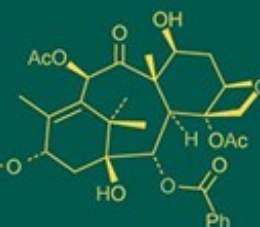
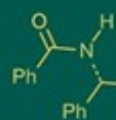


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Comparative evaluation of different estrus synchronization protocols on reproductive performance and conception rate in goats

Chamaraj Pujar¹, Narasimha Murthy², Ravindranath B.M³, Sharadha R⁴, Nagaraj⁵, Mahadevappa Gowri⁶, Umashankar BC⁷, Sudha G⁸, Pallavi Bhatambre⁹, Prathviraj¹⁰

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ABSTRACT

The present study was undertaken to evaluate the effectiveness of different estrus synchronization protocols in goats with special emphasis on conception rate and associated reproductive performance. A total of 36 clinically healthy, non-pregnant cyclic does were randomly allocated into three equal groups ($n = 12$). Group I received a natural progesterone-impregnated intravaginal sponge for seven days followed by cloprostenol sodium (125 μg IM) at sponge withdrawal. Group II received a letrozole-impregnated intravaginal sponge (7.5 mg) for seven days followed by cloprostenol sodium (125 μg IM) at sponge withdrawal. Group III received oral clomiphene citrate (150 mg/day for five consecutive days) following copper sulphate administration, followed by cloprostenol sodium (125 μg IM). Estrus detection was performed twice daily using teaser bucks, and does exhibiting standing estrus were naturally mated. The sponge retention rate was 100% in both intravaginal treatment groups. Estrus induction rates were 91.66% in Groups I and II and 83.33% in Group III, with no significant difference among groups ($P > 0.05$). The mean time to onset of estrus differed significantly among synchronization protocols ($P < 0.05$), being earliest in Group I (31.5 ± 3.50 h), followed by Group II (55.0 ± 5.50 h), and longest in Group III (82.5 ± 6.50 h). The duration of estrus was 27.5 ± 2.50 h, 26.5 ± 3.50 h, and 30.2 ± 2.50 h in Groups I, II, and III, respectively, and did not differ significantly ($P > 0.05$). Conception rates following natural mating were 90.91% (10/11), 90.91% (10/11), and 90.00% (9/10) in Groups I, II, and III, respectively, while corresponding kidding rates were 90.91%, 90.91%, and 90.00%, with no significant variation among groups ($P > 0.05$). The male:female sex ratio of kids born was 7:7 (50.0% males, 50.0% females) in Group I, 8:5 (61.53% males, 38.46% females) in Group II, and 5:6 (45.45% males, 54.54% females) in Group III with no significant difference in sex distribution among synchronization protocols ($P > 0.05$). The findings indicate that intravaginal progesterone sponge, intravaginal letrozole sponge, and oral clomiphene citrate protocols were all effective in inducing fertile estrus and achieving high conception and kidding rates in goats. Although the progesterone sponge protocol resulted in the earliest estrus exhibition, the intravaginal letrozole sponge protocol was equally efficient in terms of estrus induction, conception rate, and kidding performance, and therefore represents a practical, cost-effective, and field-applicable alternative for reproductive management and planned breeding programs in goats.

Keywords: Goat, Estrus synchronization, Progesterone sponge, Letrozole, Clomiphene citrate, Conception rate, Kidding rate, Sex ratio

Introduction

Reproductive efficiency is a major determinant of productivity and profitability in goat farming systems. Seasonal breeding activity, silent estrus, and difficulties in heat detection often limit optimal reproductive management. Estrus synchronization protocols facilitate planned breeding, improve management efficiency and enable grouped kidding periods (Chemineau *et al.*, 2004 [1]; Abecia *et al.*, 2012 [2]) [1, 2]. Progestagen-based intravaginal devices are among the most extensively studied synchronization methods in small ruminants because they provide predictable control of the luteal phase and synchronized follicular turnover (Menchaca and Rubianes, 2004 [3]; Rubianes *et al.*, 2003 [4]) [3, 4]. Short-term protocols of 5 to 7 days have gained considerable acceptance as they reduce prolonged vaginal exposure while maintaining estrus and fertility responses comparable to conventional long-term treatments (Karaca *et al.*, 2010 [5]; Vilarino *et al.*, 2011 [6]; Letelier *et al.*, 2009 [7]) [5, 6, 7].

Alternative pharmacological agents such as letrozole, an aromatase inhibitor and clomiphene citrate, a selective estrogen receptor modulator, have emerged as practical and cost-effective options for inducing ovulation and synchronized estrus by modulating endogenous gonadotropin secretion (Goss and Strasser, 2001 [8]; Simpson *et al.*, 2002 [9]; Clark and Markaverich, 1981 [10]) [8, 9, 10]. Letrozole suppresses estrogen synthesis

Corresponding Author:
Chamaraj Pujar
PhD scholar, Dept. of
Veterinary Gynaecology
and Obstetrics, Veterinary
College, Hebbal,
Bangalore, KVASU,
Karnataka, India

by inhibiting aromatase activity, whereas clomiphene citrate blocks hypothalamic estrogen receptors, resulting in increased GnRH, FSH and LH secretion and enhanced follicular development (Duarte *et al.*, 2016 [11]) [11].

Although numerous synchronization strategies have been evaluated in goats, comparative information regarding their effectiveness with respect to conception rate, kidding performance, estrus exhibition timing and offspring sex ratio remains limited under Indian field conditions. Therefore, the present investigation was undertaken to assess the effectiveness of intravaginal progesterone sponge, intravaginal letrozole sponge and oral clomiphene citrate protocols with particular emphasis on conception rate and associated reproductive performance parameters.

Materials and Methods

The study was conducted at the Department of Livestock Farm Complex and the Department of Veterinary Gynaecology and Obstetrics, Veterinary College, Hebbal, Bengaluru, under uniform management conditions. Thirty-six clinically healthy, non-pregnant, cyclic does aged 1 to 4 years were selected based on clinical examination, normal physiological parameters and ultrasonographic confirmation of non-pregnancy. The animals were randomly allocated into three equal groups ($n = 12$ per group).

Group I (Progesterone sponge)

Intravaginal sponge containing 350 mg natural progesterone (Avikasil-S®) for seven days, followed by cloprostenol sodium 125 µg IM at sponge withdrawal.

Group II (Letrozole sponge)

Intravaginal polyurethane sponge impregnated with 7.5 mg letrozole for seven days, followed by cloprostenol sodium 125 µg IM at sponge withdrawal.

Group III (Clomiphene citrate)

Copper sulphate 750 mg orally followed by clomiphene citrate 150 mg/day orally for 5 consecutive days and cloprostenol sodium 125 µg IM on day 5.

The synchronization procedures were based on established short-term protocols described for small ruminants (Menchaca and Rubianes, 2004 [3]; Karaca *et al.*, 2010 [5]; Vilarino *et al.*, 2011 [6]) [3, 5, 6].

Estrus detection, breeding, pregnancy diagnosis and kidding

Estrus detection was performed twice daily using teaser bucks. Behavioral signs such as tail wagging, restlessness, bleating, mounting acceptance, and standing to be mounted were recorded. Does exhibiting standing estrus were naturally mated with fertile bucks. Pregnancy was confirmed by transabdominal ultrasonography approximately 50 days after mating, and all pregnant animals were monitored until kidding.

Statistical analysis

Sponge retention rate, estrus induction rate, conception rate, kidding rate, and sex ratio were analysed using Fisher's Exact Test or Fisher Freeman Halton exact test as appropriate. Time to onset of estrus and duration of estrus were analysed by one-way ANOVA followed by Tukey's post hoc test. Differences were considered significant at $P < 0.05$.

Results

The reproductive performance of goats subjected to different estrous synchronization protocols is presented in Table 1. Both intravaginal progesterone and letrozole sponges exhibited excellent retention, with a 100% sponge retention rate until the scheduled time of withdrawal. Estrus was induced in 91.66% of does in Group I and Group II, whereas 83.33% of does in Group III exhibited estrus; however, the difference among groups was not statistically significant ($P > 0.05$).

A significant variation was observed in the time to onset of estrus ($P < 0.05$). Does treated with the progesterone sponge exhibited estrus earliest (31.5 ± 3.50 h), followed by the letrozole sponge group (55.0 ± 5.50 h), while the clomiphene citrate group showed the latest onset (82.5 ± 6.50 h). In contrast, the duration of estrus ranged from 26.5 to 30.2 h and did not differ significantly among synchronization protocols ($P > 0.05$).

Conception and kidding rates were consistently high across all groups, with 90.91% in Group I, 90.91% in Group II, and 90.00% in Group III, indicating that all three protocols were comparably effective in achieving successful pregnancy and parturition following natural mating.

A total of 38 kids were born during the study. The male:female sex ratios were 1:1 in Group I, 1.6:1 in Group II, and 0.83:1 in Group III. Statistical analysis using the Fisher–Freeman–Halton exact test revealed no significant difference in sex distribution among synchronization protocols ($P > 0.05$), suggesting that the synchronization treatments did not influence offspring sex ratio.

Table 1. Effect of different estrous synchronization protocols on reproductive performance in goats

Parameter	Group I (Progesterone sponge)	Group II (Letrozole sponge)	Group III (Clomiphene citrate)
Sponge retention rate (%)	100	100	—
Estrus induction rate (%)	91.66 (11/12)	91.66 (11/12)	83.33 (10/12)
Time to onset of estrus (h)	31.5 ± 3.50^a	55.0 ± 5.50^b	82.5 ± 6.50^c
Duration of estrus (h)	27.5 ± 2.50	26.5 ± 3.50	30.2 ± 2.50
Conceived / Mated	10/11	10/11	9/10
Conception rate (%)	90.91	90.91	90.00
Kidded / Mated	10/11	10/11	9/10
Kidding rate (%)	90.91	90.91	90.00
Male kids (n)	7	8	5
Female kids (n)	7	5	6
Male : Female sex ratio	1 : 1	1.6 : 1	0.83 : 1

Discussion

The present study demonstrated excellent sponge retention (100%) in both progesterone and letrozole intravaginal protocols, indicating that the polyurethane sponge devices were well tolerated and suitable for short-term synchronization under field conditions. Similar high reten-

tion rates have been reported in goats treated with short-term progesterone devices (Abecia *et al.*, 2012 [2]; Karaca *et al.*, 2010 [5]) [2, 5]. High retention is critical because premature sponge loss can reduce hormonal exposure and compromise synchronization efficiency. Estrus induction rates above 90% in Groups I and II indicate that both intravaginal protocols effectively synchronized ovarian activity. Comparable estrus response rates have been reported with short-term

progesterone-based synchronization programs in goats and sheep (Karaca *et al.*, 2010 [5]; Vilarino *et al.*, 2011 [6]) [5, 6]. The slightly lower response observed in the clomiphene citrate group may be related to individual variation in ovarian responsiveness and the absence of continuous intravaginal hormonal exposure.

A significant difference was observed in time to onset of estrus. The progesterone sponge protocol produced the earliest estrus exhibition, followed by the letrozole sponge protocol, whereas the clomiphene citrate protocol required a longer interval. The earlier onset in sponge-treated groups is consistent with reports showing that estrus generally occurs within 24 to 48 h after sponge withdrawal due to abrupt progesterone decline and synchronized preovulatory follicular maturation (Dutt and Casida, 1948 [12]; Greyling, 2000 [13]; Simões *et al.*, 2006 [14]) [12, 13, 14]. In contrast, clomiphene citrate acts indirectly through hypothalamic estrogen receptor blockade and stimulation of endogenous gonadotropin release, which may require a longer interval before dominant follicle maturation and ovulation (Clark and Markaverich, 1981 [10]; Duarte *et al.*, 2016 [11]) [10, 11].

Despite differences in estrus onset, conception and kidding rates remained uniformly high across all protocols. These findings indicate that synchronization method influenced the timing of estrus expression but did not compromise fertility. Similar observations have been reported in small ruminants, where short-term synchronization protocols achieved conception and kidding outcomes comparable to conventional hormonal programs when breeding was performed during standing estrus (Menchaca and Rubianes, 2004 [3]; Vilarino *et al.*, 2011 [6]) [3, 6].

The high conception rates obtained in the present study also suggest that transient alterations in vaginal microbiota associated with sponge retention did not adversely affect fertility. Earlier studies have shown that bacterial proliferation during sponge retention is generally temporary and that vaginal flora returns near baseline levels after device withdrawal, with minimal impact on reproductive performance (Suárez *et al.*, 2006 [15]; Gatti *et al.*, 2011 [16]; Oliveira *et al.*, 2013 [17]; Manes *et al.*, 2013 [18]).

The sex ratio results further demonstrated that none of the synchronization protocols influenced offspring sex distribution. The observed variations among groups were within the range expected under natural breeding conditions and did not deviate significantly from the expected 1:1 ratio. Therefore, the hormonal treatments used in the present investigation appear to affect estrus timing and ovarian synchronization rather than embryonic sex determination.

Overall, the reproductive outcomes of the present study indicate that progesterone sponge, letrozole sponge, and oral clomiphene citrate protocols are all effective for inducing fertile estrus and achieving satisfactory conception and kidding performance in goats. Among them, the progesterone sponge protocol provided the earliest and most predictable estrus exhibition, which is advantageous for planned breeding and fixed-time reproductive management.

Conclusion

The present investigation demonstrated that intravaginal progesterone sponge, intravaginal letrozole sponge, and oral clomiphene citrate protocols were all effective in inducing synchronized fertile estrus and achieving high conception and kidding rates in goats. The progesterone and letrozole sponge protocols exhibited excellent sponge retention (100%) and produced a significantly earlier onset of estrus compared with the oral clomiphene citrate protocol. However, estrus induction, conception, and kidding rates were statistically comparable among treatments, with all protocols achieving approximately 90%

fertility outcomes. Furthermore, the synchronization methods did not influence the male:female sex ratio of offspring. Therefore, all three protocols can be considered physiologically safe and practically suitable options for reproductive management and planned breeding programs in caprine production systems, while the progesterone sponge protocol may be preferred when precise timing of estrus exhibition is required.

References

1. Chemineau P, Malpau B, Delgadillo JA, *et al.* Control of sheep and goat reproduction: Use of light and melatonin. *Animal Reproduction Science*. 2004;82–83:583–592.
2. Abecia JA, Forcada F, González-Bulnes A. Hormonal control of reproduction in small ruminants. *Animal Reproduction Science*. 2012;130:173–179.
3. Menchaca A, Rubianes E. New treatments associated with timed artificial insemination in small ruminants. *Reproduction, Fertility and Development*. 2004;16:403–413.
4. Rubianes E, Menchaca A, Carbajal B. Response of the corpus luteum to prostaglandin F2 α in goats. *Theriogenology*. 2003;59:1109–1118.
5. Karaca F, Ataman MB, Çoyan K. Synchronization of estrus with short- and long-term progestagen treatments in goats. *Small Ruminant Research*. 2010;90:63–66.
6. Vilarino M, Rubianes E, Menchaca A. Re-use of intravaginal progesterone devices associated with short-term protocols for fixed-time artificial insemination in goats. *Theriogenology*. 2011;75:1195–1200.
7. Letelier CA, Contreras-Solis I, García-Fernández RA, *et al.* Effect of dose and duration of progesterone treatment on ovarian response in goats. *Theriogenology*. 2009;72:1090–1098.
8. Goss PE, Strasser K. Aromatase inhibitors in endocrine therapy. *Journal of Clinical Oncology*. 2001;19:881–894.
9. Simpson ER, Clyne C, Rubin G, *et al.* Aromatase: A brief overview. *Annual Review of Physiology*. 2002;64:93–127.
10. Clark JH, Markaverich BM. The agonistic and antagonistic actions of clomiphene citrate. *Pharmacology and Therapeutics*. 1981;15:467–519.
11. Duarte G, Rodrigues A, Silva J. Clomiphene citrate and ovarian response in small ruminants. *Small Ruminant Research*. 2016;144:198–203.
12. Dutt RH, Casida LE. Alteration of the estrual cycle in sheep by use of progesterone and its effect upon subsequent fertility. *Endocrinology*. 1948;43:208–217.
13. Greyling JPC. Reproduction traits in the Boer goat doe. *Small Ruminant Research*. 2000;36:171–177.
14. Simões J, Almeida JC, Valentim R, *et al.* Follicular dynamics and ovulation in goats. *Animal Reproduction Science*. 2006;95:16–28.
15. Suárez G, Zunino P, Carol H, *et al.* Changes in vaginal bacterial flora associated with intravaginal sponge treatment in ewes. *Theriogenology*. 2006;66:1923–1930.
16. Gatti M, Ungerfeld R, Bielli A. Vaginal bacterial population during intravaginal synchronization protocols in sheep. *Reproduction in Domestic Animals*. 2011;46:115–120.
17. Oliveira MEF, Rodrigues LF, Teixeira PPM, *et al.* Vaginal microbiota and fertility following intravaginal sponge use in goats. *Animal Reproduction Science*. 2013;138:153–159.

18. Manes J, Fiorentino MA, Kaiser G, *et al.* Influence of intravaginal synchronization devices on vaginal flora and reproductive performance in goats. *Small Ruminant Research*. 2013;113:164-170.

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Authors

Chamaraj Pujar

PhD scholar, Dept. of Veterinary Gynaecology and Obstetrics, Veterinary College, Hebbal, Bangalore, KVAFSU, Karnataka, India

Narasimha Murthy

Associate Professor, Dept. of Veterinary Gynaecology and Obstetrics, Veterinary College, Bangalore, KVAFSU, Karnataka, India

Ravindranath B.M

Professor and Head, Dept. of Veterinary Gynaecology and Obstetrics, Veterinary College, Hebbal, Bangalore, KVAFSU, Karnataka, India

Sharadha R

Professor and Head, Dept. of Veterinary Microbiology, Veterinary College, Gadag, KVAFSU, Karnataka, India

Nagaraj

PhD scholar, Dept. of Veterinary Gynaecology and Obstetrics, Veterinary College, Hebbal, Bangalore, KVAFSU, Karnataka, India

Mahadevappa Gowri

Associate Professor, Dept. Of Livestock Farm Complex, Veterinary College, Bangalore, KVAFSU, Karnataka, India

Umashankar BC

Associate Professor, Dept. Of Livestock Farm Complex, Veterinary College, Bangalore, KVAFSU, Karnataka, India

Sudha G

Professor of Veterinary Gynaecology and Obstetrics, Veterinary College, Gadag, KVAFSU, Karnataka, India

Pallavi Bhatambre

Veterinary Officer, GOK, Gadag, Karnataka, India

Prathviraj

Veterinary Officer, GOK, Raichur, Karnataka, India