MAY 2026

Sheep reproduction RD&A alert

This sheep reproduction RD&A alert is an initiative of the Sheep Reproduction Strategic Partnership (SRSP).

The May wave of the Sheep Producer Intentions Survey (SPIS) is now open. The SPIS is run three times a year by MLA and AWI to collect sheepmeat industry livestock numbers and lamb production expectations.

The survey provides forward-looking information on breeding ewe numbers, sheep breed and expected lamb sales. This survey results allows the sheep industry to better manage the supply chain and meet both producer and customer expectations.

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The May survey will provide an estimate of the total flock size, a profile of the breeding ewe flocks and measures of producer intentions for breeding ewes and lambs.

Click here to participate in the May 2026 SPIS.

The SRSP aims to help sheep producers to profitability and sustainably increase lamb production through increasing lamb survival and weaning rates and will coordinate a national approach to improving sheep reproductive performance.

Feature project update

Investigating heat stress in ewes – reproductive performance

Background

Extreme heat events are an increasing challenge for Australian sheep production systems, particularly during the joining period when ewes and rams are typically exposed to high temperatures. Heat stress disrupts key reproductive processes, reducing fertility, embryo survival and lamb outcomes. While these effects are well documented in controlled environments, there has been limited understanding of how sheep respond to heat under real-world grazing conditions, where factors such as solar radiation, wind, shade, and paddock variability interact to influence animal behaviour and physiology.

Aim

To better understand how sheep experience and mitigate heat stress in commercial systems and how these responses affect reproductive performance.

Key findings

- Sheep reproductive performance is driven more strongly by radiant heat load (notably solar radiation) than by traditional indices such as temperature–humidity index (THI) or nutrition alone.
- Shade improved reproductive outcomes in one of the three years, particularly when solar radiation was high, highlighting the importance of radiant heat exposure and environmental context.
- Wool length and shearing timing also influenced heat balance, as fleece can both insulate against radiation and limit evaporative cooling.
- Across commercial sites, reproductive outcomes varied between farms, reinforcing the role of local microclimates and behavioural adaptation in shaping heat stress impacts.
- Heat stress alters both ewe and ram biology. In ewes, behavioural responses such as reduced activity and increased shade-seeking during hot periods can influence mating interactions and reproductive outcomes. In rams, heat exposure can damage sperm at a molecular level, even when standard fertility indicators appear normal; however, mitigation strategies such as long-acting melatonin and antioxidants show promise.

Benefits to industry

This study highlights management strategies, including optimising shearing timing relative to joining, improving access to effective shade, and implementing targeted pre-joining management of rams to mitigate the impact of heat stress during joining on reproductive performance. It also challenges reliance on THI alone, recommending development of improved heat load indices that incorporate solar radiation.

For more information on the **Investigating heat stress in ewes – reproductive performance** project contact Shane Maloney (shane.maloney@uwa.edu.au).

Review papers

Overcoming cryopreservation challenges in mammalian sperm: Strategies for mitigating cryoinjuries

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Reproduction in Domestic Animals, Volume 65, Issue 5 May 2026

DOI https://doi.org/10.1111/rda.70214

Abstract

Cryopreservation is a critical tool in the livestock industry, particularly for disseminating genetic materials and establishing sperm banks to preserve species. Developing a successful semen storage procedure is essential to minimize the negative effects caused by the cryopreservation process. Mammalian sperm are highly susceptible to cryoinjury and primarily inflicted during the freezing and thawing processes when extracellular water freezes and intracellular water is lost, negatively impacting sperm quality parameters and fertility. Cryoinjuries generally cause irreversible damage to sperm structure and function. Currently, various cryopreservation measures, such as selection of cryoprotectants and optimization of freezing and thawing processes, are employed to reduce sperm cryoinjuries and to elucidate the mechanisms underlying cryodamage. However, the exact nature of sperm cryoinjury remains largely unclear. This review discusses the current understanding of sperm cryodamage induced by the cryopreservation process, factors influencing sperm susceptibility to cryoinjury, the impacts of cryopreservation on proteins, metabolites, lipids, and RNAs. As one of the important measures to mitigate sperm cryoinjuries, the application of antioxidants is becoming increasingly important. So, the effects of antioxidants on post-thaw sperm quality are reviewed here.

Cryopreservation-induced oxidative damage in ram sperm and the role of natural antioxidants as cryopreserved sperm quality enhancers

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Animal Production Science, Volume 66, Issue 8, May 2026

DOI https://doi.org/10.1071/AN25222

Abstract

Ram sperm cryopreservation is crucial for artificial insemination and genetic improvement programs in the small ruminant industry. Semen handling and cryopreservation can negatively affect sperm quality irrespective of the storage conditions and extenders used. Studies have reported an increase in reactive oxygen species in ram sperm during cryopreservation, leading to oxidative stress. Oxidative stress significantly compromises the sperm fertilising ability by inducing oxidative damage to protein, lipid, and nucleic acid components of the sperm cell. The supplementation of antioxidants to semen extenders before cryopreservation can minimise this detrimental effect. Natural antioxidants have emerged as an economical and effective source of additives to preserve and enhance ram sperm quality during semen preservation. This review presents an overview on harmful effects of oxidative stress on ram spermatozoa, extrinsic and intrinsic factors responsible for occurrence of oxidative stress, as well as natural antioxidants and their potential as an additive for sperm quality enhancers in different ram breeds. Taken together, we suggest that synergistic combinations of antioxidants that are economically feasible, such as resveratrol with vitamins C or E, could be the way forward, but warrant further investigations into dosage versus toxicity, standardised extraction protocols, and breed-specificity in their supplementation in semen extenders.

Effects of genetic and environmental factors on reproductive traits, with a focus on gestation length in sheep: Implications for molecular breeding—A review

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Agriculture, Volume 16, Issue 10, **OPEN ACCESS**

DOI https://doi.org/10.3390/agriculture16101021

Abstract

The reproductive traits of sheep are very important characteristics influencing productivity. Among these, gestation length (GL) is an important trait with positive or negative influences on birth weight, lamb survival, lambing intervals, ease of lambing, and the dam's health. This review evaluates the existing knowledge of genetic and environmental factors influencing reproductive traits, with a focus on GL in sheep, and the potential of this knowledge to inform effective molecular breeding programs. The mean GL for sheep is 147 days, generally ranging from 142 to 152 days. Both extremely long and extremely short GL may have either positive or negative effects on sheep rearing. Variations among breeds and within populations arise from complex interactions between nature and nurture. GL has a moderate level of heritability, indicating that genetic factors contribute to phenotypic variation in this trait. The GL is a result of gene-regulatory pathway interactions, hormonal signaling, placental, and fetal–maternal communication. Three stages of gestation are characterized by distinct patterns of gene expression, hormonal regulation, and physiological functions. Advances in genomic technologies, including whole-genome sequencing (WGS) and genome-wide association studies (GWAS), have enhanced the ability to identify the genetic determinants of GL and facilitate their incorporation into molecular breeding strategies. In addition, the invention of molecular

biology in the discovery of single-nucleotide polymorphisms (SNPs), insertion/deletion (InDels), and copy number of variants (CNVs) has created new opportunities to uncover the molecular basis of GL. In general, this review offers a comprehensive framework that identifies genetic and environmental determinants of GL and describes their practical implications for sustainable sheep breeding.

Factors influencing small ruminant colostrum quality: A comprehensive review from 2020 to present

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Small Ruminant Research, Volume 259, June 2026 **OPEN ACCESS**

DOI https://doi.org/10.1016/j.smallrumres.2026.107750

Highlights

- Colostrum synthesis in small ruminants is driven by multiple interacting factors.
- Breed, litter size and maternal nutrition shape colostrum yield and quality.
- Heat stress can impair colostrogenesis through metabolic and endocrine pathways.
- Enriched diets and melatonin implants can enhance colostrum quality.
- Omics tools can be used to enhance and select for colostrum traits.

Abstract

Colostrum is the primary source of passive immunity and nutritional support for neonatal small ruminants. Its quality and quantity are influenced by multiple interrelated factors including breed, litter size, parity, environmental stressors, maternal nutrition, metabolic and health status and management practices. This review consolidates findings from 2020 to the present, highlighting the genetic, physiological, nutritional, and environmental determinants of colostrum formation and their implications for offspring viability. Heat stress, maternal health and undernutrition during late gestation can compromise colostrum synthesis, composition, or immunoglobulin transfer. Conversely, targeted dietary supplementation and melatonin implants have shown potential in enhancing colostrum immunological and nutritional quality. Given the challenges posed by climate change and intensifying production demands, optimizing colostrum quality through genetic, nutritional, and management interventions remains a priority for improving early-life health outcomes in small ruminant systems.

Scientific papers

Breeding for sheep robustness: simulation of the consequences of ewe-lamb energy allocation trade-offs

Maya Hiltpold, Ronan Trépos and Frédéric Douhard

Genetics Selection Evolution, April 2026

DOI https://doi.org/10.1186/s12711-026-01047-8

Abstract

Background Sheep farmed in grazing systems are usually exposed to seasonal feed quality fluctuations that are likely to increase with climate change. In this context, a major challenge is to breed robust ewes, able to sustain a high lifetime performance in a large range of feeding conditions. However, trade-offs can exist between components of lifetime performance, in particular due to energy allocation constraints at the individual level. Here we focus on predicting ewe-lamb trade-offs that correspond to the competitive energy allocation between the mother and her lambs until weaning. We explored the consequences of those trade-

offs on lifetime performance (i.e. the total number of lambs weaned) using a bioenergetic model coupling the ewe and her lambs. To this end, we ran a global sensitivity analysis of our model to a set of input parameters differentiating “individual types” in terms of energy allocation mechanisms, and in two contrasted grassland-based feed environment scenarios.
Results The unfavorable scenario, which included poor grass and forage quality due to summer drought, resulted in an average reduction of about 37% in the total number of lambs weaned compared with the favorable, high feed quality scenario. This lifetime performance was only moderately correlated between the two environmental scenarios. A re-ranking of individual types occurred across environments and was driven by a re-ranking in neonatal survival and ewe longevity whereas ewe prolificacy showed little environmental sensitivity. The ewe-lamb trade-offs assumed at the individual level did not lead to the negative consequences expected among-individuals: at this level, the correlations between ewe longevity and prolificacy or lamb survival were close to zero in both environments.
Conclusions Provided that energy allocation trade-offs are under genetic control, they could underpin a genotype-by-environment interaction in ewe lifetime performance. However, energy allocation constraints alone do not exclude the existence of robust ewes that manage well the consequences of ewe-lamb trade-offs, in particular by combining high target levels of intake and body condition.

Nutritional regulation of reproductive physiology in ruminants: A mechanistic review

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Life, Volume 16, Issue 4, April 2026

DOI https://doi.org/10.3390/life16040630

Abstract

Modern genetic selection for high productivity has created a physiological conflict in ruminants, where the metabolic demands of lactation compete directly with the energy requirements of reproduction. This review provides a mechanistic synthesis of how key nutritional factors modulate the endocrine and cellular pathways governing reproductive success in cattle and sheep. Negative energy balance (NEB), characteristic of the early postpartum period, suppresses the hypothalamic–pituitary–gonadal (HPG) axis by impairing the pulsatile secretion of gonadotropin-releasing hormone (GnRH) and luteinizing hormone (LH), mediated through reduced kisspeptin signaling, growth hormone (GH) resistance, and decreased circulating insulin, insulin-like growth factor-1 (IGF-1), and leptin. At the macronutrient level, excess rumen-degradable protein elevates blood urea nitrogen and impairs the uterine environment, while omega-3 polyunsaturated fatty acids inhibit prostaglandin F2α synthesis to support corpus luteum maintenance. At the micronutrient level, selenium, copper, and zinc are essential antioxidant cofactors protecting gametes and embryos from oxidative stress, while vitamins A, D, and E regulate gene expression in reproductive tissues. Furthermore, maternal nutrition during critical gestational windows programs the reproductive capacity of offspring through epigenetic modifications, with profound implications for long-term herd fertility. Understanding these nutritional–reproductive interactions is crucial for developing precision feeding strategies that optimize herd fertility, improve animal welfare, and ensure the economic sustainability of livestock management. A thorough understanding of these nutritional–reproductive interactions is essential for developing precision feeding strategies that optimize fertility in high-producing ruminants.

Dietary protein imbalance impairs sperm morphology and promotes testicular degeneration in rams

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Reproduction in Domestic Animals, Volume 61, Issue 5, May 2026

DOI https://doi.org/10.1111/rda.70215

Abstract

Reproductive efficiency is a primary determinant of profitability in ruminant production, with male fertility being a critical factor for genetic progress and herd productivity. While nutritional management is a central component in modulating reproductive capacity, the effects of excessive dietary protein on testicular function remain incompletely elucidated. This study evaluated the impact of different dietary crude protein (CP) levels on reproductive and metabolic parameters in rams. Twenty-eight Santa Inês rams were randomly assigned to four groups (n = 7) and fed for 120 days with isoenergetic diets containing distinct CP levels: control (13.4%), hypoproteic (11.4%), hyperproteic I (17.5%) and hyperproteic II (22.4%). Periodic evaluations of body parameters, sperm kinetics and morphology, testicular ultrasonography, testicular cytology and hormonal profiles were conducted. Diets did not influence body weight or sperm motility ($p > 0.05$). However, variations in testicular echogenicity were observed ($p < 0.05$), and rams fed hyperproteic diets showed a progressive and marked increase in total sperm defects, exceeding 29.5% on day 80 ($p < 0.05$) compared with the control group (12.86%). Cytological analysis confirmed the presence of multinucleated giant cells and testicular degenerative changes from day 40 onwards in the hyperproteic groups. In conclusion, diets containing 17.5% and 22.4% CP are detrimental to sperm morphology and testicular integrity in rams, even in the absence of changes in body weight or detectable ultrasonographic alterations. The diet with 13.4% CP proved more suitable for maintaining testicular function and reproductive health.

Risk factors for non-adapting weaner lambs entering South African feedlots

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South African Journal of Aniaml Science, Volume 56, Issue 5 May 2026 **OPEN ACCESS**

DOI https://doi.org/10.17159/sajas.v56i05.01

Abstract

A growing concern in South African feedlot systems is the increased prevalence of non-adapting weaner lambs. This study aimed to identify on-farm risk factors associated with poor adaptation using retrospective production data and a structured questionnaire administered to 80 lamb-rearing farms across South Africa. Risk factors were estimated using Poisson regression to calculate risk ratios and 95% confidence intervals. Of the farmers interviewed, 56% (45/80) did not supply creep feed to their pre-weaned lambs in any form, whereas 75% (60/80) supplied additional feed to their ewes. A lack of creep feed supplementation, extensive lamb rearing, and lambs being born in seasons other than summer were significant risk factors for non-adapting lambs. Spatial clustering of high-death locations was also observed. Creep feeding offers critical benefits, including improved rumen development, increased weight gain, earlier weaning, and improved feedlot adaptability. Lamb-producing areas in South Africa occur in semi-arid regions with low carrying capacities, favouring extensive management systems. Creep feed is often infrequently offered or omitted in extensive rearing systems, owing to logistical challenges. The weaner lamb price, typically determined by feedlots, is rarely influenced by on-farm managerial practices such as creep feed supplementation. As a result, producers may view creep feeding as an unnecessary expense, because of the lack of financial incentives. Promoting awareness of the production and economic benefits of creep feeding, improving communication between feedlots and lamb producers, and encouraging the implementation of good agricultural practices would encourage farmers to adopt specified production and management practices to improve lamb adaptability in South African feedlots.

Estimation of genetic parameters for growth and wool traits in South African Merino sheep

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South African Journal of Animal Science, Volume 56, Issue 5 May 2026 **OPEN ACCESS**

DOI https://doi.org/10.17159/sajas.v56i05.02

Abstract

The estimation of genetic parameters allows for the accurate prediction of estimated breeding values (EBVs), which play a crucial role in developing selection indices used to generate genetic progress for economically important traits. This study aimed to estimate genetic parameters and EBVs for the South African Merino sheep breed. A population of 864 754 South African Merino sheep were included in this study. Pedigree information included animals born between 1919 and 2022, of which 457 757 (52.94%) were females and 406 996 (47.06%) were males. Variance components were estimated for all sheep born after 2009, consisting of 62 460 sheep. A multi-trait animal model was used to estimate the variance components, using VCE6 statistical software. Heritability values and standard errors were estimated for seven traits: direct weaning weight (0.25 ± 0.01), maternal weaning weight (0.20 ± 0.00), body weight at wool test (0.26 ± 0.01), clean fleece weight (0.33 ± 0.01), staple length (0.33 ± 0.00), fibre diameter (0.63 ± 0.00), and coefficient of variation of fibre diameter (0.43 ± 0.00). Using the same genetic models as used for variance component estimation, EBVs were predicted using PEST2. Genetic trends were determined by averaging the EBVs of the measured animals per year of birth per trait, and these were compared to the national trends provided by SA Stud Book. This study updates the variance components and EBVs of the South African Merino sheep breed, enabling the accurate genetic selection of animals and facilitating faster genetic progress.

Functional and proteomic changes in ram sperm during 48-hour liquid storage at 5 °C across the breeding season

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Agriculture, Volume 16, Issue 10, May 2026 **OPEN ACCESS**

DOI https://doi.org/10.3390/agriculture16101045

Abstract

This study evaluated functional and proteomic changes in ram sperm during 48 h of liquid storage at 5 °C, comparing samples collected at two breeding-season stages (July and November). Semen from six Assaf rams was diluted in INRA 96® and stored at 15 °C for 6 h and at 5 °C for 24 and 48 h. Sperm functionality (motility and kinetics, viability, apoptotic-like changes, and mitochondrial reactive oxygen species content) and proteomic profiles were assessed at each storage protocol. Sperm collected in July showed a significantly faster decline in motility and kinetics, viability, and mitochondrial reactive oxygen species levels, along with increased apoptotic-like changes during storage ($p < 0.05$), resulting in lower values for several functional parameters after 48 h compared with November samples. Proteomic analyses revealed more pronounced changes in protein abundance during storage in July samples, including enrichment of metabolic pathways and reduction in proteins associated with membrane stability and ion regulation. In contrast, November samples showed fewer changes in protein abundance, mainly involving mitochondrial and regulatory proteins. These results indicate that ram sperm resistance to liquid storage varies across breeding-season stages and is associated with distinct proteomic profiles. The findings provide descriptive molecular insights that may support future studies aimed at improving semen preservation strategies in ovine reproduction.

Assessment of milk production in Assaf ewes born as twin based on correspondence analyses and mixed model

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Small Ruminant Research, Volume 259, June 2026 **OPEN ACCESS**

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Highlights

- Presence and number of male or female twins during foetal life influence adult dairy ewe productivity.
- Ewes born from male twin lambs produce more milk than those from singleton births.
- Findings support management strategies to improve efficiency in dairy sheep production systems.

Abstract

The aim of this study was to determine whether the presence and number of male and female twins affected the future milk yields of female ewes in adulthood. The study was based on 10,049 milk production records from 12 dairy sheep farms in Spain. Total milk yield (TMY) was categorized as either Low or High, and daily milk yield (DMY) was categorized as either Low/1, Intermediate-low/2, Intermediate-high/3, or High/4. Twins were categorized as follows: (1) ewes born without a twin (0 T), (2) ewes born with at least one female twin (at least 1FT: 1 and 2 sisters), (3) at least one male twin (at least 1MT: 1 and 2 brothers), or (4) with one male and one female twin (1MT+1FT: one brother and sister). Correspondence analyses indicated that ewes in the 0 T group were associated with low TMY and DMY, and twin births (at least 1MT and 1FT groups) were associated with 2–4TMY levels, and 3–4DMY levels. Mixed-effect-model indicated that ewes in the at least 1MT group had a positive effect on TMY ($P < 0.05$) and DMY ($P < 0.01$), than did ewes in the 0 T group. In summary, litter size and litter sex ratio in intrauterine life had a positive effect on milk production in ewes in adulthood. This effect is positively evidenced in ewes born with at least one-male-twins. This information might be useful in identifying ways to improve the economic-productive efficiency of sheep dairy systems.

A multimodal pharmacological treatment of incomplete cervical dilation and softening ('Ringwomb') in ewes: Effects on delivery outcome, survival, and animal welfare

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Small Ruminant Research, Volume 259, June 2026

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Highlights

- Multimodal therapy (oxytocin, Ca/Mg, glucose) resolved 52.9% of ICDS.
- Labor over 12 hrs increases fetal mortality and reduces ewes survival.
- ICDS in multiparous ewes reflects metabolic exhaustion, not hormonal failure alone.
- Breed did not predict ICDS outcome; larger litters significantly raised fetal loss.
- Treatment mode did not affect pregnancy rate or ICDS recurrence in surviving ewes.

Abstract

Incomplete cervical dilation and softening (ICDS), commonly referred to as “Ringwomb”, remains a significant cause of dystocia and neonatal mortality in sheep. This study evaluated the clinical efficacy of various pharmacological protocols and the impact of labor duration and breed on maternal and fetal outcomes in 64 ewes over a seven-year period (2019–2025). Ewes were distributed into four groups: Group A (oxytocin), Group B (calcium/magnesium), Group C (multimodal: oxytocin, calcium/magnesium, glucose and glucose precursors), and Group D (control). Results indicated that the multimodal protocol in Group C was

significantly more effective in facilitating vaginal delivery (52.9%) compared to other groups ($p = 0.031$). Labor duration was identified as the most critical predictor of survival; fetal mortality escalated from 10.0% in interventions occurring within 6 h to 52.5% in cases exceeding 12 h ($p = 0.001$). Maternal survival similarly declined from 92.6% to 68.8% over the same interval ($p = 0.048$). While litter size significantly influenced fetal mortality ($p = 0.046$), ewe breed did not significantly affect clinical success or survival rates ($p > 0.05$). Longitudinal analysis revealed that neither the mode of delivery nor the treatment protocol impacted subsequent pregnancy rates or the recurrence of ICDS (17.5% average). These findings suggest that early intervention with a multimodal approach can effectively resolve ICDS, reducing the requirement for surgical intervention and improving overall animal welfare.

A machine learning-based wearable system for automated detection of sheep parturition events using accelerometer data

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Computers and Electronics in Agriculture, Volume 248, July 2028 **OPEN ACCESS**

DOI https://doi.org/10.1016/j.compag.2026.111784

Highlights

- Wearable accelerometer technology enables the detection of lambing events by monitoring ewe discomfort and lying bouts.
- A learning model was developed to define time intervals leading up to lambing.
- The learning model identifies time intervals based on lying bout patterns.
- The detection system provides near real-time lambing detection.

Abstract

The quality and safety of sheep farming increasingly depend on automated monitoring systems, with parturition detection representing a critical challenge due to its direct impact on lamb survival. This study presents the development and evaluation of two machine learning approaches for predicting sheep parturition: a lightweight model designed for deployment on collar-mounted devices with limited computational resources, and a full-featured model intended for scenarios without such constraints. The models were developed using data from 53 parturition events collected via collar-mounted accelerometers and thermometers, within a system that supports real-time data acquisition, processing, and visualization of parturition predictions. The lightweight model, operating under strict computational and memory limitations, achieved an accuracy of 0.74 and a Matthews Correlation Coefficient (MCC) of 0.71. In contrast, the full-featured model delivered superior performance, reaching an accuracy of 0.81 and an MCC of 0.79 when predicting time to birth up to 11 h in advance. Additionally, temporal filtering optimization contributed to stable performance in extended validation scenarios for both models. The work included the development of a detection tool based on the use of an MQTT broker, that includes two subscribers that perform detection, and alarm triggering, and a producer that streams monitoring data gathered by the the collars. Overall, this work advances precision livestock farming by offering two practical solutions for automated parturition monitoring, enabling farmers to select either a resource-efficient or a high-performance approach according to their specific operational requirements and available infrastructure.

Research on an automated detection for sheep estrus based on multimodal fusion of thermal images and sensor data

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Computers and Electronics in Agriculture Volume 249, July 2026

DOI https://doi.org/10.1016/j.compag.2026.111848

Highlights

- A multimodal method uses thermal images, eye temperatures, and environmental features for ewe estrus stage classification.
- INC-SE-MSF-ResNet18 combined with LightGBM achieves over 98.39% accuracy in diestrus, estrus, and metestrus classification.
- Eye surface temperature is a sensitive indicator of estrus, while rectal temperature reflects thermoregulation.
- Stage-dependent of surface and core temperatures provide physiological support for ovulation timing inference.

Abstract

Estrus monitoring is essential for improving reproductive efficiency and optimizing artificial insemination timing in ewes. However, existing studies mainly focus on binary estrus detection and often rely on wearable sensors, invasive physiological measurements, or vision-based behavioral analysis methods, which are insufficient for fine-grained estrus stage discrimination and are limited by animal stress, high deployment cost, and sensitivity to farm environmental disturbances. To address these limitations, this study proposes a non-contact multimodal framework for classifying ewe estrus stages into diestrus, estrus, and metestrus. Thermal infrared features were extracted using an improved ResNet18 incorporating initial convolution (INC), squeeze-and-excitation (SE), and multi-scale fusion (MSF) modules, denoted as INC-SE-MSF-ResNet18. In parallel, bilateral eye temperature features and environmental temperature and humidity features were extracted by multilayer perceptron (MLP)-based eye temperature feature extractor and MLP-based environmental variable feature extractor. These three types of features were then concatenated into a multimodal feature and classified using a Light Gradient Boosting Machine (LightGBM). Under the same LightGBM classifier, INC-SE-MSF-ResNet18 generated more discriminative thermal infrared features than ResNet18, MobileNetv3, EfficientNet, ShuffleNet, and DenseNet, yielding improvements of up to 15.10% in recall, 7.67% in F1-score, and 3.10% in accuracy. Under the same feature extraction and fusion strategy, LightGBM consistently outperformed support vector machine (SVM), eXtreme Gradient Boosting (XGBoost), gradient boosting decision tree (GBDT), random forest (RF), decision tree (DT), logistic regression (LR), and convolutional neural network (CNN) across all estrus stages, with precision improvements of up to 21.23% over CNN, 13.17% over DT, and 11.11% over RF. Temperature analysis further revealed clear stage-dependent divergence between bilateral eye temperatures and rectal temperature (RT). The bilateral eye temperatures peaked during estrus, whereas rectal temperature decreased during estrus and increased markedly during metestrus. These results indicate that surface and core temperatures reflect different physiological processes and exhibit unsynchronized temporal dynamics across the estrous cycle. Overall, this study extends infrared thermography-based ewe estrus monitoring from conventional binary detection to protocol-defined estrus stage classification, providing a feasible approach for ovulation timing inference and precision reproductive management in large-scale sheep farming systems.

In silico analysis of cholesterol binding to species-specific and non-specific albumins and their effects on *in vitro* quality parameters of ram spermatozoa

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Animal Reproduction Science, Volume 290, July 2026 **OPEN ACCESS**

DOI https://doi.org/10.1016/j.anireprosci.2026.108168

Abstract

This study combined *in silico* analyses of albumin-cholesterol (CHOL) interactions with *in vitro* assessment of the effects of species-specific (ovine serum albumin, OSA) and non-species-specific albumins (bovine: BSA; human: HSA; caprine: CSA) in cooled ram sperm. Docking, molecular dynamics, and quantum biochemical calculations characterized albumin-CHOL binding. Experiments used 10 ejaculates from 10 rams cooled for 3 h (15 °C) or 24 h (5 °C) and incubated in TALP with BSA, HSA, OSA or CSA. OSA combined energetically favorable poses with stable complexes, at FA1-FA9 and FA1, and was the most consistent CHOL binder across *in silico* methods. In 3-h samples, OSA decreased total motility (44.0 ± 2.4%; $P < 0.05$) versus the other groups, reduced viability (28.8 ± 5.3%, $P < 0.05$) versus control (50.1 ± 4.2%), and increased acrosomal damage (40.2 ± 3.5%; $P < 0.05$) compared with control and BSA (24.4 ± 1.6%, 23.5 ± 1.4%). In 24-h samples, OSA reduced motility and viability (48.8 ± 3.8%, 21.9 ± 1.6%; $P < 0.05$) compared with BSA (72.2 ± 4.5%, 44.4 ± 4.3%), increased apoptosis (93.9 ± 0.6%) versus all the other albumins, and decreased mitochondrial ROS levels (6.1 ± 0.4%; $P < 0.05$) versus BSA and HSA (22.4 ± 3.9% and 16.4 ± 2.8%). Both HSA and OSA increased acrosomal damage (35.1 ± 2.3%, 30.8 ± 1.4%; control: 19.2 ± 4.2%). OSA thus induces pronounced membrane and acrosome alterations under capacitating conditions, likely linked to favorable OSA-CHOL binding, but concomitantly compromises motility, viability and mitochondrial ROS in cooled samples. These results indicate that the species-specific albumin is detrimental for cooled ram spermatozoa and cannot be recommended as a substitute for BSA under the present conditions. Nevertheless, the species-related effects of albumins indicate that strategies tailored for each species will help refine *in vitro* sperm handling protocols.

A plasma metabolomics analysis reveals a panel of metabolic biomarkers for early pregnancy diagnosis in Hu sheep

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Highlights

- This study utilized an untargeted metabolomics approach combined with Random Forest analysis to identify 353 differentially expressed metabolites (DEMs) in plasma samples from non-pregnant and pregnant ewes, revealing potential early pregnancy biomarkers.
- Four metabolites (N-Acetylcytidine, cAMP, Flavanone 7-O-Glucoside, and Bisdethiobis(methylthio)gliotoxin) were found to decrease progressively during pregnancy, becoming undetectable by day 30, highlighting their potential as diagnostic markers for early pregnancy detection.
- By integrating Random Forest and ROC curve analyses, the study identified 8 metabolites with significant changes during gestation, paving the way for the development of novel molecular diagnostic techniques to enhance reproductive management and productivity in sheep breeding.

Abstract

In an effort to enhance reproductive management and reduce non-productive periods in sheep breeding, this study utilizes an untargeted metabolomics approach combined with Random Forest analysis for the identification of early pregnancy biomarkers in ewes. We examined differentially expressed metabolites (DEMs) in the plasma samples from non-pregnant ewes (NP, n=7), pregnant ewes at 19 days (P19, n=8) and at 30 days (P30, n=7). This study identified 353 DEMs among three groups, mainly influenced by lipids and

lipid-like molecules, organic acids and derivatives, and organoheterocyclic compounds, affecting plasma metabolite changes during pregnancy. Among these, the expression levels of four metabolites (N-Acetylcytidine, cAMP, Flavanone 7-O-Glucoside, and Bisdethiobis(methylthio)gliotoxin) gradually decreased as pregnancy progressed, becoming undetectable by day 30 of gestation, and were identified through ROC (Receiver Operating Characteristic) curve analysis as potential early pregnancy diagnostic markers. Additionally, by combining Random Forest analysis with ROC curve analysis, we identified 2 metabolites that were continuously upregulated with increasing gestational time (Indoxyl Sulfate, PC(17:0/20:4)) and 6 metabolites that were continuously downregulated with increasing gestational time (PS(18:0/20:4), PC(18:0/18:1), PI(17:0/14:1), Altenuene, 4-Hydroxy-3-methoxy-cinnamoylglycine, methyl 2-{2-[9-(4-methylphenyl)-6-oxohydropurin-8-ylthio]acetylamino}benzoate) that could serve as early pregnancy diagnostic markers based on feature importance using Random Forest. This research establishes a robust theoretical foundation for the development of innovative molecular diagnostic techniques and explores new avenues for molecular genetic breeding, ultimately enhancing fertility and productivity in ewe herds.

Successful classification of pregnant and empty ultrasound imagery of sheep using convolutional neural network

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Highlights

- A deep learning model classified ultrasound imagery from pregnant and empty ewes.
- Model achieved 100% ewe-level accuracy on internal datasets.
- Training the model with balanced data improved frame-level precision.
- First deep learning model for free-hand ultrasound diagnosis of pregnant ewes.
- Model supports more consistent and accurate on-farm pregnancy diagnosis.

Abstract

Point-of-care diagnostic imaging is crucial in various veterinary and agricultural settings. In sheep, pregnancy diagnosis by ultrasound is routinely undertaken to determine pregnancy status, fetal number, age and health. However, diagnostic accuracy remains challenging, even for experienced scanners. Deep learning holds potential to address such challenges and improve accuracy and efficiency of ultrasound interpretation. This study evaluated a deep learning model to identify pregnant and empty (non-pregnant) ewes from continuous free-hand ultrasound video frames, reflecting real world conditions. Transcutaneous ultrasound (OviScan 6) imagery collected from 951 ewes, 44 days post 5-week joining. From these recordings, frames were extracted and labelled with diagnosis class (pregnant or empty). Two datasets were constructed: an unbalanced subset reflecting field conditions (884 pregnant; 67 empty), and a class-balanced subset for comparison (67 pregnant; 67 empty). A binary Convolutional Neural Network with two convolutional layers and one fully connected layer was trained on each. During internal testing, both models achieved 100% ewe-level classification accuracy, with only minor frame-level misclassification. Threshold optimization indicated the balanced model maintained perfect performance across thresholds, while the unbalanced model required a higher decision threshold (0.80) to achieve optimal performance. External evaluation on an independent cohort of 390 ewes demonstrated high diagnostic accuracy for both models, with the balanced model achieving 0.987 accuracy and the unbalanced model achieving 0.995 accuracy at the ewe level. These findings show that deep learning can accurately distinguish pregnant and empty ewes under commercial scanning conditions, with strong generalizability across variation in fetal number and gestational age.

Upcoming events

Date	Event	Location
5 June 2026	Feed Budgeting Masterclass AWI Extension NSW	Gundagai, NSW
11 June 2026	Feed 365 – Designing a year-round feedbase for WA sheep Meat & Livestock Australia PDS Updates	Webinar
11 June 2026	Sheep production for tomorrow: feed, health and market opportunities Agriculture Victoria	Elmore, Vic
14 - 15 June 2026	Train the Trainer – BredWell FedWell sheep workshop Meat & Livestock Australia	Bridgetown, WA
15 June 2026	BredWell FedWell sheep workshop Meat & Livestock Australia	Boyup Brook, WA
16 June 2026	Reproduction Masterclass AWI Extension NSW	Yass, NSW
19 June 2026	BredWell FedWell sheep workshop Meat & Livestock Australia	Bombala, NSW
23 - 24 June 2026	2026 BestWool BestLamb Conference and Dinner Agriculture Victoria	Ballarat, Vic
23 June 2026	Merino Lifetime Productivity (MLP) Project Results Seminar Australian Wool Innovation	Pingelly, WA
24 June 2026	Weaning Planning for 2026 AWI Extension NSW	Webinar
3 July 2026	Merino Lifetime Productivity (MLP) Project Results Seminar Australian Wool Innovation	Dubbo, NSW
7 – 10 July 2026	LambEx Sheep Producers Australia	Adelaide, SA
23 July 2026	Merino Lifetime Productivity (MLP) Project Results Seminar Australian Wool Innovation	Balmoral. Vic
7 August 2026	Merino Lifetime Productivity (MLP) Project Results Seminar Australian Wool Innovation	Armidale, NSW