Seasonal effects on puberty and reproductive characteristics of female Chios sheep and Damascus goats born in autumn or in February

C. Papachristoforou*, A. Koumas, C. Photiou

Agricultural Research Institute, P.O. Box 22016, Nicosia, Cyprus

Received 11 August 1999; accepted 27 March 2000

Abstract

Ten Chios ewe lambs and 10 Damascus she-kids born in October–November and similar numbers born in February along with eight multiparous females from each species, were used to examine pubertal events and reproductive seasonality. Reproductive activity was monitored by determining serum progesterone concentrations once a week for 12 months. The mean date of onset of ovulation (puberty) in autumn-born Chios females (7 August) was earlier ($p<0.05$) than in February-born ones (11 September) though the onset of regular cyclicity was not significantly different between the two groups (30 August and 19 September, respectively). The age and live weight at puberty in autumn-born females was higher ($p<0.01$) than in February-born ones, the respective values being 43.3 weeks and 50.1 kg, versus 29.9 weeks and 42.0 kg. All animals, irrespective of time of birth, started ovulating after the summer equinox. Multiparous Chios ewes had reproductive cycles covering most time of the year with acyclic periods during spring and summer. In ewe lambs, about half of the animals ceased cycling during the second half of winter and in spring, while the rest continued cycling. The total number of cycles detected over the experimental period was lower ($p<0.05$) for February-born ($n=9.4$) compared with autumn-born females ($n=13.7$) and adult ewes ($n=17.1$). In Damascus she-kids born in autumn or in February, onset of puberty was at the same time in the following autumn, the respective mean date for the two groups being 1 November and 27 October. For autumn-born animals, age (48.4 weeks) and live weight (53.8 kg) at puberty were higher ($p<0.01$) than for those born in February (37.3 weeks, 42.9 kg). Reproductive cycles in adult goats started in the second half of September and continued until the end of March. Most young goats (75%) had their last seasonal cycle in February and the rest in March. The total number of cycles was higher ($p<0.01$) in adult ($n=8.1$) than in young goats born either in autumn ($n=6.3$) or in February ($n=5.7$). It is concluded that reproductive development and puberty in Chios female sheep are mostly under seasonal influences though age and body weight are also contributing factors. This breed has a long reproductive season with some animals cycling throughout the year. The Damascus female goat is strictly seasonal with distinct periods of reproductive cyclicity and inactivity. Puberty attainment of Damascus females born in autumn or in February is at the same time the following autumn. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Chios sheep; Damascus goats; Puberty; Season

1. Introduction

Young female sheep and goats attain the ability to breed for the first time in their life during the adult
breeding season. However, reproductive cycles start later and the breeding season is shorter in pubertal ewes (Hafez, 1952) and goats (Trodahl et al., 1981) than in adults of the two species. Reproductive development is affected by genetic and environmental factors and the interaction between these factors (Land, 1978). Breed differences exist for age at puberty or age at first parturition (Dyrmundsson, 1981; Devendra and Burns, 1983); there is also evidence for interbreed genetic variation for age at puberty (Bradford et al., 1991). Photoperiod is the primary environmental factor controlling seasonal reproduction not only in sheep and goats but also in many other mammalian species (Turek and Campbell, 1979). Depending on the time of the year lambs and kids are born, they experience different photoperiodic stimuli and, therefore, age at puberty differs according to the season of birth. Provided body growth is not affected by food restriction, ewes born in spring or autumn reach puberty during the first autumn following their birth (Foster, 1981). Chios sheep and Damascus goats imported to Cyprus some 50 years ago are presently the predominant small ruminants. The Chios lambing season extends from October to March and the Damascus kidding season from November to April (Mavrogenis, 1988). Age and date of first ovulation and first oestrus in Chios ewe lambs born in November were 41 weeks and 30 August, and 46 weeks and 30 September, respectively (Bizelis et al., 1990). These results were obtained in the presence of rams and it is known that puberty in ewe lambs is affected by male stimulation (Oldham and Gray, 1984; Kassem et al., 1989). Information on puberty and seasonality of the Damascus goat in Cyprus is lacking.

The aim of the present work was to examine in female Chios sheep and Damascus goats born in two different seasons, the onset of puberty and the length of their first reproductive season in comparison with seasonal cyclicity of adult animals.

2. Materials and methods

2.1. Animals

The study was conducted at the Athalassa sheep and goat experimental farm of the Agricultural Research Institute (latitude 35°10’N), Nicosia. Chios ewe lambs and Damascus she-kids born in October–November or in February, along with eight adult females of each breed were used. The number of young animals in each group was 10, and groups were kept separately from each other in open-yard sheds. All adult animals were randomly chosen among those that had a normal parturition during the previous lambing/kidding season and they were fed according to maintenance requirements. Lambs and kids had voluntary intake of concentrates until 100 days of age and, thereafter, were offered a concentrate mixture of 14% CP and 0.4 kg barley hay per head daily. In order to maintain a moderate body growth of about 90–100 g per day from 100 to 365 days of age, the amount of concentrates fed during this period was between 0.75 and 1.0 kg per head daily depending on the mean live weight of each group recorded every month.

2.2. Methods

Blood sampling started on 25 May for adults and autumn-born females and on 30 June for those born in February. One blood sample was collected weekly for about 12 months from the jugular vein and the serum harvested was stored at −20°C until assayed.

Serum concentrations of progesterone were determined by a non-extraction coated tube radioimmunoassay method (Spectria, Orion Diagnostica, Turku, Finland). Briefly, 50 μl of serum and 500 μl of 125I-labelled progesterone were added to tubes coated with a second antibody to which a primary polyclonal progesterone antibody had already been bound. Following a brief mixing on a vortex mixer, the tubes were incubated at room temperature for 2 h decanted, firmly tapped against absorbent paper and counted. Performance characteristics of the assay were tested in our laboratory and are in very good agreement with values given by the manufacturer, except for the cross-reactivity of the anti-progesterone serum with pregnenolone, 5α-dihydroprogesterone and 5β-dihydroprogesterone, which according to our estimates, was 0.25, 9.2 and 12.3%, respectively, for the three steroids. Cross-reactivity with other steroids was less than 1.0%. Assay sensitivity was 0.3 nmol/l. For three different progesterone standards (low:4.5, medium:19.2 and high: 45.6 nmol/l), intra- and inter-assay precision (CV%) were 11.6, 3.7 and 3.4, and 12.7, 5.5 and 3.8, respectively. All samples falling below assay
sensitivity were given the value of assay sensitivity (0.3 nmol/l).

Serum progesterone concentrations greater than 3 nmol/l were used to identify reproductive cycles assuming that such levels of progesterone were of luteal origin.

Data for age, body weight and mean calendar date at puberty and number of cycles per lamb/kid were analysed within species and between seasons of birth using general linear models (SAS, 1990).

3. Results

Ewe lambs born in autumn (Group AL) had their pubertal ovulation between 16 June and 6 October (Table 1), whereas for February-born lambs (Group FL), the respective period was from 28 July to 3 November, with eight out of 10 occurring within a 5-week period (25 August–29 September).

The distribution of reproductive cycles in Chios sheep is shown in Fig. 1. In some animals there was a 2–6-week lapse characterised by low progesterone (<3 nmol/l) in-between the first 2–4 successive cycles, after which regular cyclicity was established. In the rest, after the pubertal ovulation, cycles were normally repeated as indicated by the sequence of luteal phase concentrations of progesterone in one and/or two consecutive weekly samples followed by one weekly sample with low progesterone concentration. Adult ewes were cycling at the end of May when blood sampling started. Until the middle of September, in four out of eight ewes, the interval between successive cycles was in some cases extended to 3–6 weeks.

From September until the end of winter, AL ewe lambs and adult ewes exhibited regular cyclicity. The behaviour of these two groups was also similar in the spring season, during which some animals ceased cycling, other continued to exhibit regular cyclicity, while two animals had cycles at both regular and irregular intervals.

Almost all animals in the FL group were cycling regularly from mid October to the beginning of January. In four animals, the breeding season was short (10–19 weeks) and they entered into anoestrus during winter. Regular cyclicity continued in four ewe lambs through winter and spring. One ewe lamb (No. 9576) had high serum progesterone concentration (19–29 nmol/l) for a period of 20 weeks, indicating the probable presence of a luteal cyst. She restarted cycling regularly from 30 March onwards.

Age, live weight at puberty, time of puberty and number of cycles per ewe and goat are shown in Table 1. Autumn-born Chios ewe lambs had their first pubertal ovulation 5 weeks earlier in the year, 13.4 weeks older and 8.1 kg heavier than February-born ones. Similarly, age and live weight, but not time of the year at the onset of regular cyclicity, differed significantly between AL and FL ewe lambs. Adult ewes and AL ewe lambs had on average more reproductive cycles per year (p<0.05) than FL ewe lambs.

The distribution of reproductive cycles in Damascus goats is shown in Fig. 2. Female kids born in autumn (AK) had their pubertal ovulation between 22 September and 24 November, and those born in February (FK) between 29 September and 2 December. The first seasonal ovulation of adult goats occurred within a 2-week period in mid September. Onset of puberty in kids and onset of seasonal breeding in adults was followed by regular cyclicity.

The reproductive season lasted on average for 26 weeks in adult goats and 17–18 weeks in young females. In most cases (15 of 20 kids), the reproductive season lasted for 12–18 weeks, whereas in the remaining five, between 22 and 28 weeks and was similar to that of the adult goats (24–29 weeks). In both groups of kids and in adult animals, the last cycle of the season was in February or March.

In February-born kids, age and live weight at puberty were lower by 11.1 weeks and 10.9 kg, respectively, than in autumn-born ones (Table 1) though mean date of puberty did not differ between the two groups (FK: 27 October; AK: 1 November). Regarding the total number of reproductive cycles, significantly more (p<0.05) were exhibited by adult goats (n=8.1) than by autumn-born (n=6.3) and February-born (n=5.7) goat kids.

4. Discussion

The Chios ewe lambs born in February reached puberty in early September at 30 weeks of age, 5 weeks later in the season than those born in autumn which were also 3 months older. These findings are in general agreement with findings on Suffolk sheep.
Table 1
Means±SEM for age, live weight (LW) at puberty and number of cycles in female Chios sheep and Damascus goats

<table>
<thead>
<tr>
<th>Variables</th>
<th>Animals</th>
<th>Ewe lambs born in</th>
<th>Adult ewes</th>
<th>She-kids born in</th>
<th>Adult goats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Autumn</td>
<td>February</td>
<td>Autumn</td>
<td>February</td>
</tr>
<tr>
<td>n</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Onset of ovulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>7 August±14.1 a</td>
<td>11 September±8.30 b</td>
<td>&lt;25 May</td>
<td>1 November±5.62 a</td>
<td>27 October±6.58 a</td>
</tr>
<tr>
<td>Period</td>
<td>16 June–6 October</td>
<td>28 July–3 November</td>
<td></td>
<td>22 September–24 November</td>
<td>29 September–2 December</td>
</tr>
<tr>
<td>Age (weeks)</td>
<td>43.2±1.79 a</td>
<td>29.9±1.04 b</td>
<td></td>
<td>48.4±0.82 a</td>
<td>37.3±0.99 b</td>
</tr>
<tr>
<td>LW (kg)</td>
<td>50.1±1.70 a</td>
<td>42.0±1.18 b</td>
<td></td>
<td>53.8±2.12 a</td>
<td>42.9±2.00 b</td>
</tr>
<tr>
<td>No. of cycles</td>
<td>Mean</td>
<td>13.7±1.30 a</td>
<td>10.1±1.44 b</td>
<td>17.1±0.72 a</td>
<td>6.3±0.58 b</td>
</tr>
<tr>
<td>Onset of regular cyclicity&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>30 August±12.1 a</td>
<td>19 September±8.44 a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (weeks)</td>
<td>46.5±1.51 a</td>
<td>31.0±1.02 b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LW (kg)</td>
<td>52.0±1.24 a</td>
<td>42.7±1.02 b</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Means within rows and species, with different letters differ significantly (p<0.05).

<sup>b</sup> Only in ewe lambs respective variables differ from those referring to onset of ovulation.

<sup>c</sup> The number of February-born lambs was nine for this variable.
(Foster, 1981), a breed with distinct and shorter breeding season than the Chios. In the work by Foster (1981), puberty in autumn-born lambs started about 4 weeks later in the season but at an older (by 4 months) age compared with spring-born lambs. In addition, the onset of reproductive cycles in ewe lambs started later in the season than in adult ewes. Similar results were observed in the present study. It appears, therefore, that similar physiological mechanisms are involved in the reproductive development and onset of puberty of genetically divergent sheep breeds in different environments. The average age at first ovulation in Chios ewe lambs born in autumn and exposed daily for 30 min to mature rams was 41 weeks (Bizelis et al., 1990) and it is in agreement with the present result of 43 weeks in the autumn-born Chios lambs that had no contact with males. Prepubertal ewes and goats may ovulate in response to the male effect only towards the beginning of the normal breeding season but not earlier, though contact with males seems to advance onset of puberty by about 2 weeks (Amoah and Bryant, 1984; Kassem et al., 1989; Al-Mauly et al., 1991).

In May, age and live weight of autumn-born lambs in the present study, were similar to the respective values of the February-born lambs at puberty, yet the mean date of the onset of pubertal ovulations in the former group was 7 August. Since age and live weight in the AL group were not limiting factors for initiation of pubertal events towards the end of spring, the delay was probably due to photoperiodic influences (Foster, 1981; Foster et al., 1985; Forcada et al., 1991). For normal sexual maturation, ewe lambs must be exposed to long days during development (Foster et al., 1988) and under natural conditions, this happens during late spring and summer. Exposure to long photoperiod seems to be related to the activation of the system regulating gonadotrophin secretion as...
shown in intact (Pelletier and Almeida, 1987), and
gonadectomised sheep (Sanford et al., 1984; Papa-
christoforou, 1987).

Within each of the AL and FL groups of lambs,
puberty occurred over a wide range of ages and
live weights and this finding is in agreement with
previous results (Foster, 1981; Fitzgerald and Butler,
1982; Vesely and Swierstra, 1987). For AL lambs,
age and live weight may have contributed to the
onset of puberty earlier in the season compared
with FL lambs. In both groups, however, onset of
ovulations occurred after the summer solstice,
indicating the critical influence at this time of the
year of photoperiod on pubertal events (Woodfill et al.,
1994).

In spring and summer ovulatory activity of adult
Chios ewes is reduced in the sense that about 50% of
animals become anovulatory for a short period of time
(Avdi et al., 1988, present results), while the rest of the
animals has cycles with normal and/or with long inter-
cycle intervals. Such considerable variation among
ewes in the expression of cyclicity could be due to
variability in the secretion of gonadotrophins and/or in
the ovarian response to gonadotrophin stimulation
(Jackson et al., 1990). Individual differences of this
nature may become more obvious during periods of
decreased activation of the reproductive system (Jack-
son et al., 1990).

In Damascus goats, females born in autumn reached
puberty the following autumn at the same time as
those born in February but at an older age and heavier
weight. This result indicates a strong seasonal effect
on the onset of reproductive activity in this breed with
photoperiod apparently, playing a key role since in
both sheep and goats the effects of photoperiod on
reproduction are mediated by similar physiological
mechanisms (Chemineau et al., 1988; Yellon et al.,
1992). Besides goat kids, adult goats also exhibited
distinct reproductive seasonality starting their breed-
ing season in September.

The seasonality of Damascus goat in an environ-
ment not characterised by extremes in photoperiodic
changes between seasons (longest day is 14 h 30 min
in June, shortest day 9 h 48 min in December) shows
that this aspect of reproduction is a characteristic of
the breed. In this respect, it was shown by Chemineau
et al. (1992) that the seasonal pattern of oestrus and
ovulation was maintained when the highly seasonal
Alpine goat was subjected to minor changes in photo-
period.

The first breeding season of young Damascus goats
could be considered as relatively short and was
also characterised by small number of cycles per
goose (4–6) in most cases. On the other hand, adult
goats had a more extended breeding season during
which the number of cycles per animal varied between
7 and 10. This result is in line with previous findings
regarding the length of the breeding season in pubertal
and adult sheep and goats (Hafez, 1952; Trodahl et al.,

In all groups of goats, the last ovulatory cycles of
the season were recorded in February or March and
thereafter, the animals entered into seasonal anoestrus
that apparently lasts until the following autumn. It is
therefore, almost certain that all matings of Damascus
goats during the anoestrous period leading to parturi-
tions in autumn (Mavrogenis, 1988) are the result of
ovarian and oestrous stimulation induced by the intro-
duction of males since no other methods in this respect
are presently used in Cyprus.

Acknowledgements

We acknowledge the assistance of Mrs. X. Evripidou and Mrs. M. Efthimiou with the computation of data, Dr. A.P. Mavrogenis with the statistical analyses and Mrs. M. Alexandrou for preparing the manuscript.

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attainment and reproductive characteristics in ewe lambs of
Chios and Karagoumiki breeds raised on two planes of nutrition.


