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# Estimation of Genetic Growth Parameters of Lambs of Ouled Djellal Algerian Sheep Breed

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## ABSTRACT

**Background:** The sheep population in Algeria is composed of several breeds including the Ouled Djellal breed, numerically the most important in the national herd. The Ouled Djellal sheep breed suffers from a lack of genetic studies carried out on it. This is why its genetic capacities remain unknown. In this regard, the success of any selection program is based on knowledge of the estimation of genetic parameters and especially the parameters of growth.

**Methods:** The genetic parameters of growth of lambs of the Algerian breed Ouled Djellal were estimated for five variables: birth weight (BW), weight at 10 days (W10), weight at 30 days (W30), weight at 70 days (W70) and weaning weight (W90). The data base used in this study consists of 817 records of birth weight (BW), 817 records of weight at 10 days (W10), 805 records of weight at 1 month (W30), 803 records of weight at seventy days (W70) and 800 records of weight at ninety days (W90). The year, ewe age, month of birth (September, October, November), sex (male or female) and birth type (single or double) were tested as factors with fixed effects. The direct genetic effects and the permanent environmental effects of the ewe were considered as random factors.

**Result:** The use of the direct genetic effect model in this study gives heritability coefficients ($h^2_a$) of 0.17 (BW), 0.07 (W10), 0.07 (W30), 0.20 (W70) and 0.10 (W90). Thus, the values of the maternal heritability coefficient ($h^2_m$) vary around 0.20 (BW), 0.11 (W10), 0.04 (W30), 0.04 (W70) and 0.07 (W90).The heritability coefficients obtained were low overall, due to the influence of the environment and the non-normal mode expression of these variables.

**Key words:** Direct genetic effect, Environmental effect, Heritability coefficients, Maternal effect, Ouled djellal breed, Repeatability.

## INTRODUCTION

In Algeria, sheep farming (steppe and high plateaus) represents one of the oldest activities and is also a very important economic activity for the country. Among the existing sheep breeds, the Ouled Djellal breed is the most important and the typical sheep in Algerian steppe and the high plains region (Chellig, 1992; Boukerrou *et al*., 2024). Meat production in Algeria is mainly based on Ouled Djellal sheep because this sheep breed is primarily used for the production of red meat (Trouette, 1933; Sagne, 1950; Chellig, 1992; Dekhili, 2002; Mennani *et al*., 2011a).

Many authors agree to recognize it for a multitude of advantages: good maternal abilities, good reproductive qualities, good resistance to difficult conditions (drought and high temperatures), good utilization of coarse feeds of low nutritional value, good ability to walk long distances, absence of seasonal anoestrus with lambing throughout the year, with the possibility of adjusting meat production according to needs (Trouette, 1933; Cabbée, 1959; Dekhili, 2002; Dekhili and Aggoun, 2006; Mennani *et al*., 2011a). However, due to the absence of an improvement and selection program, the genetic potential of sheep in Algeria is still poorly understood, despite the fact that the genetic parameters of growth traits of several breeds raised in Africa have been estimated and reported in several scientific studies (Monkotan *et al*., 2021). From the results obtained, it has been difficult to make a judgment regarding the capacities of our breeds (the Algerian breeds), including the Ouled Djellal breed. In fact, the results obtained are mainly a reflection of the breeding management, which was visibly poor. Sheep in Algeria are raised extensively where there are strong constraints that affect sheep farming

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systems. In these conditions, the hardiness of the animals becomes a very important factor for the survival of the animals and their products and production (Kanoun *et al*., 2016). Therefore, the productivity of herds in uncontrolled conditions is the result of the joint action of environmental factors and the genetic potential of the animals. According to Bouix (1992), hardiness traits are expressed in adult animals more as the environment is difficult, since mothers per form two functions at once: production and protection of the young. To this end, it becomes imperative that maternal qualities be taken into consideration in any improvement and selection program of local breeds. The present study focused, firstly, on the growth of Ouled Djellal lambs to determine the different environmental components that influence production parameters. Secondly, the study also focused on the quality of the chosen analysis model on the estimation of the variance components of weights at standard ages.

## MATERIALS AND METHODS

The set of individual data of the animals used in this study comes from the Yahia Ben Aïchouche pilot farm located in the Southwest area of the wilaya of Bordj Bou Arreridj in Eastern Algeria (high plateaus area), this area is mainly characterized by the combination of cereal cultivation and sheep farming. Individual sheets for each animal were developed to record all events and information that occurred during the three years of follow-up (2009-2011). Each animal was identified by an identification tag placed at the level of its ear bearing a number. Light green ear tags were assigned to ewes, blue to rams and yellow to lambs. The total number of sheep studied is 319 ewes, 25 rams and 817 lambs of the local Ouled Djellal breed. The database used in this study consists of 817 records of birth weight (BW), 817 records of weight at 10 days (W10), 805 records of weight at 1 month (W30), 803 records of weight at seventy days (W70) and 800 records of weight at ninety days (W90).

### Feeding management

The basic diet of the animals on this farm throughout the year is essentially provided by oat hay, wheat straw, chopped straw and pasture grass if needed. During the autumn and spring seasons, the herds receive green barley and graze, for short periods, on alfalfa meadows. In summer, the sheep graze on barley and wheat stubble and receive oat hay and straw. In winter, the sheep receive a supplement of barley grain and oat hay or chopped straw. This feeding mode is generally practiced throughout the cereal-livestock region of the high plateaus of Eastern Algeria and is considered a semi-intensive management mode with grazing during the day, on uncultivated fallow during autumn and spring, on wheat and barley stubble in summer and on green barley during winter. Flushing was applied one month before mating, that is, in the month of March. During this month, a distribution of barley grain was practiced at a rate of 200 g/day per ewe and per ram, followed by spring regrowth, which thus constitutes a natural flushing for the animals. This practice of flushing aims to improve the body condition of ewes and also to improve their reproductive performance by increasing the ovulation rate and reducing early embryonic mortality (Paquay, 2004).

### Management of reproduction and lambing

Mating was of a controlled type in batches, at a rate of one ram for twelve or thirteen ewes. The assignment of animals was done randomly. Mating took place each year in the months of April-May: As a result, the majority of lambing occurs in September. All events concerning lambing were recorded within twelve hours following lambing in a register (date of birth, number, sex, birth weight, mortality and causes, lamb pedigree …). After lambing, the lambs and their mother are separated from the rest of the herd in prepared boxes to facilitate their monitoring and stay with their mother for duration of two to three days and then they follow their mother to pasture until weaning at 90 days of age. Disinfection of the umbilical cord and administration of medication against septicemias take place quickly right after parturition. After this period, the lambs follow their mother (in the sheepfold and at pasture) until weaning (at 90 days of age). Lambs that were sick or abandoned by their mother (primiparous ewes) were artificially fed with powdered milk. Moreover, their number is low so they are not taken into account. Ewes were culled from the age of seven years, while the rams were renewed every two years. No selection method was used on the farm.

### Variables analyzed, factors tested and method of analysis

The growth traits available in the data base were weights at standard ages: Birth weight (BW), weight at 10 days (W10), weight at 1 month (W30), weight at seventy days (W70) and weight at ninety days (W90). The average daily gains (ADG) are derived from the weights at standard ages recorded: ADG between 10 days and 30 days, ADG between 30 days and 70 days, ADG between 70 days and 90 days and ADG between 30 days and 90 days. Weaning of lambs was systematically practiced at 90 days of age. Lambs are weighed at birth and then on fixed dates for the entire flock,

**Table 1:** Main effetcs of variation of weight of Ouled Djellal breed for three years.

| Factors | BW | W10 | W30 | W70 | W90 |
|---|---|---|---|---|---|
| Month of mating | *** | NS | NS | NS | *** |
| Sex | *** | NS | NS | NS | *** |
| Mode of birth | *** | *** | *** | *** | *** |

NS: Not significant; ***: p<0.001; BW: Birth weight; W10: Weight at 10 days; W30: Weight at 30 days; W70: Weight at 70 days; W90: Weight at 90 days (weaning).

until the age of 3 months, at the same hour, generally on an empty stomach.

The significance of several factors with a fixed effect by the least squares method was tested using the IBM SPSS Statistics software (IBM group 2020 Version 27). The factors tested are the following: the year (2009 to 2011), the age of the ewe (1 to 7 years), the month of mating (April-May), the sex (male-female) and the mode of birth (Single-Twin). No significant factors were not considered in the final model (Table 1).

The second factors with random effects include the direct effect of the ewe and the effect of the permanent environment of the ewe for all variables. The estimation of genetic parameters was carried out according to the animal model using the method of estimating variance components by restricted maximum likelihood (REML) using the MTDFREML software written by Boldman *et al*. (1995). Each variable was analyzed separately to obtain estimates of heritabilities and repeatabilities. The present model used, based on the direct effect and the permanent environment of the ewe, was strongly suggested by Cleot *et al*., 2004; Ekiz *et al*., 2005; Mokhtari *et al*., 2010.

## RESULTS AND DISCUSSION

### Variation factors

According to the results of the variance analysis (Table 1), only the mode of birth was highly significant (p<0.001) for all the analyzed variables which are the weights at typical ages: birth weight (BW), weight at 10 days (W10), weight at 1 month (W30), weight at seventy days (W70) and weight at ninety days (W90). Our results supporting the effect of mode of birth on the different weights of lambs during the phase from birth to weaning (90 days) are similar to those found by Gbangboche (2005) and Mennani *et al*. (2011b) who reported that the mode of birth strongly influences the weights and thus the growth of lambs as well as the weaning rate with a superiority of single-born lambs.

On the other hand, the month of mating and the sex of the lamb were highly significant for only two variables which are: BW (birth weight) and W90 (weight at 90 days).

The results found in our study concerning the effect of month of mating and sex of lamb on the weights of lambs at different ages are identical to the results found by Dekhili (2003); Dekhili and Mahnane (2004); Chikhi and Boujenane (2004); Kerfal *et al*. (2005); Gbangboche (2005), who found that sex had a very significant influence (P<0.0001) on the weights of lambs at different ages with a superiority of males compared to females for Algerian, Moroccan and West African sheep breeds.

The year and age of ewe were both non-significant (p>0.05) and were ignored from the model. The overall averages of lamb growth during the three years, although non-significant, are shown in Table 2 and Fig 1.

According to the results in Table 3, there is agreement between the variance analysis and the results obtained. We find that the month of mating, sex and mode of birth

**Table 2:** Global averages of the weights of Ouled Djellal breed lambs during 3 study years.

| Variables | Effectif | Means±S.D(Kg) |
|---|---|---|
| BW | 817 | 3.9±0.85 |
| W10 | 817 | 5.4±1.30 |
| W30 | 805 | 7.9±2.40 |
| W70 | 803 | 12.3±3.90 |
| W90 | 800 | 16.5±3.60 |
| ADG1 | - | 188.0±58.6 |
| ADG2 | - | 152.7±50.10 |
| ADG3 | - | 114.9±51.10 |

ADG1: Average daily gain between birth and 30 days; ADG 2: Average daily gain between 30 days and 70 days; ADG 3: Average daily gain between 30 days and 90 days. The average daily gains (ADG) are expressed in grams (g); SD: Standard deviation; BW: Birth weight; W10: Weight at 10 days; W30: Weight at 30 days; W70: Weight at 70 days; W90: Weight at 90 days (weaning).

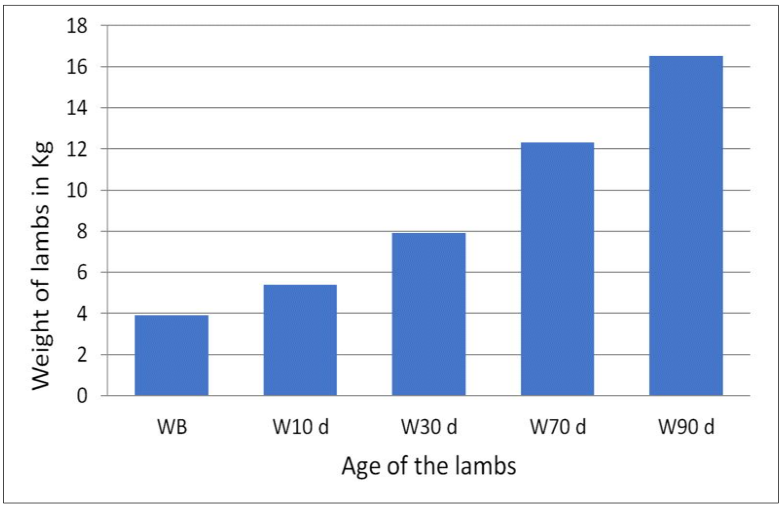


**Fig 1:** Relationship between the age of the lambs and their weight.

have the most important influence on the growth of lambs from birth to weaning. Indeed, the decomposition of the growth variance of lambs (Table 1) revealed that growth performances are dependent on environmental conditions. This result highlights the action of climatic and nutritional changes or the environment in general which are not controllable and in the same context, Mallick *et al.* (2016), confirms in their study that seasons are considered as one of the main environmental factors affecting the growth performance of sheep, as weather conditions and feed availability vary considerably depending on the seasons. The second effect, which is the mode of birth, has two levels. Single-born lambs have superior growth performances compared to twin-born lambs from birth to weaning (Table 3). The growth obtained by the single birth group is higher than that of double births. Indeed, the results show that the mode of birth of lambs has a very important effect on weight at different ages. With a high weight at birth that is maintained up to 90 days. Probably due to the absence of competition from birth. For the other effects, sex and month of birth, we observe that there is a superiority of males over females, an advantage that is widely recognized, at birth and at 90 days. As for the month of birth effect, births in September are high at birth and at weaning (Table 3).

**Results of the animal model**

Using this model with a direct genetic effect, the heritability coefficients recorded in the present study are around 0.17±0.02 (BW), 0.07±0.01 (W10), 0.20±0.02 (W30), 0.20±0.02 (W70) and 0.10±0.02 (W90) (Table 4). For this “direct genetic effect” model, it should be noted that the maternal and environmental genetic effect is not taken into account. The heritability values observed in our study are relatively comparable to those obtained by Mokhtari *et al*. (2010) in the literature, but for different breeds (sheep breeds raised in North Africa) and somewhat different environments. They found that heritability values for birth weight vary between 0.02 and 0.43; these birth weight heritability values concern eight sheep breeds raised in North Africa as well as those from the product obtained from the cross between the D’man breed and the Timahdite breed (El Fadili *et al*., 2000). According to Chalh *et al*. (2007), the Tunisian Black Thibar breed is characterized by heritability values for weight at 10 days of age and at 30 days higher than those found in our study; their values vary between 0.3±0.08 (W10), 0.23±0.08 (W30) and 0.28±0.09 (W70). This may be explained by the inclusion of the maternal genetic effect in the different models for estimating genetic parameters, which has a very important effect on the estimated value of direct heritability (Mohammadi *et al*., 2010; Boujenane *et al*., 2015). In another study on the Egyptian Rahmani sheep breed, (Radwan *et al*., 2018) used 6 different models and found values of the heritability coefficient that vary between 0.25 and 0.41 for birth weight.

According to the second model, the results in Table 5 shows that the values of the direct heritability coefficient ($h^2a$) in this study are around 0.08±0.01 (BW), 0.03±0.01 (W10), 0.02±0.01 (W30), 0.01±0.01 (W70) and 0.01±0.01 (W90). Thus, the values of the maternal heritability coefficient ($h^2m$) vary around 0.20±0.03 (BW), 0.11±0.03 (W10), 0.04±0.02 (W30), 0.04±0.02 (W70) and 0.07±0.02 (W90). The repeatability coefficient (r) values also vary from 0.2±0.02 (BW), 0.07±0.02 (W10), 0.04±0.01 (W30), 0.01±0.01 (W70) and 0.01±0.01 (W90). Regarding the genetic correlation between direct and maternal effects, the coefficient of this correlation r (a,m) was high and positive for all weights and varies between 0.54 and 0.99, except for W30 where it was negative (r = -0.87±0.06). From these results, it appears that the action of maternal effects on the growth of lambs before weaning, measured by $h^2m$,

**Table 3:** Least mean squares for the analyzed traits during three years in kg.

| | variables | BW | W10 | W30 | W70 | W90 | ADG1 | ADG 2 | ADG 3 |
|---|---|---|---|---|---|---|---|---|---|
| Mode of birth | Single | 3.4 | 5.9 | 8.8 | 13.6 | 17.9 | 162.2 | 119.9 | 157.1 |
| | Twin | 3.6 | 4.5 | 7.1 | 11.1 | 15.2 | 137.8 | 103.8 | 146.4 |
| Sex | Male | 4.1 | 5.5 | 7.9 | 12.4 | 17.2 | 149.4 | 112.0 | 161.3 |
| | female | 3.8 | 5.4 | 8.0 | 12.3 | 15.9 | 150.6 | 111.7 | 142.2 |
| Month of birth | Sept. | 4.0 | 5.7 | 8.7 | 13.6 | 18.4 | 156.7 | 122.5 | 161.7 |
| | Oct. | 4.2 | 5.6 | 7.9 | 13.5 | 16.1 | 123.3 | 140 | 136.7 |
| | Nov. | 3.7 | 5.0 | 6.8 | 10.0 | 15.2 | 103.3 | 80 | 140 |

**Table 4:** Estimation of hıritability for the analyzed traits using animal model (the weights of the lambs from birth BW until weaning at 90 days W90).

| Variance | BW | W10 | W30 | W70 | W90 |
|---|---|---|---|---|---|
| $\sigma^2_a$ | 0.13±0.02 | 0.14±0.02 | 0.34±0.07 | 3.4±0.65 | 1.33±0.08 |
| $\sigma^2_e$ | 0.62±0.04 | 1.83±0.08 | 4.86±1.12 | 13.6±3.97 | 11.87±2.06 |
| $\sigma^2_p$ | 0.75±0.09 | 1.97±0.09 | 5.2±0.92 | 16.9±3.54 | 13.21±2.76 |
| $h^2$ | 0.17±0.02 | 0.07±0.01 | 0.20±0.02 | 0.20±0.02 | 0.10±0.02 |

$\sigma^2_a$: Direct genetic variance; $\sigma^2_e$: Residual variance; $\sigma^2_p$: Phenotypic variance; $h^2$: Direct heritability; BW: Birth weight; W10: Weight at 10 days; W30: Weight at 30 days; W70: Weight at 70 days; W90: Weight at 90 days (weaning).

**Table 5:** Estimation of variance components and genetic parameters for the analysed traits (the weights of the lambs from birth BW until weaning at 90 days W90).

| Parameters | BW | W10 | W30 | W70 | W90 |
|---|---|---|---|---|---|
| $\sigma^2_a$ | 0.034±0.01 | 0.01±0.01 | 0.10±0.03 | 0.10±0.02 | 0.17±0.02 |
| $\sigma^2_m$ | 0.084±0.01 | 0.09±0.02 | 0.175± 0.02 | 0.375±0.08 | 0.98±0.08 |
| $\sigma^2_e$ | 0.22±0.02 | 0.64±0.04 | 3.97±0.84 | 9.83±2.32 | 12.46±3.52 |
| $\sigma^2_p$ | 0.42±0.04 | 0.82±0.07 | 4.19±0.95 | 10.51±2.76 | 13.83± 3.67 |
| $\sigma^2_{pe}$ | 0.05±0.03 | 0.05±0.01 | 0.07±0.01 | 0.001±0 | 0.0007±0 |
| $h^2_a$ | 0.08±0.01 | 0.03±0.01 | 0.02±0.01 | 0.01±0.01 | 0.01±0.01 |
| $h^2_m$ | 0.20±0.03 | 0.11±0.03 | 0.04±0.02 | 0.04±0.02 | 0.07±0.02 |
| r | 0.2±0.02 | 0.07±0.02 | 0.04±0.01 | 0.01±0.01 | 0.01±0.01 |
| r (a, m) | 0.76±0.05 | 0.99±0.08 | -0.87±0.06 | 0.99±0.08 | 0.54±0.04 |
| $c^2$ | 0.12±0.01 | 0.06±0.01 | 0.02±0.01 | 0.00±0.00 | 0.00005±0.00 |
| $e^2$ | 0.51±0.04 | 0.79±0.05 | 0.95±0.07 | 0.94±0.07 | 0.90±0.07 |

BW: birth weight; W10: weight at 10 days; W30: weight at 30 days; W70: weight at 70 days; W90: weight at 90 days (weaning); $\sigma^2_a$: Additive genetic variance; $\sigma^2_m$: Maternal genetic variance; $\sigma^2_e$: Residual variance; $\sigma^2_p$: Phenotypic variance; $\sigma^2_{pe}$: Permanent environnemental variance; $h^2_a$: direct heritability; $h^2_m$: maternal heritability; r: Repeatability=( $\sigma^2_a$ + $^2_{pe}$) / $\sigma^2_p$; r (a,m): Genetic correlation between direct and maternal effects; $c^2 = \sigma^2_{pe}/\sigma^2_p$: Proportion of permanent environmental variance to phenotypic variance; $e^2 = \sigma^2_e/\sigma^2_p$: Proportion of residual variance to phenotypic variance.

is more important than that of direct effects h²a across all ages. Thus, the potential of the lamb is poorl expressed despite early supplementation. However, although the values of maternal heritability (h²m) appear to be higher than those of direct heritabilities (h²a), they never the less remain low in absolute terms (Table 5). Several authors have found values close to ours, citing the results found by Boujenane *et al*. (2015), who found estimates of direct heritability of 0.05±0.02; 0.03±0.02 and 0.08±0.03 for BW, W30 and W90, respectively. Maternal effects significantly influenced growth performance; hence maternal heritability for BW, W30 and W90 was 0.10±0.02; 0.07±0.03 and 0.07±0.03, respectively. These differences in heritability values for the same trait are also bserved when several analys is models were used with or without the inclusion of the maternal effect and/or the permanent environmental effect due to the mother (Boujenane and Diallo, 2016; Mohammadi *et al*., 2010). These h²m values originate from high phenotypic variability ( $\sigma^2_p$), especially at the residual level ( $\sigma^2_e$). These results raise several questions regarding the model for studying performance in the highlands environment. Moreover, in their estimation of genetic parameters, Boujenane *et al*. (2015) also take into account the temporary environmental influence related to the mother. Furthermore, it is the only study that has incorporated this constant factor in various valuation models. In the present case and with a capricious environment playing a very large role in the expression of genetic growth potentialities of lambs. It appears essential according to the results obtained to consider in the animal model all the genetic effects that can intervene in the determinism of the studied variables. To this is added the number of years to consider as well as the number of sites to test. The choice of the analysis model is decisive for a good estimation of genetic parameters because these are the most important source of information in animal selection. They allow estimating the expected genetic progress by using an appropriate selection method.

## CONCLUSION

The low estimates of heritability and repeatability obtained in the present study for the individual growth performance of lambs of the Algerian Ouled Djellal breed, which has never been the subject of a real selection program, indicate that selection based on these individual parameters of lambs may lead to slow genetic improvement despite the observation of great variability in zootechnical performance and especially the weights of lambs and their growth. Therefore, selection for individual growth performance of lambs in the future should be based on individuals with correlated traits that have a high and positive genetic correlation with other traits of high heritability. In future studies, traits that could be used as selection criteria to indirectly improve growth traits should be studied to lead to genetic improvement of individual growth performance of lambs of the Algerian Ouled Djellal breed, in this context adding weight estimates at typical ages of 6 months, 9 months and 12 months and estimating their genetic parameters. Thus, it is necessary to consider that maternal effects on lamb weights are not negligible and must also be taken into account in any selection program undertaken for this breed.

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### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

### Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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