Reprod. Nutr. Dev. 38 (1998) 551–558

Original article

Reproductive and productive performance in Chios ewes mated in spring or in autumn

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(Received 20 December 1996; accepted 5 October 1998)

Abstract — One hundred and sixty adult ewes of the Chios breed were divided randomly into two groups. One group was used for breeding in spring (S) and the other in autumn (A). In both groups oestrous behaviour was detected once a day. Ovulatory activity, 7 d after oestrus, fertility, prolificacy, embryo mortality, birth weight of lambs and milk production were recorded. The percentage of ewes which exhibited oestrous behaviour was 92 and 100 % in S and A groups, respectively, while fertility of mated ewes was 98 and 100 %. Ovulation rate was significantly lower in S than in A ewes (M ± sd; 2.85 ± 1.07 versus 3.44 ± 1.45, respectively, $P < 0.0001$). However, prolificacy did not differ between the two groups (2.04 ± 0.77 versus 2.13 ± 0.85, for S and A ewes, respectively) as it did not increase after an ovulation rate of 4.0. There were no differences in birth weights (except for triplets) but total milk production was significantly higher in S ewes (257.5 ± 100.7 kg versus 153.0 ± 51.9 kg, for S and A, respectively, $P < 0.001$). These results suggest that despite a higher ovulation rate in autumn, higher embryonic mortality at this time of the year leads to equivalent fertility, prolificacy and birth weight in spring as in autumn. © Inra/Elsevier, Paris.

Chios ewes / reproductive performance / productive performance / fertility / prolificacy / birth weiglet

Résumé — Performance de reproduction et de production de brebis Chios en lutte de printemps ou d'automne. Cent soixante brebis adultes de race Chios ont été reparties au hasard en deux groupes. Un groupe est lutté au printemps (P), l'autre en automne (A). Dans les deux groupes, le comportement d'œstrus est détecté une fois par jour. Le taux d'ovulation (7 j après l'œstrus), la fertilité, la prolificité, la mortalité embryonnaire, le poids de naissance des agneaux et la production laitière sont enregistrés. Le pourcentage de brebis manifestant un comportement d'oestrus n'est pas différent entre saisons (P : 92 % ; A : 100 %), et la fertilité des brebis saillies est identique (P : 98 % ; A : 100 %). Le taux d'ovulation est significativement plus faible au P qu'en A (M ± sd ; 2,85 + 1,07 versus 3,44 ± 1,45, respectivement, $p < 0,0001$). Toutefois, la prolificité n'est pas significativement différente entre

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saisons (2,04 ± 0,77 versus 2,13 ± 0,85, respectivement), du fait que celle-ci ne continue pas à s'accroître au delà d'un taux d'ovulation de 4,0. Il n'y a pas de différence de poids de naissance des agneaux (sauf pour les triplés), mais la production laitière totale est plus importante pour le groupe P que pour le groupe A (257,5 ± 100,7 kg versus 153,0 ± 51,9 kg, respectivement, $p < 0,001$). Ces résultats suggèrent qu'en depit de taux d'ovulation élevés à l'automne, l'accroissement de la mortalité embryonnaire conduit à des fertilité, prolificité et poids de naissance équivalents au printemps et à l'automne. © Inra/Elsevier, Paris.

brebis de Chios / performance de reproduction / performance de production / fertilité / prolificité / poids de naissance

1. INTRODUCTION

Reproductive performance in sheep is limited by a long inter-lambing interval, by periods of seasonal and post-partum anoestrus and by low ovulation rate (OR).

In the Mediterranean basin, most breeds present a seasonality in their reproductive activity. Spontaneous ovulatory activity stops at end of winter. Oestrous behaviour and ovarian activity recommence from late spring to the beginning of summer. This low seasonality of reproductive activity allows most Mediterranean breeds of ewes to be mated between the end of spring and mid-summer in addition to the autumn [5, 12].

Chios ewes have a high ovulation rate which varies with season (M ± sd; spring: 2.3 ± 0.33, autumn: 4.09 ± 0.24; [2]) and high prolificacy (2.45 lambs per lambing; [1]). Seasonality appears to be low in spite of the presence of a period of decreased sexual activity in April and May. In traditional Chios sheep flocks, breeding period begins at the end of May when the sexual activity of ewes, and especially ovulation rate, is at its lowest level in the year [2].

Thus, the aim of the present study was to compare the reproductive and productive performances of Chios ewes mated in spring (traditional period of matings) to the performance of those mated in autumn (when ovulatory activity is at its maximum).

2. MATERIALS AND METHODS

2.1. Animals and experimental design

One hundred and sixty mature (≥ 2 years, weight: 65–70 kg) Chios ewes maintained at Agricultural Research Station (Chalkidiki, Greece) were selected randomly and used in this study. Ewes were separated into two groups: S ($n = 80$), for breeding during the traditional breeding season (onset of matings at the end of spring) and A ($n = 80$), for breeding during the autumn (period of the highest ovulation rate; Avdi et al. [2]).

Both groups were kept under the same feeding and management conditions: permanent sheep barns (with identical feeding of hay plus concentrate between the two seasons), except pasture in the afternoon around the experimental station. Oestrus detection using rams was carried out for the S group from 21 May to 15 July and for the A group from 21 October to 15 December.

In both groups oestrous behaviour, fertility, prolificacy, ewe weight at mating (kg), embryonic mortality, birth weight (kg) and lactation were recorded.

Lambs were weaned at 42 d old. Ewes were dried off about 2 months before the next lambing.

2.2. Detection of oestrus and measurement of ovulatory activity

Oestrous behaviour was detected once a day (in the morning between 0800 and 1100 hours) using Chios rams selected for the high expression of their sexual behaviour. Standing of female and mounting by the male were considered as

characteristics of oestrous behaviour [7]. All ewes following the detection of oestrus, under visual control, were mated twice (in the morning between 0800 and 1100 hours) by fertile rams. Total duration of oestrous behaviour was not recorded.

The ovulation rate was measured 7 d following mating by laparoscopy [15]. One cycle later oestrous behaviour was detected again for control of returns.

All animals were left undisturbed until parturition when litter size was recorded. After autumn mating, 26 ewes were eliminated before lambing, for health reasons.

2.3. Definition of parameters

1) The percentage of oestrous behaviour was defined as the number of females exhibiting oestrus in relation to the number of females in the flock that were introduced to the rams.

2) The percentage of fertility at the first oestrus was defined as the number of females which lambed or aborted in relation to the number of females which had been mated.

3) The ovulation rate was defined as the number of corpora lutea (CL) in relation to the number of females which ovulated.

4) The prolificacy was defined as the number of lambs born in relation to the number of females which delivered.

5) The percentage of embryonic mortality was measured as the difference between OR at mating and litter size at birth, for females which lambed, and only for them.

2.4. Statistical analysis

Differences in percentages (exhibition of oestrus and fertility, ovulation rate, prolificacy and embryonic mortality) were subjected to Chi^2 analysis. Comparisons of weight at mating, birth and weaning weight, milk production and duration of lactation in the two reproductive periods were carried out by *t*-test. Results are presented as means ± sd.

3. RESULTS

3.1. Reproductive parameters

There was no effect of season on the percentage of ewes exhibiting oestrus (92 % versus 100 %, for groups S and A, respectively; *table I*). The distribution of oestrus, after the onset of mating differed between seasons and is presented in *figure 1*. In spring, about 40 % of ewes exhibited oestrus for the 20 d following the introduction of rams, while in autumn more than 75 % of ewes exhibited oestrus during the first 20 days following the introduction of rams.

The proportions of ewes not returning to oestrus, and therefore assumed to be pregnant following mating, were similar in spring (98 %) and in autumn (100 %). Fertility in ewes mated during spring was identical to that in autumn (98 % versus 100 %, *table I*).

Table I. Effect of season on oestrous behaviour, fertility, ovulation rate and prolificacy of Chios ewes mated in spring and autumn.

Season of mating	Number of animals	Oestrus (%)	Fertility (%)	Ovulation rate (M ± sd)	Prolificacy (M ± sd)
Spring	80	74/80 (92)	73/74 (98)	$2.85^a \pm 1.07$ ($n = 74$)	2.04 ± 0.77 ($n = 67$)*
Autumn	80	80/80 (100)	80/80 (100)	$3.44^b \pm 1.45$ ($n = 80$)	2.13 ± 0.85 ($n = 54$)**

[a, b] $P < 0.0001$.

* Seven ewes aborted before term.

** Twenty three animals were eliminated before lambing for health reasons and three ewes aborted before term.

There was a significant effect of season in ovulation rate measured 7 d after mating. Ovulation rate was significantly higher in the autumn group of ewes than in the spring group of ewes (3.44 ± 1.45 versus 2.85 ± 1.07, $P < 0.001$, *table I*). The seasonal difference in mean ovulation rates originated in a higher frequency of ewes present in the classes 1, 2 and 3 ovulations in spring, and in a higher frequency of ewes present in the classes 4, 5, 6 and 7 ovulations in autumn (*figure 2*).

The relationship between ovulation rate and prolificacy in spring and autumn is shown in *figure 3* and indicates that prolificacy did not increase beyond an ovulation rate of 4.0, irrespective of the season. No significant effect of season was detected on embryonic mortality.

There was no significant effect of season on prolificacy of Chios ewes between spring and autumn (2.04 ± 0.77 versus 2.13 ± 0.85, for groups S and A, respectively, *table I, figure 4*).

3.2. Productive parameters

There was no difference in ewe weight at mating between the two groups (*table II*).

The birth weight of lambs was similar between the two seasons and there were no differences in birth weight of singles, twins or > 3 lambs. However, a slight difference ($P < 0.05$) was observed in birth weight of triplets. There was no effect of season on the weaning weight of lambs (*table II*).

There was a significant effect of season on milk production and duration of lactation in Chios ewes ($P < 0.001$). Milk production, following weaning at 42 days, was higher in spring than in autumn because

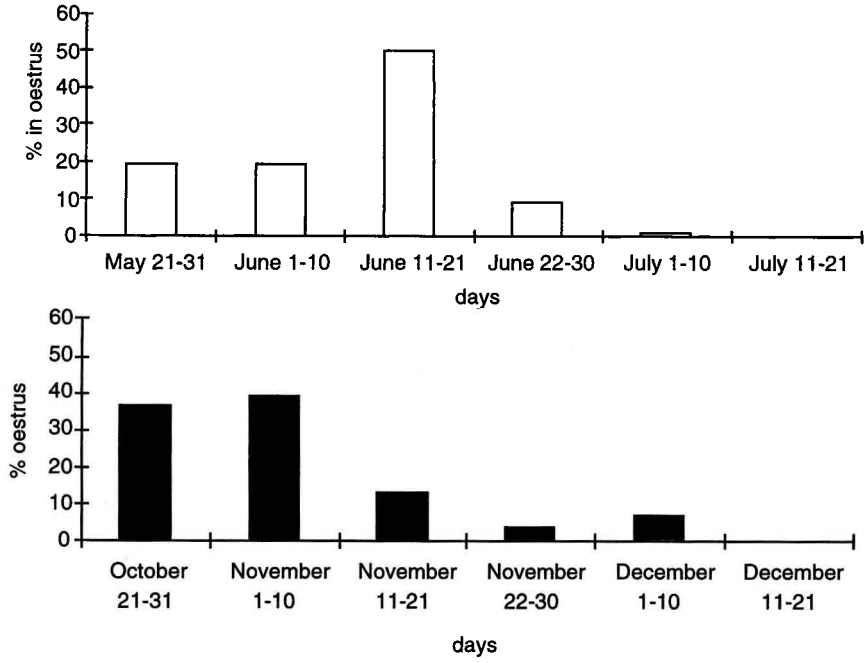

Figure 1. Distribution of first oestrus (%) in Chios ewes after spring (open bars) and autumn (closed bars) joinings.

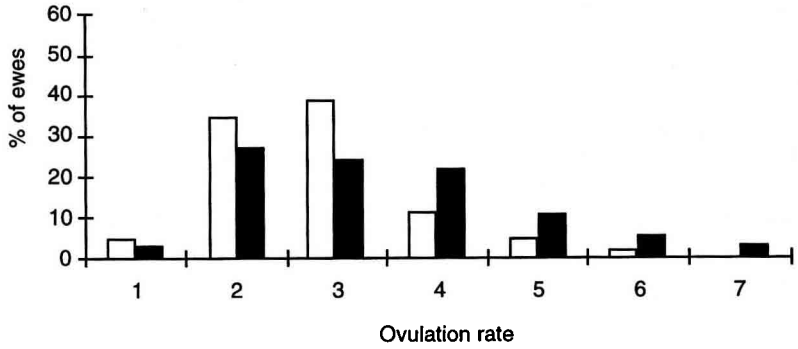

Figure 2. Effect of season on distribution of ovulation rates in Chios ewes mated in spring (open bars) and autumn (closed bars).

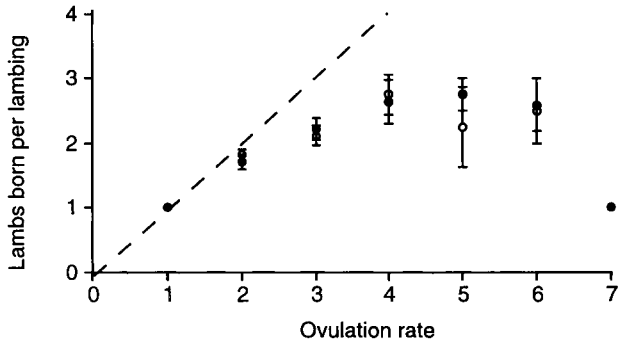

Figure 3. Relationship between ovulation rate and mean prolificacy (± sd) of Chios ewes mated in spring (open circles) and autumn (closed circles). Dashed line indicates a theoretical linear increase between ovulation rate and prolificacy of one lamb born per ova shed.

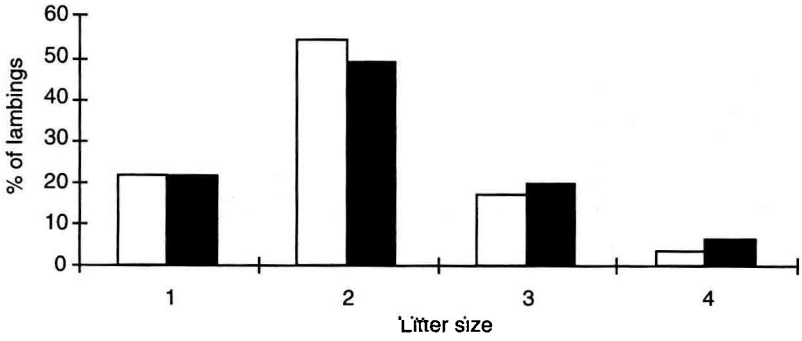

Figure 4. Effect of season on prolificacy of Chios ewes mated in spring (open bars) and autumn (closed bars).

Table II. Effect of season on mating weight of Chios ewes mated in spring and autumn and birth weight and weaning weight of lambs born.

Season of mating	Weight at mating (kg) (M ± sd)	Birth weight (kg) (M ± sd)				Weaning weight (kg) (M ± sd)
		Single	Twins	Triplets	Quadruplets	
Spring	61.12 ± 7.22 (n = 74)	4.38 ± 0.65 (n = 15)	7.90 ± 1.25 (n = 36)	10.70[a] ± 1.32 (n = 11)	11.83 ± 1.83 (n = 3)	15.03 ± 2.57 (n = 130)*
Autumn	63.88 ± 9.24 (n = 80)	4.08 ± 0.90 (n = 9)	7.41 ± 1.26 (n = 24)	8.74[b] ± 1.62 (n = 7)	12.65 ± 1.20 (n = 2)	14.56 ± 2.88 (n = 80)**

[a, b] $P < 0.05$.
* Two lambs were dead before weaning.
** Six lambs were dead before weaning.

duration of lactation was 103 days longer (*table III*). However, there was no statistical difference in milk production at first 100 d of lactation after weaning between the two groups (154.6 ± 45.0 kg versus 143.9 ± 40.4 kg, for S and A, respectively).

4. DISCUSSION

This is the first report comparing two seasons of mating in Chios ewes. This was achieved by comparison of reproductive and productive performance between two breeding seasons: spring (21 May–15 July) and Autumn (21 October–15 December).

The main conclusions of this study are:

1) there is an effect of season on the ovulation rate in Chios ewes, with a higher ovulation rate in autumn than in spring;

2) the observed higher ovulation rate in autumn is not followed by increased prolificacy due to higher embryonic mortality at ovulation rates higher than 4.

The first conclusion is in agreement with the earlier report of Avdi et al. [2] in Chios ewes. This breed presents a significant variation in ovulation rate during the year. A higher ovulation rate in autumn is also found in this study.

In contrast, the second finding was surprising, because the higher ovulation rate in autumn was not followed by a higher prolificacy. This can be explained by the higher embryonic mortality observed for the highest ovulation rates recorded in autumn. In fact, embryonic mortality seems to be the most important factor determining prolificacy, after the threshold of four ovulations per ewe is reached. Our results show that prolificacy increases proportionally with the ovulation rate in spring as well as in autumn for Chios ewes but only until the threshold of 4. More specifically, as the ovulation rate increases from 1 to 4, we observe a consistent increase in the number of lambs born. When the ovulation rate is higher than 4, the number of lambs born per lambing

Table III. Effect of season on total milk production and duration of milk production of Chios ewes mated in spring and autumn.

Season of mating	Total milk production (kg) (M ± sd)	Milk production during the first 100 d of lactation (kg) (M ± sd)	Total duration of milk production in days (M ± sd)
Spring	$257.5^{a} \pm 100.7$ ($n = 51$)	154.6 ± 45.0 ($n = 51$)	$214.4^{a} \pm 61.8$ ($n = 51$)
Autumn	$153.0^{b} \pm 51.9$ ($n = 44$)	143.9 ± 40.4 ($n = 44$)	$110.9^{b} \pm 22.9$ ($n = 44$)

$^{a, b}$ $P < 0.001$.

remains stable. Similar results were reported by Cognié and Scaramuzzi [3], in Merinos ewes. Hanrahan and Quirke [4] have also shown that the litter size increases proportionally with the number of ovulations until the uterine capacity becomes the most limiting factor.

These results are also in agreement with those from Murrey et al. [8] who suggested that this embryonic mortality is caused by genetic anomalies or by an unfavourable uterine environment for embryonic development. Such an unfavourable uterine environment may have various origins. This embryonic mortality could be avoided or reduced according to Pearce et al. [11] and Peterson et al. [13] by administration of progesterone 5 to 15 d after mating. However, others disagree with regard to the efficiency of this treatment [14]. According to Parr et al. [10] this controversy is partly due to the interactions between the nutrition level of the treated ewes and the metabolism of progesterone.

The dispersion of oestrus exhibition was higher in spring than in autumn. This is in agreement with previous results [2] and was probably the consequence of the ewe's response to a 'ram effect' after spring joining, at least for some of the ewes. This moderately strong 'ram effect' in the spring mated ewes, which can be seen in *figure 1*, provokes the splitting of ewes into at least three groups in the appearance of oestrous behaviour. This dispersion could be explained by the occurrence of silent ovulations and of short ovulatory cycles in response to the 'ram effect' [6]. This is considered as an important remark for applied intensive breeding conditions.

Although milk production at first 100 d after weaning was similar in both groups, total milk production and duration of lactation were affected by breeding season in Chios ewes, with the highest values observed after spring mating. The early lambings of S group, at the end of the autumn (compared to late ones of the A group) are responsible for the increased milk production and the longer duration of lactation. The weather conditions in early spring in Greece are an advantage for mid lactation ewes, as the availability of pastures can support increased milk production thus explaining the difference between the two groups [9].

In conclusion, there is a season effect on ovulation rate but not on prolificacy. The traditional mating period for Chios ewes in spring seems, consequently, preferable to that of autumn. In order to plan more intensive breeding schemes for the Chios breed further research is needed on the causes of embryonic mortality for high ovulation rates.

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