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Impact of Environmental Factors on Average Daily Gains of Local kids Population under Pastoral Mode in Tunisian Arid Region

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Abstract – The present study was carried out to study the effects of environmental factors on average daily gains (ADG) of Tunisian local kids population (ADG1 from birth to 30 days, ADG2 from 30 to 60 days, ADG3 from 60 to 90 days, ADG4 from 90 to 120 days and ADG5 from 120 to 150 days). The data comprised 13.095 records belonging to 945 local kids (progenies of 22 sires and 285dams) born between 1998 and 2014. A GLM procedure was applied to decompose the total variance of the kids' traits. A mean comparison test (SNK, α=0.05) was applied to identify homogenous class by factors. Results showed that the GLM determination coefficient R^2 remains lower than 87% for all studied traits due to the observed data structure. All traits seems affected by the significant effects ($P<0.01$ or 0.05) of all factors related to the restrictions and the irregularity of the technical and natural environment of pastoral husbandry. The non-genetic factors impact increases with kid's age and requirements. The interaction between year and month of birth and between type of birth and sex of kids have a significant effect ($P<0.01$) on all studied traits. The interaction between year of birth and age of dam at kidding have only a significant effect ($P<0.05$) on ADG1.The findings of this study revealed that improvement in growth traits is possible by minimizing the effect of environmental sources.

Keywords: Environmental factors, improvement, goat population, average daily gain, interaction

1. Introduction

Actually, more than 60% of the national caprine herd estimated to 1 500 000 goats were raised in the Tunisian arid area (FAO, 2016). Since centuries, the pastoral breeding mode allows to valorize the rangelands resources by ambulant small ruminant herds under harsh conditions. In southern Tunisia, kids' meat represents about 75% of the local meat production (Najari, 2005). Further, the demand for meat from kids is increasing because of its nutritional quality.

Therefore, body weight and average daily gains are also economically important in breeding objectives that need particular attention in order to improve meat production of the local goat population. Genetic improvement programs are based on exploitation of genetic variation, identification of superior animals for specific traits or trait combinations, and widespread utilization of these animals in a population. However, the productive and reproductive traits are also influenced by environmental factors that need to be precisely accounted for in order to estimate genetic parameters and to predict genetic values accurately. Among environmental factors, climate and seasonal differences from year to year influence the production of entire flocks, while sex, type of birth, parity, age and weight of dam effect the performance of individuals. It is necessary to precisely estimate the magnitude of these factors so that genetic variation for economically important traits and animal breeding values can be precisely estimated and effective genetic improvement plans implemented.

The study aims to estimate the non genetic effects on local kids'ADG under pastoral conditions in the Tunisian arid regions. Results may improve the husbandry policy to optimize the herd production and land conservation considering the serious desertification risks in the studied area.

2. Materials and methods

2.1. Animals and management

All experimental goats were raised in the Arid Areas Institute of Médenine (IRA), in the South-East of Tunisia with an arid continental Mediterranean climate, with irregular and sporadic rains. The season of kidding begins in October and continues until February, with a concentration during November and

December. Throughout the study, replacement animals were selected based on weaning weight and physical conformation.

Animals grazed in natural pastures during the day. In general, grazing pasture grasses covered about 70% of breeding animals feed requirements. The remaining 30% was covered by a supplementation provided during the mating (600 g/day), the last month of pregnancy and the beginning of lactation (750 g/day). Goats received about 1 kg per day of concentrate mixture. All animals were provided with water allowed twice a day; before and after grazing.

2.2. Data recording and studied traits

The data used in present study were collected between 1998 and 2014 from a total of 945 kids (531 males and 414 females), the progeny of 19 sires and 284 dams. Out of the 284 dams, 88 had weight records as kids. Since the start of the kidding period and till 150 days of age, kids were weighed once every two or three weeks. Based on the weight records of individual kids, average daily gains (ADG) were calculated assuming linear growth rate between the appropriate weights. The investigated traits were: ADG1 (from birth to 30 days), ADG2 (from 30 to 60 days), ADG3 (from 60 to 90 days), ADG4 (from 90 to 120 days) and ADG5 (from 120 to 150days).

2.3. Statistical analysis

A general linear model (GLM) analysis was applied to decompose the total variance and to apply the F statistical significance test.

The statistical GLM model used with independent variables was as follows:

$$\mathbf{Y_{ijklm} = \mu + yob_i + mob_j + sex_k + tob_l + dalc_m + (yob\times mob)_{ij} + (yob\times tob)_{il} + (tob\times sex)_{lk} + (yob\times dalc)_{im} + e_{ijklm}}$$

Where:

Y_{ijklm}= observation on the trait;

μ = population mean;

yob_i year of birth (i=1998_2014);

sob_j = month of birth (j= November, December, January, February , Marsh, April);

sex_k= sex of kids (k= male, female);

tob_l= type of birth (l= single, double , triple);

$dalc_m$= age of dam at kidding (m=2,….,10);

$(yob\times mob)_{ij}$= interaction between year and month of birth;

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

$(yob\times dalc)_{jk}$ =interaction between year of birth and age of dam at kidding;

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

e_{ijklm} = model random residual error.

Only intercations of two degree were considered. Except the residual error, all factors and intercations are considered fixe. The variance decomposition was follwed by a student Newman and Keuls (SNK) test, in order to compare subclasses averages of factors having a significant statistical effect (P<0.05 or P<0.01) upon the anlayzed trait.

3. Result and discussion

3.1. Data description

The descriptive statistics for average daily gains (ADG) are presented in table 1. The overall ADG were 85.62, 75.25, 72.67, 50.04 and 39.21 respectively for ADG1, ADG2, ADG3, ADG4 and ADG5. Kids had a faster growth rate from 60 to 90 days with daily gain 72.67 (g/d) that the ADG in kids decreased with the age increase from 120-150 days of age. A similar result was found by Al-Shorepy et al. (2002). A reduced value of ADG reflects the ability of this population to survive. It is considered as an adaptation character to hard environmental conditions in arid regions (Oltenacu, 1999). This adaptation is explained by an association between morphometric and physiological characters with a complex genetic determinism and the result allows the animal to reduce suffering in restrictive and irregular environment (Najari, 2005).

Table 1. The characteristics of the data structure for average daily gains of Tunisian local kids population

	Statistical characteristics				
Age groups (days)	**Min.**	**Max.**	**Mean**	**SD**	**CV%**
ADG1(0-30)	31.02	179.18	85.62	37.71	44.04
ADG2 (30-60)	42	165	75.25	23.46	31.17
ADG3 (60-90)	36.70	156.04	72.67	23.24	31.98
ADG4 (90-120)	40	144.6	50.04	24.52	49.00
ADG5 (120-150)	35.66	111	39.21	14.26	36.36

ADG: Average Daily Gains; SD: Standard Deviation; CV: Coefficient of Variation

Table 2 presents the results of the GLM analysis of variance for kids' ADG estimated at fixed ages. The GLM model coeffecient of dermination R^2 varied for all traits between 0.64 and 0.87. It seems that an important part of the total variability remains not represented into the model. This can be statistically tolerated when data is collected during larger period and under arid irregular environmental conditions (Najari et al. 2007). When the perfermonces corresponds to a later age, the R^2 value tends to increase. So, more the kids were older, more the ADG variability is explained by unknown environmental factors.

Table 2. Test of significance probability of environmental factors and interactions on ADG of local kids

		ADG(g/d)				
Factors	**DF**	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
Year of birth (yob)	15	HS	HS	HS	HS	HS
Month of birth (mob)	5	NS	HS	HS	HS	S
Dam age at kidding (dalc)	7	HS	S	S	S	NS
sex	1	HS	HS	HS	S	S
Type of birth (tob)	2	HS	HS	HS	S	NS
Yob*mob		HS	HS	S	HS	HS
Sex*tob	2	HS	HS	HS	HS	HS
Dalc*yob		S	NS	NS	NS	NS
Yob*tob	15	HS	S	S	NS	S
R^2		0.64	0.66	0.72	0.73	0.87

DF= degrees of freedom; S = Significant ($p<0.05$); HS = Highly Significant ($p<0.01$); NS = Non Significant; R^2= Model determination coefficient

3.2. Environmental factors affecting the ADG of local kids population

3.2.1. The year of birth effects upon the kids' ADG

Local kids' ADG means and the SNK test results were regrouped in table 3. The better kids' ADG were registered during 2001-2002 and 2005-2006 (Table 3). Rather than its harsh conditions, the arid environment is essentially defined by its irregular conditions (Ferchichi, 1996).

Table 3. Means comparison test (SNK, α=5%) for local kids population' ADG by year of birth

	ADG(g/d)				
Year of birth	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
1998-1999	77.26^{a}	77.26^{bc}	74.12^{ab}	66.16^{f}	33.34^{ab}
1999-2000	60.51^{ab}	62.21^{ef}	53.24^{ef}	51.66^{e}	44.26^{e}
2000-2001	66.83^{a}	77.81^{a}	66.7^{d}	46.94^{ac}	35.66^{ac}
2001-2002	78.61^{bc}	88.51^{ce}	56.04^{ce}	47.17^{ac}	11.71^{ef}
2002-2003	97.62^{e}	67.52^{d}	57.16^{e}	68.76^{ce}	28.19^{e}
2003-2004	78.35^{ef}	48.15^{ab}	70.77^{de}	50.12^{ef}	48.11^{ab}
2004-2005	44.84^{f}	34.94^{b}	73.12^{a}	68.78^{ef}	30.15^{ce}
2005-2006	99.09^{ce}	79.19^{ef}	66.35^{ab}	87.32^{a}	22.17^{c}
2006-2007	92.99^{cd}	72.29^{cd}	70.14^{c}	47.27^{bd}	20.18^{be}
2007-2008	62.05^{e}	70.05^{ce}	68.34^{ad}	27.81^{ab}	18.45^{a}
2008-2009	82.79^{ab}	70.19^{ef}	80.12^{ef}	57.41^{de}	37.07^{ef}
2009-2010	60.26^{cd}	61.36^{f}	71.56^{f}	41.97^{f}	31.22^{c}
2010-2011	96.51^{ef}	56.21^{ab}	36.17^{df}	35.13^{bc}	25.16^{de}
2011-2012	81.37^{f}	71.17^{bc}	81.89^{ef}	56.66^{bc}	26.45^{e}
2012-2013	39.10^{ab}	49.20^{a}	39.22^{a}	41.71^{ce}	29.89^{ef}
2013-2014	88.46^{a}	38.66^{d}	33.34^{ab}	52.67^{a}	33.11^{bd}

a, b, c,d,e,f: Means with different superscripts within a column are significant (P<0.05).

Since early age, the year effect is highly significative (P<0.01). This ambient effect becomes higher with the kids' age which expresses that the nutritive requirements can be covered by land grass during this young age. When the animal needs are low, we can expect phenotypic differences expressing various genetic potentialities, whereas, at older age and high needs, the phenotypic differences were essentially attributed to the nutritional availability defined by environmental factors. This qualitative aspect for the year effects upon the kid's ADG must be considered to manage genetic improvement plan adapted to the local kid population and the arid conditions. The year effect upon the kids' ADG was verified by several authors (Ouni et al. 2006; Alexandre et al.1997a).
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).

3.2.2. The Month of birth effects upon the kids' ADG

The ADG variation according to the month of birth is presented in table 4. The kids early born, during the winter season (November-January), show a high gain. Thus, it seems that indigenous kids grew till the spring end; and the growth rate decreases seriously at summer even if the kids' age is reduced. Also, kids born in the end of birth season are unable to realize heavy gain in spite of their genetic potentialities which can't be expressed under summer conditions and heat stress. A significant interaction between year and month of birth (P<0.01) was found here, suggesting that months effects differed across years.

Table 4. Means comparison test (SNK, α=5%) for local kids population' ADG by month of birth

	ADG (g/d)				
Month of birth	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
November	77.11^{b}	72.13^{a}	68.78^{c}	56.56^{ab}	33.12^{bc}
December	83.34^{ab}	77.78^{ab}	70.13^{a}	50.67^{b}	40.22^{e}
January	86.12^{ab}	74.35^{b}	67.6^{ab}	47.70^{a}	35.67^{ab}
February	80.14^{a}	70.11^{a}	65.56^{ab}	52.11^{c}	30.30^{a}
Marsh	74.56^{c}	68.78^{c}	60.13^{a}	44.45^{b}	32.19^{a}
April	69.89^{b}	60.14^{b}	57.57^{b}	39.12^{a}	28.78^{b}

a, b, c: Means with different superscripts within a column are significant (P<0.05).

The spring season, judged having the better natural conditions (Floret and Pontanier, 1982; Ouled Belgacem, 2006) correspond to the better growth rate independently with the physiologic growing stage. Thus, having the majority of births during winter season can been considered as an adaptation aspect of the population to agree the period of maximal nutritional needs of the kids growth with the favorable season. Similar kidding season effects have been signaled by many authors (Ogebe et al. 1995). This typical effect of the month of birth led to recommend the reproduction regrouping in the aim to decrease the number of the later births (after February). In fact, this later kid not allow an additive meat production and rather. Equally, their presence in herd till summer complicates the herd mobility and, also, affects negatively the reproductive performances of lactating goats.

3.2.3. The sex effects upon the kids' ADG

Kids' ADG means and the SNK test results were regrouped in table 5. Since the birth, differences of kids' gain are remarkable for the two sexes. The ADG1 estimated at 95.62g/d and 77.71g/d respectively for male and female explains the superiority of earlier male gain (Najari, 2005). This male superiority continues during the growth period and reaches 15.17g/d at five months in favor to males' kids. Similar sex effect is commonly concluded in several studies (Ogebe et al., 1995; Oltenacu, 1999).

Table 5. Means comparison test (SNK, α=5%) for local kids population' ADG by sex of kids

	ADG(g/d)				
Sex of kids	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
Male	95.62^{b}	81.23^{b}	71.93^{b}	58.87^{b}	39.34b
Female	77.71^{a}	63.46^{a}	57.24^{a}	44.52^{a}	24.26^{a}

a, b: Means with different superscripts within a column are significant (P<0.05)

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 gain against males (Najari, 2005).

The study also revealed a significant interaction between type of birth and sex of kids for all studied traits (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.

3.2.4. The type of birth effects upon the kids' ADG

Kids' ADG means and the SNK test results were regrouped in table 5. The effect of this factor is considered classic in the bibliography (Okello, 1993; Gromela et al. 1998; Ouni, 2006). The single kids have normally better conditions to realize heaviest weights and gains. Alexandre et al. (1997a), indicate that the difference between simple and double could represent until 15% of gain from birth to 10 days of age. The simple births have some best conditions to achieve some heavier gains (Alexandre et al. 1997b; Oltenacu, 1999).

Table 6. Means comparison test (SNK, α=5%) for local kids population' ADG by type of birth

	ADG(g/d)				
Type of birth	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
Simple	90.84^{b}	80.89^{ab}	73.77^{a}	55.45^{b}	38.67^{b}
Double	61.94^{a}	56.78^{a}	61.31^{a}	46.32^{a}	27.67^{a}
Triple	55.23^{a}	50.12^{a}	66.48^{a}	40.40^{b}	23.85^{a}

a, b: Means with different superscripts within a column are significant (P<0.05)

3.2.5. The age of dam effects upon the kids' ADG

Kids' ADG means and the SNK test results were regrouped in table 6. The dam age at kidding represents essentially the lactation range with which varies the milk potentialities. In fact, goat lactation evolves to a maximum reached at the 3rd or 4th lactation (Ba diao et al. 1994). The relation between kids' growth and the mother age was demonstrated in several studies (Ouni et al. 2006; Pinkerton, 1994). In our case, the lowest kids' ADG were registered for the kids of oldest goats. Goats aged between 3 and 7 years seem to allow the better kids growth; it seems that the forage scarcity avoid to distinguish differences into this group.

The significant interaction between year of birth and age of dam at kidding, indicated that the combined effect of these factors were more important than their individual effects on this trait.

Table 7. Means comparison test (SNK, α=5%) for local kids population' ADG by age of dam at kidding

	ADG (g/d)				
Age of dam (Year)	**ADG1**	**ADG2**	**ADG3**	**ADG4**	**ADG5**
2	90-.19[ab]	77.-13[a]	70.70[ab]	69,88[b]	44,34 [ab]
3	88.98[b]	69.78[b]	61.13[b]	53.40[b]	34.12[b]
4	93.77[a]	76.89[a]	71.12[ab]	46.18[a]	22.12[a]
5	81.81[b]	69.23[ab]	64.14[c]	50.51[a]	30.36[b]
6	84.78[a]	75.67[b]	70.12[bc]	43.63[a]	30.09[b]
7	87.06[b]	74.12 [b]	70.08[a]	79.69[ab]	31.89[b]
8	85.93[b]	80.19[ab]	72.13[ab]	74.64[ab]	36.56[ab]
9	77.21[ab]	73.34[b]	70.09[b]	81.16[b]	40.45[ab]
10	80.21[ab]	60.34[ab]	55.34[a]	68.19[a]	29.98[a]

a, b: Means with different superscripts within a column are significant ($p<0.05$)

4. Conclusion

Kids' daily gains illustrate an important variation with respect to the environmental factors such as year and month of birth. The importance of those factors seems to be higher when the kids were older and when requirements are considerable. To maintain a reasonably productive and profitable goat production system, feeding and management would need to be flexible to effectively respond to changes in type and availability of range feed with climate fluctuations. Thus, effects of non genetic factors need to be corrected for mixed model approaches such as the Best Linear Unbiased Prediction (BLUP) values are to be used for breeding value evaluation in local kid population.

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