ruminants

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Editorial

Feature Papers of Ruminants 2024–2025

Leilson R. Bezerra [1,*] and Phillip Lancaster [2,*]

[1] Department of Animal Science, Federal University of Campina Grande, Patos 58708110, Paraíba, Brazil
[2] Beef Cattle Institute, Kansas State University, Manhattan, KS 66506, USA
* Correspondence: leilson@ufpi.edu.br (L.R.B.); palancaster@vet.k-state.edu (P.L.)

1. Introduction

Ruminants continue to play a pivotal role in sustainable food production by converting abundant resources, such as rangelands, pastures, crop residues, and agro-industrial byproducts, into human-edible products of high nutritional value (meat, milk, and other dairy products). Although the contribution of ruminants to food security is historically well established and remains substantial, debate persists regarding the efficiency of converting feed resources into animal products and the environmental externalities associated with livestock production.

Contemporary discussions increasingly focus on the use of potentially human-edible feeds in ruminant diets, the need to optimize feeding systems, and the challenge of mitigating environmental impacts without compromising productivity. This Special Issue was designed to assemble cutting-edge research on these topics, offering an integrated perspective on recent scientific advances and the knowledge gaps that remain to be resolved in ruminant science.

2. Materials and Methods

The *Special Issue Feature Papers of Ruminants 2024–2025* brings together a diverse collection of original research articles, reviews, and communications that reflect scientific progress and emerging directions in ruminant research. The contributions span themes ranging from physiology and nutrition to management technologies, animal welfare, genetics, and sustainability.

Collectively, the papers provide a broad and cohesive view of the multiple dimensions that currently shape ruminant production, underscoring that sustainability, productive efficiency, animal welfare, technological innovation, and socioeconomic context are inseparable components of modern livestock systems. From a socioeconomic standpoint, the study conducted in Türkiye [Varalan et al., Contribution 1] indicates that sheep farming remains largely grounded in extensive systems, primarily managed by middle-aged or older producers with limited formal education and a strong reliance on direct marketing. This profile reveals structural constraints but also delineates clear pathways for sectoral sustainability, including generational renewal, expanded technical training, and the adoption of more modern production practices. Complementing this structural perspective, the morphological characterization of the Sanmartinero Creole bovine breed using geometric morphometrics [Salamanca-Carreño et al., Contribution 2] highlights the value of advanced quantitative tools for genetic conservation by demonstrating consistent sexual dimorphism in head size and shape, information that is strategically relevant for preservation programs, population standardization, and the valorization of locally adapted breeds.

In the domain of growth and development, the assessment of the relationship between stature and live weight in dairy cows from birth to maturity advances understanding of

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body growth trajectories and the development of productive capacity, showing that linear measures exhibit strong associations between early life and adulthood. In contrast, traits related to thoracic capacity and live weight remain environmentally sensitive for more extended periods [Gibson et al., Contribution 3]. These findings reinforce the importance of adequate nutritional management up to later ages to maximize future productive potential, with direct implications for reproductive efficiency and lactational performance. This emphasis on nutrition is also mirrored in experimental work with growing cattle, in which replacing urea-treated rice straw with silages derived from maize–soybean or grass–soybean intercrops produced consistent improvements in performance and feed efficiency without altering dry matter intake or body conformation, demonstrating the potential of integrated forage strategies to improve the energy–protein balance in tropical production systems [Nguyen et al., Contribution 4].

The interface among nutrition, behavior, and animal welfare is further strengthened by studies that address both pathological conditions and innovative feeding strategies. Research on the behavior of cows affected by Johne's disease [Charlton et al., Contribution 5] identifies subtle yet meaningful changes in lying and rumination patterns around peak lactation, suggesting that behavioral metrics can serve as sensitive tools for monitoring health status and welfare. However, the underlying mechanisms require further clarification. In a complementary approach, the study evaluating the inclusion of technical cashew nutshell liquid combined with vegetable oils differing in fatty acid profiles in sheep diets shows that dietary lipid composition influences feed selectivity and rumination patterns without adverse physiological or thermoregulatory effects, highlighting the role of monounsaturated fatty acids in optimizing energy intake and feeding efficiency [Andrade et al., Contribution 6].

More integrative and technology-oriented contributions extend this discussion to large-scale production systems. The invited review on total mixed ration (TMR) feeding [Dey et al., Contribution 7] consolidates evidence that TMR enhances rumen fermentation stability, improves microbial activity, and increases productive performance across ruminant species, while also emphasizing challenges related to formulation errors, mycotoxin risks, and environmental outcomes, reinforcing the need for nutritional precision and sound management practices. Similarly, the review of virtual fencing technology underscores its promise as a core tool within precision livestock farming, capable of increasing grazing-management flexibility and reducing labor demands, while also recognizing technical, economic, and welfare-related constraints that must be addressed to enable broader adoption across diverse production contexts [Gadzama et al., Contribution 8].

The ethical and societal dimensions of ruminant production are robustly addressed through the analysis of enhanced animal welfare labeling schemes for cattle, sheep, and goats in Europe [Papageorgiou et al., Contribution 9]. This contribution demonstrates that growing demands for transparency and sustainability have accelerated the development of more stringent welfare standards grounded in animal-based measures, with a strong emphasis on pasture access, comfort, environmental enrichment, and, in some cases, mother–young bonding. Such labeling systems not only reflect societal expectations but also function as strategic instruments for market differentiation and for rewarding more responsible production systems.

Finally, the review on slow-release urea technologies [Bezerra et al., Contribution 10] synthesizes essential advances in the use of non-protein nitrogen sources in small ruminants, showing that microencapsulation and other controlled-release systems can improve nitrogen-use efficiency, enhance microbial protein synthesis, reduce environmental nitrogen losses, and, under specific dietary and management conditions, improve animal performance and product quality. At the same time, the review highlights the need for

greater methodological standardization, long-term evaluations, and comparative economic assessments to support large-scale adoption of these technologies.

Taken together, these studies demonstrate that the future of ruminant production depends on integrated, interdisciplinary approaches that simultaneously address biological efficiency, economic viability, animal welfare, conservation of genetic resources, and societal acceptance. The contributions in this Special Issue reinforce the central role of science in building more resilient, efficient, and sustainable production systems capable of responding to global challenges related to food security, climate change, and evolving societal demands.

3. Conclusions

The Special Issue Feature Papers of Ruminants 2024–2025 consolidate studies that advance understanding of the mechanisms influencing production efficiency, animal welfare, and the sustainability of ruminant production systems. Collectively, the contributions emphasize the value of integrated approaches that consider not only nutritional and productive variables but also technological, behavioral, and socioeconomic factors. Despite these advances, significant knowledge gaps remain, including (i) the integration of nutritional efficiency with reduced environmental impacts, for which robust predictive models are still needed to optimize diets that maximize output while minimizing emissions; (ii) improved connectivity between emerging technologies (e.g., sensors and precision livestock farming) and on-farm practices to translate data streams into operational decisions that create measurable value; and (iii) a deeper understanding of the interactions among genetics, management, and nutrition across contrasting climates and production systems.

To accelerate progress, future research should prioritize the development of feeding systems that maximize the use of resources that do not compete with the human food supply while reducing environmental losses; the application of big data analytics and artificial intelligence to improve predictions of performance and animal health; and interdisciplinary studies integrating genetics, the rumen microbiome, precision nutrition, and public policies to advance sustainable production practices at a global scale. This body of work not only brings a relevant thematic issue to a close but also opens promising avenues for investigation that may further strengthen the role of ruminants in sustainable agriculture in the twenty-first century.

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