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Effects of Genotype-Environment Interaction upon Local Goat Dairy Production in the Tunisian Oases

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Abstract: Dairy data harvested during 16 years in a goat herd composed by local goat, Alpine, Damascus, Murciana and 6 crossed groups was used in the present study. The aim is to establish the effects of genotype-environment interaction upon goat milking potentialities under oasian husbandry conditions. For each goat, total production per lactation (Kg), daily average (kg day^{-1}) and milking period (days) were estimated by Fleischmann method. A GLM Procedure was applied to identify the interactive effects of genotype towards the year and the kidding mode, respectively. Analysis show the milk production per lactation varies differently both with genetic groups and the year of kidding. Among pure breeds the productive behaviour for each group depends largely to the year. For example, the Alpine production varied between 329 kg during 179 days and decreased to 217 kg during the year 1990/1991. The kidding mode effect seems not similar for all genetic groups, especially among crossed genotypes. Results allow to conclude that the oasian environment modulate largely the dairy potentialities of caprine genetic groups. Some genotypes have more regular performances than other subjected to the same conditions. Such interactive effect should be considered to organise genetic improvement program.

Key words: Local goat, cross breeding, dairy production, interaction, environment, oases

INTRODUCTION

In the Tunisian arid region, local goat is essentially raised in pastoral mode and ambulant herds valorise the vegetal resources of range lands under harsh conditions (Alexandre *et al*., 1997). Local goat population is often considered genetically adapted to arid climate and is able to reproduce during all the years, as well as for other caprine rustic populations (Najari *et al*., 2006). The lactated kid's meat is the main product for this breeding mode and contributes with about 75% in the regional meat consumption (Najari *et al*., 2007a, c). Since centuries, local goat was equally raised in the regional oases where the intensive goat husbandry plays a key role in the farmer's incomes. In fact, rather than milk and meat production, goat herd has various contributions in the agronomic activities and the family's economy (D'Aquino *et al*., 1995). Goat benefits from an intensified breeding mode under low climatic risks which characterize the arid area (Morand-Fehr and Doreau, 2001).

Contrary to pastoral mode, the main goat oasian production goal of reduced herds is milk; however, although under favourable conditions local goat milk production remains reduced (Najari *et al*., 2007a, b; Gaddour *et al*., 2007b). The natural selection process had oriented the local population to reduce genetic dairy potentialities as an adaptation aspect to restrictive conditions.

Thus, a crossing program to substitute local goat by more productive caprine crossed genotypes was carried out and some specialized breeds (*Alpine*, *Damascus* and *Murciana*) were imported.

Based on a large data base issued from 16 animal surveys of pure breeds and crossed genotypes performances, several studies was realized to evaluate genotypes productivities as a step to choice the suitable breed to cross the local goat (Najari, 2003; Gaddour, 2005). Rather than productive performances, a particular importance is assigned to the effects of interaction genotype-environment. Such factors illustrate how each genotype varies its production when non genetic factors changed. This research is aiming to establish the statistical effects of genotype-year and genotype kidding mode interactions upon some dairy performances of local goat, selected caprine breeds and crosses raised under oasian conditions.

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MATERIALS AND METHODS

Animal material: The local goat population is characterised by its small size with an average height of 76 cm for the male and 60 cm for the female (Ouni *et al*., 2007a; Najari *et al*., 2007b). It is distinguished by the ability to walk long distances, water shortage resistance and good kidding ability. Fertility rate is about 87% and prolificacy rate varies between 110 and 130% (Gaddour *et al*., 2007c). Kidding season begins in October and continues till February with a concentration in November and December when 69.2% of kid's are born.

To cross local goat, three ameliorative breeds were used: *Alpine*, *Damascus* and *Murciana* breeds were imported, respectively from France, Cyprus and Spain (Gaddour *et al*., 2007b, d).

Crossing scheme: To produce the first crossed generation, local goats are mated with bucks of ameliorative breeds and at each generation, the crossed females were mated by ameliorative breeds. So, the crossing scheme allows a progressive increase of the ameliorative percentage genes pool, during successive generations (Gaddour *et al*., 2007b).

Statistical analysis: To identify the statistical effects of the studied interactions, an analysis of the variance with the GLM procedure was applied using the following statistical model:

$$Y_{ijkl} = \mu + (RA_i \times AN_j) + (RA_i \times MN_k) + e_{ijkl};$$

Where:

Y_{ijk} = Total milk production (kg), milking period (days) and average daily milk production (kg day^{-1}).
μ = The general average.
$RA_i \times An_j$ = The genotype × year interaction.
$RA_i \times Mn_k$ = The interaction genotype × kidding mode
e_{ijkl} = Residual error.

After the variance analysis an SNK mean comparison test (α = 5%) was applied to identify homogeneous statistical groups for each interaction level. Statistical analysis was done by SPSS program (SPSS, 1998).

RESULTS AND DISCUSSION

Table 1 summarizes the GLM procedure relative to the model components effects on dairy performances.

Table 1 show that the coefficient of determination R^2 varied from 82-96%. These values can be accepted for a data collected on goat herd during 16 years. The GLM test shows that total milk production, Average daily milk production and Milking period were essentially affected either by genotype-year ($p<0.01$) and by genotype*kidding birth ($p<0.05$).

Several authors assigned an important affects of environmental and genetic factors upon caprine dairy performances (D'Aquino *et al*., 1995).

In the arid region, the irregular annual conditions affect herd resources by forage variation in pastoral mode especially on rangelands (Ouled Belgacem, 2006). However, under oasian mode, goat alimentation is sufficient and animal are correctly feed by Alfa Alfa and concentrate. So, such year effect can be mainly justified by the climate variations such heat picks. Also, the herd genetic level, whose vary with cross breeding, can explain such effect. This year impact seems to be differently felt by each genetic group with a heterogeneous performances variation under similar conditions. The performances of dairy production of the various studied genetic groups and the SNK test (α = 5%) are presented in Table 2 and 3.

Among pure breeds, Alpine goat which is known as the more productive breeds (Gaddour *et al*., 2007b, c) reached their maximum production, superior to 300 kg per lactation, during 1980/1981, 1994/1995 and 1995/1996. This production decreased seriously during other years to be comparable to the production of others breeds. The performances variation per year seems to be more important for some breeds than for others and also, for some variables than for others. The same annual conditions affect negatively or positively the goat dairy potentialities depending to the genotype. Regarding the interaction effect genotype and year presented in (Table 2), in 1989/1990, the Alpine goat presents the best performances of mean dairy with a total production of 240.47 kg during a period of more than 123.68 days and with a daily mean production of 1.99 kg day^{-1}, followed by Damascus with a total production of 212.98 kg during 172.25 days. The Alpine breed is known with its high dairy performances (Najari, 2005).

The Murciana breed registered the weaker performances since its total production is about 197.98 kg. Also, Murciana breed is characterized by its long period of lactation with 180 days.

Among crosses performances (Table 3), all studied variables vary largely by year especially for Alpine crossed genotypes. Concerning the crossing genotypes, the crossed Alpine confirm the superiority of their performances as compared to the other groups. Also, their

Table 1: GLM test of the effects of interaction on goat dairy performances

	Total production (kg)	Daily average (days)	Millking period (kg day^{-1})	Degree of freedom
Genotype*year	**	**	**	26
Genotype*KM	*	*	*	10
R^2	0.82	0.93	0.96	

* Significant ($p<0.05$), ** significant ($p<0.01$), R^2: coefficient of determination, KM: kidding mode

Table 2: Dairy performances of local goat, Alpine, damascus and murciana breeds in Tunisian oases with respect to the year of kidding

Interactions		Local	Alpine	Damascus	Murciana
1980-1981	P		329.00		
	M		1.83		
	D		178.00		
1981-1982	P	108.00	239.00		
	M	0.77	1.61		
	D	137.00	146.00		
1982-1983	P	99.00			151.00
	M	0.79			0.99
	D	122.00			150.00
1983-1984	P		266.00		146.00
	M		1.48		0.93
	D		177.00		157.00
1984-1985	P		294.00	172.00	226.00
	M		1.75	1.21	1.19
	D		165.00	144.00	186.00
1989-1990	P		240.00	212.00	197.00
	M		1.99	1.24	1.10
	D		123.00	172.00	180.00
1990-1991	P		217.00	172.00	138.00
	M		1.93	1.50	1.29
	D		111.00	114.00	107.00
1992-1993	P		219.00		230.00
	M		2.00		1.32
	D		108.00		174.00
1993-1994	P	139.00	255.00	183.00	222.00
	M	0.76	1.58	1.05	1.15
	D	185.00	160.00	174.00	190.00
1994-1995	P	148.00	305.00	111.00	251.00
	M	0.95	1.85	0.82	1.50
	D	181.00	163.00	137.00	170.00
1995-1996	P	60.00	300.00	113.00	101.00
	M	0.40	1.45	1.17	0.57
	D	148.00	210.00	115.00	163.00

P: Total production (kg), M: Daily average (days), D: Millking period (kg day^{-1})

Table 3: Dairy performances of crossed caprine genotypes in Tunisian oases with respect to the year of kidding

Interactions		F1 A	F2 A	F1 D	F2 D	F1 M	F2 M
89-90	P			142.00		244.00	221.00
	M			0.84		1.35	1.18
	D			171.00		184.00	188.00
90-91	P	232.00	202.00	168.00	167.00	93.00	123.00
	M	1.54	1.42	1.27	1.33	0.83	1.34
	D	152.00	143.00	131.00	129.00	111.00	91.00
93-94	P			337.00	253.00		
	M			1.65	1.43		
	D			205.00	173.00		
94-95	P	138.00	284.00		160.00		
	M	0.91	1.80		0.84		
	D	157.00	146.00		190.00		
95-96	P	122.00			108.00		
	M	1.17			1.05		
	D	105.00			102.00		

F1 A, F2 A: crossed Alpine*local, F1 D, F2 D: crossed Damascus*local, F1 M, F2 M: crossed Murciana*local, P: Total production (kg), M: Daily average (days), D: Millking period (kg day^{-1})

dairy productions increase with the degree of substitution through crossbreeding. Indeed, the production by lactation of F1 A and F2 A.

Morever, Table 3 shows that the impact of the environment is correlated to the crosses genetic potentialities. More the genetic level is favourable, more

Table 4: Dairy performances of local goat, Alpine, damascus and murciana breeds in Tunisian oases with respect to the kidding mode

	Interactions	Local	Alpine	Damascus	Murciana
P	Single	94.00	238.00	144.00	169.00
	Multiple	159.00	250.00	193.00	212.00
M	Single	0.55	1.80	1.11	1.11
	Multiple	0.90	1.91	1.28	1.31
D	Single	177.00	133.00	133.00	155.00
	Multiple	183.00	134.00	155.00	161.00

P: Total Production (kg), M: Daily average (days), D: Millking period (kg day^{-1})

Table 5: Dairy performances of crossed caprine genotypes in Tunisian oases with respect to the kidding mode

	Interactions	F1 A	F2 A	F1 D	F2 D	F1 M	F2 M
P	Single	145	234	125	131	196	177
	Multiple	192	197	215	215	156	134
M	Single	1,11	1,57	0,88	0,94	1,18	1,18
	Multiple	1,26	1,37	1,33	1,35	1,07	1,44
D	Single	131	144	150	148	163	150
	Multiple	161	142	159	157	138	93

F1 A, F2 A: Crossed Alpine*local, F1 D, F2 D: Crossed Damascus*local, F1 M, F2 M: Crossed Murciana*local, P: Total production (kg), M: Daily average (days), D: Millking period (kg day^{-1})

the phenotype express the ambiantal conditions. Such effect was illustrated on kid's growth of the local population (Najari, 2003; Najari *et al*., 2007a, b). The Table 4 and 5 present the variation of the dairy performances in relation to the genotype and birth mode interaction. Commonly, all mammalian domestic species produce more milk with the increasing of the births number (Williams and Helliwell, 1993). But this production increasing depends to the genotype ability to improve dairy performances (Table 4 and 5). The local goat, characterized by its maternal instinct, improves its total production with about 70% when the mother has a twin. Whereas, the Alpine goat milk production remains quasi invariable and independent to the kids number. Thus the kid's number affects differently the milk production of each genotype.

Another important illustration of the genotype-environment effects can be deducted comparing the dairy performances of imported breeds towards those registered in their original zones. In fact, all breeds realized below than the half of their average milk produced in their original countries (Gaddour *et al*., 2007b, d).

CONCLUSION

The analysis of the genotype environment interaction allow to deduct the dairy performances of genotypes were differently affected by non heritable factors. Some caprine genotypes express a phenotypic regularity towards ambiantal variation. The ability of the genetic groups to temporize the impacts of environment irregularities remains a suitable quality to produce milk under variable resources and conditions. These results consolidate anterior works to offers sufficient parameters indispensable to choice the suitable breed to use as paternal groups to cross local goat in Tunisian oases. However, to manage the crossing program, more studies remain necessary to focus other production parameters such as kids' mortality and goat reproductive performances.

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