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Assessment of genetic and environmental effects on growth traits of Tunisian local goat kids population

A.Atoui, S. Tlahig, M. Abdennebiand S. Najari

Abstract—The study aims to investigate some environmental factors as potential variation source upon three growth traits of Tunisian local goat kids bred under rangelands' irregular arid conditions. Data were collected on a local goat herd from 1998 through 2014. Means ± SE were 9.44±0.96 kg, 11.67±0.13 kg and 14.07±0.16 kg for kids' weight adjusted respectively to 90, 120 and 180 days of age. Statistical analysis was performed using ANOVA procedure. The model included the effects of year and season of birth, sex, type of birth and age of dam at kidding, and two-way interactions between these factors on the assessed traits. Growth traits seem to be affected ($p<0.01$ or 0.05) by the factors related to the restrictions and the irregularities of the technical and natural environment of pastoral husbandry, which illustrates the local population genetic response towards environmental resources in arid zone. The interaction between year and season of birth and between type of birth and sex of kids have a significant effect ($p<0.01$) on all studied traits. A significant interaction ($p<0.05$) between year and type of birth existed for weight adjusted to 90 days of age. The interactive nature of ambient factors allows better correction of non-genetic effects and prevents genotypic evaluation bias. Also, the herd management needs to be flexible to face any harsh climate and feed scarcity situation to maintain a productive and profitable goat production system with local goat population.

Index terms: Environmental factors, genetic evaluation, goat population, growth, interaction

1 Introduction

LOCAL goats comprise one of the most important domestic livestock species in Tunisia and play an important role in the livelihood of a large proportion of small and marginal farmers and landless labors [7]. Since, the goat provides a good source of meat, milk, fiber and skin. The diversity in various production traits of this breed suggests that there is a great scope for improvement of performance traits. This variability could be due to several genetic and environmental influences.

Breeding programs are based on the exploitation of genetic variation. Variation in production and reproduction traits can be skillfully exploited; if the extent of genetic and environmental sources of variation in these traits is accurately known and controlled. The observed performance of each animal for each trait, or the phenotype, is the result of the heredity that it receives from both parents and the environment in which it is raised. Performance records of animals should be adjusted to reduce or eliminate known environmental factors affecting performance so that genetic differences among animals can be recognized and used for effective breeding scheme. Modeling ambient factors, to predict the animal genetic value, must reflect the true nature of the environmental effects upon animal phenotype. Especially under harsh irregular conditions, the consideration of the non-genetic variation sources as independent fixed factors elapse their effective action, and can produce a genetic evaluation bias with major error of prediction.

The meat production remains the main objective of the goat breeding in the Tunisian arid zone; kids were traditionally slaughtered after 3 months of age. Thus, the weights of kids can be considered as an important quantitative phenotype to characterize local caprine population and to perform the appropriate genetic and economic improvement plans. The current study pretends to identify the impact of known environmental factors

- *Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
- *Co-Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com*
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on three performances traits of local goat population bred under restrictive and irregular arid breeding conditions: weight adjusted to 90, 120 days and 180 days of age.

2 MATERIALS AND METHODS

Study area: data were collected from arid regions of Tunisia as ecologically defined by a mediterrannean arid climate[4], hard and precarious [11]with an annual precipitation average of 200mm presenting a large spatial and seasonal variation.

Description of the animal material : The local goat population constitutes an animal group adapted to the arid rangelands harsh conditions [7]. The local goat population shows a large variability both in morphology and growth performances [5]. Characteristics of the population include the small body size with an average height of 76 cm for the male and 60 cm for the female [10] and the ability to walk along distances. Fertility rate was about 87% and prolificacy rate was about 110-130% [7]. Kidding season begins in October and continues till February, with a concentration during December and January.

Data collection: Data were assessed during sixteen years, from a periodical weighing plan of 946 local kids (progenies of 22 sires and 285 dams) bred under arid land conditions in the southern Tunisia. Since the beginning of the kidding perioduntil 180 days of age, kids were weighed once every two or three weeks. Each kid records included goat mother and kid identification, birth date, sex, birth mode and kid's weights measured with corresponding assessment dates. Individual kid's weight at standard ages was estimated by inter- or intra-population.

Statistical Analysis: ANOVA analysis was applied to estimate the effect of year of birth, season of birth, sex of kids, type of birth, age of dam at kidding, and two way interactions between these factors on three performances traits: weight adjusted to 90 days of age, weight adjusted to 120 days of age and weight adjusted to 180 days of age. Means comparison test (SNK, α=5%) was performed to test the homogeneity within the intra factors' classes. The mathematical model used to analyze the studied traits was as follows:

$$Y_{ijklm}= \mu + yob_i+ sob_j+ sex_k+ tob_l+ dalc_m+ (yob\times sob)_{ij}+(yob\times sex)_{ik}+ (yob\times tob)_{il}+ (sob\times sex)_{jk}+(sob\times tob)_{jl}+(sex\times tob)_{kl} + e_{ijklm}$$

Where:

Y_{ijklmn}= observation on a trait

μ = population mean

yob_i = year of birth(i=1998_2014),

sob_j = season of birth(j= season1: November--January; season2: February --April)

sex_k= sex of kids (k=1,2: male or female)

tob_l= type of birth(l=1,2; single or multiple)

dalcm= age of dam at kidding (m=1,….,8)

$(yob\times sob)_{ij}$= interaction between year and season of birth

$(yob\times sex)_{ik}$= interaction between year of birth and sex of kids

$(yob\times tob)_{il}$ = interaction between year of birth and type of birth

$(Sob\times sex)_{jk}$ =interaction between season of birth and sex of kids

$(Sob\times tob)_{jl}$= interaction between season and type of birth

$(Sex\times tob)_{kl}$ = interaction between sex of kids and type of birth

$e_{ijklmnp}$ = model random residual.

RESULTS AND DISCUSSION

For the three studied traits, the parameters means ± SE, standard deviations, minimums and maximums, are shown in table1. Till 5 months age, the local kid's weights remains below 15kg and reaches 17.35kg as a maximum weights. Such reduced weight at different age reflects the ability of this population to survive with limited meat performance of the local population, as well as it is known for all caprine breeds of the desert and arid areas. Such limited performance allows reducing animal needs. Thus, it is considered as an adaptive character to hard environmental conditions in arid regions [9]. Moreover, table 1 shows a limited individual variation of all the studied phenotypes as illustrated by the reduced values of SE; it seems that harsh conditions elapses individual differences and, by the way, unable the complete genotypic expression [6].

Table 2 gathers the results of ANOVA test of significance. The estimated coefficient of determination ranges between 0.62 and 0.63. Similar values is considered acceptable for such direct

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studies realized on herds, but this illustrate that the model of variance analysis is unable to consider all non-genetic factors affecting the kid's studied phenotypes [9].

Weight adjusted to 90 days of age

The analysis of variance indicated a significant effect of the year of birth ($p<0.01$), the season of birth ($p<0.01$), the age of dam at kidding ($p<0.05$) and the type of birth ($p<0.01$) on weight adjusted to 90 days of age of local kids.

However, the effect of the kid's sex was no significant on this trait (Table2). [1] reported that season of birth had non-significant effect on weaning weight, while the effect of year of birth, sex, type of birth was significant ($p<0.01$) in Beetal goat breed in Pakistan. The difference in weight at 90 days of age during different years is indicative of change in weather which characterizes the Mediterranean and arid environment. Climate and environmental changes affect the quality and quantity of pasture forages, which also affects the provision of food and other animal needs. Differences in nutrition, management and hygiene in the various years, are some reasons for the effect of birth year on body weight in different ages [13].

The interaction between sex and type of birth had a significant effect on weight adjusted to 90 days of age ($p<0.01$). Male kids born as singles were heavier at 90 days of age as compared to the others, which is quite normal as twins and triplets get lesser chances to suckle and hence lesser quantity of milk, necessary for growth. This trend continued in the same way at four and six months of age. Least squares means for the interaction between type of birth and sex of kids are shown in table3. A significant interaction was found here between year and season of birth ($p<0.05$). This suggested that season effects were changed across years.

Table1 Statistical parameters of the local kid's weights at standardized ages.

Weight (Kg) adjusted to	No.	Mean ± SE	SD	Minimum	Maximum
90 days of age	946	9.44±0.96	2.96	4.34± 0.88	11.12 ±0.23
120 days of age	946	11.67±0.136	3.89	6.03± 0.66	13.33± 0.77
180 days of age	946	14.07±0.16	4.27	7.01± 0.35	17.35 ±0.53

SE = Standard error; SD = Standard Deviation.

Table2 Test of significance probability of environmental factors and interactions on standardized growth traits of local kids.

Sources of variation	DF	90 days	120 days	180 days
Year of birth (yob)	15	**	**	**
Season of birth (sob)	1	**	**	**
Sex of kids (sex)	1	ns	**	*
Type of birth (tob)	1	**	**	**
Dam age at kidding (dalc)	7	*	*	ns
yob*sob	15	**	**	**
yob*sex	15	ns	**	*
yob*tob	17	**	**	**
sob*sex	1	ns	ns	ns
sex*tob	2	**	**	**
Sex*dalc	7	ns	ns	ns
R^2		0.631	0.628	0.625

DF= degrees of freedom; * = Significant (p<0.05); ** = Significant (p<0.01); ns = non significant; R^2= Model determination coefficient.

Table3 Least squares means by sex-type of birth subclass for growth traits.

Interaction	weight adjusted to 90 days	weight adjusted to 120 days	weight adjusted to 180 days
Male* Singles	11.21 ± 0.14^a	13.76 ± 0.19^a	16.48 ± 0.24^a
Male*Multiples	8.28 ± 0.18^b	10.34 ± 0.25^b	12.93 ± 0.31^b
Female*Singles	9.54 ± 0.18^a	11.57 ± 0.24^a	13.32 ± 0.30^a
Female*Multiples	7.70 ± 0.18^b	9.70 ± 0.25^b	11.80 ± 0.33^b

^{a,b}, Means with different superscripts within a column are significant (p<0.01).

Similarly, the significant interaction between year of birth and type of birth of kids estimated here depicted different effects by different combinations of type of birth and years (p<0.01). The changes in value of least squares means over the years for the interactions years – seasons and years – type of birth are shown in figure 1 and figure 2 for weight adjusted to 90 days of age.

Weight adjusted to 120 days of age

The analysis of variance revealed a highly significant effect of year (p<0.01), season of birth (p<0.01), sex (p<0.05) and type of birth (p<0.01) on weight adjusted to 120 days of age. Thus the effect of age of dam at kidding were significant (p<0.05). The findings of present study were in agreement with the findings of [14] and [13]. [1] reported that season of birth had a non-significant effect on weight at four months, however effect of year of birth, sex, type of birth was significant (p<0.01) in Beetal goat breed in Pakistan.

The difference in weight during different seasons is indicative of change in pastoral resources from one month to another [15]. The lowest kid's weights are those born in season2 which corresponding to the end of birth season (9.81±3.58Kg). Those kids are unable to realize heavy weight in spite for their genetic potentialities which can't express under hot conditions and heat stress. Thus, the majority of births were during the winter season (December-January) which is considered as an adaptation aspect of the local population to agree the period of maximal nutrition needs of kid's growth with the favorable season [9].

A significant interaction between year and season of birth (p<0.01) was found here, suggesting that season effects differed across years. The study also revealed a significant interaction between year of birth and sex of kids for this trait (p<0.01). This reflected that these two factors were not independent and that different estimates of sex effects were obtained during the years of the study.

Figure 3 shows a graphical representation of fluctuations in least squares means for weight adjusted to 120 days of age across years for the seasons 1 and 2. Similarly, figure 4 shows changes in least squares means for male and female kids from 1998to 2014. The interaction between sex and type of birth had a significant effect (p<0.01) (Table3). Least squares means for the interaction between type of birth and sex of kids ranged from 10.34 ± 0.25 kg (males born as multiples) to 13.76 ± 0.19kg (males born as singles).

Weight adjusted to 180 days of age

The significance levels of environmental factors and two-way interactions forweight adjusted to 180 days of age have been depicted in table2. Year of birth (p<0.01), season of birth (p<0.05) and type of birth (p<0.01), sex of kids (p<0.05) as well as the interactions between year and season of birth (p<0.01), year of birth and sex (p<0.05) and type of birth and sex (p<0.05) were found to be the important sources of variation for this trait.

The results were in agreement with the findings of [12] who reported a significant effect of year of birth, sex and type of birth on weight at six months in Markhoz goat breeds. The age and weight of the dam had a non-significant effect on studied trait, which were supported by the findings of [2]. The analysis of variance revealed that male kids were heavier at six months of age (15.15±0.52kg) as compared to the females (12.61±0.66Kg). Differences in sexual chromosomes, probably in the position of genes related to growth, physiological characteristics, difference in endocrinal system lead to difference in animal growth. In relation to endocrinal system, estrogen hormone has a limited effect on the growth of long bones in females. That could be one of the reason in which females have smaller body and lighter weight against males [12].

The effect of weight adjusted to 90 days of age taken as co-variables was also significant on weight at six months. In present study, the kids having weight at 3 months ranging from 11 to 12kg, were heavier in weight at six months (15.44±0.64), while kids having weight ranging from 7 to 8kg were lighter in weight (12.07±0.02 kg) at six months of age, which clearly shows that kids having more weight at weaning are naturally growing quickly and gaining more weight as compared to those who are lighter in weight at 90 days of age. The trait seems to be under stronger influence of environment as has been the case with other growth traits, which suggests that by improving the management of assessed factors, better results can be achieved.

The significant interaction between year and season of birth (p<0.01) pointed that season effects varied across years for this trait. The fluctuation in least squares means by year and season of birth combinations is shown in figure 5. Similarly, the significant interaction between year of birth and sex of kids indicated that the combined effect of these factors were more important than their individual effects on this trait. The fluctuation in least squares means by year-sex combinations for years 1986 to 1999 is illustrated in figure 6.

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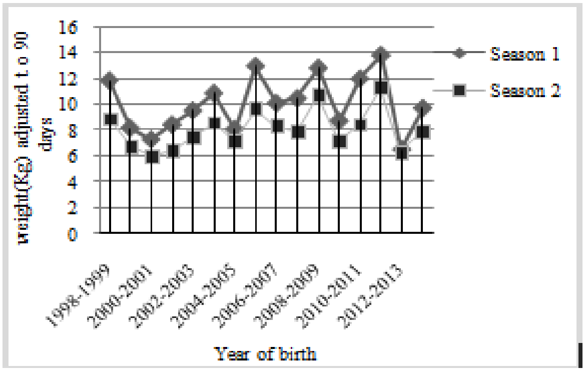

Figure1 Least squares means by year-season subclass for weight (kg) adjusted to 90 days of age.

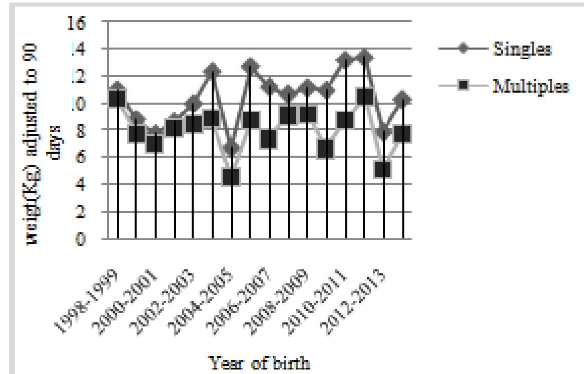

Figure2 Least squares means by year-type of birth subclass for weight adjusted to 90 days of age.

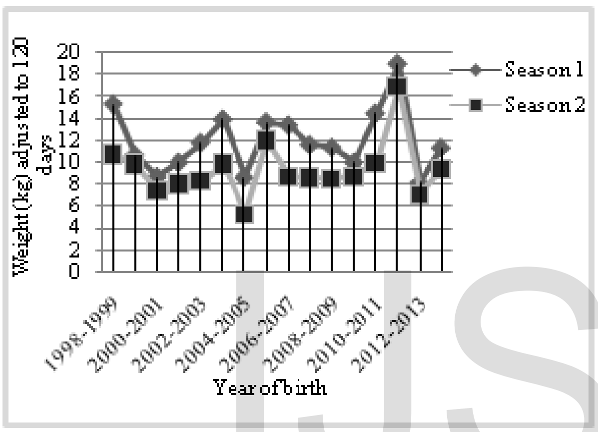

Figure3Least squares means by year-season subclass for weight (kg) adjusted to 120 days of age.

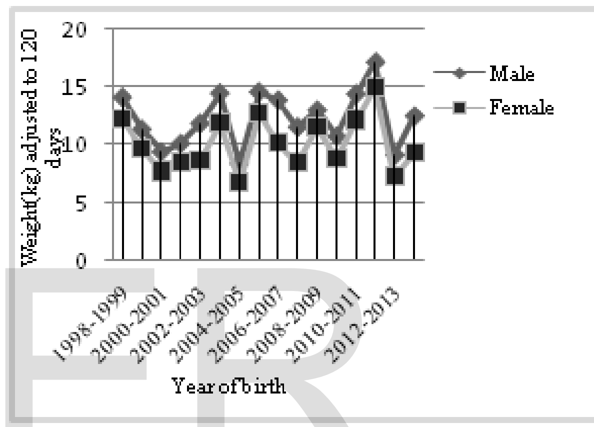

Figure4 Least squares means by year-sex subclass for weight adjusted to 120 days of age.

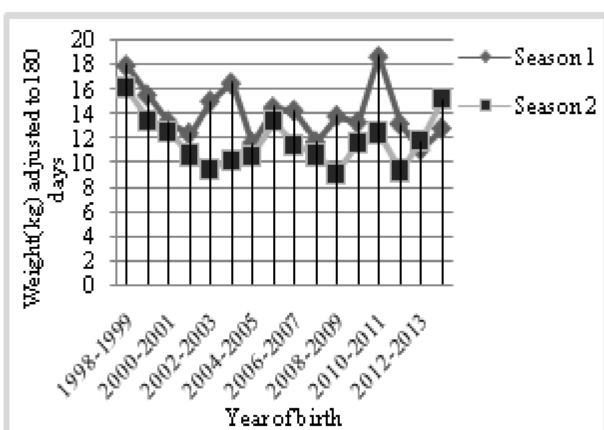

Figure5Least squares means by year-season subclass for weight adjusted to 180 days of age.

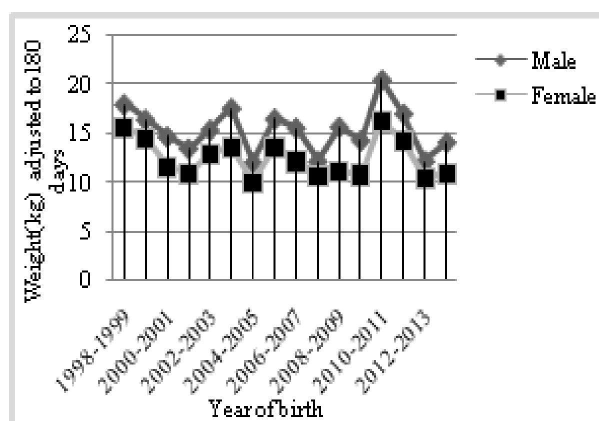

Figure6 Least squares means by year-sex subclass for weight adjusted to 180 days of age.

CONCLUSION

The growth performances of Tunisian local kids with respect to environmental factors, illustrates the adaptation of the local population towards natural and technical conditions. The performances averages and their variation sources illustrate mainly the adaptive and productive aptitude of the local goat population, raised under harsh and irregular arid environment. The environmental factors affect significantly the kid's meat production after 3 months of age, especially the factors year and season of birth.

The environmental factors affects kid's weights directly or through combined action illustrated by the interaction impacts importance revealed upon all studied performances traits. It seems that the environment factors effects no have the same impacts on all animals groups. So, modeling animal performances under arid conditions needs a deep review to optimize the phenotype decomposition in the aims to correct genetics values. Non genetic factors, and their levels, consideration as fixed factors no reflect their real nature as it is observed on phenotypes. An unbiased genetic evaluation of local population under arid conditions needs some appropriate models to perform the adequate genetics values prediction as a step to the genetic improvement.

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