season of lambing		***		**
Autumn	272	110.77[a]±4.31	117	47.81a±11.51
Summer	174	102.36[b]±4.45	95	37.55b±12.14
Winter	315	86.98[c]±4.28	124	40.98a±11.16
Sex of lamb		**		*
Female	380	108.29±4.15	166	38.05[b]±9.45
Male	381	99.77±4.16	170	49.85[a]±15.49
Type of Birth				*
Single	735	110.19±2.61	309	49.86a±6.32
Twin	26	94.87±6.82	27	35a.76±11.21
Weight of Dam		***		n.s
< 24	64	83.65[b]±5.31	104	43.37[a]±13.21
25-33	660	102.92[a]±3.49	110	39.14[a]±8.52
>33	37	113.52[a]±6.23	124	46.42[a]±12.36
Parity of dam		*		n.s
1	288	93.81[b]±4.25	55	49.79[a]±9.85
2	172	98.91[ab]±4.48	49	50.21[a]±10.38
3	104	97.83[ab]±5.04	50	48.38[a]±10.02
4	71	104.54[a]±5.39	63	51.59[a]±14.12
5	53	103.46[a]±5.91	50	35.39[a]±16.01
6	73	101.64[ab]±5.23	69	43.50[a]±11.54

[a] means with different letters in each subclass within a column differ significantly at ($P < 0.05$). **Significant effect at $P<0.01$; * Significant effect at $P < 0.05$; ns: not significant

Table 3: Estimates of heritability with standard error (diagonal), genetic (above diagonal) and Phenotypic (below diagonal) correlation among various productive traits of indigenous White Boni sheep.

Traits	BW	WW	WM6	GR1	GR2
BW	**0.19±0.02**	0.685	0.387	0.221	0.014
WW	0.331	**0.43±0.02**	0.861	0.687	0.541
WM6	0.345	0.793	**0.29±0.10**	0.524	0.336
GR1	0.21	0.431	0.379	**0.30±0.08**	0.212
GR2	0.023	0.152	0.423	0.014	**0.11±0.07**

BW: Birth weight, WW: Weaning weight, WM6: Six-month Weight, GR1: Growth rate at pre-weaning, GR2: Growth rate at post-weaning.

The estimates of heritability of weaning weight and six-month weight were 0.43 and 0.29, respectively. In general, estimates of heritability in the current study was comparatively moderated than those reported values for weaning weight using comparable model (Al-Shorepy and Notter 1996; El Fadili et al., 2000; Al-Bial et al, 2010). Higher estimates reported by several authors (Ghafouri Kesbi et al., 2008; Rashidi et al., 2008). More over, Behzadi et al., (2007) working with Kermani sheep reported estimates of h^2 to be between 0.22- 0.62 for weaning weight. 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 weight gain at pre- and post-weaning was 0.30. and 0.11respectively. These results were similar to those observed by Dixit et al., (2001) in Bharat Merino.

2.2 Genetic and phenotypic correlation

the genetic and phenotypic correlation estimates for some productive traits in White Boni are presented in Table 3.The phenotypic correlation of birth weight with the body weights and weight gain at subsequent ages ranged from medium to low and were positive (0.023- 0.431). The magnitude of these correlations declined steadily with age, but genetic correlation for these traits was strongly and significantly correlated with body weights and weight gains at all ages. The phenotypic correlations of weaning weight with the six month body weight and pre-weaning average daily gains were also significant and moderate to high (0.793 to 0.431) but with pre-weaning average daily gains was low (0.15). The genetic correlations of weaning weight with W6, GR1and GR2 showed also high correlations (0.861, 0.687 and 0.541 respectively). The six month body weight had a significant high positive and genetic correlation with pre- and post-weaning average daily gains. These weighted mean genetic and phenotypic correlations were remarkabley similar to those reported by Fogarty (1995), Singh et al. (2009), Mendal et al. (2003), Kushwaha et al. (2010) and Thiruvenkadan et al. (2009).

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REFERANCES

Abbas, S. F., Abd Allah., M. Allam, F.M., and Abooul-Ella, A. A., (2010). Growth performance of Rahmni and Chios Lambs weaned at different ages. Australin Journal Basic & Applied Science, 4: 1583-1589.

Alazazie, S. Alshami, A. Al Mas'udi, A. R., and Rawia, S., (2005) Productive and reproductive characteristics of Barri , Black Boni, White Boni breedof sheep. Annual report, Regional Research Station of the Central highlands, AREA.

Al-Bial, A.M., Al-Karmah A., Al-Ashwal M., Alazazie S., Alshami, A. and Sharaf, R. (2010). Performance of White Boni sheepYemeni 1. Some of non-genetic factors influencing growth traits. Egypt J. of Appl. Sci. 25: 432-442.

Al-Shorepy, S. A., and Notter, D.R. (1996). Genetic variation and covariation for ewe reproduction, lamb growth, and lamb scrotal circumference in a fall-lambing sheep flock. J. Anim. Sci. 74: 1490-1498.

Behzadi, R., Shahroudi F.E. and Van Vleck, L.D. (2007). Estimates of genetic parameters of growth traits in Kermani sheep. Journal of Animal Breeding and Genetic 5: 296- 301.

Dixit, S.P., Dhillon, J.S. and Singh, G. (2001). Genetic and non-genetic parameters for growth traits of Bharat Merino lambs. Small Rumin Res 42: 101-104.

El Fadili M., Michaux, C., Detilleux J. and Leroy, P.L. (2000). Genetic parameters for growth traits of the Moroccan Timahdit breed of sheep. Small Rumin. Res. 37: 203-208.

Fogarty, N.M., (1995). Genetic parameters for live weight, fat and muscle measurements, wool production and reproduction in sheep: a review. Anim. Breed. 63: 101–143.

Gamasaee, V.A., Hasan, S., Ahmadi, H.A., Baneh, H., Farhadi, A. and Mohamadi, A. (2010). Estimation of genetic parameters for body weight at different ages in Mehraban sheep. Afr. J. Biotechnol. 32: 218-223.

Gbangboche, A.B., Youssao, A.K.I., Senou M., Adamou-Ndiaye, M., Ahissou A., Farnir F., Michaux, C., Abiola, F. A. and Leroy, P.L. (2006). Examination of nongenetc factors affecting the groeth performance of Djllanke sheep .Trop Anim Health prod 38: 55-64.

Ghafouri, Kesbi, F., Eskandearinasab, M. and Hassanabadi, A. (2008). Estimaation of genetic parameters for lamb wieght at various age in Mehraban sheep. Ital. J. Anim. Sci. 22: 95-103.

Kushwaha, B.P., Ajou, M., Ravendra, K., and Sushil, K., (2010). Environmental and genetic effects on growth traits of Chokla sheep. Indian Journal of animal science, 80(4): 346-349.

Mandal, A., Pant, K.P., Nandy, D.K., Rout, P.K. and Roy, R. (2003). Genetic analysis of growth traits in Muzaffarnagari sheep. Trop Anim Health Prod 35: 271-284.

Mishra, A.K., Arora, A.L., Kumar, S. and Singh, V.K. 2007. Improving productivity of Malpura breed by crossbreeding with prolific Garole sheep in India. Small Rumin Res. 70: 159-164.

Rajab, M.H., Cartwright, T.C., Dahm, P.F. and Figueiredo, E.A. (1992). Performance of three tropical hair sheep breeds. J. of Anim. Sci. 11: 3351-3359.

Rashidia, A., Mokhtarib, M.S., Safi, Jahanshahic, A. and Abadid, M.R. (2008). Genetic parameter estimates of pre-weaning growth traits in Kermani sheep. Small Rumin Res. 74: 165-171.

SAS, 2004. User's Guide. Statistical analysis system institute, Inc. Cary, NC, USA.

Singh, D., Kumar, R., Pander, B.L., Dhaka, S.S. and Singh, S., (2006). Genetic parameters of growth traits in crossbred sheep. Asian-Aust. J. Anim. Sci. 10: 1390-1393.

Thiruvenkadan, A.K., Karunanithi, K., Muralidharan, J. and Narendra, Babu, R. (2009). A comparative study on geowth performance of crossbred and purebred Mecheri sheep raised under dry land farming condition. Afr. J. Anim. Sci. 39: 121- 125.