Out-of-season breeding of milk goats – the effect of light treatment, melatonin and breed

E R du Preez[a], E F Donkin[b], P A Boyazoglu[b], G H Rautenbach[a], D M Barry[c] and H S Schoeman[d]

ABSTRACT

The purpose of this study was to evaluate the effectivity of melatonin in addition to light treatment (exposure to 2 hours of light during the night = a long-day photoperiod) to modify the breeding season of Saanen and cross-bred milk goats and to compare the difference between the breeds. Twenty-two Saanen and 22 cross-bred does were randomly divided into 3 treatment groups. Group 1 (controls) received no treatment, Group 2 received light treatment for 37 days and Group 3 received light treatment plus melatonin implants after the light treatment. After a further 35 days the 3 groups were brought together and a billy goat that had also been exposed to the extra light at night, had received a melatonin implant and had been isolated from the does during the treatment period, was introduced to the does for natural mating. Ultrasound scanning was used to diagnose pregnancy and all the pregnant goats kidded. Significantly more Saanen does compared to cross-bred does (P = 0.018) became pregnant and kidded after natural mating, when the group that received melatonin as well as light treatment was compared to the group that received light treatment only. Compared to light treatment only, the addition of melatonin to light treatment improved (P = 0.0028) conception after natural mating, in both the Saanen and the cross-bred does.

Key words: fertility, light treatment, melatonin, milk goats, out-of-season breeding.

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INTRODUCTION

Many mammalian species and breeds have developed a relationship with their environment that allows the birth of their young to occur at the most favourable time of the year for them to survive. Breeds like the Saanen that originate from temperate climates are seasonal breeders[3,6]. The indigenous goats of South Africa are not strict seasonal breeders, but crossed with Saanen they show more seasonality in breeding activity. This seasonal nature of milk goats limits the kidding to a single period of the year (September to November), which is not optimal for continuity of milk production and marketing. In addition, the kids are born during a time of the year that is not optimal for raising the kids in the summer rainfall area of South Africa, owing to heavy parasite burdens at the end of summer. Out-of-season breeding can thus be important to improve production of goat milk and decrease kid mortality.

Out-of-season breeding in milk goats can be achieved by light and/or melatonin treatment. By applying either or both of these methods during the anoestrous season, they can be stimulated to show oestrus and breed[3, 4,5,9,12].

The purpose of this study was to evaluate the effect of melatonin in addition to light treatment in order to modify the breeding season of Saanen and cross-bred milk goats and to assess the difference between breeds. Melovine (Sanofi, S.S.N.A. 33501) was used as melatonin implants. Natural mating was performed using a billy goat that also received light treatment and melatonin. The 'male effect' was achieved by separating the billy goats from the does until the time that the does were expected to show oestrus.

Owing to a limited number of goats available for the trial, the sample size of the different treatment groups was small, which made a better design of the project impossible. The use of a single billy goat on the does in the trial was not ideal, but owing to management preferences was unavoidable.

MATERIALS AND METHODS

The study was conducted in collaboration with the Milch Goat Research Project in the Department of Animal Health and Production at the Medical University of South Africa, situated at 25°36'S, 28°02'E. At this latitude the day length decreases (dark period increases) from January to June and increases from July to December. Only goats that had kidded before were included in the trial. The same management was applied to all goats, whether lactating or dry, as past experience indicated that there was little effect on whether the ewes were in milk or dry at the start of the light treatment.

To maintain uniform nutrition among groups, all goats in the trial were kept on the same total mix ration, which was the normal ration used for the milk goats in this Farm Animal Production Unit. Condition scoring was performed at the beginning of the trial and again after the mating period, only as an indication of general health and feeding status. The goats at the production unit were weighed every month and the masses were monitored throughout the period of the trial, also as an indication of general health.

The adult female goats consisted of pure Saanens and cross-breds resulting from breeding Saanen with South African indigenous goats. For the purpose of this trial all the pure Saanen goats were assigned to the Saanen group, while all the goats that had some indigenous genetic composition were assigned to the cross-bred group. The cross-bred group included 6 does that were 50 % Saanen : 50 % indigenous, 10 does that were 75 % Saanen : 25 % indigenous and 6 does that were 87.5 % Saanen : 12.5 % indigenous. Each of these 2 groups of goats was randomly subdivided into 3 treatment groups. The number of each breed assigned to each treatment group is shown in Table 1.

The control group was kept in a

[a]Department of Production Animal and Community Health, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort, 0110 South Africa.

[b]Department of Veterinary Production and Ethology, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort, 0110 South Africa.

[c]Department of Human and Animal Physiology, University of Stellenbosch, Private Bag X1, Matieland, 7602 South Africa.

[d]Department of Mathematics and Statistics, Faculty of Basic Sciences, Medical University of Southern Africa, Medunsa, 0204 South Africa.

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Table 1: **The number of Saanen and cross-bred goats assigned to each treatment group.**

	Control[a]	LD[b]	LD + MEL[c]
Saanen	3	11	8
Cross-bred	6	7	9
Total in trial	9	18	17

[a]Control = no light treatment or melatonin.
[b]Long day = light treatment.
[c]Long day and melatonin = melatonin treatment in addition to light treatment.

separate closed building to prevent exposure to artificial light at night. Group 2 received light treatment (LD), and the treatment for Group 3 consisted of light treatment plus melatonin (LD + MEL). The LD and LD + MEL groups were kept in an open shed and received light treatment during the spring from 31 August until 7 October (37 days). The light treatment consisted of turning on the fluorescent lights in the shed for 2 hours, from 22:00 to 24:00, at night, thereby creating the effect of a long day (LD)[3]. The amount of light applied was about 200 lux at the level of the goats. On 15 October, Group 3 received melatonin as a subcutaneous implant at the base of the ear.

Although melatonin can be administered *via* different routes, subcutaneous implants (Melovine, Sanofi SSNA, 33501) were chosen for this study, as this method is best suited to local conditions. Melovine contains 18 mg melatonin in silicone implants for subcutaneous implantation at the base of the ear and releases melatonin for a period of about 35 days. According to Chemineau[3] and the manufacturer, no meat or milk withdrawal is necessary with this product.

The billy goat, together with some other billy goats, was isolated from the does to eliminate any contact with the females, whether by sight, smell or sound, in order to achieve the 'ram effect' when later introduced to the ewes. As it was planned by the management of the production unit to use 1 fertile billy goat among the 44 does, and owing to the fact that the mating period was planned to be over a very limited period, the billy goat received the same melatonin and light treatment as Group 3.

Five weeks after the melatonin implantation in Group 3, the 3 groups were mingled in the shed and the billy goat was introduced to the ewes on 24 November for natural mating. The billy goat was with the ewes for a period of 6 weeks, until 7 January. Matings were not controlled or monitored. Pregnancy was diagnosed by ultrasound scanning 2 months after removal of the billy goat. Kidding commenced on 30 April 1998 and continued until 27 May.

Results were analysed statistically using the Fisher exact test for comparisons of pregnancy rates, fertility, breed differences and occurrence of twinning between the treatment groups and breeds.

RESULTS

All the goats that were diagnosed as pregnant produced offspring. The results of the pregnancy diagnosis and the number of goats that kidded are shown in Table 2.

The number of Saanen goats that became pregnant and kidded (as shown in Table 2) were compared between treatment groups. There was no significant difference between the control group and the light-treatment group, (Group 1 *vs* Group 2), or between the control group and the group that received melatonin in addition to light treatment (Group 1 *vs* Group 3). There was a significant difference in the number of Saanen goats that became pregnant and kidded (P = 0.018) between the light-treatment group compared to the group that received additional melatonin (Group 2 *vs* Group 3). When the same comparisons were made among the cross-bred goats, no significant differences were found.

The effects of light treatment and melatonin treatment in addition to light treatment on the fertility of the goats in the trial are shown in Table 2. When comparing the different treatment groups using the Fisher exact test, no significant difference was found in the percentage that kidded between the control group and the light-treatment group (P = 0.406), or between the control group and the group that received melatonin in addition to light treatment (P = 0.111). The difference in fertility between the light-treatment group and the group that received light treatment plus melatonin was highly significant (P = 0.00289).

The fertility of the 2 different breeds in the different treatment groups is shown in Table 2. Within each treatment group, no significant difference was found between the Saanen and the cross-breds in the number of does that kidded (control: P = 1.000, LD: P = 0.367, LD + MEL: P = N/A).

None of the treatments in this study influenced litter size. When the number of multiple and single births for each breed was compared between the 3 treatment groups, no significant differences were found in either the Saanen (P = 0.185) or the cross-bred goats (P = 0.474) (Table 3). When the multiple births were compared between the breeds within the treatment groups, no significant difference was found between the Saanen and the cross-bred goats (Saanen *vs* cross-bred: Group 1: N/A, Group 2: P = 0.167, Group 3: P = 1.000).

DISCUSSION

The approach of using supplementary light treatment is practical and economical to apply[12]. In the ewe, the illumination of a specific period of the dark phase (photosensitive phase) is able to mimic a long day. Two hours of extra light 10–18

Table 2: **Breed differences in fertility in the treatment groups.**

	Control	LD	LD + MEL
Fertility after natural mating (%)			
Saanen	66.67	45.45	100
Saanens kidded/ no. introduced to billy goat)	(2/3)	(5/11)	(8/8)
Cross-bred	83.33	71.43	100
Cross-bred kidded/no. introduced to billy goat)	(5/6)	(5/7)	(9/9)
Total fertility (%)	77.8	55.6	100
Litter size			
Saanen	2.00	1.40	1.88
Saanen kids/goat kidding	(4/2)	(7/5)	(15/8)
Cross-bred	1.80	2.00	1.78
Cross-bred kids/goat kidding	(9/5)	(10/5)	(16/9)
Total litter size	1.85	1.70	1.82
Fecundity			
Saanen	1.33	1.00	1.88
Kids/goat introduced to billy goat	(4/3)	(7/7)	(15/8)
Cross-bred	1.50	1.43	1.78
Kids/goat introduced to billy goat	(9/6)	(10/7)	(16/9)
Total fecundity	1.44	0.94	1.82

Table 3: **Multiple and single births of each breed born in the different treatment groups.**

	Control				LD				LD + MEL			
	No. kidded	No. kids	M[a]	S[b]	No. kidded	No. kids	M	S	No. kidded	No. kids	M	S
Saanen	2	4	2	0	5	7	2	3	8	15	7	1
Cross-bred	5	9	5	0	5	10	5	0	9	16	7	2

[a]M = multiple births.
[b]S = single births.

hours after a fixed dawn during the winter days are apparently perceived as a long day by the animal[3,9,14]. Donkin *et al.*[10] successfully used this treatment in goats. An attempt to breed goats in the spring of 1991 without any treatment resulted in no sexual activity. Light treatment alone during the spring of 1992 yielded a 53 % kidding rate and in 1994 yielded a 65 % kidding rate. When the light treatment is stopped, the endocrine system responds as if it were autumn (with decreasing day length), and reproductive activity is induced[10].

The administration of melatonin can also be used to manipulate rhythms[1,2,13,16]. Poulton[16] found that a minimum of 5 weeks' exposure to elevated melatonin levels is needed to advance the onset of breeding activity in ewes. However, when used alone in highly seasonal breeds, melatonin treatment provides a maximum advance of only 1.5 months, which does not satisfy the need for a complete out-of-season breeding[4,12]. To achieve complete out-of-season breeding, melatonin treatment should be preceded by about 2 months of light treatment composed either of real long days or of supplementary light treatment[3,4,11,16]. It is necessary to expose does to an adequate period of long days to break photo refractoriness to the short-day signal before the animals can respond to exogenous melatonin[9,12]. Melatonin treatment can also be used to mimic a short day when administered during spring. Researchers found that melatonin or light treatment used alone increased the percentage of does cycling and the fertility compared to control goats, but only the combination of both treatments allowed the females to reach high fertility (86 %), which is close to that observed during the sexual season[3,7]. The improved fertility with light treatment and melatonin is due to a longer persistence of oestrous and ovulatory activities in these treated does[3]. This can explain the improved fertility in this trial (and of others) of the goats that had melatonin in addition to light treatment compared to the group that only had light treatment ($P > 0.001$).

When anovular female goats are exposed to male goats, certain physiological and endocrinological events occur in the female goats that are referred to as the 'male effect'. In these females rapid changes in LH pulse frequency are followed by ovulation within 3 days, then a short luteal phase and a second ovulation 5–6 days later[9,16]. Variations in this pattern also occur. The male stimulus appears to be multi-sensorial, with odour as a major component. The male odour originates from the sebaceous glands in the neck, which increase in size before the mating season[9,18]. The male effect is influenced by factors such as individual variation, nutrition, association with females, and degree of contact with females[18]. Under conditions where a strong seasonal pattern is expressed, the use of the male effect is not sufficient to obtain good fertility, and it is necessary to couple it with techniques to reduce the effect of season, for example photoperiod manipulations[8,15,16].

The application of photoperiod treatments to bucks of seasonal breeders alleviates the problem of seasonality of sperm production and overcomes variations in testis size and sperm production. Billy goats treated with melatonin and long day light treatment should be introduced for natural mating from 35 to 70 days after the onset of melatonin treatment[3,4,6,7,16]. The 'male effect', induces an increase in LH pulse frequency and amplitude in the females within an hour after introduction of billy goats, with peak conceptions in 10 days and some females being fertilised at the return to oestrus 1 cycle later [3,17,18].

In contrast to the results of Donkin *et al.*[10] in 1991, where there were no results without light or melatonin treatment, the does in the control groups (without any treatment) of several trials as well as the present trial, showed relatively good reactions when billy goats were introduced for out-of-season breeding trials. In this trial the control group was small owing to limited availability of goats for the trial. It is possible that the relatively good reaction of the control group can be ascribed to several factors such as the male effect, the female effect, or the very small sample size.

In the trial by Donkin *et al*[10] in 1991, the billy goats were not treated with light and/or melatonin, and were thus not stimulated and did not induce the male effect. In this trial the billy goat was treated with light and melatonin and was active and ready for breeding when introduced to the does. Their sexual activity, together with pheromones, could elicit a good male stimulus. In addition, the females in this trial were all mingled for the mating period. The pheromones from the treated groups and all the sexual activity of the does and the billy goat may well be a reason for the stimulation of the control group.

In a trial by Chemineau[3] with Alpine goats, the does that were submitted to 1 month of long-day treatment had a significantly lower fertility than does submitted to 2 months of long-day treatment (48 % *vs* 71 % respectively). In this trial, the does in the light-treatment group (Group 2) did not perform as well as the control group. This is in contrast to the results of other researchers, where this group performed better than the control group. A possible explanation for this result may be that this group only had light treatment for 37 days owing to problems initiating the lighting treatment. The small sample size may also have affected the results.

A significant difference ($P > 0.01$) was found in the trial where more Saanen does became pregnant and kidded in the group that had melatonin in addition to light treatment compared to the group that only had light treatment (as shown in Table 2). This is in contrast to the cross-bred does, which showed no significant difference between these treatment groups. This might be explained by the fact that the Saanen, being a more seasonal breed, is more sensitive to melatonin, and seasonality is lost by mixing these 2 breeds.

In conclusion, it is clear that without any treatments, poor results can be expected from complete out-of-season breeding in Saanen and cross-bred milk goats, and that supplementary light treatment during spring is effective in changing the breeding season of Saanen and Saanen cross-bred goats from autumn to spring. Distinct advantages for the goat milk producer have been demonstrated, because

efficiency of marketing was improved by ensuring continuity of milk supply. The addition of melatonin (in this case Melovine implants) proved to be even more effective by improving conception rate during the out-of-season spring mating. Both methods are practical and easy to apply.

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