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Vijayakumar Chinnathambi

Ph.D., Post Doc (USA),

Assistant Professor, Department
of Veterinary Pharmacology and
Toxicology, Veterinary College
and Research Institute, Salem,
TANUVAS, Tamil Nadu, India

Chitrambigai K

Assistant Professor, Animal
Husbandry Statistics and
Computer Applications,
Madras Veterinary College,
Chennai TANUVAS, Tamil
Nadu, India

Enbavelan PA

Assistant Professor, Department
of Veterinary Medicine,
Veterinary College and Research
Institute, Salem TANUVAS,
Tamil Nadu, India

Optimizing sheep reproductive performance through technological interventions

Vijayakumar Chinnathambi, Chitrambigai K and Enbavelan PA

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Abstract

Sheep farming plays a vital role in India's livestock sector, contributing to the economy through meat, wool, and manure production, particularly for small and marginal farmers. Despite its importance, low productivity remains a significant challenge, primarily due to inbreeding, poor breeding practices, and inadequate management. This study investigates the impact of inbreeding on sheep productivity and examines sustainable breeding strategies among smallholder farmers in Tamil Nadu, specifically in the Krishnagiri District. A benchmark survey involving nearly 200 sheep farmers revealed that prolonged use of the same breeding ram (four to five years or more) unintentionally led to inbreeding, resulting in lower fertility rates, poor growth performance, and increased disease susceptibility.

To address these issues, a capacity-building program was implemented for 50 farmers, focusing on scientific breeding practices, genetic improvement, and ram replacement strategies. The introduction of improved breed able rams resulted in significant improvements in reproductive parameters such as tupping percentage, fertility rate, and lambing rate. Statistical analysis showed a notable increase in reproductive efficiency, with improved farms recording a tupping percentage of 17.31 ± 0.18 ewes per ram, a fertility rate of $77.90 \pm 0.90\%$, and a lambing rate of $89.24 \pm 2.00\%$. Furthermore, stillbirths and neonatal mortality rates decreased significantly after the intervention.

This study emphasizes the importance of genetic improvement in enhancing sheep productivity, benefiting the economic viability of smallholder farmers. It also highlights the need for ongoing breeding interventions, financial support, and scientific flock management to sustain these improvements.

Keywords: Sheep farming, inbreeding, genetic improvement, reproductive performance, smallholder farmers

1. Introduction

Sheep farming plays a vital role in India's livestock sector, contributing significantly to the livelihoods of small and marginal farmers. The sector provides multiple economic benefits, including meat, wool, and manure, making it an essential component of rural economies. India ranks among the leading countries in sheep production, with states such as Tamil Nadu, Karnataka, Rajasthan, Andhra Pradesh, and Maharashtra being major contributors (Bhatia and Arora, 2019) ^[4]. Despite its economic importance, low productivity remains a persistent challenge, primarily due to poor breeding practices, disease prevalence, inadequate nutrition, and lack of scientific interventions. Among these factors, breeding management plays a pivotal role in enhancing productivity by improving growth rate, fertility, disease resistance, and overall flock performance (Tibbo and Jembere, 2021) ^[18].

One of the most pressing issues affecting sheep productivity in India is inbreeding, a practice where closely related animals, such as parent-offspring or sibling pairs, are repeatedly bred within the same flock. Inbreeding is widely observed among smallholder farmers, as they often fail to introduce new breeding stock due to financial constraints or lack of awareness. Over successive generations, inbreeding depression leads to a decline in genetic diversity, resulting in lower fertility rates, reduced growth performance, higher disease susceptibility, and increased mortality in lambs. These factors collectively impact the sustainability and profitability of sheep farming (Pundir and Singh, 2019) ^[15]. Field observations and a benchmark survey conducted in the Krishnagiri district of Tamil Nadu revealed that a

Corresponding Author:

Vijayakumar Chinnathambi

Ph.D., Post Doc (USA),

Assistant Professor, Department
of Veterinary Pharmacology and
Toxicology, Veterinary College
and Research Institute, Salem,
TANUVAS, Tamil Nadu, India

significant proportion of sheep farmers maintain the same Ram for extended periods (four to five years or more), leading to unintentional inbreeding within their flocks. Farmers were largely unaware of the negative impacts of prolonged use of the same Ram, believing it to be beneficial for maintaining genetic uniformity. However, our preliminary data indicate that such practices contribute to declining flock performance, lower market value of animals, and increased veterinary costs due to poor health outcomes (Vijayakumar Chinnathambi *et al.*, 2025) ^[19].

To address these challenges, this study aims to assess the impact of inbreeding on sheep productivity and explore the adoption of effective breeding strategies among smallholder farmers. The key objectives of this research are:

- To analyze the prevalence of inbreeding practices among small and marginal sheep farmers in Tamil Nadu, their implications for flock productivity, and the effects on key reproductive parameters and overall productivity.
- To facilitate the replacement of breeding rams through NABARD schemes, enabling farmers to adopt sustainable breeding practices, and to assess improvements in reproductive performance and overall productivity following ram replacement and capacity-building programs for farmers.

This research is expected to generate valuable insights into livestock management practices, contributing to enhanced productivity, improved animal health, and better economic outcomes for marginal farmers engaged in sheep rearing.

2. Methodology

2.1 Selection of Farmers and Benchmark Survey

The study was conducted among sheep farmers who owned a minimum of 20 animals, based on a set of predefined criteria for participant selection. To ensure a fair and unbiased selection process, a score-based index was developed. Beneficiaries were selected based on the marks they obtained according to established criteria and criteria are outlined below.

2.1.1 Criteria for selecting farmers under the NABARD Scheme

The total evaluation consists of 80 marks across multiple parameters.

- **Experience (10 Marks):** Farmers with 1-2 years receive 2 marks, 3-4 years get 4 marks, 5-6 years earn 6 marks, and those with more than 6 years receive 10 marks.
- **Education (10 Marks):** Illiterate individuals receive 0 marks, primary school graduates get 2, high school graduates receive 4, and college-educated individuals earn 10 marks.
- **Caste (10 Marks):** SC/ST individuals receive 10 marks, while others get 5 marks.
- **Sex (10 Marks):** Males receive 5 marks, and females receive 10 marks.
- **Land (10 Marks)-Must cultivate fodder crops:** Landless individuals receive 0 marks, those with less than 0.25 acres get 2, 0.25-0.50 acres earn 4, 0.50-0.75 acres get 8, and 0.75-1.0 acres receive 10 marks.
- **Training (10 Marks):** No training earns 0 marks, while undergone training awards 10 marks.
- **Mode of Grazing (10 Marks):** Grazing around the village earns 10 marks, while migratory grazing receives 0 marks.

- **Fodder Production (5 Marks):** Those producing fodder earn 5 marks, while those not producing receive 0 marks.
- **Participation in government schemes (5 Marks):** Participants receive 5 marks, while non-participants get 0 marks.

A benchmark survey was conducted to assess farmers' awareness levels and adoption of modern technologies in sheep farming like existing management practices, breeding patterns, and health interventions, providing a baseline for measuring the impact of interventions.

2.2 Capacity-building program for sheep farmers

Based on the preliminary survey findings, 50 farmers were selected for participation in a hands-on training program. The program provided scientific knowledge and practical skills on various aspects of sheep breeding, with a specific focus on the role of rams in reproduction, tupping percentage, pregnancy rate, and lambing rate. The training aimed to enhance farmers' breeding practices and improve overall flock productivity.

2.3 Replacement of Existing Rams

To mitigate the effects of inbreeding, farmers were guided on replacing their existing rams with new breeding stock. The process involved either selling the ram locally or exchanging it with another farmer, ensuring that the exchanged ram was genetically suitable for breeding. Farmers were advised on best practices, including the avoidance of combined grazing among exchanged rams to prevent inbreeding and ensure genetic diversity within their flocks.

2.4 Measurement of Tupping Percentage

Tupping percentage is a key indicator of reproductive success, representing the proportion of ewes that are receptive to mating and successfully bred during the breeding season. Farmers were trained during the capacity-building program on how to observe and record estrus behavior in ewes. Additionally, periodic field visits were conducted by the research team to collect data, monitor flock health, and verify farmer observations.

2.5 Measurement of Fertility Rate

Fertility rate measures the proportion of ewes that successfully conceive after exposure to a ram. It is calculated as:

$$\text{Fertility Rate} = \left(\frac{\text{Number of Pregnant Ewes}}{\text{Number of Ewes Exposed to Mating}} \right) \times 100$$

Pregnancy diagnosis was carried out by monitoring ewes that did not return to estrus and confirming pregnancy through abdominal palpation from 100 days of gestation.

2.6 Measurement of Lambing Rate

It indicates the number of lambs produced per pregnant ewe. It is calculated as:

$$\text{Lambing Rate} = \left(\frac{\text{Number of Lambs Born}}{\text{Number of Pregnant Ewes}} \right) \times 100$$

This parameter reflects flock reproductive efficiency and was recorded based on on-farm data collection.

2.7 Other Reproductive Parameters

Additional reproductive parameters assessed included the drop rate (prolificacy), which measures the number of lambs born (both alive and dead) per ewe lambing. The proportion of stillbirths and neonatal mortality was also recorded, providing insights into overall reproductive health and lamb survival rates.

2.8 Statistics

Results are presented as the mean±standard error of the mean (SEM) or as means with 95% confidence limits. Statistical significance was determined using Student's t-test, with $p < 0.05$ considered statistically significant. Data analysis was performed with GraphPad Prism (GraphPad Prism Software, San Diego, CA, USA).

3. Results and Discussion

3.1 Capacitive Building Program to Farmers

The two-day training program had a significant positive impact on the future economy of the participating sheep farmers by enhancing their knowledge of scientific sheep farming practices. One of the major outcomes of the training was the introduction of improved rams, which is expected to enhance genetic diversity and reduce inbreeding-related problems such as low fertility, weak offspring, and poor growth rates. With better breeding strategies, farmers can expect higher tupping and lambing rates, leading to more lambs per breeding cycle and increased income potential.

Additionally, the adoption of scientific feeding practices has equipped farmers with the ability to improve nutrition and growth rates in their flocks. The use of hydroponic fodder, Azolla supplementation, and formaldehyde-treated groundnut oil cake will enable farmers to provide high-quality nutrition at lower costs, ensuring that lambs grow faster and reach market weight sooner. This will allow farmers to sell lambs at an earlier age and at higher prices, ultimately increasing their profit margins and cash flow.

Another critical economic benefit of the training is the reduction in mortality rates through improved health management and ethno veterinary first aid practices. With better knowledge of disease prevention and early treatment, farmers can significantly decrease losses due to illnesses and reduce veterinary expenses, resulting in higher overall profits. Furthermore, techniques such as oesophageal groove stimulation and rumen defaunation will help improve feed efficiency, minimizing feed wastage and reducing input costs (Mohan *et al.*, 2023) [13].

The adoption of modern sheep farming techniques will also enhance market competitiveness and open up opportunities for farmers to sell healthier, high-quality livestock at premium prices. Moreover, implementing sustainable farming practices will help ensure long-term economic stability and increase farmers' eligibility for government support programs, such as NABARD schemes, which can further support farm expansion and productivity improvements (NABARD, 2022) [14].

Overall, the training program has provided farmers with valuable knowledge and skills that will lead to higher productivity, reduced costs, and improved profitability. By integrating these best practices into their farming systems, smallholder sheep farmers can achieve better financial stability and sustainable economic growth in the long run (Rege and Gibson, 2018) [17].

3.2 Introduction of improved rams (Breedable male) for genetic improvement of flock

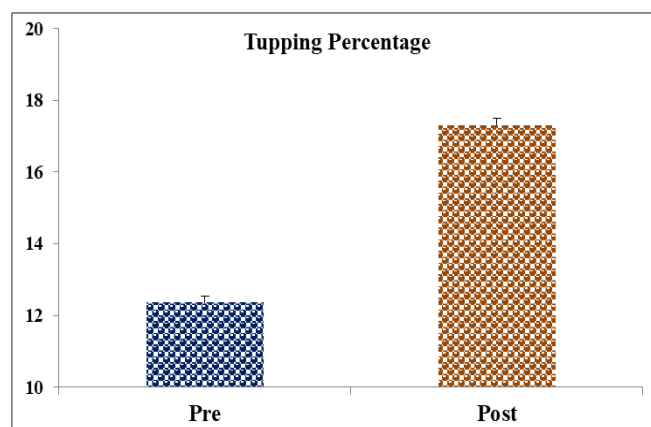
The introduction of genetically superior breedable rams played a crucial role in improving the genetic potential of sheep flocks and mitigating inbreeding-related challenges. Prior to intervention, flocks exhibited lower fertility rates and poor growth performance due to prolonged use of the same breeding males, leading to genetic stagnation (Mengesha and Tsega, 2018; Dixit *et al.*, 2021) [12, 6].

The introduction of high-quality rams from reputable breeders resulted in enhanced genetic diversity, reproductive efficiency, and overall flock productivity.

Furthermore, to prevent accidental mating and ensure controlled breeding, the previously existing rams were castrated or sold, allowing for optimized breeding programs. Regular deworming practices ensured improved flock health, further enhancing productivity. The genetic improvement initiative contributed to the increased survival rate of lambs, better marketable weight, and higher economic returns for smallholder farmers. These findings strongly support the role of scientific breeding interventions in improving sustainable sheep farming (Kumar and Singh, 2020; Mahmoud and Galal, 2022) [10, 11]. For instance, a study by Balasundaram *et al.* (2023) [2] emphasized the importance of developing selection strategies for genetic improvement in production traits of Mecheri sheep, highlighting the role of superior breeding males in achieving these goals.

3.3 Introduction of improved rams on Tupping Percentage in sheep farming

The tupping percentage, a critical parameter in assessing the reproductive performance of sheep, showed a significant improvement following the introduction of superior rams. The study revealed that farms utilizing improved germplasm recorded an average of 17.31 ± 0.18 successfully mated ewes per ram, compared to only 12.36 ± 0.18 in farms relying on traditional breeding methods.



The increase in tupping percentage can be attributed to:

- Enhanced mating vigor of improved rams with superior libido and endurance.
- Stronger sperm motility and quality, leading to higher conception rates.
- Reduced inbreeding depression, ensuring healthier and more fertile ewes.

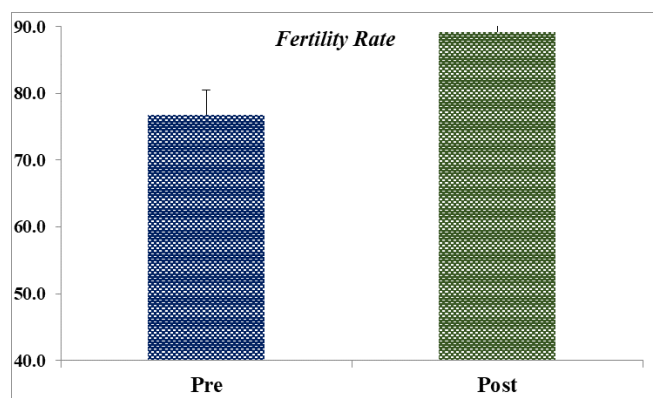
These findings indicate that strategic genetic improvement interventions positively influence breeding efficiency, leading to higher reproductive success and greater lamb production per mating season. This outcome aligns with previous studies emphasizing the significance of breed selection and controlled

mating practices in improving overall reproductive outcomes in small ruminants (Doekes *et al.* 2021; Gowane *et al.* 2017) [7, 9].

Research indicates that genetically superior rams exhibit enhanced reproductive vigor, leading to higher mating success rates. For example, a study conducted in Eastern Ethiopia reported that strategic breeding practices, including the use of selected rams, improved reproductive performance in indigenous sheep populations (Abebe, 2020) [1].

3.4 Introduction of improved rams on fertility rate in sheep farming

A notable enhancement in fertility rates was observed following the replacement of inferior rams with genetically superior breeding males. Farms that introduced improved rams recorded an average pregnancy rate of $77.90 \pm 0.90\%$, whereas farms relying on traditional breeding practices exhibited a significantly lower pregnancy rate of $61.80 \pm 0.98\%$. The observed difference highlights the substantial influence of genetic selection on reproductive efficiency.



The primary factors contributing to this improvement include:

- Superior sperm quality and reproductive vigor of improved rams
- Reduced incidences of unsuccessful matings and fertility-related disorders
- Regular deworming programs, ensuring optimal ewe reproductive health

The increased fertility rate not only translates into higher lambing percentages but also ensures sustainable breeding cycles, ultimately leading to greater farm productivity and profitability for smallholder farmers. Studies have demonstrated that genetic selection and controlled breeding programs contribute to higher conception rates (Boujenane and Chami, 1997; Belkheir *et al.* 2019) [5, 3].

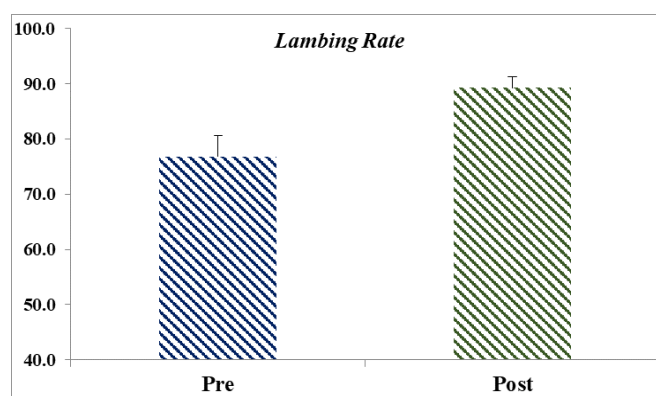
3.5 Introduction of improved rams on Lambing Rate rate in sheep farming

Lambing rate, a direct indicator of reproductive success, was significantly improved following the introduction of superior breeding rams. The study findings demonstrated that farms utilizing improved rams achieved an average lambing rate of $89.24 \pm 2.00\%$, whereas those continuing traditional breeding practices recorded a lower lambing rate of $76.80 \pm 3.74\%$.

The observed increase in lambing rates can be attributed to:

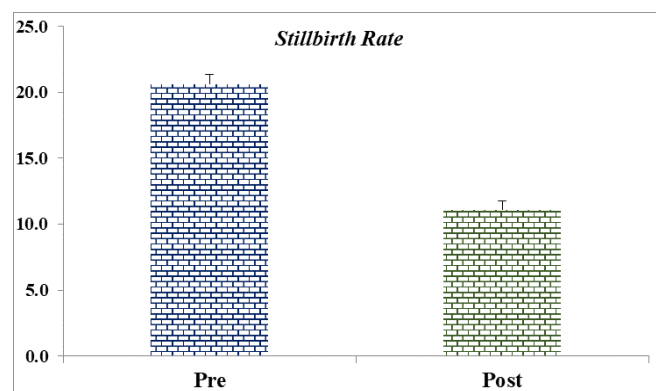
- Higher conception rates and reduced pregnancy losses due to improved genetic vigor.
- Minimized effects of inbreeding, leading to stronger and more viable offspring.

From an economic standpoint, higher lambing rates result in increased production and profitability for farmers. The greater number of lambs born per breeding cycle enhances market supply, leading to better economic sustainability in sheep farming. This underscores the need for continuous genetic selection and flock improvement programs to maintain and further enhance reproductive success in sheep farming systems (Rao and Sharma, 2019; Tibbo and Jembere, 2021) [16, 18].



3.6 Introduction of improved rams on other reproductive parameters in sheep farming

Beyond fertility and lambing rates, the intervention significantly reduced stillbirths and neonatal lamb mortality, further reinforcing the benefits of genetic improvement in sheep farming. Prior to intervention, the average lamb mortality rate after birth was alarmingly high at 20.66 ± 0.77 , which significantly declined to 11.09 ± 0.67 following the introduction of superior breeding rams.



The reduction in stillbirths and neonatal losses can be linked to:

- Stronger genetic makeup of lambs, resulting in higher birth weights and greater survival rates.
- Minimized congenital defects and genetic disorders, previously exacerbated by inbreeding.

These findings emphasize the importance of strategic breeding interventions and genetic selection in reducing reproductive failures and improving lamb survival rates. The economic impact of this reduction is also substantial, as it leads to higher flock viability, lower production losses, and better financial stability for farmers. The reduction in

stillbirths and neonatal lamb mortality following the introduction of improved rams aligns with findings from various studies emphasizing the importance of genetic diversity and controlled breeding (Yavarifard *et al.*, 2016; Yadav and Gaur, 2020) ^[21, 20]. Research on indigenous sheep production systems in Eastern Ethiopia highlighted that improved breeding practices contribute to better lamb survival rates and overall flock viability.

4. Conclusion

The introduction of improved breedable rams has significantly influenced reproductive performance, genetic enhancement, and economic profitability in sheep farming. The intervention led to higher tupping percentages, increased fertility and lambing rates, and reduced stillbirths, contributing to overall flock sustainability and productivity. The study highlights the need for continued genetic improvement programs, strategic breeding interventions, and scientific flock management to sustain these benefits. Future research should focus on long-term genetic impact assessments, optimal ram-to-ewe ratios, and additional management practices to further enhance reproductive efficiency and economic gains in smallholder sheep farming.

5. Acknowledgments

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Conflict of Interest

The author declares that there are no conflicts of interest.

6. Ethical Clearance

No animal model was used in this study; therefore, ethical clearance is not required.

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