Volume 50(4). Published February, 01, 2018
www.jnsciences.org
E-ISSN 2286-5314

JOURNAL OF NEW SCIENCES AGRI & BIOTECH
WWW.JNSCIENCES.ORG

Estimation of Genetic Parameters and Adjustment Factors for Growth Characters of Barbarine High Lambs in Low Input Production Systems

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Abstract – The Barbarine breed with big tail still requires interest although it has been the subject of several studies given its size and distribution in different geographical areas and production systems. The objectives of this study were to: 1) Identify the main sources of variation in the different traits of breed growth, 2) Estimate the adjustment coefficients for dominant non-genetic effects, and 3) Estimate the genetic parameters of the trait traits growth in the breed.
Records of a total of 191 371 lambs collected over 10 years (from 2004 to 2014) were used in this study. A linear model including the livestock sector (state or private), farm-herd-year of birth-lambing season, maternal age, and sex-mode of birth was used to identify the main sources of variation in the growth of Barbarine. Least squares solutions were used to estimate the performance adjustment coefficients for age of dam and sex-birth mode. The REML method was used for estimating heritability.
The main results showed that the average performance was 4,2 ± 0,42 kg; 5,37 ± 1,32 kg; 8,29 ± 2,11 kg ; 14,04 ± 3,46 kg; 16,21 ± 3,83 kg; 127 ± 56 g/day; 187 ± 49 g/day; 165 ± 61 g/day; 134 ± 45 g/day and 135 ± 42 g/day for BW, W10, W30, W70, W90, ADG030, ADG1030, ADG3070 and ADG3090, respectively.
The coefficients of determination R^2 varies between 36% and 48%. Sector, age of dam, sex-mode of birth, and farm-herd-year-in-season combination were found to be the major factors that significantly affect lamb growth from birth to weaning at 90 days.
The phenotypic correlations between different weights were positive and ranging from 0.122 to 0.99 between ADG030-ADG3090 and W30-ADG030, respectively. The estimated heritabilities ranged for the first group from 0.09 ± 0.31 to 0.409 ± 0.64 for the weights BW, W30, W70 and W90 and from 0.14 ± 0.37 to 0.468 ± 0.68 while the second group was 0.109 ± 0.33 to 0.251 ± 0.5 and 0.124 ± 0.35 to 0.444 ± 0.66.

Keywords: sheep, Barbarine, growth, adjustment, heritability.

1. Introduction

The global sheep population was estimated at 1.2 billion in 2012, with Africa accounted for 22%. Africa is also home to a total of 117 sheep breeds out of a global total of 1155 breeds (FAO, 2015). In Tunisia, sheep breeds contribute with 45% of the total red meats produced in the country. The majority of the 274 000 sheep owners are small breeders where 64% hold less than 10 ewes. The Barbarine Fathead sheep are the most important breed in size, 2/3 of the size of the sheep population with 3.9 million female units (OEP, 2016). However, the breed has a relatively low growth rate and its preference by butchers, particularly in large urban markets, decreases for lambs that produce a fat-free carcass (Bedhiaf et al., 2008b).

Since the 1960s, Tunisia has created a national sheep identification and registration program that provides information to select improved brood stock. However, the growth characteristics of lamb from birth to weaning are still low for a breed with great phenotypic variability. The objectives of this study were: 1) to identify the main sources of variation of the different growth traits, 2) to calculate the adjustment coefficients for the non-genetic effects, and 3) to estimate the genetic parameters of growth in the Barbarine breed.

2. Material and Methods

Growth records of a total of 191 371 lambs born during the 2004-2014 period in 79 herds were used in this study. These data are provided by the Livestock and Pasture Office mandated by the Ministry of Agriculture to manage the programs of performance control in domestic animal. A linear model (1) was used to identify the sources of variation affecting the growth characteristics of the lamb in the environmental conditions encountered.

$$Y_{ijklm} = \mu + Sec_i + FHYS(Sec)_{ij} + A_k + ST_l + e_{ijklm} \quad (1)$$

With:

Y_{ijklm}	= Weights in (kg) and average daily gains of lambs (g/d)
μ	= Average population
Sec_i	= Effect of the eleventh breeding sector or type of owner (i = 1-6)
$FHYS(Sec)_{ij}$	= Effect of Farm-herd-year of birth-Saison intrasector
A_k	= Effect of age of dam (k=2-10)
ST_l	= Effect of sex-birth mode (l=1-4)
e_{ijklm}	= residual error.

All the factors of the model (1) were fixed, except the residual error being considered random.
The least square averages of maternal age and sex-mode of birth were used to estimate the respective adjustment coefficients for the different growth traits. The following formula has been used (Schaeffer, 1983):

$$k_i = {}^{m_i}/_{(m_i + s_i)} \quad (2)$$

With:

k_i	= Adjustment coefficient
m_i	= Average of the level of the factor taken as a baseline
s_i	= Least squares solution of level (i) of the factor in question

Genetic parameters were made according to a father (3) model using the Maximum Likelihood Restricted (REML) method. The lack of complete information on the pedigree of the lambs and the difficulty of having connections between herds was the reason for considering the estimation of the genetic parameters only in herds of the OEP. Only herds of the OEP where the connection was made in two groups of herds.
The estimation of the components of the variation

$$Y_{ijk} = \mu + FHYS_i + F_j + e_{ijk} \quad (3)$$

With:

Y_{ijk}	= Weight in (kg) and weight gains at the different typical ages in (g)
μ	= Average population
$FHYS_i$	=Fixed effect of the same farm-herd-year of birth season
F_j	=Genetic effect of the father
e_{ijk}	=Random residual value of the performance y

3. Results and Discussion

The lamb frequencies by sex-birth mode are presented in Table (1). Only sixteen percent of the lambs born were multiple.

Table1. Frequency of lambs by sex-mode of birth

Type of birth	Number of lambs	Frequency (%)
Male	93 515	48.86
Female	97 856	51.13
Simple	159 283	83.23
Double	32 088	16.76

3.1. Average growth performance

The main results show that a Barbarine lamb weights on average 4.2 ± 0.42 kg; 8.29 ± 2.11 kg; 14.04 ± 3.46 kg and 16.28 ± 3.84 kg at birth, 30 days, 70 days and 90 days, respectively. The average daily gain between birth- 30 days, 30-70 days and 30-90 days was 127 ± 56 g / day; 134 ± 45 g / day and 135 ± 42 g / day (Table 2).

Table2. Mean and standard deviation of lamb weights and average daily gain

Growth traits	Number of lambs	Mean	Standard Deviation
BW (kg)	50182	4.2	0.42
W10 (kg)	104616	5.37	1.32
W30 (kg)	152614	8.29	2.11
W70 (kg)	109860	14.04	3.46
W90 (kg)	63598	16.28	3.84
ADG0-30 (g/j)	48902	126.86	55.98
ADG 10-30 (g/j)	102612	164.58	60.82
ADG 30-70 (g/j)	39136	134.07	44.71
ADG 30-90 (g/j)	50670	135.27	42.37

BW: birth weight, W10: Weight at 10 days, W30: Weight at 30 days, W70: Weight at 70 days, W90: Weight at 90 days, ADG0-30: weight daily gain 0-30, ADG10-30: weight daily gain 10-30, ADG30-70: weight daily gain 30-70, ADG30-90: weight daily gain 30-90

Compared to previous studies on breed performance, there has been a steady decline in the average growth of lambs of this breed since the 1960s. Tchamichan and Sarson (1970) reported an average of 22 kg at weaning during 1963-1969. Khaldi et al. (1987) recorded an average of 20 kg for a period of 17 years (1963-1979). Djemali et al. (1994) reported an average of 17.8 kg for a 21-year period (1968-1988).

3.2. Sources of variation

The analysis of the sources of variation of the growth traits showed that all the factors of the model (1) were highly significant ($p < 0.01$) for the different growth traits studied (Table 3). The coefficients of determination R^2 vary between 36% and 48%. These results prove that the growth of the lamb is not only a reflection of its genetic potential but there are non-genetic factors such as sex-birth-mode and age of dam and driving factors such as the farm-herd -season that create differences between lambs.

Table 3. Sources of variation of growth traits

Sources of variation	Ddl	BW	W10	W30	W70	W90	ADG030	ADG1030	ADG3070	ADG3090
Sec	5	***	***	***	***	***	***	***	***	***
FHYS(Sec)	592	***	***(841)	***(1422)	***(1129)	***(839)	***(575)	***(842)	***(422)	***(724)
A	8	***	***	***	***	***	***	***	***	***
ST	3	***	***	***	***	***	***	***	***	***
R^2 %	-	45	36	46	48	46	47	37	43	46

***: P< 0.01, Sec: Sector; FHYS: Farm-Herd-Year of birth-Saison; A: Age of dam; ST: Sex-birth mode.

3.3. Performance adjustment

The estimation of the adjustment coefficients for the sex-mode of birth and the age of the mother are presented in Table (4). Male and single lambs were used as a basis of comparison to quantify the effect of sex-birth mode on growth traits. The age of the 5-year-old mother was used as a baseline to quantify the effect of the mother's age on the growth of her lambs. The estimated coefficients of adjustment are shown in Table (5).

Table 4. Coefficients of adjustment for age of dam and sex-mode of birth

Growth character Sex-type of birth	BW	W10	W30	W70	W90	ADG030	ADG1030	ADG3070	ADG3090
11	1	1	1	1	1	1	1	1	1
12	1.09	1.3	1.29	1.24	1.23	1.6	0.94	1.2	1.17
21	1.02	1.05	1.04	1.05	1.05	1.07	1.08	1.05	1.07
22	1.1	1.4	1.35	1.3	1.3	1.77	1.01	1.3	1.25
Growth trait /Age of dam	**BW**	**W10**	**W30**	**W70**	**W90**	**ADG030**	**ADG1030**	**ADG3070**	**ADG3090**
2	1.04	1.1	1.1	1.09	1.09	1.2	0.99	1.09	1.07
3	1.01	1.03	1.03	1.03	1.03	1.05	1.01	1.03	1.03
4	1	1.01	1	1	1.01	1	0.98	1	1
5	1	1	1	1	1	1	1	1	1
6	1	1.01	1.01	1.01	1.01	1.01	0.99	1.01	1
7	1.01	1.02	1.02	1.02	1.02	1.05	1	1.04	1.03
8	1.02	1.03	1.05	1.04	1.04	1.1	1	1.07	1.04
9	1.03	1.06	1.08	1.07	1.07	1.1	1.03	1.1	1.08
10	1.04	1.08	1.1	1.1	1.09	1.2	1.06	1.1	1.09

The average growth performances and their variation are illustrated in Table (5). These coefficients are of the multiplicative type and make it possible to eliminate the differences due to the sex-mode of the lambs and the age of dam. Lambs can be compared in a more objective way.

Table5. Average adjusted growth characteristics of Barbarine breed

Growth characteristic	Mean	Standard deviation
BWc (kg)	4.33	0.41
W10c (kg)	5.91	1.37
W30c (kg)	9.12	2.19
P70c (kg)	15.4	3.65
W90c (kg)	17.87	4.06
ADG030c (g/j)	147.44	64.31
ADG1030c (g/j)	169.64	62.52
ADG3070c (g/j)	146.51	48.31
ADG3090c (g/j)	147.97	47.24

3.4. Genetic parameters

The estimation of genetic parameters of growth traits by the REML method was carried out in two groups of herds. The first closes 670 lambs with 70 fathers and the second closes 634 lambs with 46 fathers. The variance components and estimated heritabilities are shown in Table (6).

Table 6. Estimation of the heritability of Barbarine breed traits

Variances	BW	W30	W70	W90	ADG030	ADG3070	ADG3090
Groupe 1							
σ^2_p	9027.1	58786.4	3011955.9	1133341.8	90.15208	55.26052	138.89296
σ^2_e	83650.5	2455145	532365.6	9948076.2	2482.7	1358.8	1046.7
σ^2_t	92677.6	2513931.4	7834321.5	11081418	2572.85208	1414.06052	1185.59296
h²	0.389	0.093	0.154	0.409	0.14	0.156	0.468
Groupe 2							
σ^2_p	4220.1	77281.8	445910	724399.4	91.88198	83.81894	146.41282
σ^2_e	94232.4	2745783.9	8033335	10813135	2848.5	1302.4	1172.3
σ^2_t	98452.5	2823065.7	8479245	11537534.4	2940.38198	1386.21894	1318.71282
h²	0.171	0.109	0.21	0.251	0.124	0.241	0.444

σ2p: paternal genetic variance, σ2e: residual variance, σ2t = σ2p + σ2e: total variance.

Heritability values range from 0.093 to 0.468. These results are similar to those obtained by Ben Hamouda (1985) and Ben Gara (2000), for W70 and W90 at group 2 level. The low heritability values for W30 and ADG0-30 could be a result of maternal effects. Phenotypic correlations between growth traits vary between 0.12 and 0.99 and are shown in the table (7). Phenotypic correlations were high between W30 and ADG0-30 and decreased between ADG0-30 and ADG30-90.

Table 7. Phenotypic correlations

Characters	BW	W30	W70	W90	ADG030	ADG3070	ADG3090
BW	1	0.96	0.82	0.75	0.92	0.3	0.25
W30		1	0.81	0.73	0.99	0.29	0.18
W70			1	0.94	0.78	0.67	0.59
P90				1	0.68	0.69	0.75
ADG030					1	0.24	0.12
ADG3070						1	0.85
ADG3090							1

4. Conclusion

Non-genetic factors such as sex-lambing mode and age of dam are real sources of variation even in low-input production systems. Adjustment for these variation factors is essential to optimize the selection of future breeding rams. The average weight and weight gains of Barbarine lambs are down from the sixties and seventies. There is an urgent need to re-examine the national registration program and the methods of selecting rams and replacements. All the phenotypic correlations between weights and weight gains at different ages are more or less high, with significant heritability for weight at 90 d of age and ADG 30-90, indicating that selection is possible for growth in low-input environments.

Acknowledge

The authors thank the Office of Livestock and Pasture for providing the data of this research.

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