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ADVANCING SHEEP REPRODUCTION: THE SCIENCE AND PRACTICE OF LAMBING INTENSIFICATION

Tudor POPA[1], Ellda Mellisa SAVU[1], Raluca-Aniela GHEORGHE-IRIMIA[1], Dana TĂPĂLOAGĂ[1], Cosmin ȘONEA[1], Makki Khalaf Hussein AL DULAIMI[3], Eugen Adrian CHISA[4], Paul-Rodian TĂPĂLOAGĂ[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Veterinary Medicine, 105 Splaiul Independenței, District 5, 050097, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Animal Productions Engineering and Management, 59 Mărăști Blvd, District 1, 011464, Bucharest, Romania
[3]Al-Furat Al-Awsat Technical University, Baghdad, Iraq
[4]Technologic High School "Vintilă Brătianu", Dragomirești Vale, Romania

Corresponding author email: raluca.irimia@fmv.usamv.ro

Abstract

The physiological basis for lambing intensification is rooted in the reproductive physiology of ewes, which governs lambing intervals and is influenced by factors such as photoperiod and seasonal breeding patterns. Strategies for intensification include the implementation of accelerated lambing systems, which utilize hormonal treatments and photoperiod manipulation to achieve three lambings within two years. Genetic selection for prolific breeds, such as Finnsheep and Romanov, is emphasized as a critical component of breeding programs aimed at enhancing lamb output. Nutritional management strategies, including flushing and balanced diets during gestation and lactation are also discussed as vital for improving reproductive efficiency. Furthermore, the application of reproductive technologies such as artificial insemination, embryo transfer, and oestrus synchronization techniques is highlighted to achieve tighter lambing windows and increased reproductive rates. Despite the potential benefits of lambing intensification, several challenges and limitations must be addressed. Health and welfare concerns arise from the increased metabolic demands placed on ewes, leading to risks of reproductive exhaustion and poor maternal care. Additionally, the management of diseases associated with higher lambing frequencies, such as mastitis, is critical. Economic constraints, including increased labour demands and costs associated with feed and veterinary care, pose further challenges to the adoption of intensive systems. In conclusion, this paper aims to elucidate the intricate interplay between physiological mechanisms, management strategies, and the challenges faced in advancing lambing intensification, ultimately contributing to the sustainability and productivity of sheep farming systems.

Key words: *ewe management, prolificacy traits, reproductive physiology.*

INTRODUCTION

Lambing intensification is a vital component of contemporary sheep husbandry that seeks to improve productivity and efficiency in lamb production. This method involves increasing the frequency of lambing cycles, optimising breeding strategies, and enhancing management practices in order to achieve higher lamb survival rates and superior meat quality. The importance of lambing intensification can be understood through its effects on productivity, economic viability, and sustainability in the sheep farming industry. The main advantage of lambing intensification is the increase of production. Research indicates that the use of an accelerated lambing system can enhance lambing percentages and decrease lambing intervals, therefore optimising the yield from each breeding ewe (Fogarty & Mulholland, 2012; Fozi et al., 2020). This is particularly important in areas where the demand for premium lamb meat is rising, prompting producers to enhance their production techniques to satisfy consumer desires for fine and superfine wool as well as high-quality meat (Krehbiel, 2013; Knapik et al., 2017). Furthermore, the intensification of lambing enhances the economic sustainability of sheep husbandry. Increasing lamb production enables farmers to enhance economic stability and mitigate financial risks linked to livestock husbandry. The capacity to generate additional lambs during the same period facilitates improved cash flow management and may result in increased profitability, particularly in competitive markets (Benoît & Laignel, 2014). Moreover, the implementation of advanced breeding and management techniques, including hormonal manipulation for oestrous cycle regulation, can significantly improve lambing efficiency, but these approaches may not consistently adhere to conventional extensive management systems (Fozi et al., 2020). Sustainability represents a vital element of lambing intensification. Studies indicate that more intensive lamb production systems can decrease greenhouse gas emissions per kilogramme of meat produced, mainly due to enhanced feed efficiency and superior management of grazing grounds (Gill et al., 2010; Geß & Hazar, 2023). Through the optimisation of production processes, sheep producers can enhance environmental sustainability while ensuring economic viability. Moreover, the incorporation of regenerative agriculture strategies, including biosequestration and enhanced soil management, can further alleviate the negative environmental impacts of increased lamb production.

The aim of this review is to explore the physiological mechanisms, management strategies, and challenges associated with lambing intensification, with the goal of enhancing reproductive efficiency and sustainability in sheep farming systems.

MATERIALS AND METHODS

The data for this review was collected through a thorough literature search in academic databases such as PubMed, ScienceDirect, Scopus, and Google Scholar, using key words like "lambing intensification", "accelerated lambing cycles", "reproductive efficiency in sheep", and "sustainable sheep farming". Relevant peer-reviewed articles, conference proceedings, and industry reports were selected for their scientific credibility, publication date, and methodological rigour, and the extracted data was systematically analysed.

RESULTS AND DISCUSSIONS

Physiological basis of lambing intensification

Environmental factors, especially photoperiod, have a significant impact on ewes' seasonal breeding patterns and are closely linked to their reproductive physiology. It is crucial to comprehend how ewes' hormones control their reproductive cycles in order to maximise breeding strategies in sheep farming. Ewes display a seasonal breeding pattern, mostly determined by the length of daylight they receive throughout the year. The hypothalamic-pituitary-gonadal (HPG) axis controls this seasonal reproductive behaviour, which is defined by a separate breeding season that usually takes place in the autumn. Gonadotropin-releasing hormone (GnRH), which triggers the pituitary gland to release luteinizing hormone (LH) and follicle-stimulating hormone (FSH), resulting in the development of ovarian follicles and ovulation, is secreted by the HPG axis (Chemineau et al., 2004; Narayan et al., 2018; Dupré et al., 2010). Photoperiod has a vital function in controlling the reproductive cycles of sheep. Melatonin, a hormone secreted by the pineal gland and essential for indicating ewes' reproductive state, is influenced by the duration of sunshine. During longer days, melatonin secretion decreases, which promote reproductive activity, while shorter days increase melatonin levels, were inhibiting reproductive functions (He et al., 2023; Wagner et al., 2007). According to studies, ewes kept on long-day photoperiods perform better reproductively, exhibiting higher ovulation rates and an earlier onset of oestrus (Dardente & Lomet, 2018; Gómez-Brunet et al., 2008). Furthermore, research has shown that variations in photoperiod affect the expression of particular genes in the pituitary and hypothalamus. For instance, lengthy photoperiods are associated with reproductive activation and a substantial increase in the expression of RFamide-related peptide (RFRP) (Dardente et al., 2008). Furthermore, the thyroid hormone system also interacts with photoperiod cues to regulate reproductive cycles, indicating a complex interplay between environmental factors and hormonal responses (Dardente & Lomet, 2018; Wang et al., 2022). The hormonal regulation of reproductive cycles in ewes is primarily governed by the interactions of GnRH, LH, FSH, and sex steroids such as estrogen and progesterone. This hormonal balance can be upset by stressors such as physiological stress and environmental changes, which can impact reproductive performance (Narayan et al., 2018; Dardente et al., 2022). For instance, elevated glucocorticoid levels due to stress can negatively impact the secretion of reproductive hormones, thereby affecting ovulation and fertility (Narayan et al., 2018; Dardente et al., 2022). Moreover, the role of leptin, a hormone associated with energy balance, has been highlighted in the context of reproductive physiology. Leptin levels can modify the sensitivity of the hypothalamus to GnRH, consequently changing the timing and effectiveness of reproductive cycles (Zieba et al., 2019; Biernat et al., 2021). For ewes to be in the best possible condition for breeding, metabolic signals and reproductive hormones must be integrated, especially during seasonal contexts when energy availability may vary (Archer et al., 2005; Dobbins et al., 2004).

Strategies for lambing intensification

Accelerated lambing systems are increasingly being adopted in sheep farming to enhance productivity by allowing ewes to lamb more frequently within a given timeframe. This method can greatly enhance the number of lambs produced per ewe and boost overall farm profitability because it usually aims for three lambings in two years. Hormonal therapies, photoperiod adjustment, genetic selection for prolific breeds, and nutritional management are some of the crucial elements involved in the implementation of such systems. The idea of having three lambings in two years stems from the desire to increase ewes' capacity for reproduction. To enable more frequent lambing, this approach necessitates the careful control of breeding cycles and the application of hormonal treatments to synchronise ovulation and oestrus (Naqvi et al., 2011; Cirne et al., 2016). Farmers may successfully raise lambing rates by using methods like controlled breeding and artificial insemination, which is essential for satisfying consumer demand for lamb meat and wool. In order to increase reproductive efficiency, ewes are frequently given hormonal therapies, such as gonadotropins and prostaglandins, to promote oestrus and ovulation (Naqvi et al., 2011; Farrag, 2019). Furthermore, ewes' reproductive cycles can be significantly regulated by photoperiod alteration. Farmers can further promote the goal of rapid lambing by manipulating light exposure to mimic seasonal variations that encourage ewes to breed outside of their natural season. Improved reproductive performance and a higher frequency of lambing can result from this combination of environmental and hormonal control techniques. Another essential element of faster lambing systems is genetic selection. Breeds like Romanov and Finnsheep are frequently used in breeding projects to increase lamb production because of their high prolificacy (Nosrati et al., 2018; Sarvinda et al., 2022). Compared to other breeds, Romanov ewes usually have bigger litter numbers, and Finnsheep are renowned for their capacity to give birth to several lambs throughout a pregnancy. Sheep flocks' total reproductive capacity can be greatly enhanced by including these prolific breeds into breeding programs. The effectiveness of rapid lambing systems depends on efficient breeding programs that emphasise genetic enhancement techniques. In order to find and spread desirable features linked to reproductive performance, these algorithms frequently employ genomic selection techniques (Yang et al., 2024; Gizaw et al., 2011). Farmers can improve the genetic potential of their flocks and raise lamb production and economic results by selecting for qualities like litter size and ovulation rate. An essential component of assisting rapid lambing systems is nutritional control. It has been demonstrated that feeding sheep a high-energy diet before breeding, known as flushing, improves body condition and increases ovulation rates, which in turn improves reproductive success (Khotijah et al., 2022; Naqvi et al., 2011; Farrag, 2019). Studies show that ewes fed flushing diets have better lambing results and higher reproductive rates, especially when paired with hormonal therapies (Cirne et al., 2016; Farrag, 2019). Furthermore, ewes and their lambs' health and production depend on maintaining appropriate meals during pregnancy and lactation. Successful lamb rearing depends on ewes receiving adequate nourishment during these crucial times, which also supports foetal growth, improves milk production, and enhances ewes' general wellbeing (Sejian et al., 2010).

Reproductive technologies in lambing intensification

Key technologies include artificial insemination (AI), embryo transfer (ET), and oestrus synchronization techniques. These techniques promote more effective breeding techniques and enhance genetic diversity, which eventually results in higher lamb production. A popular reproductive technique in sheep farming is artificial insemination, which eliminates with the necessity for natural mating and makes use of superior genetics. AI can boost genetic advancement in flocks by dramatically increasing the number of ewes bred with superior semen from chosen rams (Gibbons et al., 2019). The time of insemination in relation to ovulation, the quality of the semen used (fresh or frozen), and the insemination technique utilised are some of the aspects that affect the success of AI (Saha et al., 2021; Sitepu et al., 2023). Although AI can be useful, there is still opportunity for improvement in its use, as studies have shown that conception rates with AI in sheep range from 26% to 61% (Sitepu et al., 2023). Another cutting-edge reproductive technique that enables the quick reproduction of animals with improved genetic makeup is embryo transfer. According to Khan et al. (2022), this method entails harvesting embryos from donor ewes that have experienced superovulation and then transferring them to recipient ewes. Because ET enables the birth of numerous offspring from a single donor ewe in a single breeding season, ET can greatly increase the reproductive output of high-performing ewes. According to research, the quality of the embryos and the time of the embryo transfer can have an impact on the pregnancy rates linked to ET (Bergstein-Galan et al., 2018; Romão et al., 2016). Techniques for oestrus synchronisation are crucial for maximising AI and ET time. These techniques enable more effective breeding by using hormone treatments to cause synchronised oestrus in a group of ewes (Berean et al., 2021). There are several methods that can successfully synchronise ovulation and enhance ewes' overall reproductive performance, such as the use of progestagens, gonadotropins, and melatonin implants (Lu et al., 2021; Korkmaz & Yaprak, 2022). It has been demonstrated that synchronisation methods shorten the lambing window, enabling more focused lambing times and improving lambing and post-lamb care management (Zhang et al., 2024). Reproductive rates and lambing windows are significantly impacted by the combination of AI, ET, and oestrus synchronisation approaches. Sheep breeders can decrease the interval between lambing events and increase lambing rates by utilising these technologies. For example, fixed-time artificial insemination (FTAI) streamlines the breeding procedure and increases the efficiency of lamb production by enabling insemination without the necessity for oestrus identification (Lu et al., 2021). According to studies, using synchronisation techniques can result in a more consistent lamb crop and higher lambing percentages, both of which are advantageous for management and marketing (Khan et al., 2022).

Challenges and limitations

A number of challenges and restrictions exist when rapid lambing technologies are used in sheep farming, which may have an effect on the sustainability, economic viability, and well-being of ewes. For such systems to be successful in the future, these issues must be addressed. Reproductive exhaustion is one of the main health and welfare issues related to lambing intensification methods. Frequent lambing cycles can cause ewes to undergo more physiological stress, which can result in problems like decreased fertility, longer recovery periods, and lower maternal care (Lomet et al., 2020). Frequent breeding needs may lead to insufficient mother care, which is essential for lambs' survival and development. According to research, ewes that don't recover well between lambing episodes can provide less milk and behave worse as mothers, which would ultimately reduce the survival rate of the lambs (Thompson et al., 2011). Another major issue with increased lambing systems is disease management. Both ewe health and lamb growth may be negatively impacted by infectious diseases like mastitis, which can spread more easily during concentrated lambing times because of the higher density of ewes and lambs (Skipor et al., 2021). The financial sustainability of sheep businesses can be further strained by mastitis, in particular, which can result in lower milk output and higher veterinary expenses (Fozi et al., 2020). To reduce these risks, effective disease management techniques - such as immunisation and biosecurity measures - are crucial. Accelerated lambing systems have a variety of economic effects. Because intense management during lambing periods might put a strain on existing labour resources, increased labour demands are a major concern (Herman et al., 2010). The additional workload brought on by frequent lambing may make it difficult for farmers to locate enough workers, which could raise operating expenses (Gheorghe-Irimia et al., 2023). The nutritional needs of ewes during pregnancy and lactation, as well as the necessity of routine veterinary interventions to address health issues resulting from intensified breeding practices, can also drive up the costs of feed and veterinary care (Lacasse et al., 2014). Furthermore, changes in the market and the demand for lamb products have an impact on the financial viability of accelerated lambing systems. Higher lamb production can boost profits, but it also puts farmers at risk in the market, especially if supply outpaces demand (Abecia et al., 2017). Therefore, to guarantee the sustainability of accelerated lambing methods, thorough financial planning and market analysis are crucial. When it comes to accelerated lambing techniques, sustainability is a crucial factor (Gheorghe-Irimia et al., 2024; Șonea et al., 2023a). To make sure that these solutions don't jeopardise the environment or the health of the flock, the long-term effects on ewe productivity and farm profitability must be assessed. Frequent lambing can cause physiological stress that eventually reduces ewe longevity and productivity, which will ultimately impact the farm's total profitability (Thompson et al., 2021). Furthermore, it is important to take into account how enhanced lambing procedures may affect the ecosystem. If improperly managed, increased feed needs and higher stocking densities might result in increased nutrient runoff and environmental degradation (Herman et al., 2017). While preserving productivity, sustainable techniques like integrated pest management and rotational grazing can help lessen these negative effects on the ecosystem.

CONCLUSIONS

Lambing intensification, particularly through accelerated lambing systems, relies on the strategic manipulation of reproductive physiology, including photoperiod responsiveness, exogenous hormone administration, and control of the oestrous cycle. The application of assisted reproductive technologies—such as oestrus synchronization, artificial insemination, and embryo transfer—permits tighter control over lambing intervals and facilitates genetic dissemination. Selection for highly prolific genotypes remains central to increasing ovulation rates and litter size, though this must be matched with appropriate nutritional regimens, such as flushing and optimized gestational feeding, to support fetal development and postnatal performance.

Despite the potential to significantly enhance reproductive output, intensification introduces physiological and metabolic challenges, including increased risk of reproductive fatigue, compromised maternal behavior, and elevated susceptibility to production-related diseases such as mastitis and ketosis. Furthermore, the biological limits of reproductive capacity, particularly in seasonal breeders, pose constraints on long-term system sustainability. The success of intensified systems is contingent upon precise reproductive monitoring, robust nutritional support, and health management protocols capable of mitigating negative outcomes. Future research should prioritize the development of ewe-centric management strategies that align endocrine manipulation with natural reproductive rhythms, explore genotype × environment interactions under intensive conditions, and evaluate the long-term effects of high-frequency lambing on ewe longevity, lamb viability, and overall system efficiency. Multidisciplinary approaches integrating physiology, genetics, nutrition, and health will be essential for optimizing reproductive efficiency without compromising animal welfare or economic returns.

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