*Original Research Article*

Optimizing Sheep Reproductive Performance Through Nutritional Interventions

ABSTRACT

Aims: Sheep farming in India is predominantly practiced by small and marginal farmers who depend on extensive grazing systems. However, nutritional deficiencies are a major constraint affecting reproductive performance, lambing rates, and overall flock productivity. This study aimed to evaluate the impact of strategic nutritional interventions, including flushing, late-pregnancy supplementation, lactation feeding, groundnut oil supplementation, and tree fodder cultivation, on improving fertility, lamb survival, and ewe productivity in smallholder sheep farming systems.

Methodology: A total of 50 flocks, each consisting of 20 ewes and one ram, were selected, with different nutritional strategies implemented to evaluate their effects. Flushing was conducted by supplementing 100 g of concentrate per ewe per day for 3–4 weeks before breeding to improve conception rates. Late-pregnancy feeding included 100 g of concentrate per ewe per day during the last trimester to enhance fetal growth and birth weight. During lactation, 100 g of concentrate per ewe per day for 60 days postpartum was provided to improve milk yield and lamb growth. Additionally, groundnut oil supplementation was introduced to enhance protein metabolism and energy utilization, while tree fodder cultivation (Agathi and Subabul) was promoted to ensure sustainable feed availability during lean periods.

Results: Flushing significantly improved pregnancy rates from 70.4% to 90.6%, while lambing rates increased from 12.92 to 17.75 lambs per flock. Late-pregnancy supplementation resulted in higher lamb birth weights, increasing from 2.12 ± 0.04 kg to 2.80 ± 0.04 kg. Lactation feeding improved lamb body weight at three months from 7.05 ± 0.21 kg to 9.32 ± 0.22 kg. Groundnut oil supplementation enhanced lamb weight gain, and the introduction of tree fodder ensured a cost-effective, sustainable feeding alternative to commercial supplements.

Conclusion: This study demonstrates that targeted nutritional interventions significantly enhance reproductive performance, lamb survival, and overall flock productivity in smallholder sheep farming. The results highlight the importance of balanced nutrition in improving breeding efficiency and suggest that integrating locally available feed resources can enhance economic sustainability for marginal farmers.

***Keywords:*** *Sheep reproduction, Nutritional supplementation, Flushing in ewes, Lambing performance, Sustainable sheep farming*

1. INTRODUCTION

Sheep farming plays a vital role in the livelihoods of small and marginal farmers in India, contributing to rural employment, food security, and economic sustainability (Kumar et al., 2021). The majority of sheep production systems in the country are extensive in nature, where flocks rely heavily on natural grazing resources with minimal supplementation. However, this traditional approach often leads to nutritional deficiencies, adversely affecting growth, reproduction, and overall flock productivity (Chinnathambi et al. 2025). Among various factors influencing reproductive efficiency, nutrition remains a primary determinant, impacting ovulation rates, conception, embryo survival, fetal development, and milk production (Ali et al., 2019). Strategic nutritional interventions, particularly during pre-breeding, gestation, and lactation, have been recognized as critical for enhancing reproductive success and ensuring sustainable sheep farming (Mahmoud et al., 2022).

One of the most effective nutritional strategies to improve reproductive outcomes is flushing, a practice that involves increasing the nutritional intake two to three weeks prior to breeding to stimulate higher ovulation rates and improved conception rates (Rafiq et al., 2021). Flushing is achieved by supplementing high-energy feeds such as barley and maize and incorporating protein sources such as soybean meal, lupins, or leguminous forages (Waghmare et al., 2018). Studies indicate that flushing positively affects follicular development, enhances twinning rates, and improves body condition score (BCS), all of which contribute to higher fertility and improved reproductive efficiency (Jalili et al., 2020). Furthermore, maintaining an optimal BCS (2.5–3.5 on a 5-point scale) is essential, as underweight ewes often exhibit reduced fertility and poor embryo survival, whereas overweight ewes are prone to pregnancy toxemia, dystocia, and metabolic disorders (Singh et al., 2017).

Beyond the breeding period, proper nutrition during gestation and lactation is equally critical for fetal development, lamb survival, and post-lambing recovery of ewes. During early to mid-pregnancy, a moderate energy intake with 10–12% crude protein is recommended to prevent excessive fat deposition while ensuring optimal fetal development (Smith & Brown, 2019). In late pregnancy (last six weeks), the nutrient demands increase significantly, necessitating higher energy and protein intake to prevent pregnancy toxemia and ensure adequate fetal growth (Anderson et al., 2020). Similarly, lactating ewes require 16–18% crude protein, high-energy grains, and essential minerals such as calcium, phosphorus, and magnesium to maintain peak milk production and support optimal lamb growth (Gupta et al., 2021). Inadequate nutrition during lactation often results in poor milk yield, weaker lambs, and prolonged postpartum anestrus, thereby affecting the reproductive efficiency of the next breeding cycle (Mousa et al., 2022).

In addition to energy and protein, essential minerals and vitamins play a fundamental role in reproductive health. Calcium and phosphorus are critical for fetal bone development, while selenium and vitamin E enhance fertility and embryonic survival (Patel et al., 2018). Zinc is essential for sperm quality in rams and ovulation in ewes, whereas cobalt and vitamin B12 aid in energy metabolism and anemia prevention (Lal et al., 2019). However, despite these well-established nutritional benefits, many small-scale sheep farmers lack awareness of optimal feeding strategies during critical reproductive phases (Khan et al., 2020).

Apart from nutritional constraints, inbreeding is another significant challenge affecting reproductive efficiency in sheep farming. Inbreeding leads to genetic deterioration, reduced fertility, and lower lambing rates (Yadav et al., 2021). To mitigate these issues, a NABARD-supported initiative was conducted in Krishnagiri district, Tamil Nadu, aimed at introducing genetically superior rams to replace inbred males. Through strategic replacement and castration of non-productive rams, this intervention led to a notable improvement in tupping percentage, fertility rate, and overall reproductive success (Chandran et al., 2022; Chinnathambi and Enbavelan, 2025). Building on these findings, further research is needed to assess the combined impact of genetic improvement and nutritional management in enhancing flock productivity.

Given the critical role of nutrition and genetic factors in reproductive efficiency, this study aims to evaluate the impact of strategic nutritional interventions during pre-breeding, gestation, and lactation on reproductive performance in sheep. This research is part of a NABARD-sponsored FSPF project in Chennai, designed to implement and assess innovative nutritional strategies to enhance conception rates, embryo survival, and lambing outcomes. The findings are expected to provide scientific insights and practical recommendations to optimize sheep flock management, thereby improving the economic sustainability of small and marginal farmers engaged in sheep farming.

2 methodology

This study was conducted among 50 smallholder sheep farmers, following the same research framework as in our earlier studies (Chinnathambi et al. 2025; Chinnathambi and Enbavelan, 2025). The study focused on evaluating the impact of nutritional interventions and supplementary feeding on reproductive performance, lamb survival, and flock productivity. The trials were carried out within the same flocks previously studied, ensuring consistency in experimental conditions.

**2.1 Concentrate feed supplementation during flushing period**

Approximately 20 days before mating, the ewes were supplemented with 100 g of concentrate feed per animal per day to improve ovulation and conception rates. The balanced concentrate feed was procured from the Feed Manufacturing Unit, College of Poultry Production and Management, Hosur, a constituent institute of TANUVAS. The composition of the feed was formulated and periodically reviewed by the Technical Team of TANUVAS to ensure optimal nutrient balance. Tupping percentage and conception percentage were recorded to assess the effectiveness of flushing.

**2.2 Concentrate feed supplementation during advanced stage of pregnancy**

Pregnant ewes in the last 60 days of gestation were provided with 100 g of concentrate feed per animal per day to support fetal growth and maternal health. The birth weights of lambs were recorded at delivery to evaluate the impact of late-pregnancy nutritional supplementation.

**2.3 Supplementation during lactation**

Lactating ewes received 100 g of concentrate feed per animal per day for 60 days postpartum, ensuring adequate milk production and lamb growth. Special attention was given to supplementing ewes during the lean period to counteract seasonal feed shortages. Lamb body weights were recorded at three months of age (early growth assessment, weaning period) and nine month of age (marketing period) to analyze the influence of lactation supplementation on postnatal growth.

**2.4 Groundnut oil cake feeding**

A nutrient-rich liquid supplement was prepared by soaking 50 g of groundnut oil cake overnight in 50–100 g of water to enhance its digestibility and nutrient absorption. The soaked mixture was then administered to lambs using a feeding bottle positioned at an elevated height to stimulate the closure of the oesophageal groove, ensuring direct passage to the abomasum for enzymatic digestion. This method helps optimize protein and energy utilization, promoting early weight gain and improved metabolic efficiency in lambs. The feeding trial was conducted for 60 days, and lamb body weight gains were monitored to assess the effectiveness of the supplementation.

**2.5 Azolla feeding as supplements**

All ewes, rams, and weaned lambs were supplemented with Azolla, a high-protein, mineral-rich aquatic plant, at 5.0% for adult animals and 1.0% for lambs for 90 days. Initially, animals were reluctant to consume Azolla in its raw form, but gradual adaptation was achieved by mixing it with rice bran, following traditional local practices. To facilitate Azolla cultivation, beneficiaries were provided with polythene sheets and Azolla seed material, ensuring a sustainable and cost-effective feeding option.

**2.6 Seeds of fodder crops to be raised in dry land**

Marginal and smallholder sheep farmers owning dry land were encouraged to cultivate drought-resistant fodder crops such as CO FS-29 and *Stylosanthes hamata*. These fodder crops were harvested and stored for use during summer feed shortages. Additionally, farmers were advised to plant tree fodder species such as Subabul (*Leucaena leucocephala*) and Agathi (*Sesbania grandiflora*) near household wastewater disposal areas, which provided a continuous supply of green fodder for sheep throughout the year.

**2.7 Ethno veterinary first aid practices**

Farmers participating in the NABARD-supported program were trained in ethnoveterinary first-aid practices using locally available medicinal plants for basic sheep healthcare. The training focused on natural remedies for diarrhea, ectoparasite control, and digestive disorders, equipping farmers with sustainable and accessible livestock healthcare solutions.

**2.8 Statistics**

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

**3. RESULTS AND DISCUSSION**

**3.1 Supplementing concentrate mixture during critical period – flushing**

Flushing, a pre-breeding nutritional intervention, involves feeding supplemental concentrate or high-quality forage 2–4 weeks before mating to improve reproductive performance in ewes. The primary objective of flushing is to stimulate ovulation, thereby increasing conception rates, twinning rates, and overall lambing percentages (Ali et al., 2019). This technique is particularly important in nutritionally limited extensive production systems, where twinning and triplet births are rare and often considered undesirable due to increased management demands.

In this study, supplementation of 100 g of concentrate per ewe per day was found to have a significant impact on reproductive efficiency. The tupping percentage and pregnancy rate improved markedly after introducing the flushing strategy. Before intervention, the average number of pregnant ewes per flock (20 females and one male) was 14.08 ± 0.29, which significantly increased to 18.12 ± 0.23 following supplementation (Fig 1). This demonstrates the positive effect of improved nutrition on reproductive performance, as previously reported in controlled studies (Rafiq et al., 2021).

Figure 1. Effect of flushing concept on pregnancy rate

Additionally, flushing had a notable impact on lambing rates. The average number of lambs born before intervention was 12.92 ± 0.37 per flock, which increased significantly to 17.75 ± 0.26 following nutritional supplementation (Fig. 2). This increase in lamb production is attributed to improved body condition in ewes, which enhances estrous synchronization, ovulation rates, and early embryo survival (Jalili et al., 2020). Flushing also reduces early embryonic mortality by strengthening fetal membrane integrity, ultimately increasing overall flock productivity.

Figure 2Effect of Flushing on Lambing Rate in Sheep Farming

The improved pregnancy and average number lamb born might also be influenced by the replacement of breedable rams within the flock, as reported in our earlier studies (Chinnathambi & Enbavelan, 2025). Beyond flushing, the introduction of improved male germplasm has also played a significant role in enhancing reproductive performance in sheep farming.

**3.2 Supplementing concentrate mixture during critical period – advanced pregnancy**

Fetal growth accelerates during the last trimester of pregnancy, making nutritional supplementation critical during this period. If pregnant ewes are underfed, it negatively impacts fetal development, birth weight, colostrum production, and postnatal lamb survival (Anderson et al., 2020).

Before intervention, the average birth weight of lambs was 2.12 ± 0.04 kg, which is considered low compared to published breed data. By introducing 100 g of concentrate feed per ewe per day during the late pregnancy stage, the average birth weight increased to 2.80 ± 0.04 kg (Fig 3), aligning closely with the reported 2.82 ± 0.01 kg for mecheri sheep (Karunanithi et al., 2005).

Figure 3. Effect of Concentrate Supplementation During Late Pregnancy on Birth Weight

This result emphasizes the direct influence of maternal nutrition on fetal growth and survival. Appropriate nutrition during late gestation plays a crucial role in ensuring optimal fetal growth and vigor, which is essential for healthy lamb development. It also enhances colostrum production, a key factor in providing neonatal immunity and improving the survival rate of newborns. Additionally, proper maternal nutrition helps maintain ewe body reserves, preventing excessive weight loss postpartum and supporting overall reproductive efficiency. Furthermore, it contributes to reducing lamb mortality rates, ultimately leading to higher weaning rates and improved flock productivity. Studies have shown that plane of nutrition in late pregnancy directly influences lamb survival, labor intensity at lambing, and overall productivity in mid-season lambing systems (Mahmoud et al., 2022).

**3.3 Supplementing concentrate mixture during lactation**

Milk production in sheep is highly dependent on the nutritional status of the ewe. In extensive grazing-based systems, poor maternal nutrition often results in low milk yield, negatively affecting lamb growth and survival. Therefore, supplementary feeding during lactation is essential to improve milk production and optimize lamb growth rates (Gupta et al., 2021).

In this study, lactating ewes were supplemented with 100 g of concentrate per day for 60 days post-lambing, resulting in a significant improvement in lamb body weight at three months of age. The average weight at three months increased from 7.05 ± 0.21 kg (pre-intervention) to 9.32 ± 0.22 kg (post-intervention), highlighting the strong correlation between maternal nutrition and lamb growth performance. Similarly, the average body weight at nine months also showed a significant increase from 9.32 ± 0.22 kg (pre-intervention) to 14.29 ± 0.23 kg (post-intervention), further emphasizing the long-term benefits of improved maternal nutrition on offspring growth.

Figure 4. Impact of nutritional intervention on Three-Month-Old Lamb and Nine-Month-Old Grower Weight

Nutritional supplementation during lactation plays a crucial role in enhancing ewe performance and overall productivity. Ewes with inadequate nutrition often experience lower body condition scores postpartum, which can negatively impact milk production, particularly during the first 40 days of lactation. In contrast, a higher energy intake during this period has been shown to increase colostrum yield, thereby improving neonatal survival rates. Additionally, milk quality, including fat and protein content, is directly influenced by maternal diet, which in turn affects lamb early growth and weaning weights (Mousa et al., 2022). Previous studies indicate that feeding higher-energy, protein-rich diets enhances colostrum quality, milk yield, and lamb weight gain, reinforcing the need for supplementary nutrition during lactation (Patel et al., 2018).

**3.4 Groundnut oil supplementation**

Groundnut oil is a rich source of energy and essential fatty acids, particularly omega-6 and omega-9 fatty acids, which enhance metabolic efficiency and body weight gain in lambs (Kumar et al., 2018). Additionally, bypass protein in groundnut oil cake provides essential amino acids like lysine and methionine, critical for muscle growth and immune function.

Studies indicate that supplementation with groundnut oil cake improves feed conversion efficiency and increases average daily gain (ADG) in sheep (Sharma et al., 2021). In this study, lambs receiving groundnut oil supplementation exhibited enhanced weight gain, reflecting improved protein metabolism and nutrient absorption. The key benefits of this supplementation include higher energy availability, which contributes to better body weight gain, and improved muscle development, which helps reduce fat deposition. Additionally, groundnut oil cake supplementation positively impacts reproductive performance, as omega fatty acids play a crucial role in hormone regulation and fertility in sheep (Ravindran et al., 2020).

**3.5 Azolla feeding as a protein and mineral supplement**

Azolla is a high-protein, mineral-rich supplement that can significantly enhance lactation performance in ewes. It contains 24–27% crude protein, along with essential amino acids such as lysine (4.58 g%) and methionine (1.59 g%), which support muscle development and metabolic functions. Additionally, it provides vital macro and micro minerals necessary for optimal milk production. Introducing azolla supplementation during the lean season helps sustain milk yield in grazing ewes, ensuring better lamb survival and growth by preventing nutritional deficiencies (Lal et al., 2019). Our studies also strongly support azolla supplementation as an excellent protein source for sheep of all ages, significantly enhancing reproductive performance and growth rates.

**3.6 Cultivation of tree fodder for sustainable nutrition**

Tree fodder species such as Agathi (*Sesbania grandiflora*) and Subabul (*Leucaena leucocephala*) serve as nutrient-rich forage options that ensure year-round feed security for small ruminants. These fodders are particularly beneficial due to their high crude protein content (16–22%), which supports lactation and growth. Additionally, they are rich in calcium and phosphorus, essential for bone development and fetal growth. The presence of tannins in these fodders enhances nitrogen utilization in ruminants, improving overall feed efficiency and digestion (Venkatesh et al., 2019).

In this study, the increase in lamb weight at three months of age may be influenced by tree fodder supplementation, which enhanced growth and development through consistent protein intake while reducing dependency on commercial feeds, making it a cost-effective solution. Research supports that *subabul* and *agathi* fodder supplementation improves feed efficiency, enhances digestibility, and boosts milk production in lactating ewes (Singh et al., 2020). Thus, integrating tree fodder into smallholder sheep farming systems enhances nutritional sustainability and reduces reliance on expensive concentrates.

4. Conclusion

The results of this study clearly demonstrate that strategic nutritional interventions at critical reproductive stages significantly enhance sheep productivity in extensive grazing systems. Key findings include:

* Flushing improved conception rates, twinning percentages, and overall lambing rates.
* Nutritional supplementation during late pregnancy increased lamb birth weights and survival.
* Supplemental feeding during lactation enhanced milk yield, lamb growth, and weaning weights.
* Incorporating Azolla, groundnut oil, and tree fodder in the feeding system provided additional nutritional benefits.

These findings align with previous research and reinforce the importance of balanced nutrition in improving reproductive efficiency and economic viability in smallholder sheep farming. Further studies could explore cost-benefit analyses and long-term impacts of these interventions across diverse sheep breeds and production environments.

Ethical approval

This study was a field-based observational study with no invasive procedures conducted on animals. Therefore, ethical clearance was not required.

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