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Reproductive performance of Lacaune dairy sheep exposed to artificial long days followed by natural photoperiod without and with additional progestagen treatment during the nonbreeding season

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ABSTRACT

This study compared the reproductive performance of Lacaune dairy ewes exposed to a light program and subsequent male introduction without (n = 36) or with (n = 36) an additional 6-day progestagen treatment during the nonbreeding season. All ewes were exposed to extended day length (16 hours light and 8 hours darkness) for 77 days during winter (December 15 until March 2) followed by increasing natural photoperiod. At the end of the photoperiodic treatment, three blood samples were collected 6 days apart for progesterone (P4) analysis to determine cyclic activity. One half of the ewes were additionally subjected to a 6-day progestagen treatment in combination with PGF2α and eCG at insert withdrawal. Rams fitted with marking harnesses were introduced to females for 45 days and marked ewes recorded. Ewes exposed to the light program only were joined 40 days after the end of photoperiodic treatment, and ewes with additional progestagen treatment were joined 1 day after insert removal (40–44 days after the end of photostimulation). Lambing data were recorded and fertility (percentage of ewes lambing, lambing rate, and litter size) assessed to the first service period and overall. Mean serum P4 concentrations were similarly ($P > 0.05$) low in both groups (0.4–0.7 ng/mL vs. 0.4–0.6 ng/mL). On the basis of elevated P4 levels (>1 ng/mL), evidence of luteal activity was found in 27.8% of the ewes at the end of the light program. Estrus response was equally high (97.2%) and estrus distribution highly synchronized in progestagen-treated ewes (91.7% within 4 days). In ewes exposed to the light program only, estrous activity was recorded within 4 days (six ewes), from Day 8 to Day 17 (17 ewes) and from Day 19 to Day 25 (12 ewes) after joining. The percentage of ewes that lambed to the first service period was higher ($P < 0.05$) in ewes exposed to the light program only than that in the group additionally treated with progestagen/PGF2α/eCG (94.4% vs. 69.4%). Overall, the percentage of lambing ewes was similar in both groups (97.2% and 94.4%), and lambing rates (1.4–1.9) and litter sizes (1.9–2.1) were high and not influenced ($P > 0.05$) by the treatment. In conclusion, this study reports that exposition of Lacaune ewes to artificial long days followed by natural day length and male introduction is highly effective to induce fertile estrous activity during the nonbreeding season and offers a reliable and practical alternative to hormonal manipulation for out-of-season breeding in sheep.

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1. Introduction

Reproduction in sheep follows a seasonal pattern, which leads to variations in the availability of products throughout the year. To fulfill consumers' demands for milk and meat all year round, out-of-season breeding is required. Hormonal estrus induction with progestagens results in a highly synchronous estrus but a variable fertility [1] and has the disadvantage of additional costs and labor. Additionally, societal constrains, animal welfare, and consumer's demand of products that are "clean" encourage producers to minimize or completely avoid pharmacologic manipulation [2].

In sheep and goats, the introduction of males in a flock of anestrous females provokes an increase in LH pulsatility followed by synchronized ovulations [3]. This phenomenon, called "male effect", works well in Merino sheep for induction of fertile estrus in the nonbreeding season; however, in other breeds, it is less effective [2]. Photoperiod is the crucial factor driving reproductive seasonality [4]. Small ruminants are short-day breeders, and decreasing day length promotes the seasonal onset of cycling activity. Light programs consist of an alternation of long days, to restore the receptivity for the following stimulatory short days [5,6]. In ewes, long days are provided by artificial illumination, whereas short days are simulated through melatonin implants [7,8]. As an alternative to the melatonin application, the exposition to naturally short day length has been shown to also be effective in the goat [8–10]. In dairy sheep, however, there are no published reports on the efficacy of light programs without melatonin application to induce cycling activity during the nonbreeding season. Therefore, the aim of this study was to evaluate the effect of photoperiodic manipulation in conjunction with the male effect on reproductive performance in Lacaune dairy sheep during the anestrous season. Furthermore, efficacy was compared with ewes treated additionally with progestagen sponges in combination with PGF2α and eCG.

2. Materials and methods

2.1. Animals

The experiment was carried out with 72 Lacaune ewes and four rams on a commercial farm in the eastern part of Switzerland (47° 22′N, 9° 4′E). All ewes were pluriparous, aged between 2 and 10 years, weighing around 65 to 75 kg, and were 176 to 250 days in milk at joining. The animals were kept in a barn with daily access to a paddock and fed hay and concentrate. Mean milk production was 400 kg over a lactation period of 270 to 300 days.

2.2. Light program, estrus induction, and breeding

The manipulation of photoperiod was carried out in winter during 77 days from December 15 until March 2. During this period, day length was extended to 16 hours by additional artificial lighting from 6 to 9 AM and from 4 to 10 PM. The light exposition at sheep-eye level reached an intensity of at least 100 lux everywhere in the barn. After the light program, the ewes were exposed to natural day length (9.5 hours day light on March 2). The rams were kept in a separated barn and not exposed to the light program. The flock was randomly assigned to two groups of 36 ewes and two rams each. The ewes of one group were separated in a pen and additionally treated with intravaginal sponges containing 20-mg fluorogestone acetate (Chronogest CR; MSD Animal Health) for 6 days. At insert removal, 0.125 mg of the prostaglandin analog cloprostenol (Estrumate; MSD Animal Health) and 500 IU of eCG (Folligon; MSD Animal Health) were administered intramuscularly. Progestagen treatment was carried out 33 to 43 days after the end of the light program. To prevent overstraining of the rams, the sponges were inserted on five consecutive days (April 4–8), and no more than four ewes were treated per ram and day. Progestagen-treated sheep were placed together with rams fitted with marking harnesses 24 hours after insert removal (April 11–15). Ewes exposed to the light program only were joined 40 days (April 11) after the end of photostimulation. Estrus detection was performed twice daily at milking time for 45 days, and ewes marked by the rams were recorded.

2.3. Fertility

In autumn, lambing dates and the number of lambs born per ewe were recorded, and gestation length was determined. The parameter "ewes lambing" was defined as the number of females lambing expressed as a percentage of treated ewes. Lambing rate was calculated by dividing the total number of lambs born by the number of treated ewes, and litter size was determined by dividing the total number of lambs born by the number of ewes that lambed.

2.4. Blood sampling and progesterone (P4) determination

At the end of the light program, three blood samples were collected 6 days apart (February 18 and 24 and March 2) from every ewe by puncture of the jugular vein using vacutainers (9-mL Z Serum Clot Activator Vacuette; Greiner Bio-One GmbH, Kremsmünster, Austria). The samples were allowed to clot during 2 hours at room temperature. After centrifugation ($\times$4000*g*, 10 minutes), serum was frozen and stored at -18 °C until analysis. Serum P4 concentrations were determined using a commercially available Coat-A-Count RIA Kit (Progesterone Coat-a-Count, TKPG1; Siemens Medical Diagnostics, CA, USA) according to the instructions provided by the manufacturer. The analytical specificity was 100% for P4 with the following cross-reactivities: 9.0% for 5α-Pregnan-3,20-dione, 3.4% for hydroxy P4, 3.2% for 5β-Pregnan-3,20-dione, 2.2% for 11-deoxycorticosterone, and 0.9% for corticosterone. The analytical sensitivity was 0.02 ng/mL, and the intra-assay coefficient of variation was 4.0%. Progesterone concentrations of $\geq$1 ng/mL were considered as indicative of ovulatory activity [11]. Ewes with P4 concentrations less than 1 ng/mL in all the three blood samples were classified as noncyclic.

2.5. Statistical analysis

The data were analyzed using R: A language and environment for statistical computing (R Foundation for