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Differences in reproductive efficiency between female sheep of the Queue Fine de l'Ouest purebred and their first cross with the D'Man

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Abstract — Ovarian status at 8 months of age, attainment of puberty, fertility and litter size were compared for Queue Fine de l'Ouest (QFO) ewes and their D'Man × QFO contemporaries. At 8 months of age, the percentages of ewe lambs cycling as indicated by the presence of corpora lutea were 91.6 and 20.0% for the D'Man × QFO genotype and the QFO breed respectively ($P < 0.001$). In a second trial, the cumulative percentage of ewe lambs ovulating at least once up to 10 months of age were 54.5 and 6.2% for the D'Man × QFO genotype and the QFO breed respectively ($P < 0.01$). Breed of sheep had the most significant effect ($P < 0.001$) on fertility following early breeding of ewe lambs with values of 83.8 and 33.3% for animals of the D'Man × QFO genotype and the QFO breed respectively. For animals of the two breeds mated at either 18 or 30 months of age, lamb production increased by 0.29 lambs per ewe lambing in D'Man × QFO ewes as compared with QFO. It is concluded that crossing with D'Man improves reproductive performances of the native QFO ewes under semi-arid, grazing systems.

D'Man / Queue Fine de l'Ouest / crossbreeding / puberty / litter size

Résumé — Différences de performances de reproduction entre des femelles ovines de race pure Queue Fine de l'Ouest et croisées avec la race D'Man. Le fonctionnement ovarien à l'âge de 8 mois, l'avènement de la puberté, la fertilité et la taille de la portée ont été comparées chez des brebis de race Queue Fine de l'Ouest (QFO) et leurs congénères issues du croisement D'Man × QFO. À 8 mois, le pourcentage d'agnelles présentant un cycle ovulatoire, caractérisé par la présence de corps jaunes, a été de 91,6 et 20,0 % respectivement pour le génotype D'Man × QFO et la race QFO ($P < 0,001$). Jusqu'à l'âge de 10 mois, le pourcentage cumulé d'agnelles ovulant au moins une fois a été de 54,5 et 6,2 % pour le génotype D'Man × QFO et la race QFO respectivement ($P < 0,01$). La race de la brebis a eu un effet hautement significatif ($P < 0,001$) sur le pourcentage d'agnelles qui ont mis bas au terme d'une lutte précoce avec des taux de fertilité respectifs de 83,8 et 33,3 % pour le croisement D'Man × QFO et la race QFO. Pour les animaux accouplés à 18 et à 30 mois, une

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augmentation de 0,29 agneau par brebis ayant mis bas a été observée pour les femelles issues du croisement D'Man × QFO comparativement à celles de la race QFO. Le croisement avec la race D'Man a amélioré les performances de reproduction des brebis locales de race QFO dans des conditions de pâturage en zone semi-aride.

D'Man / Queue Fine de l'Ouest / croisement / puberté / taille de la portée

1. INTRODUCTION

The Queue Fine de l'Ouest breed, derived from the Ouled Djellal breed in the eastern highlands of Algeria, is one of the most important suckling sheep in western and central parts of semi-arid Tunisia. The breed is used in both extensive and more intensified systems and has been gaining importance over the traditional fat-tailed Barbarine breed during the last few decades. Statistics of the Tunisian Ministry of Agriculture [18] show that the proportion of Barbarine ewes has regressed from approximately 80% in the seventies to only 60.3% in 1995 while, corresponding figures are 9 and 34.6% for Queue Fine de l'Ouest females. Flock performances recorded between 1993 and 1997 by the Tunisian National Institute of Agricultural Research (INRAT, unpublished data) show that females of the Queue Fine de l'Ouest breed normally lamb for the first time at two years of age, reach an average adult body weight of 45–49 kg prior to the mating season, have a mean fertility of 89% and an average prolificacy of 119%. Measurements for adult ewes of the Queue Fine de l'Ouest breed over a period of 13 months give an inherent low ovulation rate of 1.16 ± 0.11 [17].

Obviously, there is a genetic explanation to this low prolificacy [5] but since it is known that flocks are mated in the spring (out of season), other factors such as the effect of season on ovulation rate [17] should not be discarded. Under semi-intensive production systems, it could be advantageous to rear a reproductively early maturing and more prolific breed than the local Queue Fine de l'Ouest breed. Previous studies in

many parts of the world have shown the possibility of promoting reproductive performances by crossing with prolific breeds such as the Finn [7], the Romanov [9, 19, 21] and the Booroola [10]. Much less information is, however, available on the use of the D'Man breed including a limited number of studies in Morocco, its native country [3]. The natural adaptation of the D'Man, a small-sized breed with an average body weight of 30–45 kg for adult ewes [4], to the prevailing conditions of the region gives it an advantage over other imported prolific breeds.

Most reports compiled by Boujenane [4] stress the interesting reproductive characteristics of the D'Man. Young females reach puberty at an average age of 212 days [6], ewes exhibit cyclic ovarian activity year round [13] and their litter size (averaged over several studies) is 1.90 [4].

The present study was therefore aimed at investigating puberty and reproductive efficiency of Queue Fine de l'Ouest (QFO) and D'Man-crossed (D'Man × QFO) ewes under a predominantly grazing system.

2. MATERIALS AND METHODS

2.1. Animals and location

The three experiments described here were carried out using ewe lambs, 18 and 30 month-old ewes of the QFO breed and their D'Man × QFO contemporaries. They were conducted at the experimental farm of the École Supérieure d'Agriculture du Kef (latitude: 35°7' N, average annual rain fall: 367 mm, mean temperatures: 7.3 °C and

Table I. Successive use of groups of animals in the different experiments (number of animals).

Group of animals	Year of birth (Y)	Y + 1	Y + 2	Y + 3
1	1995	Exp. 1 (27)	Exp. 3 (23)	Exp. 3 (23)
2	1996	Exp. 3 (27) Exp. 3 (52)	Exp. 3 (44)	Exp. 3 (44)
		↑ Early breeding	↑ Reproduction at 18 months	↑ Reproduction at 30 months
3	1997	Exp. 2 (27)		

29.6 °C respectively in January and July). In many instances, the same groups of animals were used in different experiments as described in Table I. In all experiments and unless otherwise stated, animals permanently grazed barley pastures or cereal stubble in the summer.

2.2. Experiment 1: Ovarian status at 8 months of age

In early July 1996 and at the average age of 245 ± 24.0 days, 15 ewe lambs of the QFO breed and 12 of their D'Man × QFO contemporaries born between late October and early December 1995 were selected in a preliminary attempt to assess differences in early reproductive maturity. From birth and until shortly after weaning, which took place at approximately 5 months of age, the animals were weighed every 21 days. Ovarian status, assessed by the presence of corpora lutea (CL) and ovulation rate, were determined by laparoscopy on animals of the two breeds on the same day.

2.3. Experiment 2: Occurrence of the first ovulation and attainment of puberty

The initiation of ovarian activity as indicated by the presence of CL was determined

between early April and late July 1998 in 16 and 11 ewe lambs of respectively the QFO breed and the D'Man × QFO genotype born the previous autumn in late September and October 1997. The animals were weaned on March 15th and thereafter were put together in a single flock. A series of laparoscopies were carried out on all females of the two breeds from the age of six to 10 months at 25 to 30 day intervals. Puberty was defined by the development of one or several functional CL and also the establishment of cyclicity through inspection of ovaries in the subsequent laparoscopy.

2.4. Experiment 3: Reproductive performances during early breeding and at 18 and 30 months of age

For early breeding, the observations were carried out over 2 years on female sheep born in the autumn. Pooled data are presented here. The sheep used were the same that served in experiment 1 and another group that was available the subsequent year, that is in August 1997. A total of 42 and 37 ewe lambs of respectively the QFO breed and the D'Man × QFO genotype were included. During each of the two years, animals of the two breeds were managed

together in a single flock and pregnant females were supplemented with 0.5 kg hay and 0.25 kg barley-based concentrate (14% crude protein content) per head per day during late pregnancy and early lactation, a period that coincides with winter time and a shortage of grass. Starting on the 1st of August of each year and for a mating period of 45 days, females of the two breeds, 8 to 9 months old, were put with rams of the Swiss blackbrown mountain sheep breed. The age in days, live weight at mating, the incidence of lambing and the number of lambs born were recorded.

For matings at 18 and 30 months of age, the two groups of animals used in the early breeding experiment were available. Animals in each of the two groups were mated at 18 months of age and then one year later when they were 30 months old. In total, thirty-six and thirty-one sheep of respectively the QFO breed and the D'Man × QFO genotype were used and pooled data on both groups and both mating ages is presented here. At each mating occasion, starting on April 15th and lasting 70 days, animals of the two breeds were put in the same flock and were put with rams of the Swiss blackbrown mountain sheep and Black of Thibar breeds. In mid-August, the animals were supplemented with 0.5 kg hay and 0.25 kg barley-based concentrate (14% crude protein content) per head per day until mid-February. Live weight at mating, the incidence of lambing and the number of lambs born were recorded.

2.5. Statistical methods

The data on the proportion of ewe lambs exhibiting ovarian activity or attaining puberty and the data on ovulation rate were analysed using a χ^2 test.

Data on fertility and litter size were initially analysed by a method involving logit transformation and simultaneous analysis of the effect of different factors (breed, live weight at mating, age at mating, etc.) in the form of an analysis of deviance [2] using the statistical package GLIM version 3.77 (1985 Royal Statistical Society, London). Chi-square analysis was then used to examine differences. All values are presented as means \pm s.e.

3. RESULTS

3.1. Experiment 1:

Ovarian status at 8 months of age

All animals gained weight and in late April, the average live weights were 32.8 ± 1.9 and 27.1 ± 3.4 kg for the QFO breed and the D'Man × QFO genotype respectively. For the two breeds, animals with the presence of CL and those with twin ovulations are given in Table II.

Percentages of ewe lambs with the presence of CL on their ovaries were 91.6 and 20% for the D'Man × QFO genotype and the QFO breed respectively ($P < 0.001$). Only one sheep in the D'Man × QFO

Table II. The number (percentage) of animals with CL and yielding twin ovulations in 8-month old ewe lambs of the QFO breed and the D'Man × QFO genotype.

	QFO	D'Man × QFO
Number of sheep	15	12
Number of sheep with CL (%)	3 (20) ^a	11 (91.6) ^b
Animals with twin ovulations	1	4

^{a, b} Values with different superscript within rows are significantly different.

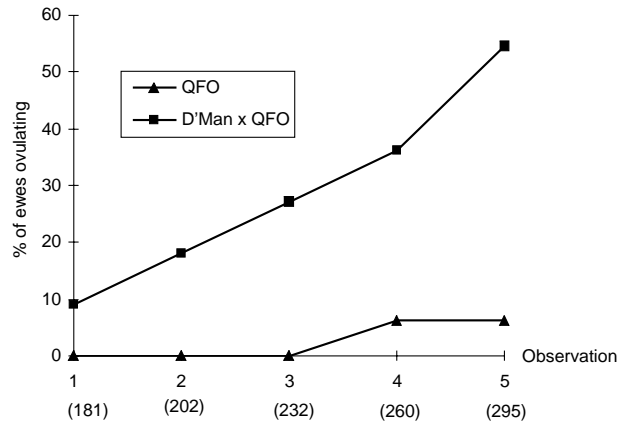


Figure 1. Cumulative percentages of females ovulating for the first time; () average age in days.

crosses did not have CL; it was the ewe lamb with the lowest (21.2 kg) live weight in late April. No significant differences occurred in the percentage of animals with twin ovulations.

**3.2. Experiment 2:
Occurrence of first ovulation
and attainment of puberty**

The cumulative percentages of ewe lambs ovulating for the first time are shown in Figure 1. Out of the 16 sheep of the QFO breed involved in the comparison, only one ewe lamb ovulated once between early April and late July and yielded one CL in comparison to 6 out of 11 females for the D'Man × QFO genotype ($P < 0.01$). In these six sheep, 5 attained puberty at the average age of

224 ± 38.0 days yielding an average 1.4 CL per ewe and the remaining sheep ovulated for the first time at the last laparoscopy in late July at the age of 273 days. The only sheep in the QFO breed that ovulated did not carry on cyclic activity and in subsequent laparoscopies only large follicles were visible on its ovaries.

**3.3. Experiment 3:
Reproductive performances
during early breeding and at 18
and 30 months of age**

Table III shows overall values and differences between the two breeds in live weight at mating, age at mating, the number of sheep lambing and mean litter size of ewe lambs mated at an early age.

Table III. Live weight and age at mating, number of sheep (percentage) lambing and mean litter size of early bred females.

	QFO	D'Man × QFO	Overall
Number of sheep joined	42	37	79
Live weight (kg)	32.6 ± 2.77	29.6 ± 2.48	31.2 ± 3.03
Age (days)	289 ± 17.9	279 ± 17.4	284 ± 18.2
Number of sheep lambing (%)	14 (33.3)	31 (83.8)	45 (56.9)
Mean litter size	1.07 ± 0.26	1.26 ± 0.44	1.2 ± 0.40

Forty-five of the 79 ewe lambs put with the rams, yielded lambs with an average litter size of 1.2 ± 0.40 . An analysis of the factors influencing the percentage of sheep lambing was carried out using a method involving logit transformation. The factors examined were the breed of ewe, its age and its live weight at mating. The results of the analysis of deviance are shown in Table IV.

It can be seen that the breed had the largest and most significant effect upon the proportion of sheep lambing. The breed \times age at mating interaction also had a significant effect with figures averaging 298 ± 16.6 and 284 ± 16.9 days old for respectively the lambing and barren sheep of the QFO breed. In the case of the D'Man \times QFO genotype, no differences were recorded between the lambing and barren sheep which were respectively aged 279 ± 18.2 and 280 ± 14.0 days old at mating. In

contrast, the effect of live weight at mating was only noticeable in the case of the D'Man \times QFO crosses with respectively 30.1 ± 2.07 and 26.6 ± 2.40 kg of live weight for the lambing and barren sheep. Corresponding figures for the QFO breed were 32.7 ± 2.77 and 32.6 ± 2.82 kg.

Concerning reproductive performances following matings at 18 and 30 months of age, data on the number of sheep lambing and litter size are shown in Table V.

A higher proportion of ewes in the D'Man \times QFO genotype lambed in comparison to their contemporaries of the QFO breed, although the difference was not statistically significant. However, litter size was a measure for which the difference is statistically significant being 1.43 ± 0.50 and 1.14 ± 0.35 for the D'Man \times QFO crosses and the QFO pure-breds respectively ($P < 0.05$).

Table IV. Analysis of deviance table to examine the effects of various factors on the proportion of ewe lambs lambing.

Source	df	Deviance	Significance (χ^2 tables)
Breed	1	21.71	***, ($P < 0.001$)
Age at mating	1	3.51	NS
Live weight at mating	1	4.22	*, ($P < 0.05$)
Breed \times age at mating interaction	1	3.95	*, ($P < 0.05$)
Breed \times live weight at mating interaction	1	6.10	*, ($P < 0.05$)
Residual	73	68.49	
Total	78	107.98	

Table V. Number of sheep lambing (percentage) and litter size of 18 and 30-month old ewes of the QFO breed and the D'Man \times QFO genotype.

	QFO	D'Man \times QFO
Number of ewes joined/mating age	36	31
Live weight at mating (kg)	45.7 ± 5.72	40.5 ± 5.88
Number of ewes lambing* (%)	28 (77.7) ^a	28 (90.3) ^a
Mean litter size	1.14 ± 0.35^a	1.43 ± 0.50^b

^{a, b} Values with different superscript within rows are significantly different.

* Average number at each mating age.

4. DISCUSSION

The results indicate that crossing the local QFO breed with the D'Man produced a reproductively earlier maturing sheep as determined by ovarian status at 8 months of age or the percentage of autumn-born ewe lambs ovulating for the first time until late July. Furthermore, major differences between the two breeds occurred in ewe lambs conceiving following early breeding and as indicated by our results on the functioning of ovaries; this probably reflects differences in the percentage of ewe lambs cycling, not in the conception of ewes that were mated. Similar results are also reported by Young et al. [22] in their review on the comparison of prolific crosses to non-prolific crosses and pure-breds in North America. This hypothesis on cyclicity is further confirmed by differences, though not statistically significant, in fertility between the two breeds following matings at 18 and 30 months of age. These matings took place in the spring (out of season breeding) and a fertility of approximately 78% in the case of the QFO breed could reflect the effect of deeper seasonal anoestrus in 18 and 30 month old females as compared to adult animals. This fertility only reached 66% for the group of females that lambed following early breeding ($n = 14$) and no single case of twinning was recorded. The depressed fertility of only 76% reported by INRAT (unpublished data) for 18 month old QFO ewes between 1993 and 1997 lends support to our conclusion. Ewes of the D'Man × QFO genotype are perhaps less sensitive to these effects. Moreover, most of the cross-bred sheep that were mated at 18 months of age lambed and suckled their lambs for at least a month and a half following early breeding with apparently no detrimental effects. Globally, these results stand for the positive effect of D'Man genes on the different components of fecundity [15] which could be related to a low sensitivity of prolific breeds to a negative feedback effect of oestrogens [16].

Despite the postulated importance of live weight as a factor affecting the attainment of puberty [12], the D'Man × QFO ewe lambs exhibited an earlier ovarian activity than QFO females and at lighter weights. Similar results are reported by Dickerson and Laster [7] for the Finn crosses with a major effect of the breed of sheep. Hare and Bryant [11] also claim that sheep that did have Finnish Landrace genes are generally precocious.

Based on the preliminary results of the ovarian status at around 8 months of age, we expected higher percentages of females attaining puberty by early August particularly for the D'Man × QFO sheep. This was not the case since only 54.5% and 6.25% of the sheep ovulated at least once until late July respectively for the D'Man × QFO genotype and the QFO breed. Possibly, live weight is important here and ideally, our observations on the timing of first ovulation should have included a monitoring of live-weight change during the course of our control period. This conclusion finds strength when comparing live weights at weaning between experiments 1 and 2. Animals in experiment 2 were a few weeks older at weaning (early March) than those used in experiment 1 and their live weights averaged 23.8 ± 2.65 and 21.5 ± 2.98 kg respectively for the QFO breed and the D'Man × QFO genotype. Corresponding figures were 27.9 ± 1.95 and 24.3 ± 2.05 kg for animals in experiment 1. Between year differences in growth performances are indicative of an important year effect under prevailing semi-arid conditions.

The mean ovulation rate in experiment 1 was not different in young female sheep of the two breeds. Some caution is however called for in drawing further conclusions because of the low number of QFO animals found cycling and the bias caused by one sheep of this breed that yielded twin ovulations. When combining information on ovulation rate of the 11 D'Man × QFO sheep in experiment 1 and the 5 sheep that reached puberty in experiment 2, we could

set, the mean ovulation rate of 8-month old ewe lambs of the D'Man \times QFO genotype at 1.4.

Litter size at birth was approximately 0.19 lambs larger for the D'Man \times QFO than for the QFO ewe lambs. Although not statistically significant, this result suggests that the twinning potential of the D'Man breed is already expressed in young animals of the first cross of D'Man with native QFO animals. Similarly, Lahlou-Kassi et al. [14] reported an increase of only 22% in prolificacy of the 10 month old D'Man \times Sardi ewe lambs over their contemporaries of the non-prolific Sardi mountain breed of Morocco. It seems however, that larger improvements in litter size are obtained for first cross ewe lambs when using the prolific Finnish Landrace breed [8] and this is largely due to differences in the ovulation rate being superior for the Finn (4.2 as reported by Scaramuzzi and Land [20]) as compared to the D'Man breed.

The beneficial effect of crossing with the D'Man on litter size was more marked in 18 and 30 month old sheep with a 29% increase in prolificacy for the cross-bred animals. While it contributes to raising the lamb output per ewe, this relatively mild increase of prolificacy can be handled by farmers under the production system studied. Our figures are higher than those obtained in another Moroccan study involving D'Man and the non-prolific Timahdit breed with the F1 cross producing 14% more lambs born per ewe than did the pure Timahdit under a system of one lambing per year [1]. In another Moroccan study, up to 1.76 lambs per lambing sheep were reported for 20 month-old Sardi \times D'Man crosses [14] and differences between our results and those obtained in Morocco could be partly explained by differences in the twinning potential of the QFO, Timahdit and Sardi breeds.

In conclusion, the present study demonstrated that first-cross sheep between the D'Man and the QFO exhibited improved

reproductive performances when compared to the QFO pure-breds. This is reflected in their early attainment of puberty, high fertility and increased twinning potential.

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