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From heat detection to conception: The science of goat AI

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Abstract

Artificial insemination (AI) and semen cryopreservation are powerful tools for genetic improvement in goat farming, enabling the use of superior bucks to enhance productivity, disease resistance, and adaptability. Success depends on accurate estrus detection, proper semen handling, optimal timing, and appropriate insemination techniques, with transcervical and laparoscopic AI showing the highest fertility, especially with frozen semen.Despite benefits such as rapid genetic gain, disease control, and reduced costs, adoption is limited by technical, infrastructural, and management challenges. With improved training, standardization, and support, AI can significantly boost productivity, conserve indigenous breeds, and strengthen rural livelihoods in India.

Introduction

Goats play a vital role in India's rural economy, with over 43 recognized breeds such as Jamunapari, Barbari, Beetal, Black Bengal, and Sirohi contributing significantly (NBAGR, 2026). A large population of non-descript goats (>100 million) can be genetically improved using quality frozen semen (Gama and Bressan, 2011). Artificial insemination (AI) using semen from proven bucks is a key tool for large-scale genetic improvement, enhancing productivity, disease resistance, and adaptability (Gangwar et al., 2016). Although small-scale farmers still rely on traditional breeding, increasing demand for superior milk and meat is driving adoption of advanced technologies like semen cryopreservation and AI (Nunes, et al.,2011).AI involves collecting semen from a buck, evaluating and extending it into multiple doses, and depositing it into the doe's reproductive tract at the optimal time. Pregnancy rates with frozen-thawed semen vary widely (7–79%) (Bispo et al., 2012). Success depends on

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proper semen handling, estrous synchronization, and accurate timing, making AI an effective strategy to accelerate genetic gain and improve overall herd productivity.

Identification of heat signs in does for effective breeding

Category	Details
Role of the Buck	A buck's presence or odor can stimulate does to exhibit heat signs
Physical Signs of Heat in Does	Swollen, reddened, and moist vulva; tail flagging; restlessness; vocalization; increased urination
Mucus Observation – Beginning of Heat	Minimal mucus
Mucus Observation – Progression of Heat	Transparent mucus on the floor of the vagina
Mucus Observation – End of Heat (Optimal Breeding Time)	Cloudy mucus

Factors affecting success of AI programs in goat breeding

Factor	Key Points
Viable Semen	Source from reputable suppliers; proper handling and storage; maintain liquid nitrogen tank
Timing of Insemination	Inseminate at optimal oestrus stage: cloudy mucus (end)-Best time for A.I
Proper Semen Deposition	Deposit semen in cervix or uterine body; avoid anterior vagina

Doe selection for AI

Suitable Does	Healthy (BCS 2.5–3); rising plane of nutrition; disease-free; good maternal traits
Does to Avoid	Irregular estrous cycles; difficulty detecting oestrus

The site of semen deposition significantly affects fertility in goat AI (Arrebola et al., 2012). The standard insemination procedure in does involves positioning the animal with the hindquarters raised and forequarters on the ground, followed by locating the cervix using a speculum and light source, as shown in Figure 1. Four main techniques are used: vaginal insemination, cervical insemination, transcervical AI, and laparoscopic intrauterine insemination (Sathe, 2018) are summarized in fig.2. Laparoscopic AI deposits semen directly into the uterus, improving sperm transport and resulting in higher pregnancy rates compared to vaginal or cervical methods. Reported conception rates are 5–15% for vaginal (Evans and

Maxwell, 1987), 40–80% for cervical (Nuti, 2007), 60–80% for laparoscopic (Shipley et al., 2007; Parkinson, 2009), and around 71% for transcervical insemination (Sohnrey and Holtz, 2005). Overall pregnancy rates with frozen-thawed semen range from 7% to 79% (Arangasamy et al., 2018).

Figure 1: Doe positioned for AI with speculum-guided cervix location.

Vaginal Insemination (VAI)

Vaginal (peri-cervical) insemination involves depositing semen in the upper vagina without locating the cervix and is commonly used with fresh semen. It is simple, fast, and cost-effective but requires a high sperm dose (150–400 million). Fertility is satisfactory with fresh semen but significantly reduced with chilled or frozen semen (Leboeuf et al., 2000). Fertility rates with frozen-thawed semen are low; single (400 million) and double (200 million) inseminations showed similar results (Nordstoga et al., 2010). Non-return and kidding rates were 37.3% and 24%, respectively (Nordstoga et al., 2011).

Cervical Insemination (Intra-cervical)

This widely used method involves depositing semen directly into the cervix using a speculum and AI gun. It provides better semen placement and higher fertility with fresh semen. Kidding rate with frozen semen reached 71% with a litter size of 1.76 (Sohnrey and Holtz, 2005). Using liquid semen (200 million sperm), non-return and kidding rates were 87% and 78% (Paulenz et al., 2005). However, fertility declines with frozen-thawed semen, and success depends on cervical penetration, which is higher in multiparous does.

Trans-cervical Intrauterine Insemination (TCAI)

TCAI deposits semen deep into the cervix or uterus using specialized equipment. Greater depth of insemination improves pregnancy and kidding rates. However, the complex cervical structure limits penetration. Cervical length averages 4.2 ± 0.2 cm in multiparous does (Intrakamhaeng et al., 2011). Cervical penetration can be improved using FSH or PGE2 (Chatsumal et al., 2011), and prostaglandin receptors (EP2, EP4) aid cervical relaxation (Leethongdee et al., 2011).

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Laparoscopic Intrauterine Insemination

This technique deposits semen directly into the uterus using a laparoscope, bypassing the cervix and improving fertility with both fresh and frozen semen. It requires fewer sperm (40–80 × 10^6) and yields high pregnancy rates. Rates of 64.5% (CIDR) and 62.7% (progestagen sponge) were reported (Ritar et al., 1990), with no major effect of synchronization method. Timing is critical, as insemination after 65 hours reduces success (Ritar et al., 1990). Although highly effective, this method requires skilled personnel, specialized equipment, and raises cost and animal welfare concerns.

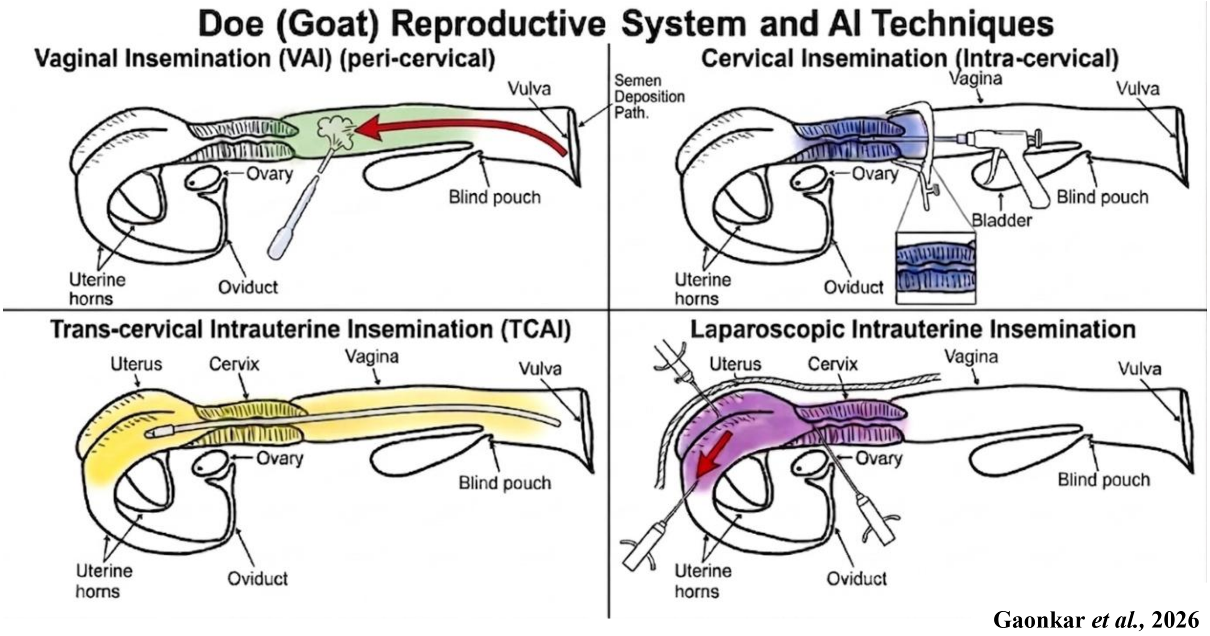

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Figure.2. Different techniques of A.I in Doe

Benefits of AI in goat farming

Category	Key Benefits
Genetic Improvement	Faster identification of superior bucks through progeny testing; rapid genetic gain; improved traits (milk, meat, fertility, disease resistance)
Efficient Use of Genetics	Use and storage of superior genetic material via semen cryopreservation; one ejaculate produces multiple doses
Disease Control	Reduces transmission of reproductive diseases; enables safe transport of screened semen; improves herd biosecurity
Reproductive Control	Precise control of breeding, ovulation, and kidding; supports estrous synchronization and out-of-season breeding
Cost-Effectiveness	Eliminates need to maintain bucks; reduces feeding and management costs

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Reproductive Management	Better timing of insemination; higher pregnancy rates; shorter kidding intervals
Genetic Diversity	Introduction of new bloodlines; reduces inbreeding and genetic defects
Breeding Program Control	Planned mating and synchronized kidding aligned with production goals
Transport & Accessibility	Semen can be transported over long distances without moving animals
Recordkeeping	Accurate pedigree tracking and improved breeding records
Predictability	Known breeding dates allow accurate prediction of kidding time

Challenges of Goat Artificial Insemination (AI)

Challenge	Key Points
Technical Expertise	Requires skilled personnel; improper technique reduces conception rates
Estrus Detection & Synchronization	Short estrus period; accurate timing is critical; hormonal synchronization requires careful management
Semen Quality & Handling	Proper collection, processing, and storage essential; mishandling lowers fertility
Infrastructure & Equipment	Specialized tools and liquid nitrogen needed; costly and sometimes limited
Conception Rates	Vary based on technician skill, semen quality, doe health, and timing; generally lower than natural breeding
Cost & Investment	High initial investment in equipment, training, and facilities; may deter small-scale farmers
Labor Costs	Increased labor needed for heat detection and insemination
Spread of Undesirable Traits	Poorly evaluated bucks can rapidly propagate genetic defects
Low Demand	Returns lower than large ruminants, leading to weaker adoption

Factors Affecting AI Success in Goats

Factor	**Key Points**
Type of Semen	Fresh semen generally gives higher fertility than frozen-thawed semen

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Number & Timing of Inseminations	Optimal timing and repeated inseminations improve conception rates
Insemination Method	Vaginal, cervical, transcervical, or laparoscopic methods affect success
Semen Quality & Quantity	Higher motility and appropriate sperm numbers increase fertility
Semen Handling Practices	Proper collection, extension, storage, and thawing are critical
Animal Management	Health, nutrition, estrus detection, and overall management influence outcomes

Opportunities for AI and Semen Cryopreservation in Indian Goat Breeding

Opportunity	**Key Points**
Access to High-Quality Genetics	Small farmers can use superior bucks' semen, improving genetic variety and breeding efficiency
Genetic Diversity & Breeding Efficiency	Enhances genetic improvement in dairy and meat breeds; boosts yields, growth, and profitability
Disease Control & Herd Health	Reduces STI transmission; semen from disease-free bucks protects herd and lowers veterinary costs
Rural Livelihoods & Economic Growth	Increases production and income for small-scale farmers; helps reduce rural poverty
Government Support & Research	Programs like the NLM and research projects improve AI and cryopreservation methods, making them cost-effective and practical

Challenges of AI and Semen Cryopreservation in Goats

Challenge	**Key Points**
Limited Availability & High Cost	Few cryopreservation facilities; AI services expensive
Lack of Knowledge & Training	Farmers and technicians may not understand or adopt the technology
No Standardized Protocols	Inconsistent methods reduce success rates
High Initial Investment & Technical Skill	Infrastructure, equipment, and skilled personnel needed
Variable Success Rates	Affected by semen quality, timing, and doe reproductive status

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Preservation of Indigenous Breeds	Need to balance productivity with conservation of local breeds
Logistical Challenges	Frozen semen transport and storage over long distances is difficult

Conclusion

Artificial insemination (AI) and semen cryopreservation offer significant potential to improve genetic quality, productivity, and disease control in Indian goat farming. While challenges such as technical expertise, infrastructure, and variable fertility exist, targeted investment, training, and standardized protocols can overcome them. Effective use of these technologies can enhance herd genetics, preserve native breeds, boost rural livelihoods, and promote economic growth, positioning AI and cryopreservation as key tools for sustainable and profitable goat production in India.

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