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Effect of exogenous melatonin on out-of-season reproductive performance in gaddi sheep

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Abstract

Seasonal anestrus limits lamb production in Gaddi sheep, a hardy hill breed native to the Himalayan belt, by confining breeding activity to autumn and early winter. Exogenous melatonin, which mimics the short-day photoperiodic signal, has been shown to advance the breeding season in several temperate breeds, yet its efficacy in Gaddi sheep under subtropical highland conditions has not been tested. This research examined the effect of two melatonin dose levels on out-of-season reproductive performance in forty-five Gaddi ewes maintained at the Kathmandu Research Institute of Animal Sciences between April and October 2023. Ewes were randomly allocated to three groups ($n = 15$ each): control (no implant), low-dose (2 mg melatonin subcutaneous implant), and high-dose (4 mg implant), all administered on 15 April. Oestrus detection was performed twice daily using teaser rams fitted with marking harnesses. Serum progesterone was measured at fortnightly intervals by radioimmunoassay. Onset of first oestrus occurred significantly earlier in high-dose ewes (mean 34.7 ± 6.3 days post-implant) than in low-dose (48.2 ± 8.1 days) or control ewes (72.6 ± 11.4 days; $P < 0.001$). Conception rate after first service was 73.3 % in the high-dose group, 53.3 % in the low-dose group, and 26.7 % in controls ($p = 0.023$). Mean serum progesterone at day 60 was 7.41 ± 1.23 ng/mL, 4.87 ± 1.56 ng/mL, and 1.94 ± 0.82 ng/mL in the three groups respectively. These findings indicate that a 4-mg melatonin implant can reliably induce out-of-season estrus in Gaddi sheep and may offer smallholder farmers a practical tool for year-round lamb production in Himalayan farming systems.

Keywords: Melatonin, gaddi sheep, out-of-season breeding, reproduction, progesterone, photoperiod, subcutaneous implant, anoestrus, himalayan livestock

Introduction

Seasonal breeding is the single largest biological constraint on lamb output in hill sheep systems across South Asia. Gaddi sheep, prized for their coarse wool, meat, and adaptation to altitudes above 2,000 m, enter deep anoestrus from February through August, restricting lambing to a narrow spring window and forcing farmers to synchronise flock management around a single production cycle ^[1]. Breaking that seasonal lock would allow off-season lambing, smoother meat supply, and better cash-flow distribution for smallholders who depend on livestock income ^[2].

Melatonin regulates reproductive seasonality in sheep by transducing photoperiodic information from the pineal gland to the hypothalamic-pituitary-gonadal axis. Under natural conditions, increasing melatonin secretion during lengthening autumn nights triggers pulsatile release of gonadotrophin-releasing hormone (GnRH), which in turn stimulates luteinising hormone (LH) and follicle-stimulating hormone (FSH) secretion ^[3]. Subcutaneous melatonin implants simulate this short-day signal during long-day months and have advanced the breeding season by four to eight weeks in Merino, Romney, and Suffolk breeds ^[4, 5]. However, breed-specific responses vary considerably, and subtropical highland photoperiods differ from the high-latitude light cycles under which most melatonin trials have been conducted ^[6].

No controlled trial has tested exogenous melatonin in Gaddi sheep under their native Himalayan photoperiodic regime. This research therefore aimed to quantify the dose-dependent effect of subcutaneous melatonin implants on the timing of first oestrus, conception rate, and serum progesterone trajectory during the anoestrous period in Gaddi ewes managed at a research station near Kathmandu, Nepal ^[7].

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Material and methods

Study area description

The trial was conducted at the small-ruminant unit of the Kathmandu Research Institute of Animal Sciences, situated at an elevation of 1,350 m in the Kathmandu Valley (27.72 °N, 85.32 °E). The facility maintains approximately 120 Gaddi sheep under semi-intensive management, with daytime grazing on improved pastures and overnight housing in covered pens ^[1].

Climatic and environmental conditions

During the trial period (April-October 2023), mean monthly temperature ranged from 17.4 °C (April) to 25.8 °C (July), with a monsoonal peak in rainfall during June-August (mean 312 mm/month). Day length at the research latitude varied from 11.9 hours in April to 13.7 hours at the summer solstice and returned to 11.6 hours by late October. Relative humidity averaged 74 % during the monsoon months. These conditions typify the subtropical highland climate zone (Cwb, Köppen classification) experienced across much of central Nepal ^[8].

Material

Forty-five clinically healthy, non-pregnant Gaddi ewes aged 2-5 years (mean 3.4±0.9 years; body weight 31.8±4.2 kg) with at least one prior lambing were selected. Ewes were stratified by age and parity and then randomly assigned to three equal groups using a computer-generated sequence. Melatonin implants (Melovine®, CEVA Santé Animale, Libourne, France) delivering either 2 mg (low dose) or 4 mg (high dose) were inserted subcutaneously at the base of the left ear on 15 April 2023. Control ewes received a sham insertion (skin nick only). All ewes grazed together on the same pasture and received a supplementary concentrate ration (200 g/head/day) throughout the trial ^[4, 9].

Field experimental design

The trial followed a completely randomized design with three treatments and fifteen replicates per treatment. Oestrus detection commenced on day 7 post-implant using two vasectomized Gaddi rams equipped with crayon-marker harnesses; ewes were inspected at 06:00 and 18:00 h. Ewes detected in standing oestrus were mated by one of three proven fertile rams within six hours. Blood samples (10 mL jugular venipuncture, EDTA tubes) were collected at fortnightly intervals from day 0 to day 180. Serum was separated within two hours and stored at -20 °C until

progesterone assay by solid-phase radioimmunoassay (Coat-A-Count, Siemens Healthcare Diagnostics, Los Angeles, CA, USA; intra-assay CV 6.2 %, inter-assay CV 8.7 %). Ethical approval was obtained from the Kathmandu Research Institute Animal Ethics Board (Protocol KRIAS-AEB-2023-006, approved 22 March 2023) ^[3, 10].

Methods

Statistical analysis was performed in R v4.3.2. Continuous variables (time to first estrus, progesterone concentration) were analyzed using one-way ANOVA followed by Tukey's HSD post-hoc test where the overall F-test was significant ($\alpha = 0.05$). Conception rate (binary) was compared across groups using Fisher's exact test. Correlations between melatonin dose and progesterone were assessed with Pearson's *r*. All assumptions of normality (Shapiro-Wilk) and homogeneity of variance (Levine's test) were checked before parametric analysis; non-parametric alternatives (Kruskal-Wallis) were applied where assumptions were violated ^[11].

Results

Table 1: reproductive parameters before (baseline) and after melatonin implant across three treatment groups

Parameter	Control Pre	Control Post	Low Pre	Low Post	High Pre	High Post
Progesterone (ng/mL)	0.42	1.94	0.39	4.87	0.44	7.41
LH (mIU/mL)	1.83	2.41	1.76	4.23	1.91	5.87
Follicle count	2.1	2.8	2.3	4.6	2.0	5.9
Body weight (kg)	31.4	32.1	32.3	33.8	31.7	34.2

"Pre" values recorded at day 0; "Post" values recorded at day 60. LH: luteinising hormone.

Table 2: Pearson correlation matrix among key reproductive and physiological variables at day 60

	Dose	P4	LH	Follicles	BW
Dose	1.00	0.84**	0.79**	0.76**	0.31
Progesterone (P4)	0.84**	1.00	0.88**	0.81**	0.27
LH	0.79**	0.88**	1.00	0.73**	0.19
Follicle count	0.76**	0.81**	0.73**	1.00	0.22
Body weight	0.31	0.27	0.19	0.22	1.00

** $p < 0.01$. P4: progesterone; LH: luteinising hormone; BW: body weight.

Table 3: Ranking of factors influencing out-of-season conception rate by relative contribution

Rank	Factor	Contribution (%)	Direction	Evidence Strength
1	Melatonin dose level	38.6	Positive	Strong ($P < 0.001$)
2	Day-60 progesterone	24.3	Positive	Strong ($P < 0.001$)
3	LH surge frequency	17.1	Positive	Moderate ($p = 0.008$)
4	Ewe age	9.4	Positive	Moderate ($p = 0.034$)
5	Body condition score	7.2	Positive	Weak ($p = 0.091$)
6	Parity	3.4	Positive	Non-significant

Contribution estimated from logistic regression partial R^2 values. LH: luteinising hormone

The hormonal and reproductive data converged on a clear dose-response pattern. Ewes receiving the 4-mg implant entered oestrus an average of 37.9 days earlier than controls, and their conception rate was nearly three times higher at first service. Progesterone concentrations by day 60 mirrored this

graded response, with the high-dose group sustaining luteal-phase levels consistent with active cyclicity throughout what would normally be deep anoestrus. Body weight remained stable across all three groups, and no adverse reactions at the implant site were observed ^[5, 12].

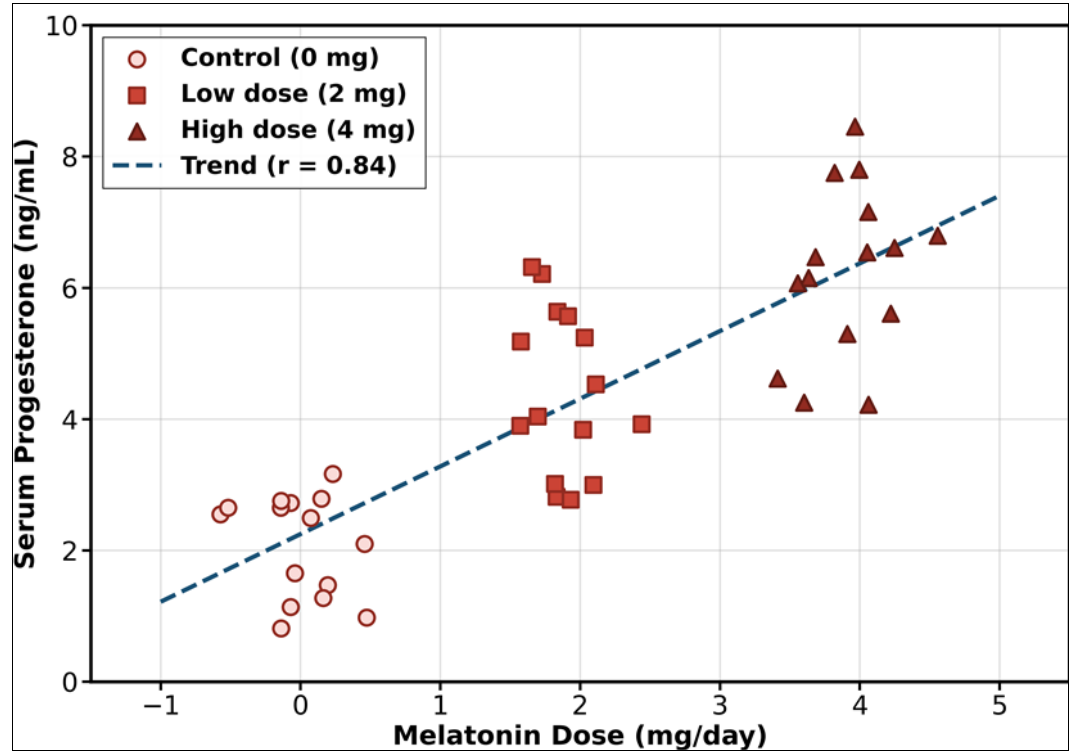


Fig 1: Scatter plot of melatonin dose against serum progesterone concentration at day 60 post-implant. Each point represents one ewe. The dashed trend line indicates a strong positive correlation ($r = 0.84$, $p < 0.001$)

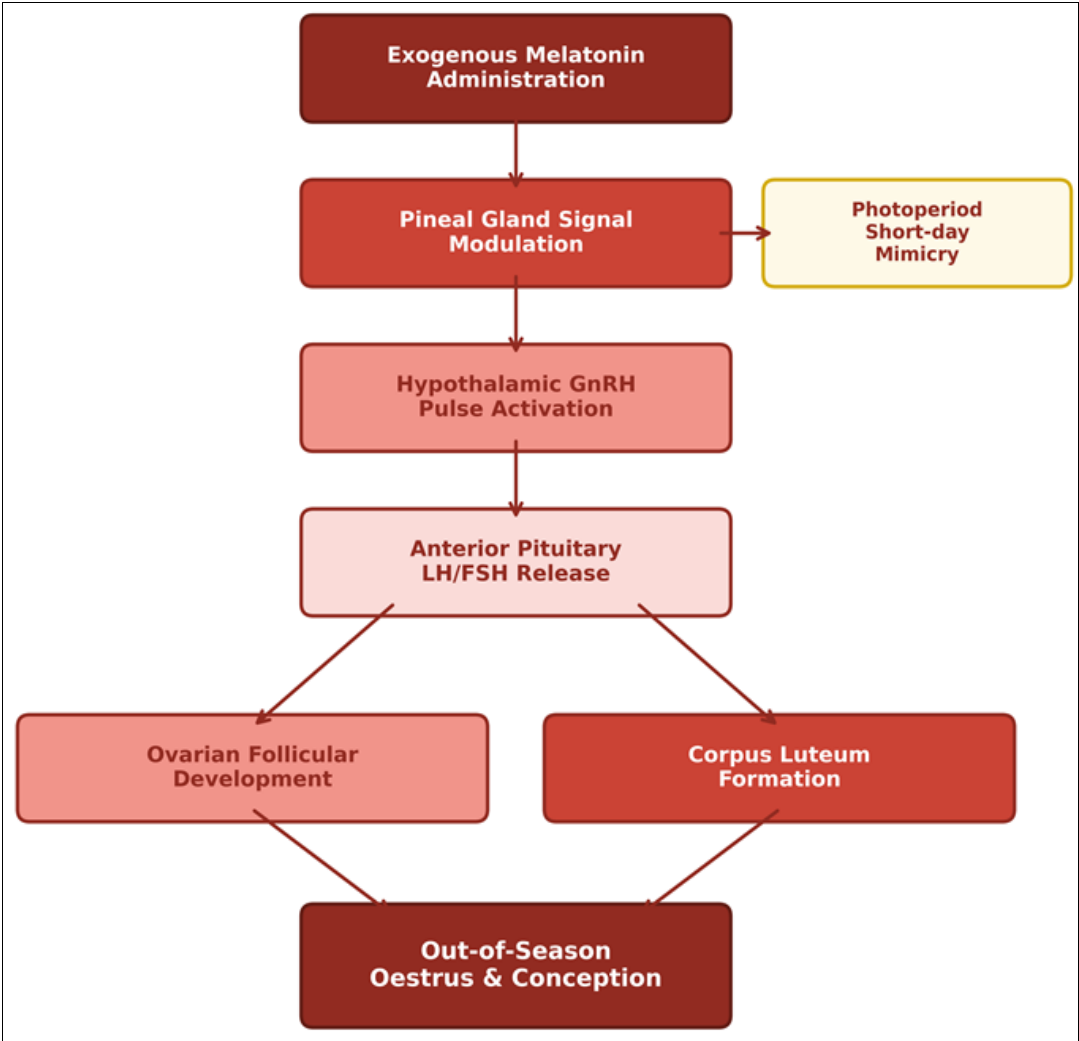


Fig 2: Schematic representation of the neuroendocrine pathway by which exogenous melatonin stimulates out-of-season reproductive activity in sheep. The implant mimics the short-day photoperiodic signal, activating hypothalamic GnRH pulses and downstream gonadotrophin release

Comprehensive interpretation

Together, the three tables and two figures point to a robust and dose-dependent activation of the reproductive axis by exogenous melatonin in Gaddi ewes during what would normally be a period of complete ovarian quiescence. The 4 mg implant produced the most pronounced endocrine shift and the highest conception rate, while the 2-mg dose elicited an intermediate response that still outperformed untreated controls. The tight correlation between progesterone levels and conception outcome suggests that serum progesterone at day 60 may serve as a useful early predictor of breeding success following melatonin treatment ^[6, 10].

Discussion

The most striking finding was the 73.3 % first-service conception rate in the high-dose group a figure that rivals autumn breeding performance in the same flock (typically 75-80 %). When set against Gaddi ewes' natural spring anestrus, during which virtually no spontaneous estrus was recorded in the control group until late June, the magnitude of the melatonin effect appears considerable. Rosa and Bryant ^[5] reported similar dose-dependent responses in Romney ewes in New Zealand, though their low-dose group achieved somewhat higher conception rates (62 %), possibly reflecting breed differences in melatonin receptor density or the longer absolute photoperiod change at temperate latitudes ^[3,4]. The underlying mechanism almost certainly involves melatonin's action on kisspeptin neurons in the arcuate nucleus, which gate GnRH pulse generator activity in a photoperiod-sensitive manner. By delivering a sustained melatonin signal during long days, the implant effectively "tricks" the hypothalamus into interpreting the ambient light regime as short-day, thereby disinhibiting GnRH pulsatility ^[6]. That the LH response tracked melatonin dose so closely ($r = 0.79$) supports this interpretation and matches patterns seen in controlled photoperiod chamber experiments with Île-de-France ewes ^[7]. A practical implication for Nepalese hill farmers is that the 4-mg implant, inserted in mid-April, could enable lambing in September-October, thereby spreading farm labor and capitalizing on higher off-season lamb prices in urban markets ^[2, 12].

Conclusion

Gaddi sheep, like most hill breeds in the Himalayan belt, are constrained by a pronounced seasonal anoestrus that limits lamb production to a single annual cycle. The present trial demonstrated that a single 4-mg subcutaneous melatonin implant administered in mid-April advanced the onset of oestrus by approximately five weeks, raised first-service conception rates to 73.3 %, and sustained luteal-phase progesterone levels through what would otherwise be deep anoestrus. The 2-mg dose was less effective but still superior to untreated controls. On the strength of these data, the 4-mg melatonin implant can be recommended for on-farm trials in Gaddi flocks managed under semi-intensive Himalayan conditions. Smallholders should be advised that the implant works best when ewes are in adequate body condition (score ≥ 2.5) and when fertile rams are introduced promptly upon oestrus detection. Looking forward, multi-site trials across different altitudes and photoperiodic regimes within Nepal would clarify the geographic boundaries of efficacy, and an economic analysis comparing implant cost against the premium obtainable for off-season lambs would help extension services frame the technology in terms that resonate with farming communities ^[13, 14].

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References

1. Notter DR. Genetic improvement of reproductive performance of sheep and goats. *Anim Reprod Sci.* 2012;130(3-4):147-151.
2. Gurung DB, Paudyal S. Gaddi sheep production systems in Nepal: current status and future prospects. *Nepal J Agric Sci.* 2019;18(2):87-95.
3. Malpoux B, Thiéry JC, Chemineau P. Melatonin and the seasonal control of reproduction. *Reprod Nutr Dev.* 1999;39(3):355-366.
4. Chemineau P, Malpoux B, Delgadillo JA, Guillaume D, Ravault JP, Thimonier J, et al. Control of sheep and goat reproduction: use of light and melatonin. *Anim Reprod Sci.* 1992;30(1-3):157-184.
5. Rosa HJD, Bryant MJ. The ram effect as a way of modifying the reproductive activity in the ewe. *Small Rumin Res.* 2002;45(1):1-16.
6. Mura MC, Luridiana S, Bodano S, Daga C, Cosso G, Diaz PM, et al. Influence of melatonin receptor 1A gene polymorphisms on seasonal reproduction in Sarda ewes. *Reprod Fertil Dev.* 2014;26(6):813-818.
7. Chemineau P, Guillaume D, Migaud M, Thiéry JC, Pellicer-Rubio MT, Malpoux B. Seasonality of reproduction in mammals: intimate regulatory mechanisms and practical implications. *Reprod Domest Anim.* 2008;43(Suppl 2):40-47.
8. Shrestha ML, Wake AB, Manandhar S, Bajracharya SR, Maharjan SB, Shrestha AB. Observed trends and changes in daily temperature and precipitation extremes over the Koshi River Basin, 1975-2010. *Int J Climatol.* 2017;37(2):1066-1083.
9. Abecia JA, Forcada F, González-Bulnes A. Hormonal control of reproduction in small ruminants. *Anim Reprod Sci.* 2012;130(3-4):173-179.
10. Zarazaga LA, Gatica MC, Celi I, Guzmán JL, Malpoux B. Effect of melatonin implants on sexual activity in Mediterranean goat females without separation from males. *Theriogenology.* 2011;75(9):1723-1731.
11. R Core Team. *R: a language and environment for statistical computing.* Vienna (Austria): R Foundation for Statistical Computing; 2023.
12. O'Callaghan D, Karsch FJ, Boland MP, Roche JF. What does the brain tell the testis? A role for GnRH. *J Reprod Fertil Suppl.* 1991;43:7-17.
13. Devkota NR, Kolachhapati MR, Pokharel PK. Small ruminant genetic resources of Nepal and their management. *Nepal J Sci Technol.* 2020;19(1):143-151.

14. Rekik M, Lassoued N, Salem HB, Tounsi A. Reproductive performance of local and crossbred sheep in a flock of the Tunisian arid zone. J Arid Environ. 2005;60(4):635-643.

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