African Journal of Agricultural Research Vol. 5(5), pp. 363-371, 4 March, 2010
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2010 Academic Journals

Full Length Research Paper

Response to absorption of the crossbreeding of the local goat with exotic breeds in the oases of Southern Tunisia

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Accepted 8 January, 2010

From 1980, the development project within the framework of genetic improvement achieved significant progress through crossbreeding of local goats with imported improver races at the Institute of the Arid Areas of Medenine. This article summarizes the performances of the various genotypes produced since 1980. The crossing between these goat races appreciably improved the performances of growth and milk production of the local goat of the southern Tunisia since the first generation. The mean weights of kids were 3.49 kg at birth and 15.78 kg at 120 days age. The Damascus race presented the best performances of growth of the kids. The milk production with the first generation reached about 248 kg per lactation for the Alpine one, 181 kg for Damascus and 190 kg for Murciana while the local race produced only 137 kg. Despite the improvement of the growth and milk production traits, it seems that this crossing appears to have negative affect on reproductive performances.

Key words: Local goat, performances, crossing, oasis, Tunisia.

INTRODUCTION

The Tunisian arid area domiciles more than 60% of the national goat and is estimated at approximately 1 million reproductive females (Najari et al., 2006). In this area, defined by its hostile natural conditions, the local goat is mostly raised in pastoral and agro-pastoral systems (Najari, 2005). This farming system constitutes a rustic animal population with large variability of characteristics and performances. The productivity of the local goat can be improved through genetic means through selection or crossing (Najari et al., 2007a, b). Considering the low production levels of local goats and the long period needed to achieve genetic progress (Najari et al., 2007c, d), especially for milk production with low heritability, the crossbreeding the local goat with ameliorative races was adopted (Najari, 2005). The choice for crossbreeding was based on the fact that the genetic potential of this indigenous population does not allow valorising the oases system of production (Gaddour et al., 2008a, b).

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The indigenous goat populations of the difficult zones are of mixed type and generally with low dairy production (Gaddour et al., 2008d, e). The production of meat of a local population adapted to an arid and very variable environment is generally low (Gaddour et al., 2007a, b). The low level of meat production from the indigenous populations does not emanate from a production of heavy kids, but rather, of a limited dairy production. These performances represent a synthesis of the animal potentialities and those of an arid environment, hot and restrictive (Gaddour et al., 2007c, d). The goat performances, in extensive system are quite lower than those of sheep and also than those of goat reared in more intensive systems (Najari et al., 2006).

In the majority of the agro-pastoral systems, milk represents generally only a secondary production (Gaddour et al., 2009a; Gaddour and Najari, 2008a). The dairy performances of the local goat are considered low (Najari et al., 2007a) since the majority of the populations are in arid zones.

This paper deals with the performances of growth and milk production of the various genotypes obtained at the Institute of the Arid Areas of Medenine by the crossing of local goat with ameliorative races. In this paper we report

Table 1. Characteristics and performances of the ameliorative races in their countries of origin.

Races	Origin	Adult weight (kg)		Lactation	
		Male	Female	Quantity (kg)	Duration (days)
Alpine	France	80	60	570	245
Murciana	Spain	70	50	500	210
Damascus	Cyprus	80	60	200	90

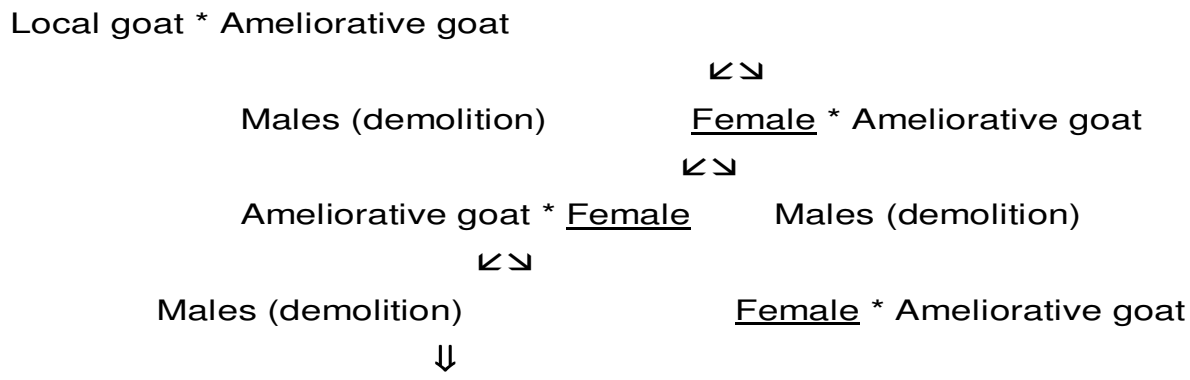

Figure 1. Diagram of the crossing of improvement of the local goat.

results of studies made to investigate the potentialities of the local goat in the intensive control, estimate the potentialities of the imported races under the Tunisian oases conditions and study the behaviour of the goat genotypes production towards the oases factors.

MATERIALS AND METHODS

Zone of study

The present study used the data of growth and milk control of the various goat genotypes (pure races and crossed) raised at the Chevrery experimental station of the Institute of the Arid Areas of Chenchou, which is located at 20 km from Gabes in southern Tunisia. The station belongs to the lower arid bioclimatic stage; the mean animal rainfall is about 188 mm. January is the coldest month of the year, with a mean temperature of 10.7°C, whereas August is the hottest month with a temperature of about 27.3°C (Gaddour et al., 2009a).

Study animals

Table 1 illustrates the performances and the characteristics of the ameliorative races in their countries of origin. The herd of the ameliorative races is used as core of production of genitors intended for the diffusion in rural area while crossed were raised with an aim of collecting the necessary data in order to estimate the zoo technical parameters.

Indigenous goats

The local goats are of small size (the height at wither is about 76 cm for males and 60 cm for females) with a variable weight according to the pastoral resources and physiological stages. It has a large genetic variability equipped with a strong resistance or adaptation to the severe climatic conditions (Gaddour et al., 2008b).

Crossing diagram

Crossbreeding was selected as the best option to improve the potential of goat of the oasis. The crossbreeding consists of the achievement of a coupling, at each generation, between the crossed females (at the first stage, local goats) with goats of the absorbing ameliorative race which results in a progressive increase in the percentage of genes of the ameliorative race from one generation to another (Najari et al., 2007d).

The use of the local race for the creation of the new genotype can represent a manner of valorisation of the capacities of adaptation of the indigenous goat (Najari et al., 1996). In addition, the evolution of the genetic level allows a progressive improvement of the level of control to be adapted to the performances of the new created genotype. The diagram of the applied crossing was schematically illustrated in Figure 1.

Basic data

The collected data correspond to the years of controls since 1980 to 1996. A total of 1928 leaflets of growth of the kids of various genetic groups with information concerning the periodic control data

Table 2. Analysis of variance of weight at the standard ages and daily growth of the kids resulting from the crossing of absorption of the local goat (AN = Year, RA = Race, NE = Sex, MN = Mode of birth.)

Factors	PN	P10	P30	P70	P90	P120	GMQ 10-30	GMQ 30-70	GMQ 70-90
AN	**	**	**	**	**	**	**	**	**
RA	**	**	**	**	**	**	*	**	NS
NE	NS	*	*	**	**	*	NS	*	NS
MN	NS	NS	*	*	*	NS	NS	NS	NS
AN*RA	**	**	**	**	**	**	**	**	**
AN*NE	*	NS	*	*	*	NS	NS	NS	NS
AN*MN	*	NS	NS	**	NS	NS	*	NS	NS
RA*NE	*	NS	**	*	NS	*	*	NS	*
RA*MN	NS	NS	**	**	**	*	*	*	NS
NE*MN	NS	**	NS	NS	NS	NS	NS	NS	NS
R^2 (%)	97	96	96	96	96	96	88	87	75

** Highly significant; * significant; NS = non significant.

of the weights were used. In addition, a total of 1123 cards of lactation for each goat, dairy control data were analysed. This considerable quantity of information was elaborated in order to estimate weight at the standard ages of the kids. Birth, 10, 30, 70, 90, 120 days and milk production for each goat, duration of lactation, total production and the daily average are computed.

Data analysis

The quantitative performances were subjected to an analysis of variance for the diagnosis of the effects of the factors of the variation. The models applied are the following:
For the growth:

$Y_{ij\ kl\ m} = \mu + RA_i + AN_j + NS_k + MN_l + (RA * AN)_{ij} + (RA * NS)_{ik} + (RA*MN)_{il} + (AN*NS)_{jk} + (AN * MN)_{jl} + (NS * MN)_{kl} + \varepsilon_{ijklm}$

Y_{ijklm} : PN, P10, P30, P70, P90, P120, GMQ10-30, GMQ30-70, GMQ70-90 and GMQ90-120.

μ : The general average
RA_i: Effect of the genotype
AN_j: Effect of the year
NS_k: Effect of the sex of the kids
MN_l: Effect of the mode of birth
$(RA * AN)_{ij}$: Effect of the interaction race * year
$(RA * NS)_{ik}$: Effect of the interaction race * sex
$(RA * MN)_{il}$: Effect of the interaction race * mode of birth
$(AN * NS)_{jk}$: Effect of the interaction year * sex
$(AN * MN)_{jl}$: Effect of the interaction year * mode of birth
$(NS * MN)_{kl}$: Effect of the interaction sex*mode of birth
ε_{ijklm}: residual error

For the dairy production:

$Y_{ijkl} = \mu + RA_i + AN_j + MN_k + (RA * AN)_{ij} + (RA * MN)_{ik} + (AN * MN)_{jk} + (RA* AN*MN)_{ijk} + \varepsilon_{ijkl}$

Y_{ijkl}: Dairy performances
μ: The general average
RA_i: Effect of the genotype
AN_j: Effect of the year
NS_k: Effect of the sex of the kids
MN_l: Effect of the mode of birth
$(RA * AN)_{ij}$: Effect of the interaction race * year
$(RA * NS)_{ik}$: Effect of the interaction race * sex
$(RA * MN)_{il}$: Effect of the interaction race * mode of birth
$(AN * NS)_{jk}$: Effect of the interaction year * sex
$(AN * MN)_{jl}$: Effect of the interaction year * mode of birth
$(NS * MN)_{kl}$: Effect of the interaction sex * mode of birth
ε_{ijklm}: residual error

RESULTS AND DISCUSSION

Performance of growth of kids

Analyses of variance of growth of the kids

The results of analysis of variance of growth performances are presented in Table 2. It is shown that the coefficient of determination of the model (R^2) varied from 75 to 96% testifying that the model is insufficient, which we could not improve in spite of the attempts. The factors included have only a partial effect on the performances which remain mainly affected by other factors which could not be identified to include them in the model. For this reason the conclusions drawn by this analysis cannot be considered very important. The only conclusion that can be retained is the importance of the effect of the genotype on all the performances.

Table 3. Mean growth performances of the various genotypes at different ages.

Group genetic	N	PM	PN	P10	P30	P60	P90	P120
Alpine	774	19.25	3.61	5.41	8.11	10.81	13.13	14.80
Damascus	169	18.01	3.66	5.49	8.16	11.3	14.51	16.48
Murciana	149	13.83	2.38	3.91	6.35	8.24	11.07	11.98
Local	188	13.26	2.92	4.48	6.68	9.12	11.88	12.85
A1	183	14.76	3.08	5.87	8.14	10.76	13.77	15.03
A2	249	17.05	3.37	5.22	8.56	12.21	14.13	15.78
A3	22	18.16	3.31	5.39	8.96	12.88	14.94	16.37
D1	104	15.70	3.55	5.88	7.79	13.13	15.74	16.42
D2	39	15.67	3.44	5.69	8.27	11.71	14.59	16.19
D3	18	16.85	2.94	5.00	7.07	10.1	12.07	13.56
M1	15	13.55	2.61	4.02	6.46	9.22	11.75	14.42
M2	17	13.77	2.72	4.29	7.21	9.24	11.99	13.90

N = manpower; PM = metabolic weight of the adults = live weight (0.75); A1, A2 and A3 = crossed Alpine*local; D1, D2 and D3 = crossed Damascus*local; M1 and M2 = crossed Murciana*local

Comparison of means

Effect of the genotype: The comparisons of mean performances by genotype are presented in Table 3. The kids of the Alpine and the Damascus race recorded had the heaviest birth weights (3.66 and 3.61 kg respectively). The mean birth weight of kids of the local population, however, was only 2.92 kg. The Murciana kids, taking into account the small size of this race, recorded the lowest weight at birth (2.38 kg).

On the level of cross, two different groups can be differentiated. The first group is composed of the cross G2 (A × Lo), G3 (A × Lo), G1 (D × Lo) and G2 (D × Lo) with respective weights at the birth of 3.37, 3.31, 3.55 and 3.44 kg and the second group is composed of cross G3 (D × Lo), G1 (M × Lo) and G2 (M × Lo) with 2.54, 2.61, and 2.72 kg, respectively. The correlation, between the weight at birth and the metabolic adult weight, was positive (r = 0.78).

As for the standard ages and among the pure races, the Damascus kids and the Alpine, had the heaviest weight for all the considered ages. The local kids present higher weights than those corresponding to the Murciana race. With the 120 days age, the Damascus kids are still the heaviest with a weight of 16.48 kg, in the second place comes the Alpine one with 14.80 kg. The local population and the Murciana race recorded the weakest weights with 12.85 and 11.98 kg respectively.

For the crossed genotypes, the kids G3 (A × Lo) had the highest weight at 30 days age which was 8.96 kg. This can be explained by the superiority of their mothers on the level of the dairy production as compared to the others cross. The kids G1 (D × Lo) have the heaviest weights since the 60 days age and continuous until the 120 days age when they reach a weight of 16.42 kg.

An important decrease of weights of cross Damascus with the generations of the crossing of absorption can be noted. Since the birth, the cross kids G3 Damascus are lighter than those G2 and G1 whereas for the Alpine cross kids, the weight increases with the degree of absorption of the local goat by the Alpine race. From the 30 days age, the cross kids (A × Lo) and (M × Lo) have higher weights than those of kids of respective pure races, Alpine and Murciana, which can be explained by the vigour of the hybrid. Their superiority in weight of the cross kids Murciana as compared to the local kids is noted only at age the 120 days.

Effect of the factor "Year": During the four years of control, rainfall varied from 37 mm during the biologic year 2000/2001 to 307 mm in 1997/1998. The scarcity and the irregularity of precipitations, heats excessive and the cold, the siroccos, remain the first natural factors conditioning the situation in which the animals live (Najari et al., 2007d).

Figure 2 presents the curves of growth adjusted by control campaign. Until one month age, the figure shows a comparable speed of growth for the 4 experimental campaigns. It appears that until this age, the low requirements of the kids could be met whatever the year; a weak production of the mother would be enough to express the growth potential of the kids of less than 1 month (Najari et al., 2006).

This aspect contributes to the comprehension of the nature of the action of the environment on the variability of the productive aptitudes and should be considered for the genetic improvement under the difficult conditions. "When the needs of kids are low, the majority of the genomes can express their real potentiality and conese-quently, can be duly evaluated to direct a diagram of genetic improvement. When the resources can meet the needs of the kid, the variability of the performances can be attributed to differences in individual potentialities of the kids; thing which is not classically possible when the

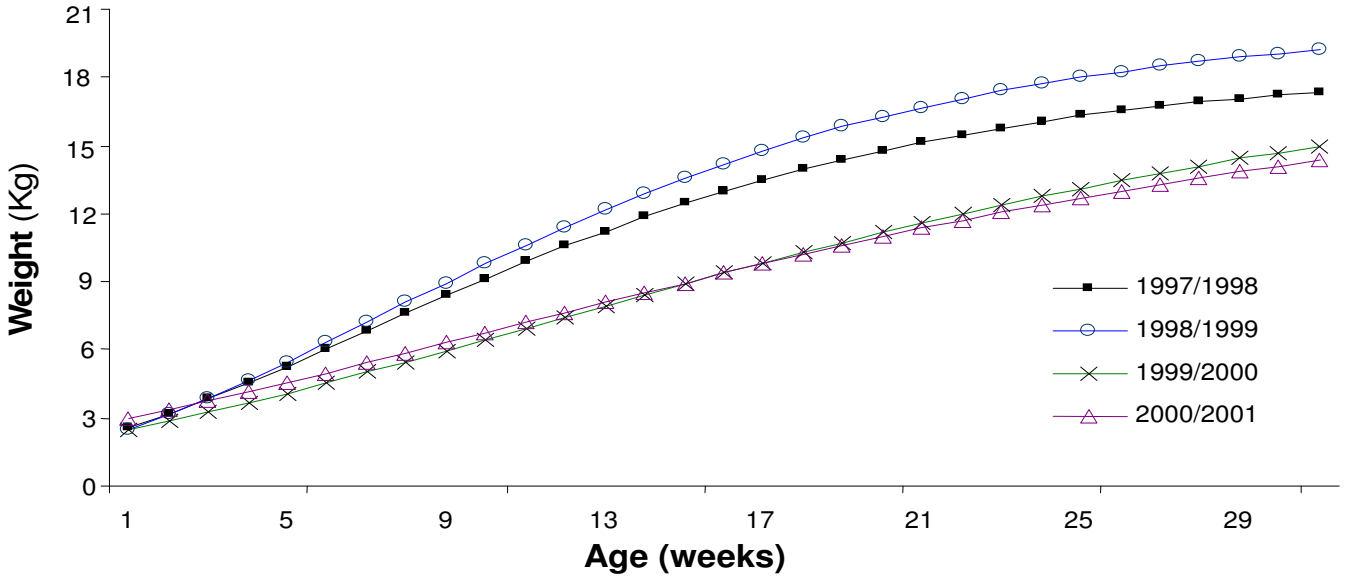

Figure 2. Growth curve of the kids in relation to the year.

environment does not ensure the requirements for the expression of the individual potentialities (Najari et al., 2007c)". Since the age of 1 month, the growth becomes marked by the effect of the year; for the relatively favourable years, such are 1997/1998 and 1998/1999, "the best" curves of growth are observed. These curves are presented in S-shape and finish by an asymptote which tends towards an "adult" relatively heavy weight. For the most difficult years, (1999/2000 and 2000/2001), the growth curves illustrate essentially the suffering of the kids and their mothers since the rangeland conditions do not ensure any more their needs. During these two last years, the growth curve does not illustrate any more the typical trend in form of S. Several authors highlighted the effect of the year on the trend of the growth of the kids; all agree on this direct and indirect effect, by the means of the reduction of the mother's milk or the rangeland resources.

During the years of drought, the weight of the kids evolves almost in a linear way to ensure a light profit and which remains until a 6 months age lower than 15 kg. During favourable years, the profit of weight becomes considerable. Consequently, it is especially the speed of growth which appears most affected by the conditions of the year.

The significant effect of the interaction year*herd on the weights at the standard ages, testifying the impact of the year "quality" on the growth, is not homogeneous for all the herds. Due to the space irregularity of the climate of the arid area, the degree of ease or suffering of a herd can be very different from that of the other contemporaries. Besides to the variability of the climatic and food conditions of each herd, the behaviour of the stockbreeders varies according to the environmental conditions (Gaddour et al., 2008c).

The reaction of the stockbreeder to the year condition varies according to the importance of the role of the livestock for the family. It is especially for the large herds that control is constantly modified for stage with the effect of the drought or, on the contrary, to benefit from the favourable conditions of the other rangeland. These stockbreeders are ready to mobilize all the resources of the family to the profit of the animals. The situation is different with small herds, located especially at the level of the coast and the urban zones, where the stockbreeders are satisfied to seek supplementary feeding for their animals.

Effect of the factor "sex": The differences between sexes are remarkable as of the birth (Figure 3). The weight at birth, estimated at 2.64 kg for the male and of 2.32 kg for the females, explains this early and clear superiority of the growth of the males (Najari et al., 2006). The difference in weight continues and permits to males to tend to an asymptotic weight higher than that of the females. These differences in precocity between sexes are also observed between weights recorded at the standard ages. Even if these differences between sexes remain weak in absolute value, they are significant and have an important incidence on the weight. Moreover, they partially explain why selection at a given age does not produce the same response for the two sexes. In our case, the female kids reach more quickly the point of inflection of the curve which is located at an age of about 37 days against 42 days for the male kids. At the point of inflection, the male kids weigh 6.65 kg whereas the females weigh only 5.52 kg. As Figure 3 illustrates, the superiority of the males is observed since the birth to be

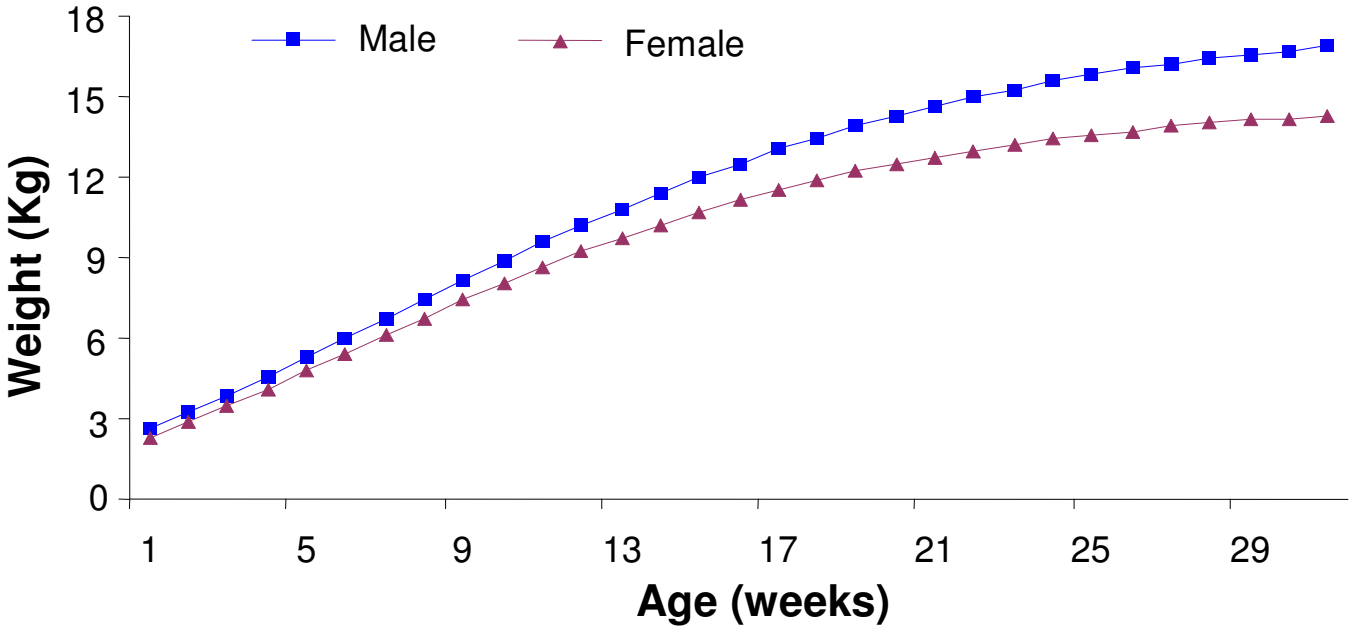

Figure 3. Growth curve of the kids in relation to the sex.

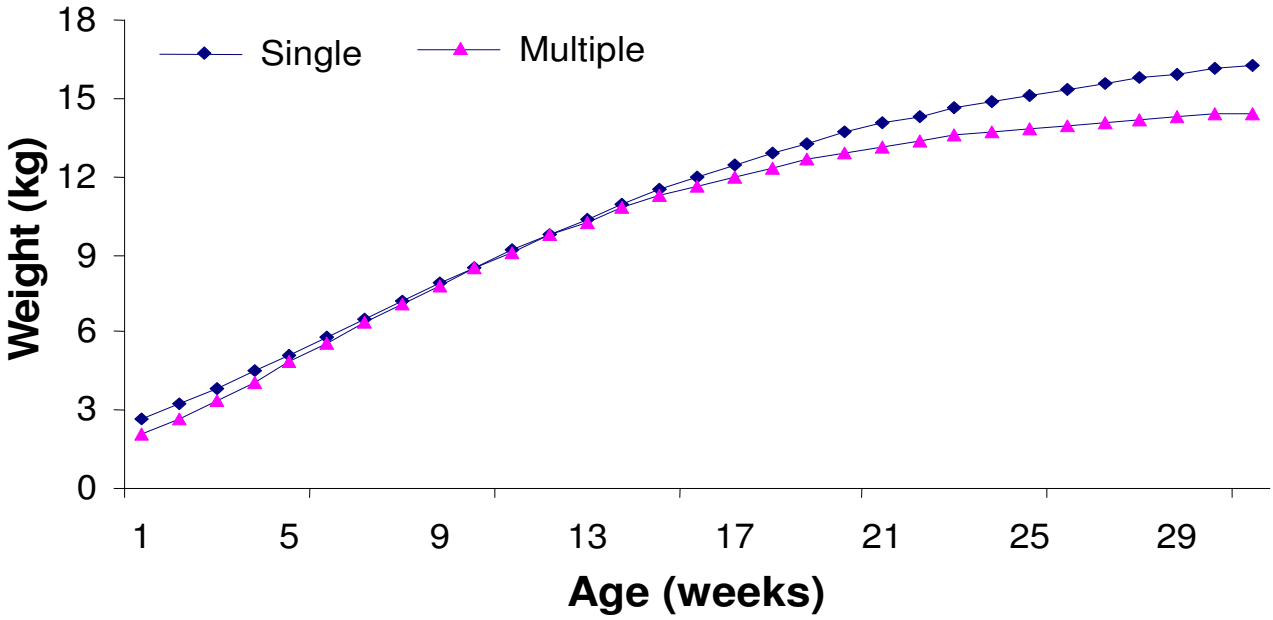

Figure 4. Growth curve of the kids in relation to the mode of birth.

clearer with the age of the kids. The effect of sex on the shape and the parameters of the growth curve were underlined by several authors (Najari, 2005).

Effect of the "mode of birth": The variation of the curve of growth according to the birth mode is presented in Figure 4. The curves of growth of the simple and multiple kids do not show significant differences between 5 and17 weeks of age. It seems that weak production of milk of the mother, representing main food of the young kids, is enough decreased permitting thus a continuous superiority of simple. In spite of their higher needs, the simple ones do not find enough milk and of food to be heavier than the kids born double (Najari, 2005).

Table 4. Analysis of variance of dairy performances of the study goats.

Factors/variables	Total production (kg)	Daily mean (kg/days)	Duration lactation (days)
Genotype	**	**	*
Year	*	NS	**
Mode of birth	*	*	NS
Genotype*Year	**	*	**
Genotype*Mode B	NS	NS	NS
Year*Mode B	*	NS	*
R^2 (%)	89	94	96

** highly significant * significant NS = not significant Mode B = mode of birth.

Table 5. Performances of lactation in relation to genotypes.

Genetic groups	Total production (kg)	Daily mean (kg/days)	Duration lactation (days)
Alpine (A)	244.44	1.85	132.12
Damascus (D)	177.05	1.22	145.12
Murciana (M)	187.75	1.20	156.45
Local (Lo)	133.53	0.76	175.69
A1	164.53	1.17	140.62
A2	226.21	1.53	147.84
D1	183.41	1.17	156.76
D2	180.18	1.17	154.00
M1	179.37	1.12	160.15
M2	160.82	1.28	125.64

(A1, A2: crossed Alpine × Local; D1, D2: crossed Damascus × Local and M1, M2: crossed Murciana × Local).

After the 4 months age, the effect of the mode of birth on the curve of growth appears again the simple mode birth kids have clearly the heavier weights. At this age, the feed of the kid is not restricted any more with the mother's milk, but it includes, mainly, the vegetation consumed from the rangelands. It seems that even if the pastoral production is limited, it permits to the simple birth mode kids simple to achieve better performances than those of the double birth mode. Similar effects were announced by other authors (Najari et al., 2006).

Performance of dairy production

Analysis of the variance of dairy performances

Concerning the dairy performances of the production, the analysis of variance has led to coefficient of determination (R^2) varying from 89 to 96%. The analysis of the variance shows a highly significant effect ($p < 0.01$) of the genotype factor on the studied performances. For the environmental factors, of non genetic nature, the effect is announced highly significant for the year and the month of control. As for the factor "mode pregnancy", or number of kids born by pregnancy, the effect proves highly significant ($p < 0.01$) on the daily mean and non significant on the duration of lactation and the total production (Table 4). Thus, the observed variability at the level of the performances is partially attributed to differences in genetic nature (Najari, 2005).

The analysis of the variance (Table 4) shows the interdependence of the action of the genetic factors and the no heritable factors of the environment. Indeed, all studied interactions: genotype * year, genotype*months and genotype*mode of birth, show significant effects on the different variables, except for the mean daily production. Consequently, the various studied genetic groups express, in addition to the differences in performances, a variable behaviour according to the variation of the environmental factors. The favourable or unfavourable variation of an ambient factor corresponds to a variable behaviour for each genotype.

Comparison of means

Effect of the genotype

The performances of dairy production of the various genetic groups studied are presented in Table 5.

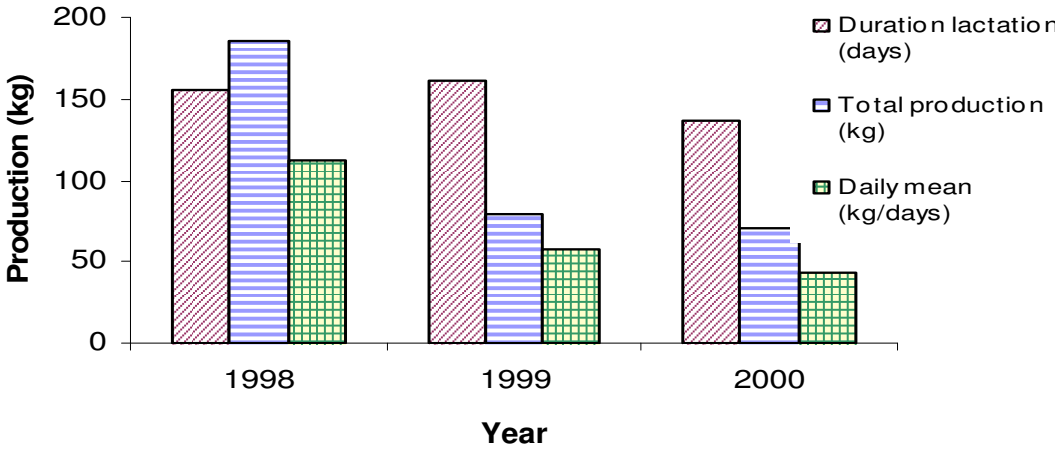

Figure 5. Effects of year on dairy performances of the local goats.

Among the pure races, the Alpine goat presents the best performances of mean dairy production with a total production of 276.34 kg during a period of more than 155 days and with a daily mean production of 1.78 kg/j, followed by Damascus with a total production of 203.27 kg during 163.44 days. The Murciana race has weaker performances since its total production is about 191 kg. However, this last race is characterized by its long period of lactation with 173 days. The local goat has the weakest performances, with a total production of 103 kg during approximately 130 days.

Within the genotypes resulting from the crossing, the cross Alpine goats confirm the superiority of their performances as compared to the other groups; their productions increase with the degree of absorption. Indeed, the productions by lactation of G1 (A × Lo) with G2 (A × Lo) were 227 kg and 249 kg milk respectively. The performances of the cross genotypes are all lower than those of the paternal pure races.

Effect of the year on the dairy performances

The Figure 5 shows the variation of the dairy performances in relation to the years of control. For thelocal goat, the weak mean performances plug the effect of the environmental factors.

Conclusion

The comparison of the pure races and the genetic groups cross shows that, the performances of the local goat remains weak whereas the ameliorative races knew a decrease of their production compared to that known in their country of origin. The Alpine race was distinguished both as pure and as crossed by the best performances in dairy production and growth of the kids. However, the comparison of performances of production remains insufficient to conclude about the bio economic interest of the choice from the ameliorative race. Indeed, other parameters of production like the reproduction and mortality need to be included to reach more valid conclusions on the level of the development of the goat breeding in the littoral oases. The important difference between the studied genotypes appears visible by studying the performances of the reproduction and of mortality. This could be explained by the interaction between genotypes and the environment.

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