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Does melatonin treatment during lactation influence milk production in Lacaune and Assaf ewes?

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Abstract

To determine whether treatment with melatonin during lactation harms milk production, two experiments were performed. In Experiment 1, 188 Lacaune ewes, lambed between September 12 and November 1 were used, and in Experiment 2, 124 Assaf ewes that lambed between November 14 and January 11. In Experiment 1, a first milk record was obtained on February 11, which was used to divide the animals into two groups, M and C. On March 11, a subcutaneous melatonin implant was administered to M animals (n = 93), and the rest (n = 95) corresponded to the Control Group (C). In Experiment 2, the first milk record was at weaning (January 5) and, on February 15, ewes were divided into M (n = 90) and C (n = 34). From that date until dry-off, monthly milk records were obtained. In both experiments, melatonin treatment significantly increased the number of lambs produced, and no detrimental effects on milk production were detected. In conclusion, the use of melatonin to improve reproduction in dairy sheep does not interfere with milk production. Moreover, an increase in the number of lambs produced, and the greater number of ewes that can be milked in the following period because of exogenous melatonin can provide economical benefits to farms.

Additional key words: dairy sheep, fecundity, fertility, reproduction.

Resumen

¿Afecta el tratamiento con melatonina durante el ordeño a la producción de leche en ovejas Lacaune y Assaf?

Con objeto de determinar si el tratamiento con melatonina durante el ordeño afecta negativamente a la producción lechera, se llevaron a cabo dos experimentos. En el Experimento 1 se utilizaron 188 ovejas Lacaune, paridas entre el 12 de septiembre y el 1 de noviembre, mientras que en el Experimento 2 se usaron 124 ovejas Assaf paridas entre el 14 de noviembre y el 11 de enero. En el Experimento 1 se hizo un primer control lechero el 11 de febrero, que sirvió para dividir las ovejas en dos lotes: M y C. El 11 de marzo, los animales del Grupo M (n = 93) recibieron un implante subcutáneo de melatonina. El resto (n = 95) fue considerado como lote control (Grupo C). En el Experimento 2, el primer control se realizó al destete (5 de enero) y el 15 de febrero se implantó con melatonina al Grupo M (n = 90), siendo el resto el Grupo C (n = 34). Desde ese día y hasta el secado, se tomaron controles lecheros mensuales. En ambos experimentos, el tratamiento con melatonina incrementó significativamente el número de corderos nacidos, sin un detrimento de la producción de leche. En conclusión, el uso de implantes de melatonina para incrementar los parámetros reproductivos de ovejas lecheras durante el ordeño no interfiere con la producción de leche. Es más, el incremento del número de corderos producidos y el mayor número de ovejas que entrarán en ordeño tras el siguiente parto debido al tratamiento con melatonina proporcionan un importante beneficio a las explotaciones.

Palabras clave adicionales: fecundidad, fertilidad, ovino lechero, reproducción.

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Introduction

In farm animals, particularly sheep, productivity is limited by sexual seasonality, which in turn is regulated by photoperiod (Yeates, 1949). Melatonin is the hormone mediating the transduction of photoperiodic information to the endocrine system, which leads to the precise timing of reproduction. Normally, melatonin is released at night, but subcutaneous implants are used to increase the concentration over 24 h and cause a short day-like response without suppressing endogenous secretion (O'Callaghan *et al.,* 1991; Malpaux *et al.,* 1997). Subcutaneous melatonin implants as a means of artificial control of oestrous activity in sheep have been developed.

Sheep milk producers need a constant supply of milk throughout the year. Sheep milk production is a direct reflection of reproductive periodicity. Prolactin, which is probably the most important hormone controlling milk production, shows a seasonal variation throughout the year, associated with daylength changes (Thimonier *et al.*, 1978), and it has been demonstrated that the seasonal rhythm of prolactin secretion is under pineal control by the secretion of melatonin (Reiter, 1991), which exerts a suppressive effect on prolactin (Lincoln and Clarke, 1995). Altered photoperiod influences milk production in dairy cattle, but evidence for this relationship in sheep is scarce. Following the initial report of galactopoietical effects of a 16:8 h light dark photoperiod in cattle (Peters *et al.,* 1978), other studies have confirmed the effect of long-day stimulation on milk yield (Stanisiewski *et al.,* 1985). Dahl *et al.* (1997) suggested that the effect is mediated by greater circulating concentrations of IGF-I caused by long daily photoperiods, which in turn induces the mammary gland to increase milk production (Forsyth, 1996). To increase the milk production of dairy cattle kept at high latitudes (Norway) in winter, Reksen *et al.* (1999) recommended exposing animals to dim illumination at night and a minimum photoperiod of 12 h of light. Melatonin appears to play an important role in regulating these mechanisms: it is reduced under a long-day photoperiod regime, and participates in the circadian GH-IGF-I axis activity (Ostrowska *et al.,* 2001). Indirectly, melatonin might affect milk production because reduced levels prompt the liver to increase production of IGF-I. Using melatonin to mimic a short-day photoperiod suppresses the increase in IGF-I in heifers induced by long days; however, melatonin treatments do not affect milk yield in cows (Dahl *et al.,* 2000).

The use of melatonin treatments to control dairy sheep reproduction could be questioned because this hormone causes a short day-like response (O'Callaghan *et al.,* 1991), by increasing its own basal plasma concentrations, which could reduce prolactin and IGF-I levels and, finally, decrease milk production. Our objective was, therefore, to evaluate the effect of melatonin treatment to improve reproductive performance in milk production in two breeds of dairy sheep that are maintained under two management systems. Lacaune and Assaf production systems use one lambing per year and three lambings over two years, respectively.

Material and Methods

Experiment 1

The experiment was carried out at the Dehesa Dos Hermanas Farm (Huelva, Spain) (37°N, 7°W). The farm maintains 5000 Lacaune ewes distributed among five sheep houses. The farm uses a one-lambing-per-year system, with a lactation period of 240-300 d. After colostrum intake, lambs are reared artificially. In this experiment, 188 lactating adult ewes (second to fifth lactation) were used. Ewes lambed between September 12 and November 1.

The first milk record was performed on February 11, which was used to divide the animals into two groups with a similar milk production. On March 11, animals in Group M (n = 93) received, at the base of the ear, a subcutaneous implant containing 18 mg of melatonin (Melovine, CEVA Salud Animal, Barcelona, Spain). Animals in Group C (n = 95) did not receive an implant and served as the Control Group. Forty days later (April 20), rams were introduced into the flock, and removed on June 10.

Experiment 2

The experiment was performed at a commercial farm located at San Miguel de la Ribera (Zamora, Spain; 41°N, 5°W). Approximately 500 ewes are maintained on the farm, which uses a production system of three lamb crops in two years, and a theoretical lambing interval of

8 months and a mean milking period of 150 d. Lambs are weaned at 20 d of age, when ewes begin to be milked. One hundred and twenty-four ewes (with at least one previous lactation) lambing between November 14 and January 11, were used.

The first milk record was obtained at weaning (January 5), which was used to divide the animals into two groups with a similar milk production. On February 15, animals in Group M (n = 90) received at the base of the ear a subcutaneous implant containing 18 mg of melatonin (Melovine, CEVA Salud Animal, Barcelona, Spain). Animals in Group C (n = 34) did not receive an implant and were used as the Control Group. Forty-five days later (April 1), rams were introduced into the flock and removed on May 15.

Milk records

To measure milk production in experiments 1 and 2, electronic milk meters integrated into a rotary stall milking system and a 12 × 2-standing platform, respectively, were used. In Experiment 1, a full milk record was not available for the Lacaune ewes, since the experiment was designed only to detect differences caused by melatonin. From February to June in Experiment 1, and January to June in Experiment 2, monthly milk records were documented on Day 11 (Experiment 1) or Day 5 (Experiment 2) of each month. Animals were dried-off on July 10 (Experiment 1) or June 16 (Experiment 2).

To calculate daily, monthly, and total milk production, a simplification of the milk-recording scheme used with Latxa milking sheep in the Basque Country, Spain (María and Gabiña, 1992) was applied. The general expression of this method is as follows:

$$TP = P_1 \times D_1 + \sum_{k=1}^{k-1} \frac{P_i + P_{i+1}}{2} \times D_{(i+1)} + P_k \times 30$$

where TP is total controlled production, P_1 is the production of the first record (February 11 or January 5), D_i is the interval between the i and the $i + 1$ records ($i = 1, \ldots, k$), and 30 is the estimated number of days between the last recording and drying-off.

Statistical analysis

After parturition, fertility (lambing rate) and mean (± SE) litter size (lambs born per lambing) and fecundity (lambs born per 100 treated ewes) were calculated.

To compare milk production, litter size, and fecundity in groups, an analysis of variance based on the following fixed effect model was applied:

$$Y = Xb + e$$

where Y is the N × 1 vector of records, b denotes the fixed effect in the model (treatment or not with melatonin) with matrix X, and e denotes the vector of residual effects. To compare the percentage of fertility between groups, a χ^2 test was used.

Results

In Experiment 1, fertility and litter sizes were not significantly different in treatment and control groups (Table 1), but groups differed significantly ($P < 0.05$) in the total number of lambs produced per 100 ewes

Table 1. Fertility (lambing rate) and mean (± SE) litter size (lambs born per lambing) and fecundity (lambs born per 100 treated ewes) in adult lactating ewes that received melatonin implants on March 11 (Lacaune) or February 15 (Assaf) (Treatment) and a control group

	Lacaune		Assaf	
	Treatment	**Control**	**Treatment**	**Control**
N	93	95	90	34
Fertility	97%	94%	79% [a]	21% [b]
Litter size	1.82 ± 0.06	1.70 ± 0.06	1.63 ± 0.08	1.58 ± 0.15
Fecundity	180 ± 7 [a]	163 ± 6 [b]	89 ± 1 [a]	58 ± 1 [b]

Within rows, means with different superscripts are significantly different ($P < 0.05$).

(fecundity). Melatonin-treated animals produced 10% more lambs than control ewes. In Experiment 2, the effect of melatonin treatment on the final number of lambs produced per treated ewe was statistically significant (Table 1) because of a significantly ($P < 0.01$) higher fertility rate in melatonin-treated ewes. Treated ewes produced 53% more lambs than control ewes. The increase in fertility produces an increase in the number of lactating ewes in the following milking period.

Figures 1 (Lacaune, Experiment 1) and 2 (Assaf, Experiment 2) illustrate the changes in daily and monthly milk production in the experimental period. In both breeds, melatonin treatment did not influence the pattern of milk production in ewes. Total milk (in liters) controlled in the experiment was similar between groups (M: 123 ± 4; C: 120 ± 4 and M: 224 ± 10; C: 228 ± 14 for Lacaune and Assaf ewes, respectively).

Discussion

In dairy Lacaune and Assaf ewes, melatonin treatments significantly increased lamb production, confirming the results of Chemineau *et al.* (1991) and

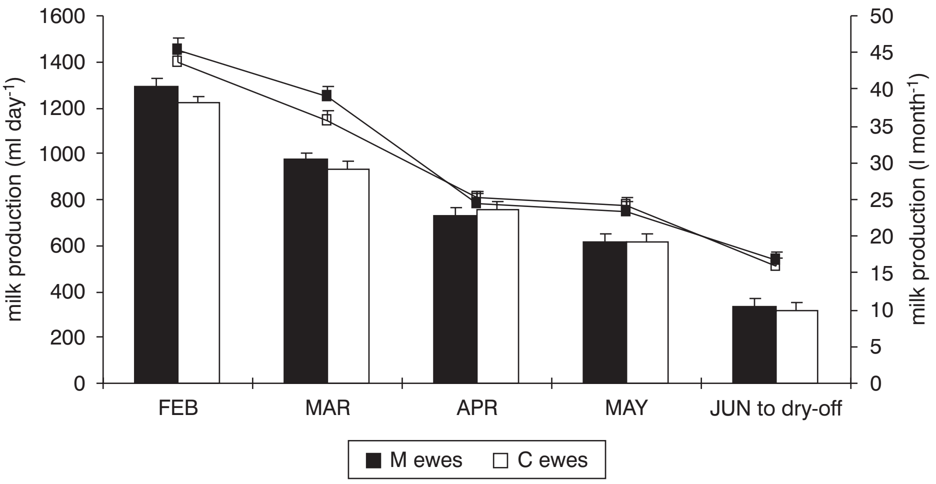

Figure 1. Mean (± SE) daily (lines, ml day^{-1}) and monthly milk productions (bars, in liters) by adult lactating Lacaune ewes that received melatonin implants on March 11 (Treatment) and a control group.

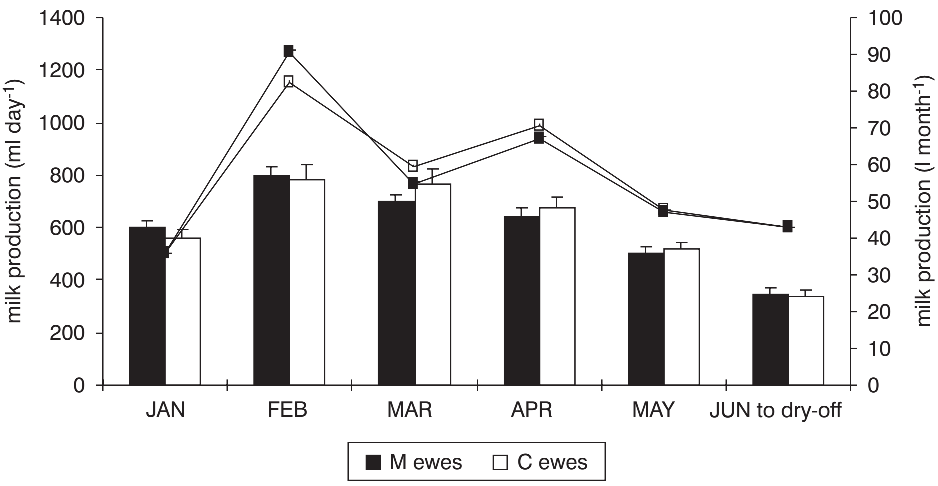

Figure 2. Mean (± SE) daily (lines, ml day^{-1}) and monthly milk productions (bars, in liters) by adult lactating Assaf ewes that received melatonin implants on February 15 (Treatment) and a control group.

Leibovich and Ziv (1996). Furthermore, as also reported in other Assaf flocks (Pollot and Gootwine, 2004), in the sample populations, melatonin did not influence milk production. In Lacaune ewes, the whole milking period was not controlled and comparisons with previous studies are more difficult. However, our results were similar to those of Barillet *et al.* (2001).

The effects of melatonin on milk production in several ruminant species are contradictory. Asher *et al.* (1994) studied the effects of administering exogenous melatonin on prolactin secretion, lactogenesis, and reproductive seasonality in pregnant red deer hinds. Melatonin treatment significantly advanced the date of first oestrus and decreased the postpartum-oestrous interval, but produced failure of lactogenesis, characterized by the presence of underdeveloped, hard mammary tissue devoid of expressible milk. Asher *et al.* (1994) concluded that the initiation of melatonin implant treatment at about 80 d before parturition compromises mammary development in red deer hinds. Peclaris *et al.* (1997), however, investigated the effect of melatonin on mammary development in prepubertal Boutsiko mountain breed ewe lambs and concluded that melatonin does not influence mammary development.

The role of prolactin in the relationship between melatonin treatment and milk production is unclear. In cows, the concentration of plasma prolactin is lower during the dark hours than during the light hours, which indicates that a continuously increasing prolactin secretion in the last month of gestation can enhance milk production in early lactation (Gustafson, 1994). Santiago-Moreno *et al.* (2000) demonstrated the day/night variations of prolactin secretion and the seasonal differences in the nocturnal rhythm of secretion of this hormone, in wild and domestic sheep. Thus, during periods of short daylight, melatonin can reduce the secretion of prolactin, which, in turn, causes a decrease in the milk yield of dairy sheep (Molik and Ciuryk, 2003). If providing a long-day photoperiod results in an increase in the growth rate of ewe udders, it is likely that ambient photoperiod can influence pre-partum udder development (Bassett, 1992). In rats, melatonin treatment and pinealectomy does not affect the milk ejection response (Mizuno and Sensui, 1970). Although in this field experiment plasma hormonal levels have not been measured, it is likely that a reduction in plasma prolactin levels caused by exogenous melatonin in spring is not solely able to reduce milk production, and perhaps other non hormonal factors can compensate for this mechanism.

It can be concluded that the use of melatonin treatments to improve reproduction in dairy sheep does not harm milk production in dairy sheep. Moreover, the increase in the number of lambs born and the number of lactating ewes in the following period caused by exogenous melatonin can provide an economical advantage to dairy sheep farms.

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