The effect of melatonin treatment on wool growth and thyroxine secretion in sheep

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Abstract

Melatonin implants are commonly used to control sheep reproduction during the winter solstice, but their effect on wool growth is unclear. In this study, wool growth was measured in 17 Assaf (carpet wool), 21 Rasa Aragonesa (medium wool) and 20 Merino (fine wool) ewes after inserting melatonin implants in January, February and April, and 13 ewes were used as control. All ewes were previously ovariectomised and treated with oestradiol implants. The mean wool fibre diameter was measured at the beginning of the study (1 January), after shearing (1 June), and at the end of the study (31 August). Wool growth was lowest in April for ewes implanted on 1 January. Plasma thyroxine (T4) concentrations differed significantly among breeds, except when peaked in June. In controls ewes, T4 levels were significantly lower in July. Fibre diameter was affected by breed but not melatonin treatment. Inserting the implants in spring appeared to influence wool production. At the same time, early treatment during the winter solstice could have a negative effect on wool growth in spring, except for fibre diameter. The differences in wool growth and fibre diameter among breeds remained constant throughout the year.

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1. Introduction

In ruminants, photoperiod can influence reproduction cycles (Yeeates, 1949), pelage growth (Ryder, 1964), spring moult (Zeuner, 1963), appetite and weight changes (Lincoln and Ebling, 1985) and horn growth (Lincoln, 1990). However, it appears to have little direct effect on wool growth rate in sheep, which appears to be more breed specific (Sumner et al., 1994).

Melatonin implants are commonly used to advance the breeding season in sheep by mimicking an increasing photoperiod (Haresign et al., 1990), but their effect on wool growth is unclear. In the Mediterranean countries, the combination of spring shearing and melatonin treatment may have a negative effect on wool production, but there is no such evidence for animals implanted with melatonin in the spring equinox (Abecia et al., 2001) or early summer (Harris et al., 1989). It has been reported that advancing the breeding season following the insertion of melatonin implants during the winter solstice (Forcada et al., 2002) may have a detrimental influence on wool production.

The Assaf, Rasa Aragonesa and Merino ewes were evaluated for wool growth in January, February and April. Assaf is a dairy breed developed in Israel by crossbreeding East Friesian (5/8) with the Awassi (3/8) breed (Goot, 1986). Ewes yield 2.5–3.0 kg
coarse fleece, long and mostly white of carpet quality and tail length is average with fat at the base. Rasa Aragonesa is the second most common breed in Spain (2.5 million heads) with medium wool, which produces a medium-quality fleece (white with square strands). The Spanish Merino is the most common sheep in Spain (3 million heads) with very fine wool.

The objective of the present study was to determine whether melatonin treatment could explain changes in wool production under an increasing photoperiod (from the winter solstice to the spring equinox). Since exogenous T4 (Donald et al., 1994) or thyroidectomy (Hynd, 1994) can have a direct effect on wool growth, the role of thyroxine was also examined.

2. Material and methods

The study was carried out at the experimental research farm at the University of Zaragoza, Spain (latitude 41°41′N), which complies with the European Union Standards for Scientific Procedure Establishments. All protocols were approved by the Animal Experimentation Ethics Committee of University of Zaragoza.

The study included 17 Assaf (A), 21 Rasa Aragonesa (RA) and 20 Merino (M) ewes. The body weights and condition scores at the beginning of the experiment were 73.6 ± 2.9 and 3.2 ± 0.1 for Assaf, 50.5 ± 0.5 and 2.7 ± 0.1 for Rasa Aragonesa, and 40.0 ± 2.5 and 2.4 ± 0.1 for Merino ewes. Treatment included 17 animals (5 A, 6 RA, 6 M) receiving a subcutaneous implant (18 mg melatonin, CEV A Sante Animal, Libourne, France) at the base of the ear on 1 January, 14 ewes (4 A, 5 RA, 5 M) on 15 February and 14 ewes (4 A, 6 RA, 4 M) on 1 April. The remaining animals, 13 ewes (4 A, 4 RA, 5 M), were used as controls.

All ewes were ovariectomised and oestradiol-implanted 4 months before the beginning of the experiment to avoid any intromission due to changes in reproductive activity and associated changes in steroid hormone profiles. A 15 cm silastic subcutaneous implant (3.3 mm internal diameter, 4.6 mm external diameter; Karsch et al., 1973) with crystalline oestradiol (Sigma Chemical Co., St Louis, USA), previously soaked in water to prevent an initial peak of steroid release was used.

Areas of wool on the flanks were dyed on 31 December using black commercial hair dye (Turcolor, Egalie S.L., Zaragoza, Spain) to determine fibre length. To calculate wool growth, a calliper was used to measure the relaxed length (to the nearest millimetre) of the un-dyed section of the fibres each month, starting 31 January. Blood samples were also taken to measure T4 levels. Ewes were sheared on 1 June and the fleeces weighed.

Mean fibre diameter was measured at the beginning of the experiment (1 January), at shearing (1 June), and at the end of the experiment (31 August), by an adaptation of the projection microscope method, which is compatible with the official ISO 9000 137/1975 method. A bundle of wool fibres was mounted on a microtome and sections were cut off on a microscope slide and magnified 400×. Fibre width was calculated using a calibrated ruler and the actual width (μm) was obtained by multiplying by 2.5.

The concentration of thyroid hormone was determined in single assay using the Coat-A-Count® solid-phase 125I radioimmunoassay for total T4 (Diagnostic Products, Los Angeles, CA). The intra-assay coefficient of variation was 9% (detection limit: 2.5 ng/ml).

The mathematical model for the analysis of fibre length, fibre growth, fibre diameter, fleece weight, fleece weight/live weight0.75 and plasma T4 concentrations included fixed effects due to breed (A, RA and M) and treatment month (melatonin in January, February or April, or control) and residual error. Interactions were tested and were found to be not significant, therefore were not included in the model. An LSD test was used to compare differences among breeds and treatments. A paired t-test was used to compare differences in fibre diameter.

3. Results and discussion

The wool growth rate was highest in winter and peaked in June in all breeds (Fig. 1). Growth rates were significantly different among breeds in January, March, April and June with the highest growth in Assaf (P < 0.01). Mean plasma T4 concentrations (Fig. 1) remained constant (except for a peak in June) and were always higher in Assaf ewes (P < 0.01).
Fig. 1. Least-squares mean (±S.E.) fibre growth (histogram, mm) and plasma T₄ concentrations (line, pg/ml) throughout the experiment of ewes implanted with melatonin on 1 January, 15 February and 1 April, or non-implanted (control), of the breeds Assaf (A), Rasa Aragonesa (RA) and Merino (M).

All ewes implanted on 1 January had the lowest rate of wool growth in April (Fig. 1). The T₄ concentrations were significantly lower in control ewes in July ($P < 0.05$). The three measurements of fibre diameter varied significantly with breed but not melatonin treatment. Fibre diameter remained constant throughout the experiment among groups and breeds (Fig. 2). Finally, fleece weight and fleece weight/live weight.
varied significantly with breed (Table 1) while melatonin treatment had no effect. Wool growth rate was highest in the winter season (January) for all breeds, in agreement with Sumner et al. (1998), and fibre growth peaked in June. Perhaps the shearing on 1 June affected the normal pattern of growth since it has a positive effect on growth rate (Hawker et al., 1985). Fibre diameter was also significantly affected by breed.

There is little data on wool growth parameters in Rasa Aragonesa sheep. According to the National Association of Rasa Aragonesa Breeders, the mean diameter is 25–28 μm and fleece weight is 1.8–3 kg (MAPA, 1985), which are similar to the present study.

For Spanish Merino, the Spanish Association of Merino Sheep Breeders reported that the average fibre diameter is 21–23 μm and the average fleece is 3.73 kg (Valera et al., 2002). In the present study, Merino ewes had higher diameters and lower fleece weight than that reported by the Association, reflecting the specialisation for meat versus wool production on the farms of origin. No data on wool quality of the Assaf breed have been reported, except for fleece weight (about 3 kg, Sheep & Goats Breeders Association from Israel, web page: http://www.sheep-goats.org.il).

In general, melatonin treatment during the winter solstice until spring had no effect on mean wool growth rate although fibre diameter was affected by breed.
growth rate or diameter. The only exception was in April, when ewes implanted during the winter solstice (1 January) had the lowest growth rates. It has been suggested that natural and experimental increases in daylength have a short-term inhibitory effect on growing wool follicles (Pearson et al., 1996). Thus, if animals implanted in January become sensitive to increasing days when implants become exhausted (90–100 days after implantation; Forcada et al., 2003), the sudden change in photoperiodic status from short-day perception (due to the implants) to long-day perception (natural photoperiod of April), could decrease wool growth. Regarding the other dates of implantation, the present findings support previous work based on Rasa Aragonesa ewes implanted in March in the same latitude (Abecia et al., 2001), where melatonin had no effect on wool growth. Other reports suggest in Merino sheep that melatonin is not directly involved in the seasonality effect of wool growth following implantation in spring (McCloghry et al., 1992). Harris et al. (1989) concluded that, although exogenous melatonin alters the reproductive characteristics of Romney rams, it does not completely explain a measurable change in the pattern of wool production.

The secretion pattern of T4 was affected by breed, in accordance with both wool parameters. The highest T4 concentrations and mean fibre growth rate were in Assaf ewes, the lowest in Merino and intermediate for Rasa Aragonesa, which supports the idea that T4 has an important influence on wool growth pattern (Donald et al., 1994; Hynd, 1994). A significant proportion of the variation in wool growth rate and mean fibre diameter in the present study may have been associated with permanent phenotypic differences among ewes according to the rhythm based on seasonal wool growth cycle (Sumner et al., 1994).

The T4 concentrations peaked in June in all three breeds. Souza et al. (2002) reported the same peak in December in the southern hemisphere. Differences in the seasonal pattern of thyroid hormones reflect the response of the thyroid to changes in the photoperiod (Hafez, 1959). The only effect of melatonin on plasma T4 concentrations was observed in July, when the control ewes had significantly lower T4 values, after the June peak. Since these animals did not receive any implants, one can assume that the reduction of plasma T4 levels after the summer peak reflects a circannual rhythm of secretion, as described by Souza et al. (2002). Breed differences in plasma T4 levels were observed throughout the experiment, which may be associated with breed differences in wool growth. Melatonin treatment did not affect fleece weight. These findings are in agreement with Harris et al. (1989) that no effect was observed for greasy fleece weight or wool production.

In conclusion, treating ewes in spring with exogenous melatonin to improve reproduction has no influence on wool production in breeds with different wool types. However, earlier treatments during the winter solstice could have a negative effect on wool growth in the medium term in spring, without affecting fibre diameter. Breeds varied in wool growth rate and fibre diameter which remained constant throughout the study.

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