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**Julio
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**"FUTURO DE LA
PRODUCCIÓN ANIMAL:
ZOOTECNIA 5.0 Y
SOSTENIBILIDAD"**



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Contenido

Volumen 79: Suplemento 1, 2026

COPACO 2026-Tercer Congreso Internacional de Producción Animal Colombia

Decano	9
Director de Departamento	9
Comité Organizador	9
Miembros Extranjeros del Comité Académico	9
Comité de Apoyo	10
Asesor Logístico	10
Diagramación	10
Edición	10
Pares Evaluadores	10
Prefacio	15
Conferencias Apertura Internacionales	19
Machine Learning and Sensor Technologies in Animal Production: From Data to Decision-Making <i>Luis Fernando Brito</i>	21
Status of Genomic Selection in the Americas and the World <i>Daniela Lourenco, Matias Bermann and Ignacy Misztal</i>	23
Between Myths and Truths: The Role of Ruminants in Global Sustainability <i>José Martín Jáuregui</i>	24
New Methodological Advances in Animal Breeding and Genetics <i>Matias Bermann, Ignacy Misztal and Daniela Lourenco</i>	26
Maternal Experience in Sheep: Implications for Development, Behavior, Stress and Welfare <i>Juan Pablo Damián Cabrera</i>	28
From Phenotypes to Decisions: Machine Learning and Statistical Methods for Sustainable and Resilient Animal Production <i>Lucio Flavio Macedo Mota</i>	30
Sustainability in Poultry Production: Concepts and How Nutrition Can Be Decisive <i>José Henrique Stringhini</i>	31
Conferencias Magistrales	33
Sustainability and Animal Production: Governance, Socio-Ecological Dynamics, and Regenerative Pathways in Colombia's Tropical Lowlands <i>Juan Fernando Naranjo Ramírez</i>	35
The Paradigm of Reproductive Biotechnology: A Conscious Exploration <i>Giovanni Restrepo Betancur</i>	37
Sustainable Poultry Farming for the Nutrition of Colombians <i>Carlos Octavio Duque González</i>	39
The DNA of Adaptation: History and Genomic Relationships of Local Cattle Breeds in Colombia <i>Juan Carlos Rincón Flórez</i>	42

Conferencistas Nacionales	45
The Future of Animal Production: IoT Applications and Real-Time Impact in Zootecnia 5.0 <i>Sebastián Villegas Palacino</i>	47
Overview of Export Regulations and Requirements Across the Americas and Globally <i>Lina Marcela de los Ríos Morales</i>	49
Implementation of Certified Sustainability in a Colombian Livestock Company <i>Juan Fernando Cadavid Santamaría</i>	50
Conferencias Egresados Sobresalientes	51
Methane Phenotyping Using a Laser Methane Detector (LMD) to Support Sustainable Genetic Improvement in Brahman Cattle <i>Natalia Andrea Marín-Garzón, Sofía Ruge Camacho, Lady Susatama Acevedo, Deisy Camargo, Diana M Parra and Yury T Granja Salcedo</i>	53
Evolving Cattle Production: Experience in Implementing Genetic Values and Functional Biotypes <i>Juan Esteban Agudelo Giraldo</i>	55
The Measure and the Gaze: Data Analysis in Agricultural Sciences Between Metrics, Methods, and Human Judgment <i>Edimer David Jaramillo</i>	56
Resúmenes Grandes Rumiantes (Vacunos y Búfalos de Leche y Carne)	59
Resúmenes Avicultura (Postura, Engorde y Coturnicultura)	105
Resúmenes Pequeños Rumiantes (Ovinos y Caprinos)	119
Resúmenes Equinos	133
Resúmenes Porcinos	139
Resúmenes Piscicultura	155
Resúmenes Especies Productivas No Tradicionales (Apicultura, Conejos, Cuyes, Patos, Entre Otros)	161
Resúmenes Animales de Compañía	171
Índice de Autores	177

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"Futuro de la Producción Animal: Zootecnia 5.0 y Sostenibilidad"

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COPACO-2026

El futuro de la producción animal: Zootecnia 5.0 y sostenibilidad

The Future of Animal Production: Animal Science 5.0 and Sustainability

La humanidad enfrenta uno de los mayores desafíos de su historia: garantizar la seguridad alimentaria de una población en constante crecimiento en un contexto marcado por el cambio climático, la pérdida de biodiversidad, la creciente presión sobre los recursos naturales y profundas transformaciones sociales y tecnológicas. En este escenario, la producción animal ocupa un lugar estratégico. Más allá de proveer alimentos de alto valor nutricional, los sistemas pecuarios contribuyen al desarrollo económico, la generación de empleo rural, la conservación de los recursos genéticos y el bienestar de millones de personas en todo el mundo.

Responder a estos desafíos exige una nueva forma de concebir la zootecnia. La producción animal del siglo XXI no puede limitarse al incremento de los indicadores productivos; debe integrar eficiencia, sostenibilidad, bienestar animal, innovación tecnológica, responsabilidad ambiental y equidad social en un modelo de desarrollo capaz de responder a las demandas de una sociedad cada vez más consciente de la necesidad de armonizar producción y conservación. Este nuevo paradigma encuentra su expresión en el concepto de Zootecnia 5.0, entendido como la convergencia entre las ciencias animales, la transformación digital y la sostenibilidad, donde el conocimiento científico y las tecnologías emergentes se ponen al servicio de sistemas de producción más inteligentes, resilientes y centrados tanto en las personas como en los animales y los ecosistemas.

La Zootecnia 5.0 integra herramientas como la inteligencia artificial, el aprendizaje automático, la genómica, la fenómica, la edición genética, la visión por computador, el Internet de las Cosas (IoT), la robótica, los sistemas de monitoreo en tiempo real y la analítica masiva de datos para comprender con mayor precisión la complejidad de los sistemas productivos y respaldar decisiones fundamentadas en evidencia científica. Sin embargo, su verdadera innovación no reside únicamente en la incorporación de nuevas tecnologías, sino en su capacidad para promover sistemas de producción que armonicen la eficiencia productiva con el bienestar animal, la rentabilidad, la adaptación al cambio climático y la sostenibilidad ambiental.

En este contexto adquieren especial relevancia enfoques integradores como One Health y One Welfare, que reconocen la estrecha interdependencia entre la salud humana, la salud animal y la salud de los ecosistemas, así como la relación entre el bienestar de los animales, las personas y el ambiente. De igual manera, conceptos como la bioeconomía, la economía circular, la ganadería regenerativa y las soluciones basadas en la naturaleza amplían el horizonte de la producción animal hacia modelos que no solo buscan reducir los impactos ambientales, sino también contribuir activamente a la restauración de los ecosistemas, la captura de carbono, la conservación de la biodiversidad y el fortalecimiento de la resiliencia de las comunidades rurales.

En este contexto, el 3^{er} Congreso Internacional de Producción Animal - COPACO 2026 adquiere una especial relevancia. Más que un espacio para la divulgación de resultados de investigación, COPACO 2026 se consolida como un escenario internacional para el análisis crítico de los retos contemporáneos de las ciencias pecuarias y para la construcción colectiva de soluciones que orienten el futuro del sector. La participación de investigadores, docentes,

estudiantes, productores, representantes del sector empresarial, instituciones públicas y organizaciones nacionales e internacionales favorece el intercambio de conocimientos y fortalece el diálogo entre la ciencia, la innovación y la sociedad.

La programación académica del Congreso refleja esta visión integradora. Las conferencias magistrales abordan temas de vanguardia como la selección genómica, el aprendizaje automático aplicado a la producción animal, las tecnologías de sensores, la adaptación genética de las razas bovinas, la sostenibilidad de la ganadería, la gobernanza de los sistemas productivos, las biotecnologías reproductivas y las aplicaciones del Internet de las Cosas en la Zootecnia 5.0. Estos aportes dialogan con más de un centenar de investigaciones presentadas en conferencias orales y sesiones de póster, que abarcan áreas como nutrición y alimentación, genética y mejoramiento, fisiología, reproducción, bienestar animal, bioseguridad, agroindustria, sostenibilidad, zootecnia de precisión, extensión rural y sistemas de producción en bovinos, porcinos, aves, pequeños rumiantes, equinos, especies acuícolas, especies productivas no tradicionales y animales de compañía.

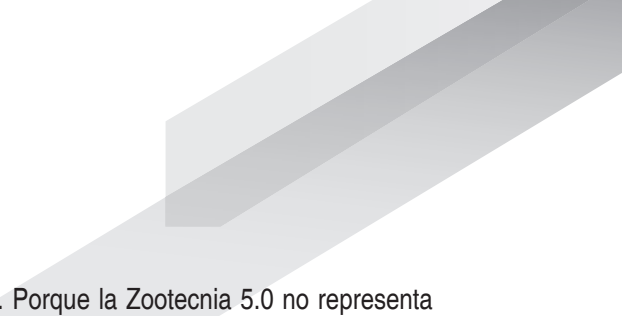
La amplitud y diversidad de estas temáticas evidencian que la producción animal contemporánea ha dejado de ser un campo disciplinar aislado para convertirse en un espacio de convergencia entre las ciencias biológicas, veterinarias, agronómicas, ambientales, económicas, sociales y computacionales. El futuro de la producción animal dependerá, en buena medida, de nuestra capacidad para integrar estos saberes y generar soluciones innovadoras que respondan simultáneamente a los desafíos de la productividad, la sostenibilidad y el bienestar de la sociedad.

Como institución pública de educación superior, la Universidad Nacional de Colombia reafirma, mediante la realización de este congreso, su compromiso con la generación de conocimiento científico de excelencia, la formación de talento humano altamente calificado y la construcción de soluciones para los problemas estratégicos del país y de América Latina. La investigación, la innovación y la extensión continúan siendo pilares fundamentales para fortalecer sistemas pecuarios competitivos, sostenibles e incluyentes, capaces de responder a las demandas de un mundo en permanente transformación.

Las memorias del 3^{er} Congreso Internacional de Producción Animal constituyen mucho más que una recopilación de trabajos científicos. Representan una muestra del dinamismo de la comunidad académica internacional, del compromiso de cientos de investigadores con la generación de conocimiento y de la convicción compartida de que la ciencia constituye la principal herramienta para transformar los sistemas de producción animal. Cada artículo, cada ponencia y cada intercambio académico reflejan el esfuerzo colectivo por construir una producción pecuaria más eficiente, resiliente, ética y ambientalmente responsable.

Expresamos nuestro sincero agradecimiento a los conferencistas nacionales e internacionales, a los autores, evaluadores, patrocinadores, instituciones aliadas, entidades colaboradoras y a los integrantes de los comités académico y organizador, cuyo compromiso y dedicación hicieron posible la realización de esta tercera edición de COPACO 2026. Su valiosa contribución fortalece un espacio que se consolida como uno de los principales referentes latinoamericanos para el intercambio científico y la discusión de los grandes desafíos de la producción animal.

Confiamos en que estas memorias no solo documenten los avances científicos presentados durante el Congreso, sino que también inspiren nuevas investigaciones, promuevan alianzas de cooperación internacional y contribuyan



a orientar las decisiones que definirán el futuro de la producción animal. Porque la Zootecnia 5.0 no representa únicamente una revolución tecnológica; constituye, sobre todo, una nueva manera de comprender la relación entre ciencia, innovación y sostenibilidad para construir sistemas pecuarios capaces de alimentar a una población creciente sin comprometer el bienestar de las personas, los animales ni la integridad de los ecosistemas.

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**CONFERENCIAS APERTURA
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Machine Learning and Sensor Technologies in Animal Production: From Data to Decision-Making

Aprendizaje automático y tecnologías de sensores en la producción animal: de los datos a la toma de decisiones

Luiz Fernando Brito^{1*}

Keywords:

Artificial intelligence
Automated phenotyping
Livestock phenomics
Machine learning
Precision livestock farming

Palabras clave:

Inteligencia artificial
Fenotipado automatizado
Fenomicismo ganadero
Aprendizaje automático
Ganadería de precisión

The rapid expansion of precision livestock farming (PLF) technologies, artificial intelligence (AI), and machine learning (ML) is transforming animal production systems across the Americas and worldwide. Modern livestock operations are increasingly equipped with automated sensors, wearable devices, cameras, robotic systems (e.g., automated milking systems), environmental monitoring tools, and genomic technologies capable of generating massive amounts of high-frequency data at the individual-animal level. These recent developments in livestock phenomics and digital agriculture have enabled the collection of longitudinal and objective measurements related to key traits such as feeding behavior, activity, social interactions, physiology, thermal stress, methane emissions, milk production, body condition, gait, and behavioral responses in real time. These advances are creating unprecedented opportunities to improve productivity, animal welfare, health, resilience, environmental sustainability, and management efficiency through data-driven decision-making.

This presentation will discuss the current global landscape and future perspectives of AI/ML and PLF technologies in livestock production, with emphasis on practical applications in animal production systems. Examples from recent scientific literature will demonstrate how AI and ML algorithms are being used to transform raw and often complex datasets into biologically meaningful information that can support management, breeding, and sustainability goals. Special attention will be given to the development of novel traits derived from automated systems and computer vision technologies. These include behavioral and welfare indicators generated from automated milk feeders, robotic milking systems, accelerometers, wearable sensors, and image-based monitoring platforms. For example, studies from our group using automated milk feeders have demonstrated the potential to derive feeding behavior,

disease resilience, and social dominance traits from large-scale longitudinal datasets collected automatically on commercial dairy farms. I will also highlight emerging applications of computer vision and ML for automated phenotyping in livestock. Our recent studies using pose estimation and facial phenotyping approaches in calves have demonstrated the feasibility of extracting biologically relevant traits such as ear posture, nostril distance, eye opening, and facial expressions associated with animal welfare and health status. These technologies illustrate how cameras and AI-based image analyses can generate new variables that were previously difficult or impossible to measure on a large scale.

Another major focus of the presentation will be the role of ML in analyzing and integrating large and

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heterogeneous datasets generated by modern production systems. Livestock data are often characterized by missing records, sensor failures, noise, inconsistent formats, and variable data quality across farms and PLF technologies. Therefore, robust methods for data cleaning, harmonization, quality control, and integration are essential before meaningful analyses can be performed. The presentation will discuss strategies for handling “messy” sensor datasets, summarizing high-dimensional longitudinal information, and integrating genomic, phenotypic, environmental, management, and sensor-derived data into unified analytical frameworks. The importance of standardized data pipelines and collaborative data infrastructures will also be emphasized as critical requirements for advancing PLF globally, with an example of the Purdue Animal Science Data Ecosystem (PASDE).

Applications for ML for genomic prediction and breeding programs will also be briefly discussed. ML methods, including deep learning algorithms such as convolutional neural networks and multilayer perceptrons, are increasingly being investigated as alternatives or complements to traditional genomic evaluation methods. These approaches may improve prediction accuracy for complex traits related to behavior, resilience, efficiency, and adaptation, especially when integrating multiple sources of high-throughput phenotypic data. Our recent studies in dairy cattle have shown the feasibility of using deep learning approaches

for genomic prediction of behavioral traits measured by automated milking systems, although important challenges remain regarding computational demand, interpretability, and implementation in large-scale breeding programs.

In addition to discussing current technologies and scientific advances, I will address major future opportunities and challenges for the implementation of PLF and ML tools in animal production systems. These include improving sustainability and environmental efficiency, enabling earlier disease detection, optimizing animal welfare, increasing resilience to climate change, and supporting precision management decisions at both farm and industry levels. The integration of phenomics, genomics, and AI is expected to redefine breeding objectives and accelerate the development of healthier, more efficient, and more resilient livestock populations in the coming decades.

Finally, I will briefly discuss ethical and societal considerations associated with the increasing use of AI and PLF technologies in animal agriculture. This will include issues related to data ownership, privacy, transparency, accessibility of technologies, governance of farm-generated data, and equitable access to digital innovations across production systems. Ensuring responsible and ethical use of AI while maintaining farmer autonomy and promoting sustainable livestock production will be crucial for the long-term success and adoption of these technologies worldwide.



Status of Genomic Selection in the Americas and the World

Estado de la selección genómica en las Américas y el mundo

Daniela Lourenco^{1*}, Matias Bermann¹ and Ignacy Misztal¹

Keywords:

Animal breeding
Genomic prediction
Genomic selection
Single-step GBLUP
SNP genotyping

Palabras clave:

Cría animal
Predicción genómica
Selección genómica
GBLUP en un solo paso
Genotipado de SNP

Genomic selection (GS) is now widely adopted across many livestock, poultry, and aquaculture species, thanks to the availability of affordable single nucleotide polymorphism (SNP) genotyping. This affordability allowed the genotyping of massive numbers of animals, including 10.3 million Holsteins and 2 million Angus cattle in the US, and 600,000 Nellore in Brazil, to name a few. Certainly, the development of methods and software also helped drive the rapid spread of GS. One of the most widely used methods is the single-step genomic best linear unbiased predictor (ssGBLUP), developed at the University of Georgia. In a nutshell, single step combines pedigree, phenotypic, and genomic information into a unified framework, enabling accurate, computationally efficient genomic evaluations. As ssGBLUP automatically creates an index with all sources of information, it dramatically simplifies the use of genomic information in genetic evaluations. Several algorithmic developments allowed genomic evaluations of practically any number of traits and millions of genotyped animals. Overall, the benefits of GS include increased prediction accuracy and reduction of generation interval, leading to greater genetic gain. For some traits, the increase can be up to twofold. However, this twofold increase does not guarantee food security for 2030. An extra fivefold increase in the rate of genetic progress may be needed to meet the global demand for animal protein. Therefore, the investments and uptake of GS need to continue. Many ongoing efforts focus on adding extra sources of information to the GS models to further boost prediction accuracy, including whole-genome sequencing, microbiome data, metabolomics, and digital phenotypes. However, boosting genetic gains in some traits may come at the expense of other traits. This is true when correlated responses for secondary traits also accelerate, intensifying the antagonism with the heavily selected primary traits. In such a case, more balanced selection indexes are needed to avoid potential negative effects to be attributed to GS. Thus, ensuring GS is being used correctly and its negative effects are prevented are the keys to long-term success. In this talk, we will review the application of GS and its impact on increasing animal protein production. We will discuss how to leverage the positive and overcome the negative aspects of GS. We will also provide perspectives on the use of additional sources of information in GS models. Finally, we will present an overview of the future of GS in animal breeding and genetics.

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Between Myths and Truths: The Role of Ruminants in Global Sustainability

Entre mitos y verdades: el papel de los rumiantes en la sostenibilidad global

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Keywords:

Carbon capture
Food security
Greenhouse gases
Methane
Ruminants
Sustainability

Palabras clave:

Captura de carbono
Seguridad alimentaria
Gases de efecto invernadero
Metano
Rumiantes
Sostenibilidad

Livestock production — and particularly ruminant systems — faces increasing scrutiny from society, policymakers, and international organizations. Much of this scrutiny is grounded in legitimate concerns about climate change, land use, and food security. However, a significant portion of the narrative surrounding livestock and sustainability is built on incomplete data, methodological inconsistencies, or interpretations that fail to consider the ecological context in which livestock systems operate. This conference presentation critically examined key myths and truths about the environmental role of ruminants, drawing on recent scientific evidence and data from global and Latin American production systems, with a focus on three central dimensions: land use, greenhouse gas emissions, and feed–food competition.

First, regarding land use, ruminants occupy approximately 77% of agricultural land globally, yet more than half of that area is not suitable for crop production. Grazing systems in regions such as the Colombian savannas, the Argentine Pampas, or the Brazilian Cerrado function as transformers of marginal environments into productive ones,

converting human-inedible biomass into high-quality protein. Second, concerning greenhouse gas emissions, livestock accounts for approximately 12–14.5% of total global anthropogenic emissions (FAO 2023), a figure that has been progressively revised downward as methodologies improve — and as fossil-fuel emissions continue to rise. Within that figure, ruminants contribute a substantial share of global anthropogenic methane emissions — a gas that, unlike CO₂, participates in a short biogenic cycle and degrades in approximately 12 years, returning as CO₂ to the same pastures that originally fixed it (Saunois et al. 2019). Evidence from Mercosur countries further suggests that well-managed grassland systems, particularly under rotational grazing,

can act as net carbon sinks, with gains in soil organic carbon that can partially or fully offset enteric methane emissions. Third, with respect to competition with human food, data from global meta-analyses indicate that up to 86% of what ruminants consume is not edible for humans, including native grasslands, perennial pastures, crop residues, and silages (Mottet et al. 2017). In pasture-based systems, the grain-to-live-weight ratio is close to 1.3 kg kg⁻¹ — a figure that stands in sharp contrast to pigs (~3.2 kg kg⁻¹) and poultry (~2.0 kg kg⁻¹), and reflects the fundamentally different role that grain plays in ruminant nutrition compared to monogastric species. Rather than competing with humans for food, pasture-based ruminants largely convert resources

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that humans cannot use into high-quality protein. Moreover, ruminants require only 600 grams of human-edible protein to produce 1 kg of edible protein, placing them as net protein contributors at the global scale.

The transversal theme of the presentation is the urgent need for the livestock sector to communicate better. The gap between scientific evidence and public perception has widened, fueled by influential narratives that often simplify complex ecological trade-offs. In much of Latin America, this communication deficit translates into policy and regulatory pressure that does not always reflect the heterogeneity of production systems or

the socioeconomic reality of producers. The sector must move from a defensive posture to an active one: generating local data, building scientifically grounded narratives, and engaging with diverse audiences — including students, industry representatives, and policymakers — with the same rigor applied in the field.

The talk concluded by acknowledging the sector's genuine pending debts — particularly around deforestation and land-use change — and by outlining integrated land-use strategies as pathways to reconcile food production, environmental responsibility, and rural development in tropical and subtropical regions.





Matias Bermann^{1*}, Ignacy Misztal¹ and Daniela Lourenco¹

Keywords:

Animal breeding evaluation
Metafounders
Multibreed evaluation
Threshold-Linear Models
Variance components

Palabras clave:

Evaluación de cría animal
Metafundadores
Evaluación de razas múltiples
Modelos lineales umbral
Componentes de varianza

The landscape of animal breeding and genetics is rapidly evolving towards larger datasets and the analysis of complex traits. In the last decades, classical breeding goals for production traits have been enhanced by selection on fitness and welfare traits. In addition, reduced genotyping and phenotyping costs yielded larger datasets, including many genotyped and phenotyped individuals. Finally, the widespread use of crossbred animals for their productive performance led to the need for large multibreed evaluations. Nowadays, producers, companies, and breeders' associations demand more frequent genetic evaluations for larger, possibly multibreed datasets, including both Gaussian and categorical traits. Given this, it is necessary for statistical methods and computational algorithms to keep pace with the growing complexity of genetic evaluations and selection goals. The joint analysis of Gaussian and categorical traits, including multiple traits such as production and fitness, can be carried out using the multiple-trait threshold-linear model. Multibreed evaluations can be performed under the metafounders theory. Furthermore, new multiple-trait models require new estimation of variance components, which can be computationally challenging for large datasets. The aim of this talk is to present the recent theoretical and computational advances for the joint analysis of categorical and continuous traits, the theory of metafounders, and the estimation of variance components.

Until recently, multiple-trait threshold-linear models could be fit only with the Gibbs sampler. This is not feasible for routine genetic evaluations due to computational demands and long run times. We developed a new method, based on the maximum a posteriori of the posterior log density, to efficiently fit multiple-trait threshold-linear models. This method has proven effective for large pedigrees and for hundreds of thousands of genotyped animals. In the context of multibreed evaluations, metafounders are useful for modeling breed differences, handling missing pedigrees, and ensuring compatibility between the pedigree

and genomic relationship matrices. The successful application of the metafounder theory relies on the estimation of its covariance matrix. Such estimation poses some theoretical challenges; the most reliable method is the recently developed pseudo expectation-maximization algorithm. The new models and datasets require re-estimating variance components, which can be computationally unfeasible because the mixed-model equations coefficient matrix must be inverted in restricted maximum likelihood estimation (REML). An attractive alternative is the Monte Carlo single-step G-REML, which replaces matrix inversion with an

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average of quadratic forms obtained via sampling. Such a method can be applied to routine genetic evaluation datasets.

In conclusion, larger datasets and more complex models drive the need for novel statistical and computational

methods to improve genetic progress in livestock populations. Enhancing education for current and future PhD students in topics such as mathematics, statistics, and programming is critical for the continuous development of novel techniques in animal breeding and genetics.



Maternal Experience in Sheep: Implications for Development, Behavior, Stress and Welfare



Experiencia materna en ovejas: implicaciones para el desarrollo, el comportamiento, el estrés y el bienestar

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Keywords:

Cognition
Ethology
Ewes
Lambs
Mother-offspring bond

Palabras clave:

Cognición
Etología
Ovejas
Corderos
Vínculo madre-descendencia

The presence and maternal experience of the ewe play a key role in lamb development in sheep. In addition to providing nutrition, warmth, care and protection, the mother also influences offspring development and their survival (Nowak et al. 2000; Damián et al. 2020). Furthermore, ewes with different levels of previous maternal experience, as well as their respective offspring, may respond differently to various stressors. The aim of this work is to review the effects and responses investigated by our research group in Uruguay regarding the influence of maternal presence and maternal experience on offspring development, behavior, and stress responses to different stressors. 1). Maternal presence is relevant for offspring development. Unlike artificially reared lambs, lambs reared by their mothers during lactation tended to reach puberty earlier and displayed a greater expression of sexual behaviors toward estrous females during the first year of life (Damián et al. 2015). Lambs reared with their mothers continued to show superior sexual performance toward estrous females during the second year of life, both during the non-breeding and breeding seasons (Damián et al. 2018a). The improved sexual performance of

maternally reared lambs was also evident in adulthood under competitive conditions in the presence of estrous females (Damián et al. 2017). 2). Maternal presence and the mother-offspring bond during lactation influenced lamb stress responses. At the end of the first breeding season, lamb responses to social isolation stress were evaluated. Lambs reared by their mothers exhibited a greater stress response than artificially reared lambs (Damián et al. 2018b). At two years of age, maternally reared lambs also showed a greater cortisol response to ACTH stimulation compared with artificially reared lambs (Damián et al. 2018b). 3). Maternal presence and the mother-offspring bond during lactation, as well as maternal experience and/or parity, affect the stress response to weaning. Lambs reared with their

mothers displayed a greater behavioral stress response to weaning than artificially reared lambs (Damián et al. 2013). Not only does maternal presence play a key role during weaning stress, but maternal experience is also highly relevant. Lambs born to multiparous ewes (with previous maternal experience) exhibited a greater stress response to weaning than lambs born to primiparous ewes (without previous maternal experience), demonstrating that the mother-offspring bond up to weaning is stronger when ewes are multiparous (Damián et al. 2025). Similarly, multiparous ewes showed a greater stress response to weaning than primiparous ewes, reinforcing the concept that the mutual mother-offspring bond is stronger in both multiparous ewes and their lambs. Weaning stress altered the circadian rhythm of behavior

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(distance traveled and movement speed), assessed using a global positioning system (GPS) (Damián et al. 2025). 4). Maternal experience also affects stress responses during gestation. Primiparous ewes showed a greater stress response to prepartum winter shearing than multiparous ewes (Nusspaumer et al. 2025). 5). Although acute stress responses differ between primiparous and multiparous ewes, our preliminary data suggest no differences in chronic stress. From one month before lambing until six months postpartum, no differences in wool cortisol concentrations were observed between primiparous and multiparous ewes. 6). Maternal experience may also influence the cognitive capacity of offspring. We observed that lambs born to ewes with previous maternal experience had a greater ability to recognize and respond to novel objects than lambs born to inexperienced ewes. Therefore, maternal presence and maternal experience during lactation

affect offspring cognitive capacity. In conclusion, maternal presence represents a central component for lamb development, as the mother's presence during lactation influences offspring development, sexual and social behavior, and stress responses. Moreover, stress responses vary according to rearing system (artificial rearing vs. maternal rearing) and the type of stressor. Rearing lambs with ewes of different maternal experience affects the stress response to weaning, demonstrating in both ewes and lambs that the strongest mother-offspring bond occurs in multiparous ewes and persists until weaning. Additionally, the stronger bond between multiparous ewes and their lambs also improves offspring cognitive capacity. Overall, these findings highlight the central role of maternal presence and maternal experience in animal welfare, behavioral and physiological resilience, offspring development, and the sustainability of sheep production systems.

From Phenotypes to Decisions: Machine Learning and Statistical Methods for Sustainable and Resilient Animal Production

De los fenotipos a las decisiones: aprendizaje automático y métodos estadísticos para una producción animal sostenible y resiliente

Lucio Flavio Macedo Mota^{1*}

Keywords:

Biomarkers
Efficiency
Emissions
Fertility
Genomics
Thermoregulation

Palabras clave:

Biomarcadores
Eficiencia
Emisiones
Fertilidad
Genómica
Termodrregulación

Introduction: Animal breeding is moving beyond maximum output toward animals that are efficient, resilient, adapted, and capable of sustaining productivity under climatic, nutritional, reproductive, and economic pressure. **Justification:** In intensive production systems, conventional selection based only on pedigree, linear assumptions, and easily measured performance is insufficient for traits that are costly, late, environmentally sensitive, or biologically complex, including feed efficiency, methane emission, fertility, metabolic health, and heat tolerance. **Objectives:** This lecture will discuss how genomic information, high-resolution phenotyping, machine learning, and statistical modeling can be integrated into Livestock 5.0 decision systems to accelerate sustainable genetic progress in beef and dairy cattle. **Methods:** The presentation synthesizes case studies using genomic selection, SNP-density and reference-population principles, multi-trait and single-trait genomic prediction, Bayesian and penalized models, support vector regression, neural networks, stacking ensembles, genome-wide association analyses, single-step genomic reaction norms, automated methane sensing, blood biomarkers, and precision dairy monitoring based on accelerometry, near-infrared spectroscopy, and temperature-humidity index. **Results/**

Discussion: Genomics improves selection by capturing realized Mendelian inheritance and by increasing accuracy for difficult-to-measure traits. In Nellore cattle, prediction of feed-efficiency traits shows that gains arise not only from algorithmic flexibility, but also from models that represent biological architecture, especially multi-trait covariance among related traits. Methane becomes a selectable sustainability phenotype when repeated, less invasive records are linked to individual animals, while genomic and rumen-related analyses connect emission, productivity, and physiology. Reproductive resilience in tropical heifers is framed through early pregnancy, successful rebreeding, environmental gradients, and reaction norms that

reveal genotype-by-environment changes in ranking and molecular pathways. In dairy cattle, ensemble learning for metabolic biomarkers and digital-twin analyses of heat stress illustrate how nonlinear models can detect non-additive genetic signals, physiological tipping points, and coordinated responses affecting intake, rumination, panting, milk yield, and milk quality. **Conclusion:** Sustainable animal production will depend on breeding programs that convert molecular, phenotypic, environmental, and physiological data into robust selection decisions for animals that remain productive, fertile, healthy, and efficient under real-world stressors. Module: Large ruminants. Thematic axis: Genetics and breeding.

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Sustainability in Poultry Production: Concepts and How Nutrition Can Be Decisive

Sostenibilidad en la producción avícola: conceptos y cómo la nutrición puede ser decisiva

José Henrique Stringhini^{1*}

Keywords:

Feed additives
Precision nutrition
Resource efficiency
Sustainable development goals
Waste valorization

Palabras clave:

Aditivos alimentarios
Nutrición de precisión
Eficiencia en el uso de los recursos
Objetivos de Desarrollo Sostenible
Valorización de residuos

The continuous growth of the global population has substantially increased the demand for food to meet the nutritional needs of increasingly demanding consumers. Among animal production systems, the poultry industry stands out as one of the most important pillars in supplying high-quality animal protein. This is mainly due to its short production cycle, the advanced technologies employed, and the high nutritional value of poultry products, including meat and eggs. The OECD (2026) projects a 1.6% increase in global per capita income this year, driven primarily by the rapid economic development of Asian countries. Consequently, poultry meat is expected to become the most consumed and fastest-growing animal protein by 2035, with an estimated increase of approximately 20%, comparable to lamb and exceeding the projected growth of other meat sectors. This projected expansion presents the challenge of achieving sustainable production, an area in which the poultry industry has demonstrated remarkable efficiency. Future growth is expected to involve not only the expansion of intensive production systems but also the adoption of alternative production

systems designed to meet specific market demands. The short biological cycle of poultry, together with continuous advances in genetic improvement, environmental management, and nutrition, will provide the foundation for sustaining the industry's long-term growth in a sustainable manner (Vaarst et al. 2015; Bist et al. 2024; Asaniyan 2025). The principles of sustainability were initially established through the eight Millennium Development Goals and later expanded into the seventeen Sustainable Development Goals (SDGs) of the 2030 Agenda (Oliveira 2024). To support these objectives, several concepts have been incorporated into modern production systems, including the 3Rs (Reduce, Reuse, and Recycle) and, more importantly, the ESG framework (Environmental, Social, and Governance). These principles have become increasingly integrated into

industrial practices, with the poultry industry serving as a leading example of their successful implementation. Animal nutrition has emerged as one of the most effective tools for mitigating the environmental impacts associated with poultry production (Khattak et al. 2026). The incorporation of industrial by-products and food industry residues into poultry diets represents one of the most promising strategies for recovering valuable nutrients that would otherwise become waste. According to Oviedo-Rondón (2024), nutrition should be regarded as one of the most efficient approaches to improving sustainability while maintaining the economic viability of production systems through appropriate feed formulation. According to Cao et al. (2024), one of the major trends in poultry production is the implementation of precision nutrition, which aims to maximize productive and economic performance while

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minimizing nutrient waste and formulation errors. Feed additives play a fundamental role in achieving these objectives. As described by Mavromichalis (2025), six groups of additives and supplements are directly associated with precision nutrition: enzymes, particularly phytase; probiotics; prebiotics; organic acids; fatty acids; and synthetic amino acids. These nutritional tools improve bird health and productive performance while simultaneously reducing the environmental impact of poultry production.

Therefore, modernizing production systems, continuously improving industrial processes, and adopting advanced feed formulation and manufacturing technologies are essential strategies for promoting sustainability in poultry production. Within this framework, nutrition represents one of the key pillars for producing more efficiently with fewer resources while reducing environmental impacts and strengthening the long-term competitiveness of the poultry industry.



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MAGISTRALES**

Sustainability and Animal Production: Governance, Socio-Ecological Dynamics, and Regenerative Pathways in Colombia's Tropical Lowlands

Sostenibilidad y producción animal: gobernanza, dinámicas socioecológicas y vías regenerativas en las tierras bajas tropicales de Colombia

Juan Fernando Naranjo Ramírez*

Keywords:

Biodiversity
Regenerative circular economy
Socio-ecological systems
Stakeholder governance
Sustainability transition
Tropical livestock

Palabras clave:

Biodiversidad
Economía circular regenerativa
Sistemas socioecológicos
Gobernanza de los interesados
Transición hacia la sostenibilidad
Ganadería tropical

The transformation of livestock production systems from extractive to regenerative configurations requires frameworks that capture, simultaneously, the structural dynamics of socio-ecological complexity, the governance architecture of multi-actor networks, and the community epistemologies that shape territorial practices. Conventional sustainability assessments—life cycle analysis, composite indicator audits, and cross-sectional diagnostic frameworks—systematically fail to represent the temporal accumulation of resource degradation and adaptive responses that delay but amplify eventual systemic stress. This presentation synthesizes findings from four interrelated research lines developed in Colombia's tropical lowlands, advancing an integrated framework that connects systems dynamics modelling, relational stakeholder governance, eco-social perceptions research, and the ecological metaphor of circular regenerative economies.

A system dynamics (SD) model, calibrated and validated for the Hacienda Cuba buffalo dairy system (Montelíbano, Córdoba; 4,440 ha; 2020–2025), integrates ten empirical datasets—including 50 years of rainfall records, weekly milk production series, rotational grazing protocols, complete financial accounts, and biodiversity inventories from the BEPREP-HORIZON project (206 vascular plant species, 40 wildlife species, 349 bats of 30 species)—within four coupled subsystems: climate–hydrology, forage–soil, animal–production, and economy–social capital. The model met all validation criteria (MAPE = 8.3%; weekly RMSE = 11.4%) and computed a Synthetic Sustainability Index (SSI) across five dimensions. The SSI remained in the limited sustainability range (0.33–0.47) throughout the study period without reaching the transition threshold ($SSI \geq 0.50$), despite the system achieving its historic peak operating margin (33.2%) in

2025. This paradox—high financial margins coexisting with minimum production volumes—constitutes the diagnostic signature of the fixed-cost trap (loop B4), a structural mechanism rendered invisible by static assessment tools. The biodiversity sub-index ($CV = 6.0\%$), anchored by a conserved 35% forest block with documented large predators, functioned as a systemic stabilizer during productivity minimum, preventing the SSI from falling below viable thresholds and empirically demonstrating that functional biodiversity operates as a structural resilience buffer rather than a supplementary indicator.

The structural sustainability constraints identified through system dynamics modelling are inseparable from the governance architecture that conditions collective action at the territorial scale. A relational stakeholder model

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constructed for the same socio-ecological system, applying Power-Interest matrix analysis, Mitchell-Agle-Wood salience modelling, and Relational Coordination Theory to a network of 110 mapped actors distributed across five sectors—productive (36.4%), academia (25.5%), private enterprise (17.3%), government and public authorities (14.5%), and civil society (6.4%)—reveals that 40.9% of actors occupy the ‘manage closely’ quadrant (high influence, high commitment) and 88.2% express willingness for active collaboration. Government and public authority actors concentrate on the highest mean influence (5.00/5.00), while academic actors exhibit the highest mean commitment (4.93/5.00). Six priority inter-sectoral relationships structure the territorial governance network, providing the collaborative substrate through which scenario-based management interventions—particularly improved pasture rest protocols and soil organic matter reinvestment—can be socially legitimized, institutionally embedded, and operationally sustained beyond individual project timelines.

Complementary qualitative inquiry into the eco-social perceptions of community members, farmworkers, and educators operating within the same territory reveals the epistemological architecture underpinning these governance dynamics. Through 16 in-depth interviews and 3 focal groups, the research identifies significant community concern about soil change trajectories driven by productive diversification, mining extractivism, agrochemical use, and climate variability. Community narratives—‘the land is tired’, ‘the forest no longer gives the same’—are not anecdotal; they condense historically accumulated, embodied, and productive experiences that constitute legitimate diagnostic frameworks for ecosystem health. Critically, the analysis reveals significant interconnections between soil degradation, biodiversity loss, and increased perception of sanitary risk, particularly regarding zoonotic and vector-borne diseases. Despite the presence of active environmental care practices—reforestation promotion, wildlife protection, abandonment of bushmeat hunting—communities express marked demand for information and training on transmission mechanisms, indicating that socially viable eco-social interventions require not only technical capacity but active integration of values, rules, and knowledge as structuring dimensions of territorial action.

These empirical convergences support and concretize the ecological metaphor of regenerative circular economies proposed by Zisopoulos et al. (2025). The tropical livestock system studied here embodies, in operational form, the tensions and potentials that this interdisciplinary research agenda addresses theoretically: the adaptive cycle of anarchy theory manifests in the forage degradation–supplementation spiral; the constructal law explains the hierarchical restructuring of metabolic flows during ENSO-induced climate stress; regenerative economics principles—particularly the balance between efficiency and resilience, and the reinvestment of natural capital—translate into concrete management prescriptions such as extended rest periods (≥ 45 days) and soil organic matter restoration. The biodiversity stabilizer function documented in the SD model provides empirical grounding for the claim that functional ecosystem integration constitutes a prerequisite for regenerative transitions, operating through mechanisms analogous to the mutualism dynamics described in process ecology and environ network theory.

The integrated framework presented here advances three interconnected propositions. First, structural sustainability in tropical livestock systems cannot be diagnosed through static auditing; system dynamics modelling operationalizes the non-trivial temporal dynamics—delayed feedback, degradation spirals, fixed-cost traps—that determine long-term system viability. Second, governance capacity, expressed through relational stakeholder networks with high collaborative disposition, constitutes not a peripheral enabler but a structural condition for the transition toward sustainability; without the social capital architecture capable of legitimizing and sustaining adaptive management, scenario-based interventions remain technically coherent but institutionally inert. Third, the ecological metaphor of regenerative circular economies, when grounded in multidimensional empirical evidence from tropical agro-pastoral systems, generates tractable research hypotheses and policy-relevant pathways that transcend the abstract normativity of much circular economy discourse. Colombia’s tropical lowlands, characterized by extraordinary biodiversity, significant institutional fragility, and growing pressure from extractive economies, constitute a critical laboratory for testing whether the regenerative transition is possible under the conditions of the global south.

The Paradigm of Reproductive Biotechnology: A Conscious Exploration



El paradigma de la biotecnología reproductiva: una exploración consciente

Giovanni Restrepo Betancur^{1*}

Keywords:

Assisted reproduction
Bioethics
Cryopreservation
Epigenetics
Gene editing
Responsible innovation

Palabras clave:

Reproducción asistida
Bioética
Criopreservación
Epigenética
Edición genética
Innovación responsable

For decades, reproductive biotechnologies have developed, evolved, and migrated from an experimental approach to human reproduction, and then to the reproduction of animals of productive interest. Like any new technology, more attention has been paid to the personal and economic benefits that it generates than to its implications, whether known or unknown.

The reproduction of “elite” animals directed towards prioritizing traits associated with productivity affects genetic variability, triggering a loss of adaptability to environmental challenges, generating diverse alterations in health and development, and even producing a significant reduction in fertility in some species.

Furthermore, the manipulation and processing of somatic cells, gametes, and embryos in laboratory settings, through procedures such as *in vitro* development and cryopreservation, could have profound consequences on the gestational and postnatal development of individuals, even generating epigenetic changes that could be preserved for several generations.

Assisted reproduction in companion animals, which has been growing in recent decades, adds a new element, where considerations such as aesthetics, particular behavioral and performance traits, and even emotional bonds, guide selection and crossbreeding; often mediated by reproductive biotechnology processes, which have even led to the recent rise of cloning.

Likewise, the use of assisted reproductive technologies for conservation purposes has become increasingly relevant and important. The accelerated loss of wildlife, exotic species, and even native breeds has led to renewed interest in adapting and developing protocols that allow for the recovery, manipulation, and storage of

reproductive cells and tissues, as well as in performing interventions that enhance the reproduction of animal species in captivity.

In addition to the above, a wide variety of useful and complementary technological capabilities and resources have recently emerged for assisted reproduction. From the evolution of computerized systems to deep neural networks, the use of time-lapse and embryo selection, the implementation of preimplantation genetic diagnosis, and even remarkable advances in cryobiology, nanotechnology, and gene editing, have come to exponentially enhance the scope of reproductive biotechnology.

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In this scenario, the following paradigm arises, or rather, gains relevance: How can reproductive biotechnologies be used consciously, ethically, and responsibly?

While it is understood that this could be considered more of a relevant, unavoidable, and necessary condition than a paradigm, in practice it constitutes a significant challenge: preventing the excessive and unregulated use of assisted reproduction, despite the immense capabilities and possibilities available, as well as the ever-present individual benefits.

As in other areas, the solution will surely arise from a comprehensive approach, starting with the development of public policies and a responsible approach by the scientific community, facilitated by the coordinated use of technological capabilities. Equally important is the role of academia through the training of ethical professionals with critical thinking skills to face new challenges. Finally, it is essential to disseminate concepts that contribute to raising awareness among all stakeholders involved in the use and application of reproductive biotechnology.

Sustainable Poultry Farming for the Nutrition of Colombians

Avicultura sostenible para nutrir a los colombianos

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Keywords:

Circular economy
Climate change
Food security
Poultry farming
Sustainability
Water management

Palabras clave:

Economía circular
Cambio climático
Seguridad alimentaria
Avicultura
Sostenibilidad
Gestión del agua

Perhaps one of the greatest challenges facing the poultry sector is contributing to food security for Colombians. Food security is not simply about producing food in sufficient quantities; the key lies in producing foods of high nutritional quality, such as eggs and chicken, and, importantly, ensuring that they are accessible to everyone.

According to the Organization for Economic Cooperation and Development (OECD), approximately 150.8 million children worldwide suffer from developmental delays. In turn, FAO, PAHO, and UNICEF report that in Latin America and the Caribbean, the number of people experiencing hunger increased by 79% between 2014 and 2020. Moreover, within a single period, from 2019 to 2021, the gap in moderate to severe food insecurity widened by 13.9 million people, meaning that approximately 57 million people experienced hunger in 2021. Against this dramatic backdrop, the Organization of Ibero-American States (OEI) and the Ibero-American Nutrition Foundation (FINUT) report that more than 152,000 children died from nutritional deficiencies in Latin America and the Caribbean. Approximately 3.6 million girls and boys between three and four years of age experience developmental delays due

to inadequate nutrition, and 5.7 million have stunted growth compared with global standards. In addition, 11.3% of children under 5 years of age suffer from chronic malnutrition, and in 2020, 7.5% of children in Latin America and the Caribbean were overweight, compared with the global average of 5.7%. Among the many factors contributing to these serious malnutrition problems are the costs associated with healthy diets. In Latin America and the Caribbean, such diets cost an average of USD \$3.89, compared with the global average of USD \$3.54.

The global population in 2025 is estimated at approximately 8,366 million people, of whom 8% live in Latin America and the Caribbean. According to a 2023

UNICEF study, by 2050, seven out of every ten people worldwide are projected to live in urban areas. This trend is creating increasing pressure to expand urban boundaries at the expense of rural lands, where food is produced. Conflicts among stakeholders sharing the same territories are becoming more frequent, making it urgent to organize land contributing to these serious malnutrition problems are use in a way that protects food production while highlighting the costs associated with healthy diets. In Latin America and the Caribbean, such diets cost an average of USD \$3.89, compared with the global average of USD \$3.54. The importance of poultry farming and its contribution to the socioeconomic well-being of populations located within the areas influenced by poultry production units.

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Land occupation also entails the use of ecosystem services, with water being a vital resource for both animals and humans. It is estimated that the agricultural sector accounts for 69% of the world's available water use, while the industrial sector accounts for 19% and the municipal sector for 12%. Without water, and water of good quality, there is no poultry production. Therefore, one of the challenges facing poultry producers is to use water resources efficiently through Cleaner Production strategies such as measuring water consumption in all operations and maintaining detailed records of water use for each activity; implementing optimal treatment, distribution, and storage systems; protecting watersheds; and harvesting rainwater, among other measures. Finally, it is important that strategies aimed at efficient water use be closely integrated with efficient energy use. These are two aspects that cannot be addressed separately, as poor water management leads to increased energy consumption.

The challenge of using resources efficiently is closely linked to the challenge of controlling the impacts generated by poultry production processes, since "the lower the efficiency, the greater the negative impact." High water consumption in operations results in greater volumes of wastewater generation, both domestic and non-domestic. Likewise, inefficiencies in the use of raw materials and inputs lead to the generation of larger amounts of waste.

Another challenge facing poultry producers is manure management. For every 60-g egg produced, an average of 120 g of laying hen manure is generated per day, while a broiler chicken produces, on average, between 90 and 100 g per day, depending on age and environmental conditions. Odor generation is the most critical issue and the source of the greatest conflicts with communities surrounding poultry production units. While odors are inherent to poultry production, poor management of production processes, large accumulations of manure, and inadequate handling, treatment, and disposal of poultry litter and manure result in increased emissions of offensive odors that may even reach areas relatively far from poultry farms. Odor-related conflicts with neighboring communities have intensified over the last two decades, and environmental regulations aimed at odor control have consequently become more stringent.

In addition, manure management has significant implications for Climate Change due to greenhouse gas emissions. AFOLU emissions—Agriculture, Forestry, and Other Land Use—account for 24% of greenhouse gas emissions from economic sectors. Within these activities, manure management and its application to soils primarily contribute nitrogen-derived gases, such as nitrous oxide (N_2O), which has a global warming potential 310 times greater than that of CO_2 equivalent.

Finally, there is pressure from consumers, as well as from international trends and markets. It is no secret that today's consumers are better informed and want to know how the foods they consume are produced, where they come from, and not only their nutritional attributes, but also their environmental, social, economic, and animal welfare attributes. This pressure comes from environmental and animal welfare organizations, consumer trends such as vegetarianism and veganism, and, of course, increasingly stringent environmental regulations. Added to these factors is the need for producers to remain competitive, not only in international markets but, above all, in domestic markets, where they must compete both with national products and with imported products entering as a result of a globalized economy.

To address these challenges and turn them into opportunities, poultry producers must view sustainability as a competitiveness strategy that strengthens organizations through policies that contribute to the sustainable development of poultry enterprises. Every company, regardless of its size, should establish a sustainability policy encompassing environmental, economic, and social dimensions, setting forth the principles that will guide its operations and enable it to act responsibly toward the environment, the economy, and society, recognizing that these principles become commitments shared by all members of the organization. A sound sustainability strategy should make companies more competitive through the efficient use of water, energy, raw materials, and inputs, as well as through reduced waste generation, thereby positively affecting treatment costs. Greater efficiency also facilitates compliance with environmental regulations and consequently reduces the risks associated with noncompliance. It becomes a competitive advantage

over rivals and opens opportunities to access markets with demanding social and environmental standards, both nationally and internationally. In addition, it fosters trust and strengthens the company's reputation among communities and environmental authorities, while facilitating access to preferential financing specifically designed for businesses that can demonstrate their commitment to sustainability.

One of the tools that contributes to business sustainability is Circular Economy. This approach encourages

organizations to rethink their business models, foster innovation, maintain analytical control over their processes, and develop indicators that support real-time decision-making. It also highlights opportunities for potential partnerships, while transforming waste into raw materials for the production of high-value-added products. Together, these strategies help companies become more competitive and reinforce the understanding that sustainability is not merely a future aspiration, but a present-day imperative for building the future.



The DNA of Adaptation: History and Genomic Relationships of Local Cattle Breeds in Colombia

El ADN de la Adaptación: Historia y Relaciones genómicas de las Razas Bovinas Locales de Colombia

Juan Carlos Rincón Flórez^{1*}

Keywords:

Creole cattle
Diversity
Inbreeding
Selection signatures

Palabras clave:

Ganado criollo
Diversidad
Endogamia
Firmas de selección

Colombia's Creole cattle represent a valuable genetic resource, having adapted locally to the country's diverse regions and climatic conditions. This process of adaptation to different conditions makes them an invaluable genetic resource for the resilience and productive capacity of tropical livestock farming. These animals are descended from cattle originally brought by the Spanish from the southern Iberian Peninsula, initially to the island of La Española. They later entered the mainland via the Darien Gap, Santa Marta, Cartagena, Cubagua, Tumbes, and Lima, among other routes. In Colombia, the spread of animals occurred primarily along the Magdalena River and the Darien. However, animals were introduced from Peru via the Cauca River into the southern regions of the country. At the same time, it is believed that migratory movements occurred from Venezuela into what is now Colombia. The factors mentioned above, combined with the fact that Colombia is bordered by two seas and has a complex topography—where the Andes Mountain range branches into three parts—means that the country has a wide variety of climate zones and

unique, contrasting, and isolated ecological regions. These specific conditions have had an impact on cattle, fostering processes of differentiation and local adaptation depending on the region where they were established. In Colombia, 10 cattle breeds are recognized (2 synthetic and 8 purebred), some of which are adapted to the Flooded grasslands, the mountains, the savanna, the Caribbean coast, the Amazon, and even the arid, semi-desert areas of La Guajira. Some of these breeds have drastically declined in numbers and are showing signs of genetic erosion, which threatens their conservation. Nevertheless, despite difficult environmental conditions, some livestock operations still exist using locally adapted resources, which has sparked significant interest in research aimed at detecting signatures selection, genes, and adaptation mechanisms in these animals to Colombia's diverse tropical conditions. This could

enable the future development of strategies and genetic resources to address the challenges of climate change and the extreme environmental conditions expected to arise in the tropics. This study conducted a genomic analysis of the relationships, diversity, genetic structure, and admixture among different Colombian native cattle breeds, as well as potential signs of selection and genes associated with local adaptation. To this end, DNA was extracted from 20–30 animals from at least two herds per breed. Genotyping was performed using the Illumina GGP100K and GGP150K platforms. Genotyping data from previous studies on other breeds were utilized. Quality control was applied by maintaining a call rate greater than 0.95, and markers with $r^2 < 0.2$ were retained. This research involved a genomic analysis of the relationships, diversity, genetic structure, and admixture among different Colombian native cattle breeds, as well

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as potential signs of selection and genes associated with local adaptation. To this end, DNA was extracted from 20–30 animals from at least two herds per breed. Genotyping was performed using the Illumina GGP100K and GGP150K platforms. Previous genotyping data from other breeds were utilized. Quality control was applied by maintaining a call rate greater than 0.95, and markers with $r^2 < 0.2$ were retained. Finally, it was found that the highest HO was for the Harton del Valle breed (0.41) and the lowest for Sanmartinero (0.36). A significant

presence of Indus was found in three Colombian breeds, although in general all breeds exhibited their own genetic profile that would allow them to be identified as distinct breeds. Some ancestry informative markers were detected, and closer genomic relationships were found among breeds with known common ancestry or those that were geographically closer. Additionally, signs of selection related to adaptive processes such as response to light, reproductive performance, and hair length, among others, were found.

CONFERENCISTAS NACIONALES

The Future of Animal Production: IoT Applications and Real-Time Impact in Zootecnia 5.0

El futuro de la producción animal: aplicaciones del Internet de las cosas (IoT) e impacto en tiempo real en la Zootecnia 5.0

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Keywords:

Animal welfare
Artificial intelligence
Feed conversion ratio
Internet of things
Precision livestock farming
Sustainability

Palabras clave:

Bienestar animal
Inteligencia artificial
Índice de conversión alimenticia
Internet de las cosas
Ganadería de precisión
Sostenibilidad

The global agricultural sector is rapidly transitioning into the era of "Zootecnia 5.0". Currently, the use of the Internet of Things (IoT) in animal production has evolved from theoretical academic research into a necessity for commercial efficiency. However, the industry faces a critical bottleneck: the "valley of death" between deploying sensors to collect raw data and actually generating actionable, real-time insights in the harsh, unpredictable environments of commercial barns. This presentation establishes the current context of IoT deployment, highlighting the technological barriers producers face today. Moving beyond theoretical frameworks, the core of this presentation focuses on the practical use and applications of IoT hardware and AI-driven analytics to solve immediate productive challenges. By utilizing edge computing, connected sensors, and advanced algorithms, we can digitize the barn. Key applications discussed will include automated biometrics, through the deployment of computer vision systems (such as Pigvision) as advanced IoT sensors to monitor real-time animal weight and growth trajectories without manual intervention, and resource monitoring, through the integration of telemetry and silo sensors (such as Insylo) to track real-time feed consumption, supply chain logistics, and inventory management. The future of the sector relies on interoperability. The true value of Zootecnia 5.0 is realized when isolated IoT systems communicate to "close the loop" on farm management. By combining real-time biometric data (weight) with real-time input data (feed consumption), the industry can achieve something historically unprecedented: the real-time estimation of Feed Conversion Rates (FCR). Instead of waiting until the end of a production cycle to calculate financial performance, producers are projected to rely on live FCR dashboards to make proactive decisions regarding animal health, nutrition adjustments, and operational efficiency. Aligning with the congress's focus on sustainability, the presentation will conclude by demonstrating how IoT directly impacts environmental stewardship. By optimizing FCR through real-time monitoring, commercial livestock operations can drastically reduce feed waste, minimize their carbon footprint, and ensure better animal welfare, proving that technological advancement and sustainable practices are mutually reinforcing goals in modern animal production.

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Overview of Export Regulations and Requirements Across the Americas and Globally

Panorama de las regulaciones y requisitos de exportación
en las Américas y a nivel mundial

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Keywords:

Food safety
Risk analysis
Sanitary measures
Sustainable trade
Traceability
Trade compliance

Palabras clave:

Inocuidad alimentaria
Análisis de riesgo
Medidas sanitarias
Comercio sostenible
Trazabilidad
Cumplimiento normativo
comercial

In today's global agri-food trade environment, sanitary and phytosanitary systems play a decisive role in market access, safeguarding health status, and enhancing national competitiveness. As markets become more interconnected and trade flows intensify, expectations around regulatory compliance, traceability, and food safety have grown significantly—making risk management the cornerstone of modern regulation.

At the international level, the regulatory framework is grounded in the WTO's Sanitary and Phytosanitary (SPS) Agreement, which requires that measures be science-based, grounded in risk analysis, and applied without discrimination. It also recognizes key international bodies—such as the World Organisation for Animal Health, the International Plant Protection Convention, and the Codex Alimentarius—as standard-setting authorities that guide global harmonization.

Regionally, the Andean Community has developed regulatory frameworks to facilitate trade among member countries by promoting equivalence of sanitary measures and strengthening cooperation between authorities. This multilevel governance model requires countries to align their national policies consistently with international commitments.

Within this framework, Colombia's Agricultural Institute (ICA), acting as the national sanitary authority, implements animal and plant health programs in line with international standards. Its approach relies on tools such as risk analysis, regionalization, epidemiological surveillance, official certification, and traceability systems. These are supported by internationally recognized risk assessment methodologies that help identify hazards, estimate the likelihood of entry and spread, and define proportionate mitigation measures.

From a production standpoint, Colombia has built a strong and growing export portfolio. Traditional exports—

such as coffee, bananas, and flowers—have successfully secured international markets thanks to consistent compliance with quality and sanitary standards, along with robust certification and traceability systems. These sectors now serve as benchmarks for others.

Meanwhile, high-potential exports—including Hass avocados, citrus fruits, passion fruits, cocoa, palm oil, and aquaculture (notably tilapia)—are experiencing rapid growth. This expansion is driven by rising global demand, market diversification, and new trade agreements. However, their long-term success depends heavily on meeting strict sanitary and phytosanitary requirements, such as market

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access approvals, export protocols, pest control measures, pesticide residue limits, and food safety certifications.

Market access requirements are becoming increasingly complex. Climate change, the spread of transboundary diseases, sustainability pressures, and evolving consumer preferences are driving stricter standards—covering areas such as animal welfare, reduced chemical residues, environmental certification, and advanced traceability. At the same time, importing countries are conducting more frequent audits and using more sophisticated verification technologies.

Colombia has made important strides in improving its sanitary status, opening new markets, and modernizing institutions. Still, key challenges remain—particularly in adapting to constantly evolving requirements, improving data system interoperability, strengthening inter-agency coordination, and integrating technological innovation into sanitary management, especially in emerging sectors.

Looking forward, sanitary systems are expected to become increasingly digital, incorporating tools like electronic certification, data-driven risk analysis, and integrated secure trade platforms. There is also a growing convergence

between sanitary, environmental, and social standards, requiring more sustainable and resilient production models. In this context, international cooperation, mutual recognition of standards, and sanitary diplomacy will be critical for countries aiming to compete effectively in global markets.

As markets become more interconnected and trade flows intensify, expectations around regulatory compliance, traceability, and food safety have grown significantly, making risk management the cornerstone of modern regulation. In this context, sanitary measures and food safety should be understood not merely as regulatory hurdles but as strategic drivers of competitiveness and access to premium markets. Building strong capabilities in risk analysis and international compliance is essential to grow and diversify exports, particularly in emerging sectors, while effective collaboration among government, industry, and international partners will be critical to meeting the increasing demands of global trade. At the same time, digital transformation offers a major opportunity to enhance efficiency, transparency, and trust in certification systems. Ultimately, Colombia must advance toward integrated and sustainable production models that align sanitary, environmental, and social standards, thereby strengthening its position as a trusted and competitive global supplier.

Implementation of Certified Sustainability in a Colombian Livestock Company

Implementación de sostenibilidad certificada en una empresa ganadera colombiana

Juan Fernando Cadavid Santamaría^{1*}

Keywords:

Beef cattle
Environmental certification
Livestock sustainability
Traceability
Tropical production systems

Palabras clave:

Ganado vacuno
Certificación medioambiental
Sostenibilidad ganadera
Trazabilidad
Sistemas de producción
tropicales

Introduction: Sustainability in animal production requires the integration of environmental, social, economic, and productive criteria into business management. In tropical livestock systems, the challenge is to harmonize productivity and environmental responsibility through solid organizational structures and verifiable processes that allow access to recognized certifications. **Objective:** Describe the experience of implementing a comprehensive sustainability model in a livestock breeding and rearing company in the department of Córdoba, Colombia, and the technical and administrative process that led to the award of the Colombian Environmental Seal (ICONTEC). **Methodology:** The experiment was carried out at Agropecuaria Francia&Lusitania, a company established in the 1980s, with fattening and subsequently breeding and rearing systems, including the incorporation of a pure red Brahman herd and genetic improvement programs. A management model was structured based on five pillars: labor, legal, environmental, social, and fiscal. Standardized protocols for production and reproductive management, digital information recording systems, and document traceability were implemented. The process included

the development of environmental indicators, regulatory compliance, technical reports, internal and external audits, and coordination with certification bodies. The analysis of production information was carried out using descriptive statistics and comparative monitoring of productivity indicators (meat production per unit area, fattening time, feed efficiency), using digital management tools. **Results and Discussion:** The systematization of information strengthened decision-making and optimized production efficiency, resulting in higher meat production with lower feed requirements, reduced finishing times, and better use of available land. The formal implementation of the five pillars facilitated the documentation required for environmental certification. Obtaining the Colombian Environmental Seal (ICONTEC) represented external recognition of compliance

with environmental, legal, and administrative standards. Experience shows that sustainability does not depend exclusively on technological innovations, but on the coherent integration of business management, genetic improvement, process control, and organizational culture. This approach transforms traditional livestock farming into a modern, competitive, and environmentally responsible business model. **Conclusion:** The implementation of a comprehensive sustainability model based on structured management, document control, and continuous improvement enables tropical livestock systems to achieve environmental certifications and simultaneously improve their production efficiency. The experience presented demonstrates that sustainability is a strategic business process that generates economic, environmental, and social value.

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CONFERENCIAS
EGRESADOS SOBRESALIENTES

Methane Phenotyping Using a Laser Methane Detector (LMD) to Support Sustainable Genetic Improvement in Brahman Cattle

Fenotipado de metano mediante un detector láser de metano (LMD) para apoyar el mejoramiento genético sostenible en ganado Brahman

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Deisy Camargo³, Diana M Parra³ and Yury T Granja Salcedo³

Keywords:

Enteric methane
Genetic improvement
Sustainability
Zebu cattle

Palabras clave:

Metano entérico
Mejoramiento genético
Sostenibilidad
Ganado cebú

Introduction: Sustainable livestock production demands the integration of breeding strategies with environmental monitoring to reduce greenhouse gas emissions. Enteric methane (CH₄) emissions are a key contributor to greenhouse gas outputs from cattle. The use of portable technologies has enabled the collection of high-frequency phenotypic data under field conditions, facilitating the development of methane-related traits for management purposes as well as for genetic selection programs. Particularly, the Laser Methane Detector (LMD) has recently emerged as a practical, non-invasive tool to capture short term CH₄ emissions in pastured based cattle. In Colombia, Brahman cattle and their crosses represent approximately 80% of the national beef herd and constitute the foundation of tropical grazing systems. This breed is widely recognized for its adaptability, resilience, and productive performance under tropical environmental conditions. Despite its central role in sustainable beef production, information on enteric methane (CH₄) emissions in Brahman cattle remains limited, particularly under real herd conditions. Thus, generating reliable methane-related phenotypes in this breed is essential to support informed decision-making in breeding programs, enabling

the integration of environmental sustainability traits into genetic improvement objectives without compromising productivity. Therefore, the aims of this study were i) to implement and evaluate a field-based protocol for methane phenotyping using LMD in Brahman cattle; ii) to develop a data processing pipeline for LMD derived measures in order to generate robust methane-related phenotypes; and iii) to evaluate the effects of biological and management factors on CH₄ phenotypes derived from LMD profiles. **Material and Methods:** The study was conducted during the National Grazing Performance Tests for Brahman cattle developed for the Colombian Association of Zebu Cattle Breeders (ASOCEBU) in collaboration with AGROSAVIA at the La Libertad

Research Center located in Villavicencio-Meta. All the measures on animals were obtained in real grazing conditions, and consisted on repeated measurements of enteric methane using a portable, non-invasive device (LMD). A total of 39 animals (16 males and 23 females) were evaluated under continuous grazing with permanent access to water and mineral supplementation. Animals were measured repeatedly over a three-month period (August to October 2025). Each animal was measured during two consecutive weeks per month, with three measurement days per week, twice a day (morning and afternoon). Due to logistical constraints, animals were divided by sex and further grouped, with each subgroup measured on alternating days to complete the repeated

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measure's structure. Methane measurements were collected using an LMD over approximately 3 minutes per session, recording data every 0.5 seconds. During each measurement session, additional information was recorded, including animal behavior (resting, rumination, grazing), location, climatic conditions, distance and time of measurement. Weekly forage sampling was conducted to characterize diet composition using near-infrared spectroscopy (NIRS), providing estimates of nutritional quality (e.g., NDF, ADF, crude protein, digestibility). Raw CH₄ data (ppm x m) were pre-processed by removing invalid measurements based on error codes, signal intensity (<100) and extreme values (>2,500 ppm x m) following the suggestions of Sorg (2022). Profiles were constructed and analyzed following Sorg et al. (2018). Peak detection was performed using a derivative-based algorithm, and CH₄ values were classified into respiration and eructation events using the boxplot threshold method ($Q3 + 1.5 \times IQR$). Methane individual phenotypes were computed, and expressed in ppm x m, as follows: MEAN: arithmetic average of all profile values; P_MEAN: arithmetic average of all peak values; ERP_MEAN: arithmetic average of peak values corresponding to eructation events and EVENT_MEAN: arithmetic average of maxima peak values corresponding to eructation events. A linear model was used to evaluate the effects of sex, measurement period (morning vs. afternoon), month (August, September, and October), behavior (resting, ruminating, and grazing), environmental conditions (presence or absence of wind) and forage fiber content (NDF) on methane phenotypes. **Results and Discussion:** A total of 221,604 methane measurements were collected using a portable LMD under grazing conditions, from which 703 valid profiles were derived after data editing and quality control. Methane phenotypes (MEAN, P_MEAN, ERP_MEAN, and EVENT_MEAN) showed substantial variability across animals and were significantly influenced by environmental and temporal factors. The effect of measurement period was consistent across all

phenotypes. Measurements collected in the afternoon showed higher methane values compared to the morning ($P < 0.01$), while wind presence reduced methane values across all traits ($P < 0.001$), confirming its impact on gas dispersion and measurement dilution. The month of measurement significantly affected methane emissions ($P < 0.001$). In particular, October showed a consistent reduction across all phenotypes compared to the other measurement months, suggesting temporal variability potentially associated with changes in forage availability or environmental conditions. The fiber content of the diet (FDN) was one of the most influential factors ($P < 0.001$), showing a negative association with all methane phenotypes, indicating a strong relationship between forage quality and methane emissions under grazing conditions likely associated with a reduction in feed intake. Sex had a moderate effect, being significant only for EVENT_MEAN ($P = 0.038$), whereas animal behavior during measurement showed no significant influence ($P > 0.05$). Despite the inclusion of multiple explanatory variables, the models showed moderate explanatory power (R^2 ranging from 0.14 to 0.17), indicating that a substantial proportion of the variability is likely due to individual animal differences and other unmeasured factors. **Conclusion:** methane phenotypes obtained using LMD under grazing conditions are significantly influenced by environmental, temporal, and nutritional factors, particularly measurement period, wind conditions, month, and forage fiber content. These results highlight the need for standardized measurement protocols and the integration of nutritional data when interpreting methane emissions. Despite moderate model fit, the presence of consistent and biologically meaningful variation supports the use of LMD-derived phenotypes under field conditions. These findings reinforce the strategic importance of integrating methane phenotyping into ASOCEBÚ's sustainability initiatives, supporting the development of more efficient and environmentally responsible Brahman cattle under tropical grazing systems.

Evolving Cattle Production: Experience in Implementing Genetic Values and Functional Biotypes

Evolución de la producción bovina: experiencia en la implementación de valores genéticos y biotipos funcionales

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Keywords:

Biotipo
Brahman
Genetic evaluation
Genetic improvement
Guzerá
Heritability

Palabras clave:

Biotipo
Brahman
Evaluación genética
Mejoramiento genético
Guzerá
Heredabilidad

Introduction: In bovine genetic improvement programs, integrating quantitative genetic information with phenotypic evaluation represents a key challenge for achieving sustainable production systems. **Justification:** In Colombia, particularly in zebu breeds such as Brahman and Guzerá, there is a need to translate the results of genetic evaluations into practical selection decisions that consider both productive performance and animal conformation. **Objective:** To present the author's experience in the integrated implementation of genetic values and the selection of outstanding functional biotypes, combining scientific and traditional knowledge to enhance the genetic improvement of Brahman and Guzerá breeds. **Methodology:** The analysis was based on productive records from 46,522 animals belonging to Hacienda SJ Bedouth. Growth traits were evaluated (body weight at 4, 7, 18, and 24 months, including maternal effects at 4 and 7 months), along with reproductive traits (calving interval and age at first calving) and carcass conformation traits (ribeye area). Direct and maternal heritabilities, genetic correlations, and a selection index based on principal component analysis were estimated. Additionally, mating strategies were implemented based on phenotypic

complementarity and projected cow–bull genetic values.

Results and discussion: Heritability estimates ranged from low to high depending on the trait, and moderate to high genetic correlations were identified among growth traits. A substantial proportion of phenotypic variation was associated with additive and maternal genetic effects, as well as with favorable genetic associations between traits. The application of the principal component–based selection index enabled the prioritization of genetically superior animals, which was reflected in productive performance

and outstanding results in national and international livestock shows. Evidence of favorable genetic progress was observed for most traits, based on selection that incorporated index results complemented by productive and functional criteria. **Conclusion:** The results indicate that the evaluated traits respond to selection processes and that the implementation of a principal component–based index, complemented by the selection of well-conformed animals, ensures efficient and commercially attractive genetic progress.

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The Measure and the Gaze: Data Analysis in Agricultural Sciences Between Metrics, Methods, and Human Judgment



La medida y la mirada: análisis de datos en las ciencias agrarias entre métricas, métodos y juicio humano

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Keywords:

Artificial intelligence
Data analysis
Open science
Reproducibility
Scientific metrics
Statistical methods

Palabras clave:

Inteligencia artificial
Análisis de datos
Ciencia abierta
Reproducibilidad
Métricas científicas
Métodos estadísticos

At present, data analysis occupies a central place in agricultural and animal production sciences. This document put forward three practical dimensions of data analysis in this field: the use of data as an input to describe the state of our own science; the body of statistical methods of habitual use, together with the complementary approaches available; and the role of human judgment in the presence of computational systems for which different degrees of autonomy can be configured.

The first dimension was approached through an analysis of Colombian indexed scientific output in agricultural and biological sciences. Data from the *SCImago Journal & Country Rank* (SCImago Lab 2026) for the period 2000-2025 showed a sustained increase in the number of published documents, accompanied by a decline in citations per document, a stable national self-citation rate close to 17%, and an editorial landscape concentrated in the third and fourth quartiles. This pattern proved consistent with previous findings: Cardona-Madariaga et al. (2015) reported that 77.74% of Colombian scientific output indexed in SciELO between 2002 and 2013 had received no citations, and only 12.64% had been cited a single time. Strathern's formulation of Goodhart's law — "*when a measure becomes a target, it ceases to be a good*

measure" (Strathern 1997; Mattson et al. 2021)— offered a useful interpretive framework for these findings.

The second dimension was approached on the basis of the prevailing methodological repertoire in applied agricultural research. Procedures such as analysis of variance, mean comparisons, and tests based on p-values remain valid tools for well-defined purposes. In 2016, the American Statistical Association issued a formal statement on the use and interpretation of the p-value, in which it warned that this measure does not quantify the probability that a hypothesis is true nor the practical magnitude of an effect, and that its dichotomous interpretation

around the 0.05 threshold has generated problematic inferences across various disciplines (Wasserstein and Lazar 2016). In response, complementary approaches have gained visibility: generalized additive models for non-linear biological curves, mixed and Bayesian models for hierarchical structures, conformal intervals to quantify uncertainty without distributional assumptions, and techniques for simulation, Monte Carlo, and inference based on *machine learning*. The proposal is not one of substitutions but of broadening the available repertoire. An analogous consideration applies to software: open environments (R, Python, and the broader ecosystem of differentiable computing libraries such as PyTorch,

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JAX, and TensorFlow) offer levels of reproducibility and traceability that proprietary alternatives can hardly match, and they make it possible to implement a wide diversity of statistical and computational models.

The third dimension examined the incorporation of agentic artificial intelligence systems into scientific workflows. The *Stanford AI Index Report* (HAI 2026) documents that current models exhibit what is termed "*jagged intelligence*": remarkable performance on certain tasks alongside unexpected fragility on others. This characteristic has operational implications: agentic systems can accelerate code generation, data analysis, and literature synthesis, but their reliability depends on human supervision. The responsible incorporation of these tools requires explicit cycles of audit and reproducible documentation that accompany the acceleration of generation.

The three dimensions discussed share a common denominator. The quality of research does not depend exclusively on the technique employed, the tool used, or the metric selected; it depends on the judgment with which they are articulated. Reproducibility, in this sense, constitutes a necessary condition of scientific practice: a study whose code, data, or computing environment are not available compromises its own status as a verifiable contribution. In summary, data analysis in agricultural sciences and animal production demands a deliberate articulation among the data that describe the state of the phenomena, the methods employed to interrogate them, and the human judgment that decides how, when, and with what degree of autonomy the available computational tools are incorporated. This articulation, more than any technique, defines the scientific character of the resulting contribution.



RESÚMENES

**GRANDES RUMIANTES
(VACUNOS Y BÚFALOS DE LECHE Y CARNE)**

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Coat Color and Heat Absorbance in Crossbred Cows in the Colombian Tropical Lowlands Color del pelo y absorción de calor en vacas mestizas de las tierras bajas tropicales de Colombia

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Introduction: Heat absorption is one of the most important factors in the onset of heat stress and homeostatic disruption in animals on tropical farms. **Objective:** The objective of this study was to evaluate heat absorption in cattle based on coat color and surface area. **Methods:** This study was conducted on a commercial farm in the municipality of Coyaima, Tolima Department, where thermal images were collected in three shots of the right side of lactating cows (37, 42, and 40, respectively) with different coat colors (black, white, and red) between 12:00 and 13:00 using FLIR ONE EDGE PRO-WIRELESS 160120 IR technology, with VividIR and MSX image enhancement technology, and adjusted using Flir Ignite - Teledyne FLIR for the evaluation of the thermograms. **Results and Discussion:** The data were analyzed using JASP 0.19.2 software (2024). The body temperatures of the animals, classified by coat color (white, black, and red), were 39.25 ± 0.05 , 40.54 ± 0.08 , and 39.818 ± 0.07 °C, respectively. It was observed that the factors of color and date had a significant influence ($P < 0.001$) on the animal's surface temperature, with significant differences between black and white ($P < 0.001$), but not between black and red or between white and red. Strong positive correlations were observed between wind speed and body temperature (0.81), and between relative humidity and body temperature ($P < 0.001$). **Conclusion:** Coat color in cattle influences the amount of radiation that grazing cattle can absorb and is strongly influenced by climatic variables such as temperature and wind speed, relative humidity, and ambient temperature.

Keywords: Hair color, heat stress, infrared thermography

Palabras clave: Color de pelo, estrés calórico, termografía infrarroja

Operational Factors Associated with Sensibility Indicators in Cattle During Captive Bolt Stunning Factores operativos asociados a indicadores de sensibilidad en bovinos durante el aturdimiento con perno cautivo

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Introduction: Stunning with a penetrating captive bolt in cattle and the accurate shot placement are determinant to achieve immediate loss of consciousness. **Justification:** Anatomical guidelines for captive bolt application have been developed primarily in *Bos taurus*; however, *Bos indicus* cattle present relevant cranial differences (greater development of the frontal sinus and variations in bone thickness) which may modify the relationship between external landmarks, brain structures, and loss of consciousness. **Objective:** To evaluate the association between variables of the stunning procedure and the presence of post-stunning sensibility indicators in cattle under commercial conditions. **Methods:** A total of 2,437 cattle were evaluated during stunning with a penetrating captive bolt in a slaughter facility. Subsequently, the following sensibility indicators, classified as signs of inadequate stunning, were systematically recorded: palpebral reflex, rhythmic breathing, spontaneous eye movements, vocalizations, pedaling, attempts to rise (righting reflex), and response to painful stimuli. Positive sensibility was defined when at least one of the signs described was present. Additionally, procedure-related variables were recorded: gun pressure, anatomical shot location, shot deviation, age, horn status, and breed. Logistic regression models were used to analyze the association between these variables and the occurrence of sensibility indicators. **Results and Discussion:** There were differences in the frequency of sensibility indicators according to anatomical shot location ($P < 0.05$), particularly in animals with predominant *Bos indicus* genetics. Anatomical positions slightly dorsal to the traditional frontal site showed fewer sensibility indicators compared with the conventional point, suggesting that cranial morphological variations may influence stunning effectiveness. In contrast, variables such as equipment pressure and age did not show consistent associations with the evaluated indicators. **Conclusion:** Anatomical shot placement may influence the occurrence of post-stunning sensibility indicators in cattle, especially in populations with zebuine genetics. Systematic assessment of these sensibility indicators may contribute to optimizing the anatomical location for captive bolt application and improving the effectiveness of the stunning process.

Keywords: Anatomy, morphology, slaughter, stunning, zebu
Palabras clave: Anatomía, morfología, beneficio, insensibilización, cebú

Effect of Three Mud Levels on Udder Health of Lactating Holstein Cows Efecto de tres niveles de barro sobre la salud mamaria de vacas Holstein en lactancia

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Introduction: Mud can affect cow udder health due to direct and/or indirect effects (stress). **Objective:** The objective of this study was to compare the prevalence of clinical mastitis (CM), new infections (NI), udder cleanliness score, and serum haptoglobin concentration in Holstein cows under three levels of mud. **Methods:** At the dairy unit of INIA Uruguay, 39 cows were blocked by number and days in milk, milk production, and live weight, and then assigned to three treatments: no mud (B0), 10 cm of mud (B10), and 20 cm of mud (B20). Over 41 days, cases of CM, individual somatic cell count (SCC), udder cleanliness score (1–4), and serum haptoglobin concentration were recorded weekly. Survival curves and generalized linear models were analyzed, considering statistical differences at $P < 0.05$. **Results and Discussion:** The probability of an NI (SCC values $\leq 200,000$ shifting to $>200,000$ cells mL^{-1}) was lower in B0 cows than in B20 over time ($P = 0.04$), with no differences compared to B10; by the end of the study, cows in B0 had a probability of remaining healthy of 0.80 vs 0.20 in B20. Additionally, B0 had a lower percentage of cows with NI than B20 (25 vs 75%; $P = 0.04$). No statistical differences were found in the probability of presenting CM, which may be attributed to the low number of animals. However, the percentage of cows with CM differed numerically between B0 and B20 (7.7 vs 38.5%; $P = 0.16$). Cows in B0 and B10 also tended to become less affected by CM, mainly at the end of the evaluation period, compared to B20. Treatment B20 showed higher values than B0 for serum haptoglobin (0.36 vs 0.20, SE = 0.03 mg mL^{-1} ; $P = 0.001$) and cleanliness score (4.0 vs 2.6, SE = 0.07; $P < 0.0001$). **Conclusion:** Cows exposed to more mud (B20) were characterized by greater udder dirtiness, higher stress and inflammation, resulting in more cases of CM and NI.

Keywords: Environmental, mastitis, milk, milking, stress
Palabras clave: Ambiental, mastitis, leche, ordeño, estrés

Animal Welfare Certification in a Highland Dairy Farm Using Official Protocols Certificación de bienestar animal en una granja lechera especializada mediante protocolos oficiales

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Introduction: Animal welfare has become a fundamental component for the sustainability of cattle production systems and for compliance with regulatory standards. In Colombia, the Colombian Agricultural Institute (ICA) has established official protocols to assess welfare in cattle, based on the five freedoms approach. **Objective:** To evaluate and apply official animal welfare protocols in the Experimental and Demonstration Farm Betania, located in Antioquia (Colombia). **Methods:** The evaluation was conducted using checklists and field protocols aligned with Law 1774 of 2016, Resolution 253 of 2020, and the official ICA methodology for cattle. Indicators related to feeding, health, management, infrastructure, and animal behavior were assessed. Data were recorded and analyzed using the “Más Bienestar” application, which allowed the calculation of an overall welfare score for the farm. **Results and discussion:** The evaluation yielded an overall welfare score of 4.30 out of 5.0, indicating a high level of compliance with the evaluated criteria. In lactating cows, the average score was 4.30, with high values observed for freedom from fear and stress (5.00) and comfort conditions (4.60), while lower values were found in the expression of normal behavior (3.80). In dry cows, the score was 4.20, with maximum values in freedoms related to absence of pain, injury and disease, normal behavior, and fear and stress (5.00), although a low value was observed for comfort (2.00). Heifers showed one of the best performances with a score of 4.60, reaching maximum values (5.00) in three of the five evaluated freedoms. Calves obtained a score of 4.20, with outstanding results in comfort (5.00) and adequate values in hunger and thirst (4.40), although relatively lower values were observed in pain, injury and disease (3.70) and in the expression of normal behavior (3.80). These results may be explained by limited shade availability in some paddocks, prolonged waiting times in pre-milking areas, and management practices that restrict behavioral expression. Additionally, the lower values in calves for health-related indicators may be linked to early-life management challenges and disease susceptibility. **Conclusion:** The results demonstrate a high level of compliance with animal welfare criteria.

Keywords: dairy, management, production, sustainability, welfare
Palabras clave: lechería, manejo, producción, sostenibilidad, bienestar

Effect of Physical Activity on Methane Production in Dairy Cows

Efecto de la actividad física sobre la producción de metano en vacas lactantes

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Introduction: Methane (CH₄) is a gas produced in large quantities during enteric fermentation in cattle, but it is difficult to quantify in grazing animals. **Justification:** The effect of the activities performed by lactating cows under grazing conditions on enteric CH₄ emissions is unknown. **Objective:** To quantify CH₄ production (L/cow/day) in lactating cows during post-milking rest (POST), during movement from the barn to the pasture (MOV), during grazing (GRAZ), and during rumination (RUMIN). **Methods:** Four adult cows in the lactation period (Jersey × Holstein) with two or more lactations and who were in the second third of lactation, previously adapted to the

measurement equipment, were fitted with a nasal spirometric mask for at least 3 hours. During this time, CH₄ concentration (ppm) and exhaled gas volume (L min⁻¹) were recorded while the animals were in POST, MOV, GRAZ, and RUMIN. The masks were programmed to record data every 200 ms, which were stored in EXCEL format on a MicroSD card. At the end of the measurement period, 33,496 data points were collected and used to quantify CH₄ production for each cow according to the activity performed. The data were analyzed using a mixed model including the random effect of the cow and the fixed effect of physical activity. **Results and Discussion:** CH₄ production differed significantly among the four recorded activities ($P<0.001$). It was highest during MOV (182.7±91 L/cow/day), followed by POST (140.7±80 L/cow/day) and RUMIA (109.9±68 L/cow/day), and lowest during GRAZ (93.9±64 L/cow/day). These results suggest that physical activity alters methane production, possibly due to its effects on gastrointestinal motility and substrate availability for ruminal fermentation. **Conclusion:** Enteric methane production in lactating cows varies throughout the day depending on the type of physical activity being performed.

Keywords: Grazing, resting, ruminantig, spirometry, walking
Palabras clave: Pastoreo, descanso, rumia, espirometría, desplazamiento

REPRODUCCIÓN

Effect of Cysteamine Supplementation in the Maturation Medium on *in vitro* Bovine Embryo Production Efecto de la suplementación con cisteamina en el medio de maduración sobre la producción de embriones bovinos *in vitro*

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Introduction: *In vitro* embryo production (IVEP) employs various supplements in maturation media to increase embryo yield, such as cysteamine. **Objectives:** To evaluate maturation, fertilization, and embryo development rates using cysteamine supplementation in the *in vitro* maturation medium. **Methods:** A total of 491 oocytes (categories I and II) were collected from ovaries of slaughtered cows and transported at 30 °C in a saline solution with antibiotics. Oocytes were randomly assigned to two treatments: 230 oocytes in Oocyte Maturation Medium (OMM) supplemented with 100 µM cysteamine, and 261 oocytes in unsupplemented OMM (control). To assess maturation to Metaphase II, 69 oocytes from the OMM + cysteamine group and 48 from the control group were stained with Hoechst B2261 and examined under an epifluorescence microscope (DAPI 350/460), evaluating the Metaphase II nucleus and first polar body after 24 hours of maturation. For fertilization, semen was processed using a 45–90% Percoll gradient and incubated for 18 hours. Embryo culture was conducted using Synthetic Oviductal Fluid. Throughout all stages, tri-gas incubators were used (5% O₂, 5% CO₂, and 90% N₂). Variables analyzed included *in vitro* maturation rate, oocytes at Metaphase II, *in vitro* fertilization rate, and embryos obtained after 7 days of culture. A completely randomized design with two treatments was used; data were analyzed using the Chi-square (χ^2) test in SAS[®] 9.4, with a significance level of $P \leq 0.05$. **Results:** Significant differences ($P \leq 0.05$) were observed in maturation, fertilization, and embryo production rates, with values of 86.52±1.92%, 77.89±2.85%, and 61.54±2.60% for OMM + cysteamine group, respectively, compared to 77.78±0.49, 66.50±1.15, and 46.84±1.67% for the control OMM. The highest percentage of oocytes at Metaphase II ($P \leq 0.05$) was observed in OMM + cysteamine (85.19±2.50%), while the control OMM showed 69.57±5.33%. **Conclusion:** Cysteamine supplementation in OMM improves all parameters of the IVEP process.

Keywords: Apoptosis, blastocyst, embryonic development, fertilization, oocyte

Palabras clave: Apoptosis, blastocisto, desarrollo embrionario, fertilización, ovocito

In vitro Embryo Production Efficiency of Different Zebu Breeds from the Colombian Tropic Eficiencia de la producción de embriones *in vitro* de diferentes razas cebuinas del trópico colombiano

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Introduction: *In vitro* embryo production (PIVE) has reached significant importance as a biotechnological tool, accelerating genetic progress. **Objective:** To characterize and compare the morphological quality of viable oocytes obtained from four Zebu breeds and their efficiency for PIVE. **Methods:** Data from 130 ultrasound-guided follicular aspiration sessions (Brahman (B) n = 56, Gyr (Gr) n = 45, Nelore (N) n = 17, and Guzerá (Gz) n = 12) intended for PIVE at the Vitrolab S.A.S. laboratory were included. The following variables were analyzed: oocyte morphology, cleavage percentage (%_CLIV), cleavage percentage with more than four cells (%_CLIV4), both on day 3 of culture, and total embryo percentage (%_EMB) on day 7 of culture. Statistical analysis was performed using software SAS 9.4 taking a p-value <0.05 as significant. Data were analyzed using an analysis of variance with a generalized linear model. Means were compared using Duncan's test, and correlations were estimated using Pearson's correlation coefficient. **Results:** Significant differences ($P < 0.05$) were found in oocyte quality, with the Gyr breed exhibiting the highest percentage of grade 1 oocytes compared to Guzerá breed ($B = 8.2 \pm 1.13\%$, $N = 7.14 \pm 0.97\%$, $Gr = 12.01 \pm 1.12\%$, and $Gz = 3.84 \pm 0.78\%$). Guzerá breed also presented a significantly lower percentage ($P < 0.05$) of grade 2 oocytes compared to the other breeds ($B = 20.37 \pm 1.44\%$, $Gr = 17.44 \pm 0.96\%$, $N = 17.39 \pm 1.35\%$, and $Gz = 6.78 \pm 1.44\%$). No significant differences were found for %_CLIV, but regarding %_CLIV4, the Brahman breed showed a significantly higher percentage ($P < 0.05$) compared to the Nelore and Gyr breeds ($B = 75.33 \pm 2.4\%$, $N = 60.08 \pm 4.24\%$, $Gr = 64.09 \pm 2.12\%$, and $Gz = 67.00 \pm 3.52\%$). As for %_EMB on day 7, the highest production was observed in Brahman and Gyr breeds, followed by Guzerá, with the Nelore breed having a significantly lower %_EMB ($P < 0.05$) ($B = 36.35 \pm 2.47\%$, $N = 19.54 \pm 4.21\%$, $Gr = 30.1 \pm 1.98\%$, $Gz = 25.98 \pm 4.03\%$). A strong and highly significant correlation ($P < 0.01$) was found between %_CLIV and %_EMB, and between %_CLIV4 and %_EMB (0.76 and 0.80, respectively).

Conclusion: The proportion of viable oocytes varies in the evaluated zebu breeds, significantly influencing the efficiency of PIVE programs under tropical conditions.

Keywords: Bovine, cleavage, embryo, oocyte, zebu
Palabras clave: Bovino, clivaje, embrión, ovocito, cebú

Evaluation of the Viability of Oocytes and Implantation of Embryos Obtained by Reproductive Biotechnologies in Pure Cattle Determined the Influence of the Presence of *Trypanosoma*

Evaluación de la viabilidad de ovocitos e implantación de embriones obtenidos mediante biotecnologías reproductivas en bovinos puros determinado la influencia de la presencia de *Trypanosoma*

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This research proposal, given the importance of cattle production and ensuring the growth of high-quality production units, aims to advance our understanding of the influence of health on bovine reproduction. It seeks to evaluate the influence of the presence in the blood of the *Trypanosoma* (*Trypanosoma vivax*) on the reproductive performance of female cattle undergoing reproductive biotechnologies, specifically ultrasound-guided follicular aspiration and *in vitro* embryo production for embryo transfer. Forty female bovine donor candidates free of brucellosis and tuberculosis, of the purebred Brahman breed, will be selected from farms in the lower tropics Colombia, where there has been an incidence of *Trypanosoma*. Then, from among the brucellosis- and tuberculosis-free and infected animals, two groups of donor cows will be selected: Group A, consisting of 8 donor cows free of *Trypanosoma*, and Group B, consisting of 8 donor cows positive for *Trypanosoma*. Subsequently, ultrasound-guided follicular aspiration will be performed to obtain oocytes; these will be taken to the laboratory for *in vitro* embryo production, and the following variables will be evaluated: ovarian oocyte presence, oocyte quality, their rate of maturation, fertilization rate, development, and implantation. It is believed that the clinical symptoms of the disease may affect these rates; the study aims to obtain data confirming whether the presence of the disease can significantly affect reproduction in female cattle.

Keywords: Animal health, embryo transfer, parasites, reproductive efficiency

Palabras clave: Sanidad, transferencia de embriones, parásitos, eficiencia reproductiva

Interaction Between Variables Affecting the Freezability of Semen from Chino Santandereano Bulls Interacción entre variables que afectan la congelabilidad del semen de toros chino santandereano

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Introduction: Total motility (TM) is a critical parameter in assessing the seminal quality of bovine ejaculates. Cholesterol, essential for the fluidity and stability of the sperm cell during the cryopreservation process, is transported by the Niemann-Pick C2 (NPC2) protein. **Objective:** To determine the relationship between the seminal plasma NPC2 protein and post-thaw total motility in Chino Santandereano bulls. **Methods:** The study was conducted at the Santa Lucía Research Center, affiliated with the Instituto Universitario de la Paz (UNIPAZ) in Barrancabermeja, Santander. Thirty ejaculates from ten bulls (three per bull) were evaluated and cryopreserved using conventional methods. The identification of the NPC2 protein was performed via polyacrylamide gel electrophoresis (PAGE) and Western blotting. Cholesterol levels were quantified using semi-automated spectrophotometry. TM assessment was carried out using a Computer-Aided Semen Analysis (CASA) system. Data analysis was performed through a multiple linear regression model in RStudio. The final model for TM prediction was selected based on the Akaike Information Criterion (AIC) and R^2 values. **Results and Discussion:** Two bands of the NPC2 protein were identified at 14 kDa and 15 kDa. The model showed significance for TM ($P < 0.05$) with a positive coefficient (4.611), indicating that as the percentage of TM in fresh semen increases, the dependent variable (post-thaw TM) also tends to increase. Furthermore, the model revealed a highly significant correlation ($P < 0.01$) with a negative coefficient (-149.552) for the 14 kDa NPC2 variant, suggesting that an increase in the relative abundance of this protein is associated with a decrease in post-thaw TM. Similar evidence has been previously reported in porcine breeders. **Conclusion:** The results of this study propose fresh TM as a predictor of cryotolerance and the 14 kDa seminal plasma NPC2 protein as a molecular marker for semen freezability.

Keywords: Cholesterol, fluidity, membrane, motility, seminal, stability

Palabras clave: Colesterol, fluidez, membrana, motilidad, seminal, estabilidad

Efficiency of Girolando Embryo Production Using Sexed Semen from Holstein Bulls

Eficiencia de la producción de embriones Girolando utilizando semen sexado de toros Holstein

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Introduction: *In vitro* embryo production (PIVE) is commonly used for genetic improvement in cattle, especially in tropical dairy systems in which F1 breeds like Girolando combine productivity with environmental adaptation. **Objective:** Evaluate if there are differences in the efficiency of PIVE using the most requested Holstein bulls by clients of Vitrolab. **Methods:** Data from Vitrolab's commercial PIVE from the months of May through August 2025 were compiled. These consisted of 368 *in vitro* fertilizations, 78 with Odana, 56 with Fitters Choice (F. Choice), 42 with Patan, 112 with Bronco, 65 with Einstein and 15 with Dropbox. Percentage of cleavage (%_CLIV), cleavage of more than four cells (%_CLIV_>4) at day three of culture and final embryo production (%_EMB) at day seven of culture were obtained. A statistical analysis of the data was performed using the Kruskal-Wallis test (which compares medians) followed by Dunn's test of multiple comparisons. The results are presented as the median followed by the interquartile range. **Results:** At Vitrolab, PIVE has an average efficiency of: %_CLIV = 78.774 (SD = 14.486), %_CLIV_>4 = 63.721 (SD = 19.551) and %_EMB = 27.353 (SD = 19.439). After analyzing the most utilized Holstein bulls by clients of Vitrolab, it was identified that Einstein had the lowest %_CLIV, with a median value of 71.429% (IQR = 62.260-83.333). This was significantly lower ($P<0.05$) than Odana which had a median of 81.579% (IQR = 66.667-90.625) and F. Choice with 81.385% (IQR = 73.445-88.568). Einstein also had the lowest %_CLIV_>4 = 57.143% (IQR = 42.857-68.333) while F. Choice had a significantly higher ($P<0.05$) percentage %_CLIV_>4 = 69.309% (IQR = 60.0-77.879). In contrast, during %_EMB, Patan had the highest efficiency (%_EMB = 33.333% (IQR = 18.056-50.0)) while Dropbox had the lowest efficiency of PIVE (%_EMB = 18.750% (IQR = 0.0-30.842)). However, none of the results were statistically significant ($P>0.05$) for %_EMB. **Conclusion:** Significant differences exist during the first stages of embryo development but not in the final embryo production, this seems to indicate that these six bulls are equally efficient for PIVE.

Keywords: Bovine, cleavage, fertilization, sperm

Palabras clave: Bovino, clivaje, fertilización, espermatozoides

Effect of Resveratrol During the Freezing of Bovine Ovarian Tissue

Efecto del resveratrol durante la congelación de tejido ovárico bovino

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Introduction: Cryopreservation of ovarian tissue is a key technique for fertility preservation and germplasm conservation; however, it faces limitations associated with oxidative stress generated during the process. Resveratrol, a polyphenol with antioxidant properties, has demonstrated protective potential in many reproductive models, although its optimal concentration in cryopreserved ovarian tissue remains undefined. **Objective:** To evaluate the effect of resveratrol on follicular integrity and morphology, cell viability, and lipid peroxidation of bovine ovarian tissue cryopreserved using programmable slow freezing. **Methods:** Bovine ovaries were collected from a slaughterhouse. Ovarian cortex fragments measuring 20 x 5 x 2 mm were sectioned. Slow freezing was performed in a CL-8800i programmable freezer using M-199 medium supplemented with 10% fetal bovine serum, 6% dimethylsulfoxide, 6% ethyleneglycol, 0.1 M sucrose, and 50 µg mL⁻¹ gentamicin. The freezing medium was supplemented with either 10 µM resveratrol (R10) or 20 µM resveratrol (R20). A control treatment without resveratrol was included. After thawing, the number of follicles and their degree of degeneration were assessed by histological analysis, and cell viability (SYBR14/propidium iodide) and lipid peroxidation (BODIPY 581/591 C11) were assessed by fluorescence microscopy. **Results:** R10 improved the total number of follicles (76.6±23.2), and the number of primordial (52.7±17.6) and primary follicles (18.3±4.5) after thawing, compared to the control (27.7±8.8, 18.1±6.6, and 6.5±2.0, respectively). In addition, R10 had the highest quantity of follicles without morphological alterations (G0) (2.2±1.1), and follicles with mild degeneration (G1) (19.1±8.6), compared to the control (0.4±0.2, and 4.2±2.3, respectively). There was no difference between R20 and the control group for the total number, stage of development, or degree of degeneration of ovarian follicles. No differences were found for cell viability or lipid peroxidation. **Conclusion:** Resveratrol protects bovine ovarian tissue during freezing, reducing the loss and degeneration of ovarian follicles after thawing.

Keywords: Antioxidants, cryopreservation, cryoprotectant, histology

Palabras clave: Antioxidantes, criopreservación, crioprotector, histología

Sperm Kinematics in Chino Santandereano Bulls Under Tropical Conditions Cinemática Espermática en Toros Chino Santandereano en Condiciones de Trópico Bajo

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Introduction: The characteristics of the seminal material of the Colombian Creole bovine breed Chino Santandereano are unknown. The use of objective semen evaluation technologies such as the CASA computerized semen analysis system provides reliable data on the kinetic variables of the sperm material. **Justification:** Generating knowledge about the behavior of seminal material in Colombian Creole bovine males is crucial for the application of biotechnologies that allow the conservation of this breed at risk of extinction. **Objective:** To evaluate sperm motility in Chino Santandereano (ChS) bulls in the low tropics. **Methods:** The research was conducted at the Santa Lucía Research Center-Reproductive Biotechnology Laboratory (LABRA), owned by the University Institute of Peace in Barrancabermeja, Santander. Ten Chinese Santander bulls were evaluated under pasture conditions with *Brachiaria humidicola* and 8% mineralized salt, one collection per week for three weeks by electroejaculation. The parameters evaluated were motility, mean path velocity (MPV), curvilinear velocity (CLV), and rectilinear velocity (SLV). The samples were analyzed using a computerized semen analysis system (CASA) (SCA®-Microptic). The data obtained were processed using IBM SPSS Statistics 22, evaluating the means, standard error (SE), and standard deviations (SD). The results were interpreted using descriptive statistics. **Results:** Motility 94.57%, SE 2.08-SD 11.43; VAP 35.07 $\mu\text{m s}^{-1}$, SE 1.89-SD 10.35; VCL 62.7 $\mu\text{m s}^{-1}$, SE 3.79-SD 20.78; VSL 20.19 $\mu\text{m s}^{-1}$, SE 1.05-SD 5.76. **Conclusion:** The data obtained contribute to expanding knowledge about seminal parameters in the Colombian Creole breed Chino Santandereano, which are scarce or nonexistent. The values for sperm characteristics in Chino Santandereano bulls under the conditions of the Magdalena Medio region of Santander are within the ranges found for these parameters in other taurine breeds.

Keywords: Semen quality, sperm speed, Chino Santandereano
Palabras clave: Calidad seminal, velocidad espermática, Chino Santandereano

Effect of Bovine Leukosis, Bovine Viral Diarrhea and *Neospora caninum* on Dairy Farms Efecto de la leucosis bovina, diarrea viral bovina y *Neospora caninum* en granjas lecheras bovinas

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Introduction: The presence of infectious pathogens in dairy herds represents a critical challenge for livestock profitability, as they affect biological and productive efficiency. Understanding their impact is fundamental for designing control strategies that mitigate economic losses in the region. **Objective:** This study analyzed the impact of seropositivity and coinfection with Bovine Leukemia Virus (BLV), Bovine Viral Diarrhea Virus (BVD), and *Neospora caninum* (Nc) on productive and reproductive performance in dairy herds in Antioquia, Colombia. **Methods:** A total of 599 blood samples from 53 dairy herds were analyzed using the Enzyme-Linked Immunosorbent Assay (ELISA) technique. Serological results were integrated with 1,363 lactation records to evaluate productive variables (milk production, protein, fat, somatic cell count, and lactation length) and reproductive variables (services per conception, age at calving, days open, and calving interval). Statistical analysis was performed using a Generalized Linear Model (GLM). **Results and Discussion:** BLV seropositivity was significant ($P < 0.05$) for KgPROa and KgGRAa, with lower average values in infected cows, and for CI ($P = 0.05$), being significantly higher in seropositive animals. BLV seropositivity impacted DO ($P = 0.093$) and CI ($P = 0.05$). Seropositivity to Nc was significantly associated with Services per Conception S/C ($P = 0.008$). In the coinfection analysis, animals seropositive for both BLV and BVD showed a significant effect on CI ($P = 0.05$). Seropositivity to all three pathogens (BLV, Nc, and BVD) showed no significant differences for S/C ($P = 0.198$) or AgeC ($P = 0.349$), with a tendency to affect DO ($P = 0.069$) and CI ($P = 0.061$). **Conclusion:** BVD seropositivity affected KgPROa and KgGRAa levels; a negative trend was observed from the interaction of the three evaluated pathogens on DO and CI, as well as the interaction between BLV and BVD

on CI, which may negatively impact herd profitability. These results highlight the importance of implementing control and prevention programs to limit the spread of these pathogens and avoid associated economic losses.

Keywords: Coinfection, efficiency, infection, performance, production, reproduction

Palabras clave: Coinfección, eficiencia, infección, desempeño, producción, reproducción

GENÉTICA Y MEJORAMIENTO

On the Impact of Adding Pedigree Information to Bayesian Inference of Wright's F_{ST} Theoretical Considerations

Sobre el impacto de adicionar información de pedigrí a la Inferencia Bayesiana del F_{ST} de Wright: consideraciones teóricas

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Introduction: Wright's fixation index (F_{ST}) is widely used in population genetics to assist both conservation and genetic improvement programs. There are several approaches to infer the F_{ST} , which is a function of allelic frequencies; in particular, the Bayesian one is well-suited to this problem since these frequencies exhibit random variation, but so far, available methods ignore probabilistic dependencies induced by kinship. **Objective:** To perform a theoretical study on the impact of including pedigree information in the Bayesian inference of F_{ST} . **Methods:** The problem setup considered a population comprised by a collection of R subpopulations. The model ignoring pedigree used a product Bernoulli likelihood on the random variable indicating whether the j^{th} copy, for each locus and individual, was the reference allele; moreover, allele frequencies (model parameters) were allowed to vary across subpopulations and were given identical and independent Beta priors. The model accounting for kinship had the same prior formulation but used a likelihood that incorporates the observed pedigree. Models were formally compared by deriving the Kullback-Leibler divergence between the posterior distributions and the difference and ratios of the expected Fisher information. We illustrated our theoretical developments using a simulated dataset and numerical examples. **Results and Discussion:** The main results of this study are summarized in two theorems. The first one formally states the impact of pedigree information via the Kullback-Leibler divergence between the two posterior distributions by identifying the key parameter explaining how this divergence increases. The second one quantifies the impact of the fallacy incurred when treating n data points as independent when there are only $m < n$ independent points in the sample, by means of the expected Fisher information.

Conclusion: Given a fixed sample from the base population, the impact of ignoring pedigree information in the inference process increases with sample size. The Kullback-Leibler divergence between the posteriors grows unbounded as well as the ratio and the difference between the Fisher information, but the ratio does not depend on allele frequencies, while the difference does.

Keywords: Fisher information, Kullback-Leibler divergence, Markov property, Monte Carlo integration

Palabras clave: Información de Fisher, divergencia de Kullback-Leibler, propiedad de Markov, integración de Monte Carlo

On the Bayesian Inference of wright's Fixation Index Via the Laplace Approximation

Sobre la inferencia Bayesiana del índice de fijación de Wright mediante la aproximación de Laplace

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Introduction: Bayesian inference of Wright's fixation index (F_{ST}) requires the use of numerical methods because the posterior distribution is mathematically intractable. When the integration domain is low-dimensional, and the distribution is unimodal, the Laplace approximation (LA) is an asymptotic alternative to these algorithms; it yields approximate algebraic expressions of posterior moments. The use of the LA is well-suited to this problem because, in most practical settings, the integrals to be computed are low-dimensional; additionally, it may reduce the computational burden. **Objective:** To derive the LA to the posterior mean and variance of the F_{ST} , and to compare the results with a baseline method using simulated data. **Methods:** The Bayesian model was formulated for R subpopulations with heterogeneous allelic frequencies. The likelihood function was a product Bernoulli for the variable indicating if the j^{th} copy ($j = 1, 2$) corresponds to the reference allele, for each locus and individual. Furthermore, the prior distribution was Jeffrey's prior, that is, a $Beta(1/2, 1/2)$. For this model, we derived the LA to the posterior mean and variance and implemented it in a simulated dataset (1,000 markers, 1,047 individuals, 3 subpopulations). We also fit an existing method based on Monte Carlo integration (MCI) and

compared the results empirically. **Results and Discussion:** The LA to higher posterior central moments was found to have an appealing recursive relation with the approximation to the posterior mean, which permits the easy computation of the posterior variance. LA reduced the computing time by 99.97% as compared to MCI using 20,000 samples per marker; moreover, the mean estimates were similar, across-loci-averaged posterior means and variances were {0.0317, 0.0326} and {0.0001, 0.00004}, respectively. A drawback of LA is the possibility of negative variance estimates. **Conclusion:** The main contribution of this study is the derivation of an alternative tool to perform Bayesian inference of the F_{ST} , a parameter used for breeding and conservation purposes. Since LA does not rely on simulating thousands of random variables, it reduces the computing effort significantly, and its point estimates were like those based on MCI, thus, it may be an alternative when analyzing large datasets.

Keywords: Asymptotic, integration, Monte Carlo, structured populations

Palabras clave: Asintótico, integración, Monte Carlo, poblaciones estructuradas

Phenotypic and Genetic Trends in Economically Important Traits Using a Genetic Index Tendencias fenotípicas y genéticas para características de interés económico usando un índice genético

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Introduction: The genetic index (GI) is a calculated value used to identify genetically superior animals simultaneously across multiple traits, enabling a more balanced selection. Breeding animal selection in production systems is often influenced by subjective criteria, typically morphological or heavily shaped by management and feeding practices, which limit the accuracy of the process. The use of GI as a selection tool allows for accelerating genetic and phenotypic gain in traits of productive and economic relevance. **Objective:** To compare phenotypic and genetic trends for three economically important traits when superior individuals are selected based on GI, relative to individuals selected by performance in the Río Grande livestock farm. **Methods:** Productive and reproductive records collected between 1985 and 2023 from a livestock farm located in the states of Antioquia and Córdoba were used, comprising 13,288 animals and a pedigree of 25,931 individuals. Genetic parameters and breeding values were estimated for the traits included in the GI: birth weight (BW), weaning weight (WW), yearling weight (W12), eighteen

(W18), and twenty-four months (W24), calving interval (CI), and age at first calving (AFC), using a single-trait animal model in the WOMBAT software. The GI was calculated through principal component analysis incorporating the estimated breeding values of all evaluated traits. For each birth year, the top 10% of animals based on GI were selected, and phenotypic and genetic trends were plotted for these animals and the general population for GI, WW, W24, and CI. **Results:** For GI, an average difference of 14.53 points was observed between superior animals and the rest of the population; phenotypically, average differences were 25.6 kg for WW, 59.4 kg for W24, and 1.69 days in favor for CI. In terms of expected progeny difference (EPD), average differences were 2.48 kg, 4.94 kg, and 0.344 days for WW, W24, and CI, respectively. **Conclusion:** The results demonstrate that breeding animal selection based on GI improves population averages in key productive traits, translating into greater profitability potential for the production system.

Keywords: DEP, genetic progress, heritability, productivity

Palabras clave: DEP, progreso genético, heredabilidad, productividad

Performance of Holstein–Jersey and Holstein–Blanco Orejinegro Crosses in a Dairy Herd in Antioquia Desempeño productivo y reproductivo de cruces Holstein-Jersey y Holstein-Blanco orejinegro en un hato antioqueño

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Introduction: The incorporation of the Jersey breed into crossbreeding schemes with Holstein for milk production is widely recognized for improving milk composition; a similar effect is observed when Blanco Orejinegro (BON) is used. However, having individuals from these genetic groups within the same herd to enable comparisons from different productive and reproductive perspectives is uncommon and allows for a more holistic evaluation of the suitability of such crossbreeding strategies. **Objective:** This study aimed to compare selected productive and reproductive parameters of crossbred cows with different proportions of Holstein, Jersey, and BON, in order to evaluate the suitability of these breed combinations. **Methods:** A total of 432 lactations from 93 crossbred cows with varying proportions of Holstein × BON and Holstein × Jersey were analyzed. Linear models were

fitted to determine the effect of genetic group on milk yield per lactation, calving interval, and services per conception. Monthly milk recording data were also used to compare milk composition parameters. **Results and Discussion:** Milk yield per lactation (L) was 7,299; 6,286; 6,030; 6,002; and 4,722 for the genetic groups $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ Jersey, $\frac{1}{4}$ Holstein $\times$ $\frac{3}{4}$ Jersey, $\frac{3}{4}$ Holstein $\times$ $\frac{1}{4}$ BON, $\frac{3}{4}$ Holstein $\times$ $\frac{1}{4}$ Jersey, and $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ BON, respectively ($P = 0.08$). The genetic group with the shortest calving interval was $\frac{1}{4}$ Holstein $\times$ $\frac{3}{4}$ Jersey, with 380 days, whereas the lowest performance was observed in $\frac{3}{4}$ Holstein $\times$ $\frac{1}{4}$ BON, with 412 days ($P = 0.06$). Milk protein and fat percentages were 4.25 and 3.25 for $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ BON, and 4.11 and 3.07 for $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ Jersey. **Conclusion:** Crossbreeding with BON showed competitive performance when compared with cow crossbred with Jersey, a breed specialized in milk production. This competitiveness may be further enhanced when considering parameters associated with resistance and adaptability; however, this analysis should be conducted in future studies.

Keywords: BON, crossbreeding, dairy production, reproduction

Palabras clave: BON, cruzamiento, producción lechera, reproducción

Price of Milk from Holstein, BON, and Jersey Crossbred Cows in a Herd in Antioquia Precio de la leche de vacas cruzadas Holstein, Bon y Jersey en un hato antioqueño

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Introduction: Milk fat and protein percentages are currently the compositional parameters that have the greatest influence on the payment made by most milk purchasing companies. The Holstein breed is recognized for its high milk yield, but also for its relatively low values in compositional parameters. In contrast, the Jersey breed is known for its high performance in milk composition. The Blanco Orejinegro (BON) is a breed for which fewer studies exist regarding its performance in milk composition. **Objective:** To compare the performance of pure Holstein cows with crossbred cows (Holstein $\times$ BON and Holstein $\times$ Jersey) in terms of milk composition and the price obtained from milk sales. **Methods:** Data from 77 cows and 405 milk recordings (a.m. and p.m.) were analyzed using linear models to determine production and milk composition

parameters such as total volume, protein percentage, fat percentage, protein yield, and fat yield. Based on this information, a projected sale price was estimated according to the payment parameters established by the dairy company purchasing the milk at the time of the study. **Results and Discussion:** The crossbred with the best compositional performance was $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ BON, with 4.25% fat and 3.25% protein, and daily yields of 990 g and 760 g for fat and protein, respectively. This performance resulted in a payment of \$2,133 per liter, derived solely from these parameters. The price obtained for milk from pure Holstein and Jersey cows was \$1,868 and \$2,047 per liter, respectively, corresponding to fat percentages of 3.69 and 4.67%, and protein percentages of 3.02 and 3.11%. The $\frac{1}{2}$ Holstein $\times$ $\frac{1}{2}$ Jersey crossbred cows had fat and protein percentages of 4.11 and 3.07%, respectively, resulting in a payment of \$1,958 per liter. **Conclusion:** Crossbreeding with BON showed the highest performance in terms of milk price. Crossbreeding with Jersey also demonstrated an important improvement compared to pure breeds.

Keywords: Composition, crossbreeding, dairy yield

Palabras clave: Composición, cruzamiento, rendimiento lechero

Effect of Management System on Body Weight at Different Ages in Buffalo Under Tropical Conditions Efecto del sistema de manejo sobre el peso corporal a diferentes edades en bovinos bajo condiciones tropicales

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Introduction: Body growth in buffalo is influenced by environmental, management, and production factors that determine the efficiency of the system. **Justification:** In the Colombian low tropics, under grazing conditions on native grasses and humidicola grass (*Urochloa/Brachiaria humidicola*) in Planeta Rica (Córdoba), it is necessary to quantify the effect of management practices on the growth trajectory in order to optimize technical decision-making. **Objective:** To evaluate the effect of two management systems (1: full milk production; 2: milking or dual-purpose) on body weight from birth to 24 months of age, stratified by sex. **Methods:** Production records corresponding to the events of birth weight (bw, $n \approx 22,753$), weight at four months

(w4months, $n \approx 4,254$), weaning weight (ww, $n \approx 17,268$), weight at twelve months (w12months, $n \approx 13,309$), weight at eighteen months (w18months, $n \approx 8,576$), and (w24months, $n \approx 7,791$) were analyzed. The data were analyzed using linear mixed models with repeated measures to evaluate the effect of the management system on the growth trajectory from birth to 24 months of age. The R software was used.

Results and Discussion: WW was similar between systems and sexes (35–36 kg). However, from 4 months onwards, significant differences ($P < 0.05$) were observed in favor of management 1: females 139 ± 24 vs 100 ± 19 kg and males 142 ± 25 vs 100 ± 18 kg (management 1 vs 2). At WW, females weighed 257 ± 38 vs 172 ± 28 kg and males 269 ± 41 vs 181 ± 30 kg. At W12months, females reached 275 ± 39 vs 201 ± 33 kg and males 292 ± 43 vs 210 ± 32 kg. At W18 months, females weighed 327 ± 44 vs 267 ± 49 kg and males 356 ± 48 vs 275 ± 50 kg. Finally, at W24 months, females weighed 395 ± 50 kg vs. 327 ± 51 kg, and males 426 ± 47 kg vs. 341 ± 61 kg. The differences ranged from 60 to 90 kg in post-weaning stages, demonstrating a significant and consistent effect of the management system on growth rate. **Conclusion:** Under tropical grazing conditions, the all-milk system promoted higher growth rates in both sexes, with direct implications for production efficiency and technical planning.

Keywords: Growth performance, live weight, repeated measures

Palabras clave: Crecimiento, peso vivo, medidas repetidas

Factors Affecting Weaning Weight in *Bubalus bubalis* in a Commercial Herd

Factores que afectan el peso al destete en *Bubalus bubalis* en un hato comercial

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Introduction: Weaning weight (WW) is a key indicator of growth and productive performance in buffalo systems, as it integrates genetic and environmental effects. In small herds, the limited availability of records and the low number of births per female make it difficult to apply robust statistical models to identify sources of variation influencing animal performance, requiring statistical approaches tailored to these conditions.

Objective: To identify factors associated with BW in a commercial buffalo herd using a linear model. **Methods:** The study began with a database of 153 individuals with PD, which was refined using biological criteria, such as daily weight gain

(filtering records between $0.2\text{--}0.8$ g day⁻¹ and standardized milk yields to 305 days between 650–1,400 L). An exploration analysis was conducted using descriptive and graphical statistics. Father, sex, weaning season, and lactation ranks (650–800, 800–950, 950–1,100, 1,100–1,250, and 1,250–1,400 L) were considered as fixed effects, restricting the analysis to sires with at least five observations and excluding the maternal effect due to the lack of a sufficient number of dams with multiple recorded births. Linear models were fitted, and the stepwise variable selection procedure was applied using the AIC criterion to identify the sources of variation influencing weaning weight. **Results and Discussion:** The average weaning weight was 143.6 ± 28.8 kg. The models showed low explanatory power (adjusted $R^2 < 0.18$), indicating that the evaluated factors explain only a limited proportion of the phenotypic variation. Model selection highlighted the sire effect as the main source of structured variation. The assumptions of normality and homogeneity of variances were met ($P > 0.05$), validating the model fit. **Conclusion:** Weaning weight in the evaluated herd is primarily influenced by the sire effect and unmodeled factors, although variation associated with the sire effect is evident. It is recommended to increase the number of evaluated records and ensure greater representation of sires with offspring in the herd for the use of mixed models to more accurately estimate the variance components and thereby lay the groundwork for a future genetic improvement program.

Keywords: Data analysis, genetic selection, growth, linear models, mixed models, variability

Palabras clave: Análisis de datos, selección genética, crecimiento, modelos lineales, modelos mixtos, variabilidad

Genealogical Analysis of the Colombian Lucerna Breed Análisis genealógico de la raza Lucerna colombiana

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Introduction: Lucerna is a Colombian synthetic breed originally composed of Hartón del Valle (30%), Milking Shorthorn (30%), and Holstein (40%). Officially recognized in 1983, it is a genetic resource adapted to tropical dairy production. Despite its importance, there are few studies on the productive performance and genetic diversity of the Lucerna breed. **Objectives:** To

characterize the genealogical structure of the population through pedigree analysis, genealogical completeness, inbreeding coefficient, genetic diversity, and effective population size. **Methods:** Information was collected from founding herds of the breed located in the municipalities of Bugalagrande and El Cerrito (Valle del Cauca). The genealogical analysis included 9,526 animals registered between 1968 and 2019. The R package Optisel was used to estimate pedigree completeness, proportion of use of different sires, inbreeding, and effective population size. **Results and Discussion:** The pedigree spanned 14 generations with a generation interval of 5 years. Mean pedigree completeness was 48%, with a decrease in recent generations. The pedigree included 8,625 females and 897 males; 292 sires had an average of 20.9 offspring, and the 10 most frequently used sires accounted for 20.96% of the progeny. Additionally, 4,507 dams had an average of 1.76 offspring, and the 10 most frequently used dams contributed 1.01%. Average inbreeding was 0.52%, with a significant increase in recent years ($\beta = 0.05\%$; $P < 0.001$) and differences between sexes (0.55% for females vs. 0.29% for males, $P < 0.001$). Estimated genetic diversity was high (99.69%), whereas the estimated effective population size was 322, although it decreased to 117 per equivalent generation and 75–95 in recent real generations. An imbalance in the use of males and females was observed, which is associated with the higher inbreeding observed in females, the progressive increase in inbreeding, and the recent decrease in effective population size. However, the low average inbreeding and effective population size indicates important genetic diversity. This variability can be exploited in tropical dairy genetic improvement programs. **Conclusion:** The breed maintains genetic variability; however, directed mating strategies are required to control the increase in inbreeding.

Keywords: Creole cattle, diversity, inbreeding, pedigree

Palabras clave: Ganado criollo, diversidad, endogamia, pedigrí

Comparative Evaluation of Productive Performance Between Brahman, Nelore and Chino Santandereano Under Tropical Conditions (Santander, Colombia) Evaluación comparativa de variables de crecimiento entre Brahmán, Nelore y Chino Santandereano en condiciones tropicales (Santander, Colombia)

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Introduction: Livestock production efficiency in the tropics

depends on genetic adaptation to thermal stress and sanitary challenges. Genetic improvement and hybrid vigor are the pillars of sustainable systems. **Objective:** To evaluate growth variables in Brahman (B), Nelore (N), and Chino Santandereano (ChS) breeds, as well as their crosses, by analyzing key growth metrics in the department of Santander. **Methods:** A descriptive-comparative study was conducted over the same period. Since animals of different ages were used, age adjustments were performed. The cattle were kept under identical grazing conditions without supplementation and were raised between January and June. A total of 30 individuals were selected and divided into five groups: Brahman ($n = 11$; 6 males, 5 females), Brahman x Simbrah ($n = 4$; 2 males, 2 females), Brahman x Nelore ($n = 4$; 2 males, 2 females), Nelore ($n = 5$; 2 males, 3 females), and Chino Santandereano ($n = 6$; 4 males, 2 females). Birth weights (BW), adjusted weaning weights (205 days), and average daily gain (ADG) were recorded. Data were analyzed using ANOVA and Student's t-test for inter-breed comparisons. **Results and Discussion:** The ANOVA analysis revealed significant differences in BW between breeds ($P = 0.018$). The highest birth weights were observed in Brahman (25.64 kg, SD: 2.2 kg) and Chino Santandereano (25.0 kg, SD: 1.8 kg). The Brahman x Nelore cross presented the lowest average (21.33 kg, SD: 2.15 kg). In the postnatal performance of males, the Chino Santandereano breed showed superiority ($P < 0.05$) compared to Brahman. ChS males reached an adjusted weaning weight of 247.47 kg (SD: 4 kg), surpassing Brahman males (210.39 kg, SD: 3.5 kg) by 37 kg. This efficiency is reflected in the ADG, where Chino Santandereano led with 1.08 kg day⁻¹, followed by Nelore (1.02 kg day⁻¹) and Brahman (0.90 kg day⁻¹). **Conclusion:** The native Chino Santandereano breed demonstrates weight gain growth that is comparable to the values found in specialized Zebu breeds under the same management conditions.

Keywords: Adaptation, bovine, development, efficiency, vigor
Palabras clave: Adaptación, bovino, desarrollo, eficiencia, vigor

Comparison of two selection indices for a cattle herd in Colombia Comparación de dos índices de selección para una ganadería en Colombia

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Introduction: The selection index (SI) is calculated to identify genetically superior animals for multiple traits, enabling a

more balanced selection. The cow index (Cowl) measures productivity by combining maternal ability and reproductive efficiency. **Objective:** To compare two SIs in a Brahman cattle herd, with and without the inclusion of Cowl. **Methods:** Phenotypic records collected between 1985 and 2023 from a cattle operation with herds located in the departments of Antioquia and Córdoba were used, comprising 13,288 animals and a pedigree of 25,931 individuals. Cowl is calculated as the ratio between calf weaning weight and the cow's calving interval (CI). Genetic parameters and breeding values were estimated for growth and reproductive traits including CI, age at first calving (AFC), and Cowl using a single-trait animal model in WOMBAT. The SI was calculated through principal component analysis (PCA) of estimated breeding values (EBVs). SI1 included birth weight (BW), weaning weight (WW), weights at twelve (W12), eighteen (W18), and twenty-four months (W24), CI, and AFC; SI2 included BW, W12, W18, W24, Cowl, and AFC. The best SI was determined based on biological interpretation, Spearman rank correlation, and expected genetic progress (GP). **Results and Discussion:** SI1 comprises three principal components (PCs): PC1 included WW, W12, and W24; PC2 included BW and W18; PC3 included CI and AFC, explaining 39.08, 18.00, and 11.28% of total variance (TV), respectively. In SI2, PC1 included W12, W18, W24, and AFC; PC2 included BW; PC3 included Cowl, explaining 39.89, 22.92, and 12.77% of TV, respectively. The rank correlation between SIs was 97.58%, and GP was similar between both. SI1 yielded gains of 0.27, 4.75, 8.95, 8.67, and 10.10 kg for BW, WW, W12, W18, and W24, respectively, and 2.50 and -7.87 days for CI and AFC. SI2 yielded gains of 0.20, 9.56, 8.40, and 10.47 kg for BW, W12, W18, and W24, respectively, -11.75 days for AFC, and 0.06 kg/day for Cowl. **Conclusion:** SI1 is recommended, as it includes simpler traits recorded more frequently in livestock production systems.

Keywords: Animal model, beef cattle, genetic gain, productivity

Palabras clave: Modelo animal, bovinos de carne, progreso genético, productividad

The Effect of Imputation Using Neural Networks on Genetic Evaluation of Growth in Brahman Cattle Efecto de la imputación con redes neuronales en la evaluación genética del crecimiento en Brahman

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Introduction: The lack of complete phenotypic records limits the accuracy of genetic evaluations in cattle. Data imputation using artificial intelligence can increase data availability and improve the quality of genetic predictions.

Objective: To evaluate the effect of weight imputation using a neural network on the genetic evaluation of weight at 7, 12, and 18 months in Brahman cattle. **Methods:** A total of 33,289 weight records (2003–2020) from birth to 24 months were used to train a neural network model, along with information on sex, season and year of weighing, conception method, parity, and age. Categorical variables were encoded as dummies, and a pedigree relationship matrix including 35,672 animals was incorporated. In Python, a multilayer neural network (200, 100, 50, 50, 50, and 30 neurons; ReLU; Adam) was trained using an 80/20 split, achieving an RMSE of 29.54 kg, MAE of 21.12 kg, R^2 of 0.907, and a correlation of 0.953 for weight prediction across the growth trajectory. Subsequently, in R, datasets were constructed for weight at 7 (P7M; $n = 3,968$), 12 (P12M; $n = 2,529$), and 18 months (P18M; $n = 3,523$), randomly replacing 20 and 50% of observed weights (simulating missing data) with imputed values. Mixed linear models, Type III ANOVA, and genetic evaluations were performed in Wombat, comparing heritability, residual variance, AIC, and ranking correlations.

Results and Discussion: Imputation increased direct heritability (P7M: 0.286–0.536; P12M: 0.322–0.674; P18M: 0.522–0.747) and reduced residual variance (P7M: 0.65–0.36; P12M: 0.68–0.33; P18M: 0.48–0.25). The reliability of breeding values increased from ~0.35–0.40 to ~0.45–0.50. Ranking correlations for direct genetic effects remained high but decreased with increasing imputation (P7M: 0.95–0.73; P12M: 0.96–0.80; P18M: 0.98–0.88), showing greater stability for P12M and P18M. Maternal genetic effects for P7M showed lower consistency (–0.75 to 0.94). **Conclusion:** Imputation increases data availability and improves the accuracy of genetic evaluations. Although it introduces changes in ranking, these are moderate, supporting its use to increase the number of phenotypes without substantially affecting decision-making.

Keywords: Artificial intelligence, kinship, prediction, ranking correlation

Palabras clave: Inteligencia artificial, parentesco, predicción, correlación de ranking

NUTRICIÓN Y ALIMENTACIÓN

Assessment of Providing Different Levels of Crude Protein for Grazing Beef Calves Evaluación del ofrecimiento de diferentes niveles de proteína bruta para terneros de carne en pastoreo

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Introduction: grazing animals fed low-quality forage may respond to increased dietary protein levels. **Objective:** to evaluate the productive and economic performance of Nelore calves during the pre-weaning phase supplemented with different crude protein (CP) concentrations under grazing conditions. **Methods:** 40 Nelore calves were used, with an initial average body weight and age of 119±5.69 kg and 3±0.1 months, distributed in a completely randomized design with four treatments: control, receiving a mineral mix; T25, receiving a supplement with 25% CP; T30, receiving a supplement with 30% CP; and T35, receiving a supplement with 35% CP. The supplements were formulated from soybean meals, ground corn grain, and mineral mix, and were offered daily at 0.5 kg per animal. The animals were managed in four 10-hectare paddocks with *Brachiaria decumbens*. The results were subjected to ANOVA and decomposition by orthogonal contrasts (control vs supplemented; linear and quadratic effects of CP level). Significant differences were considered at $P<0.10$. **Results and Discussion:** an effect ($P<0.10$) of supplementation on animal performance was observed, where supplemented calves showed higher body weight (216.0 vs 200.3 kg) and average daily gain (0.807 vs 0.699 g day⁻¹) compared to non-supplemented calves. No effect of CP level in the supplement on productive-economic performance was observed ($P>0.10$). The performance difference between supplemented and non-supplemented animals occurred due to an average intake of 221.6 g day⁻¹ of supplement at an average cost of 0.10 USD kg⁻¹. This favored supplementation economically, since the feeding cost was lower than the value of the increase in weight gain during the period, with net margins (USD) of 24.99, 24.34, 26.44, and 25.79 for the control, T25, T30, and T35 treatments, respectively, obtained

over the 5 months of evaluation. **Conclusion:** creep-feeding supplementation improves the performance of Nelore calves during the pre-weaning phase; the use of supplements with 30% CP is recommended due to its better productive-economic balance.

Keywords: *Brachiaria decumbens*, performance, profitability, supplementation

Palabras clave: *Brachiaria decumbens*, desempeño, rentabilidad, suplementación

Synergistic Effect of Perennial Ryegrass and Clover Mixtures on Ruminal Degradability Efecto sinérgico de las mezclas de raigrás perenne con trébol sobre la degradabilidad ruminal

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Introduction: Livestock production is based on feeding systems that rely on pastures with different levels of quality, species composition, and stages of maturity. **Objective:** The objective of this research was to evaluate the synergistic effect of *Lolium perenne* mixed with *Trifolium repens* or *T. pratense* on the ruminal degradability kinetics of dry matter and crude protein. **Methods:** The research was conducted in Pichincha Province, Ecuador, in the cantons of Mejía (forage mixtures), Quito (laboratory analysis), and Rumiñahui (*in situ* degradability), between December 2022 and June 2023. Two experiments were established: the first with mixtures of ryegrass (R) and white clover (Wc) [(90:10, 80:20, 70:30), 100% R, and 100% Wc], and the second with mixtures of ryegrass (R) and red clover (Rc) [(90:10, 80:20, 70:30), 100% R, and 100% Rc]. Three replicates per treatment were carried out, and each treatment was evaluated at the following incubation times: 0, 4, 8, 12, 16, 24, 36, 48, and 72 hours. A 7-year-old rumen-fistulated Holstein cow was used. Effective degradability and degradation rate were evaluated. The studied variables were ruminal degradability of dry matter (DM) and crude protein (CP). A completely randomized design was used, and mean separation was performed using Tukey's test. **Results and Discussion:** The results indicated that the inclusion of clover in mixtures with perennial ryegrass modifies the chemical composition, increasing CP concentration and decreasing neutral detergent fiber (NDF) and acid detergent fiber (ADF). Differences ($P<0.05$) were observed for DM and CP degradability. In both experiments, the mixture containing 70% ryegrass (R) and 30% clover (C)

showed the highest potential degradability, reaching 90 and 96%, respectively. **Conclusion:** The inclusion of clovers in mixtures with ryegrass improved the overall degradability of the forage mixture. However, the risk of bloating in ruminants increases with higher proportions of clover. Finally, no significant differences were found between the inclusion of white clover and red clover.

Keywords: Fermentation, grass, legumes, livestock, pastures, production

Palabras clave: Fermentación, gramíneas, leguminosas, ganado, pasturas, producción

Probiotic Bacterial Consortia Improve Ruminant Fermentation of *Brachiaria humidicola* in Buffalo Systems

Consortios bacterianos probióticos mejoran la fermentación ruminal de *Brachiaria humidicola* en sistemas bufalinos

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Introduction: Ruminant fermentation determines the efficiency of tropical forage utilization in water buffalo systems, particularly when low-quality pastures are used. The inclusion of ruminal probiotics represents a biotechnological strategy to improve forage degradability, optimize microbial fermentation, and reduce enteric methane emissions in tropical livestock systems. **Objective:** To evaluate the effect of different probiotic bacterial consortia on the ruminal degradability and fermentation dynamics of *Brachiaria humidicola* under *in vitro* conditions. **Methods:** A *B. humidicola* forage sourced from tropical water buffalo systems was characterized by proximate analysis, and 15 probiotic treatments were evaluated, consisting of combinations of *Lactobacillus rhamnosus* (a), *Lactiplantibacillus plantarum* (b), *Lactobacillus paracasei* (c), and *Pedococcus acidilactici* (d). Fermentation was assessed through the *in vitro* cumulative gas production technique using ruminal fluid from cannulated buffaloes. Dry matter degradability at 48 h, total gas volume, and methane production at 24 and 48 h were measured. Data were analyzed through descriptive statistics and mean comparisons ($P<0.05$) using R statistical software. **Results and Discussion:** Forage composition showed low protein content (5.8% CP) and high structural fiber (58.4% NDF), typical of low-quality tropical pastures. Probiotic combinations generated

significant differences in dry matter degradability ($P<0.01$). Multispecies consortia treatments showed the highest values, with combinations a+c+d and a+b+c+d standing out at mean degradabilities of 61.4 and 61.5%, respectively, exceeding the control (58.0%). In fermentative terms, total gas volume at 24 h ranged from 98.3 to 102.2 mL, while methane production at 24 h varied between 25.2 and 30.8 mL. Some bacterial combinations reduce methane production without affecting total fermentative activity, suggesting favorable modulation of ruminal microbial metabolism. **Conclusion:** Probiotic consortia based on lactic acid bacteria increase the degradability of *Brachiaria humidicola* under *in vitro* conditions and show potential to improve digestive efficiency and contribute to emission mitigation strategies in water buffalo systems.

Keywords: Bacteria, fermentation, probiotic, rumen, sustainability

Palabras clave: Bacterias, fermentación, probiótico, rumen, sostenibilidad

Isolation and Characterization of Probiotic Microorganisms from Ruminal Fluid of Water Buffalo Calves

Aislamiento y caracterización de microorganismos probióticos del líquido ruminal de bucerros de agua

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Introduction: The ruminal microbiota plays a key role in the nutrition of ruminants such as water buffalo (*Bubalus bubalis*), contributing to fiber digestion and improved feed efficiency. The use of native probiotics may optimize productive performance and promote sustainability in animal production systems, consistent with the principles of precision livestock farming. **Objective:** To isolate and characterize microorganisms with probiotic potential from the ruminal fluid of water buffalo calves, as a basis for the development of a nutritional additive. **Methods:** Sixteen ruminal fluid samples were collected from calves aged 2 to 8 months through rumenocentesis; samples were frozen and transported under cold chain. Serial dilutions in PBS were performed and

plated on MRS medium (*Lactobacillus* sp.) and APD with Bengal rose (*Saccharomyces* sp.), incubated at 35 °C for 48 h under anaerobiosis. Colonies were purified by depletion streaking and selected through biochemical tests: Gram staining, KOH reaction (Gram +), catalase (–), and lactic acid production (MRS with 1 % malachite green). Strains were preserved in 20% glycerol at –70 °C. A descriptive analysis was conducted, with the calculation of absolute and relative frequencies per sample and morphotype. **Results and Discussion:** A total of 47 strains were isolated: 31 bacteria compatible with *Lactobacillus* sp. (Gram + bacilli, catalase –, lactic acid producers), among which one atypical strain (5184-2 C) was identified that produced only lactic acid without displaying the other typical traits; and 16 yeasts compatible with *Saccharomyces* sp. (elliptical or globose spores, catalase +), two of which also showed lactic acid production. Sample 5078-6 contributed 29% of the isolated strains, followed by sample 5124-2 (12%). Four samples did not develop microorganisms of interest. These findings are consistent with previous reports on ruminal microbiota in ruminants and highlight the probiotic potential of the isolated strains to improve ruminal fermentation and nutrient absorption, although molecular identification is required for taxonomic confirmation. **Conclusion:** The preliminary isolation identifies promising strains for the development of probiotic prototypes and contributes to the design of sustainable nutrition strategies in tropical water buffalo systems.

Keywords: Additive, anaerobiosis, fermentation, *Lactobacillus*, ruminants, *Saccharomyces*

Palabras clave: Aditivo, anaerobiosis, fermentación, *Lactobacillus*, ruminantes, *Saccharomyces*

Determination of Particle Size in Corn Stover for Cattle Feed in the Highlands of Jalisco Determinación del tamaño de partícula en rastrojos de maíz para la alimentación de ganado en Los Altos de Jalisco

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Introduction: In the Los Altos de Jalisco region of Mexico, dairy production systems use corn stover, with or without grain, as part of feeding systems. Particle size is a key physical characteristic of corn stover, as it influences chewing, rumination, and saliva production. **Objective:** To determine the particle size of corn stover used in cattle feed in dairy farms in Los Altos de Jalisco, Mexico. **Methods:** A random sampling was conducted in different production units in the

Altos Sur region of Jalisco, where 14 samples of corn stover were collected. Particle size was evaluated in triplicate with the Penn State Particle Separator, which consists of three sieves (19, 8, and 4 mm) and a bottom tray. A completely randomized design with factorial arrangement was used; the percentages retained on each sieve were transformed using the arcsine method. An analysis of variance and a Tukey test for mean separation were performed using the SAS statistical package (v9.0). **Results and Discussion:** Significant differences ($P<0.05$) were observed among production units and highly significant differences ($P<0.01$) among sieves. The highest percentages of particle retention were observed in the 4 mm sieve and the bottom tray, with 54.52 and 25.81%, respectively. This particle size limits the amount of physically effective fiber, reduces rumination, and compromises saliva production, thus increasing the risk of a drop in ruminal pH. **Conclusion:** The corn stover used in dairy farms showed high variability in particle size and, for the most part, does not meet the recommended ranges for effective fiber, which can affect the productive performance of the cattle.

Keywords: Milk, nutrition, production systems

Palabras clave: Leche, nutrición, sistemas de producción

Effectiveness of Natural Rooting Agents in Asexual Propagation Golden Butter (*Tithonia diversifolia*) Municipality of Villavicencio

Efectividad de enraizadores naturales en propagación asexual botón de oro (*Tithonia diversifolia*) municipio de Villavicencio

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Introduction: The asexual propagation of Mexican sunflower (*Tithonia diversifolia*) presents limitations in rooting and survival of cuttings, affecting its availability as a forage and agroecological resource. Given this problem, the use of natural rooting agents is evaluated as a sustainable, economical, and efficient alternative to improve its establishment and production under local conditions. **Objective:** To evaluate the effectiveness of four natural rooting agents for the asexual propagation of Mexican sunflower (*Tithonia diversifolia*) in the nursery at the University of Los Llanos farm. **Methods:** Mexican sunflower (*Tithonia diversifolia*) cuttings were used for asexual propagation in this project. Instead of synthetic hormones, natural rooting agents based on coffee water, cinnamon, coconut, and bean seeds were used, applied at concentrations of 25, 50, 75, and 100% of the extract.

Variables such as root length, height, number of active buds, and percentage of root development were evaluated at 5, 10, 15, 20, 25, and 30 days. **Results and Discussion:** Statistical analyses revealed significant differences between treatments in the percentage of root development, attributable to the action of auxins and gibberellins present in natural extracts. The control group registered 5.01%, while T1 (coffee 25%), T2 (cinnamon 25%), and T3 (bean 25%) showed low values, close to 25%. In contrast, the treatments with coconut water showed the best performance, with T4 (coconut 75%) and T5 (coconut 100%) standing out, achieving up to 85% root development between 10 and 30 days after establishment in the nursery. **Conclusion:** Natural rooting agents significantly influence the root development of the Mexican sunflower (*Tithonia diversifolia*), although not all are equally effective, with some treatments being less efficient than others. The use of coconut water, especially at concentrations of 75 and 100%, proves to be the most effective alternative, promoting higher levels of rooting. This makes it a viable, economical, and sustainable option for propagating this species in nurseries.

Keywords: Auxins, cuttings, gibberellins, natural extracts, nursery, plant survival

Palabras clave: Auxinas, esquejes, giberelinas, extractos naturales, vivero, supervivencia vegetal

Early Ruminal Fluid Transfer in Beef Calves Under Tropical Grazing Conditions Transferencia temprana de fluido ruminal en terneros de carne bajo pastoreo tropical

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Introduction: early rumen colonization determines digestive adaptation and biological efficiency in young ruminants. In tropical cow-calf systems, the transfer of ruminal fluid from highly efficient adult cows could accelerate the establishment of a functional microbiome. **Objective:** to evaluate the effect of early ruminal inoculation on microbial establishment, fermentative activity, and growth of neonatal beef calves. **Methods:** a controlled pilot trial was conducted at the Turipaná Research Center (Córdoba, Colombia) using nine neonatal calves (8 Red Sindhi × CCC and 1 Romosinuano; initial body weight 30.4±4.9 kg) distributed into three

treatments (n = 3): fresh ruminal fluid, reconstituted ruminal pellet, and an uninoculated control. Inoculations began at 15 days of age and animals were followed for approximately 240 days. Ruminal DNA concentration, CH₄ emission, body weight, average daily gain, and morphometric traits were evaluated. Data were analyzed using repeated-measures mixed models including fixed effects of treatment, sampling age, and their interaction with calf as a random effect. **Results and Discussion:** during the pre-ruminal phase, no consistent differences in ruminal DNA were detected. During the post-ruminal phase, inoculated calves showed higher DNA concentrations than the control at intermediate samplings, for example 327.0 and 284.0 vs 197.7 ng μL⁻¹ at ~95 days, and 336.9 and 288.9 vs 185.2 ng μL⁻¹ at ~135 days for fresh, pellet, and control calves, respectively. At the end of the CH₄ monitoring period, fresh and pellet calves reached 2.81 and 2.75 mg min⁻¹ (48.61 and 47.53 g d⁻¹), compared with 1.98 mg min⁻¹ (34.20 g d⁻¹) in control. No significant differences were detected for final body weight (163.3–184.3 kg), average daily gain (0.62–0.69 kg d⁻¹), or morphometric traits. **Conclusion:** early ruminal transfer modulated microbial establishment and ruminal fermentative functionality but did not improve growth; therefore, its main potential lies in early microbial programming.

Keywords: Fermentation, growth, inoculation, microbiome, neonates, programming

Palabras clave: Fermentación, crecimiento, inoculación, microbioma, neonatos, programación

Quantification of Mycotoxins in Corn Stover from Jalisco, Mexico Cuantificación de micotoxinas en rastrojos de maíz de Jalisco, México

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Introduction: Jalisco Highlands are characterized by their high production of bovine milk at the state and national level, so a large amount of corn stubble is used in the cattle diet. Corn stover can serve as a reservoir for filamentous fungi of the genera *Fusarium* and *Aspergillus*; in addition, these microorganisms produce mycotoxins, including fumonisins (FUM), deoxynivalenol (DON), and zearalenone (ZEA), which affect the health and productivity of cattle. **Objective:** To quantify the presence of FUM, DON, and ZEA in corn stover used in the feeding of dairy cows in Jalisco Highlands, Mexico. **Methods:** Presence of mycotoxins were analyzed using ELISA on 76 corn stover samples collected in Jalisco

Highlands between 2017 and 2025, DON ($n = 47$), ZEA ($n = 58$), and FUM ($n = 24$). An analysis of descriptive statistics was performed using the SAS (v9.0) statistical package. **Results and Discussion:** The results showed the presence of at least one mycotoxin in all samples analyzed. The average concentrations were: FUM (1,661 ppb), DON (3,456 ppb), and ZEA (666 ppb), with very wide ranges: FUM (100-7290 ppb), DON (100-5000 ppb), and ZEA (25-1173 ppb). Most samples exceeded the limits permitted by the European Union (EC 915/2023) for animal feed: DON 96%, ZEA 95%, and FUM 42%. The observed concentrations are higher than those reported in studies worldwide, with contents of 505, 95, and 408 ppb for DON, ZEA, and FUM, respectively. **Conclusions:** Corn stover exhibits high positivity and content of mycotoxins, posing a risk to animal health and food safety, since these mycotoxins can be excreted in milk (in a smaller proportion FUM). Monitoring programs and improved management practices are necessary to mitigate these risks.

Keywords: Cattle, corn stover, mycotoxins

Palabras clave: ganado bovino, rastrojo de maíz, micotoxinas

Urea Nitrogen in Milk as an Indicator of Nitrogen use Efficiency and Milk Quality

Nitrógeno ureico en leche como indicador de eficiencia del uso del nitrógeno y calidad láctea

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Introduction: Milk urea nitrogen (MUN) is a widely used indicator for assessing nutritional balance in dairy production systems, enabling the detection of dietary imbalances, inefficiencies in nitrogen utilization, and their implications for livestock productivity and reproduction. **Objective:** To evaluate milk urea nitrogen as an indicator of nitrogen use efficiency and its relationship to milk quality in dairy cattle production systems. **Methods:** A total of 406 milk samples from lactating cows were analyzed, collected from 70 dairy systems in the municipalities of Orito, Villagarzón, and Puerto Asís (Putumayo, Colombia). The MUN and the main milk components (fat, protein, and total solids) were determined using infrared spectroscopy with automated quality control equipment. The relationship between the MUN and the milk components was evaluated using correlation analysis. **Results and Discussion:** MUN had a mean of 9.0 ± 1.15 mg dL⁻¹, ranging from 2.9 to 13.2 mg dL⁻¹. Most samples fell within the optimal range (8–12 mg dL⁻¹) for dairy cows, suggesting an adequate balance between degradable protein and fermentable energy in the diet. The correlation analysis revealed that only the association between MUN and protein

content was statistically significant ($r = 0.467$; $SE = 0.118$; $P = 0.00022$), indicating a consistent relationship between ruminal nitrogen availability and milk protein synthesis. In contrast, although correlations with fat ($r = 0.594$; $SE = 0.107$) and total solids ($r = 0.615$; $SE = 0.105$) showed numerically higher coefficients, these associations were not statistically significant ($P > 0.05$). This behavior could be associated with variations in the energy availability of the diet and in the ruminal energy fermentation processes within the ration.

Conclusion: MUN values were within the optimal reference range, suggesting adequate nutritional balance. The only significant relationship was with milk protein, confirming MUN as a reliable tool for monitoring protein nutrition and improving nitrogen use efficiency in tropical dairy systems.

Keywords: Bovine nutrition, dairy systems, milk quality

Palabras clave: Nutrición bovina, sistemas lecheros, calidad de la leche

Agave tequilana (Weber) Leaves as an alternative feed in animal nutrition

Hojas de Agave tequilana (Weber) como un alimento alternativo en nutrición animal

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Introduction: Between 2019 and 2022, the harvest price of agave reached approximately 1.3 USD per kilogram, leading to an increase in its cultivation and the substitution of traditional crops such as corn, which is a fundamental part of dairy and beef cattle diets. The excessive supply of raw materials in the tequila industry has led some producers to use agave as animal feed without considering its nutritional content. **Objective:** To evaluate the nutritional composition of agave leaves at different stages of maturity (young, intermediate, and mature). **Methods:** Sampling was conducted in five agave plantations with an average age of 3 years. Leaves were collected from the same plant at three stages of maturity: young (~10 months old), intermediate (~20 months old), and mature (~30 months old), and 10 plants per plantation were analyzed for each maturity stage. The design used was a randomized complete block design with three replications. Analysis of variance (ANOVA) and Tukey's test ($P < 0.05$) were performed using the SAS statistical package (v9.0). Samples were chopped and dried in a forced-air oven at 60 °C for 48 h and subsequently ground in a rotor mill with a 1 mm mesh. Ash (CEN), crude fiber (FC), fat (GRA), moisture (HUM), and crude protein (PC) were determined following the official methods established by the AOAC. **Results and**

Discussion: Significant differences ($P<0.05$) were observed for all variables evaluated. The PC, FC, CEN, and HUM content increased with leaf maturity to 6.70, 8.32, and 8.52%; 25.9, 36.6, and 42.1%; 9.63, 13.56, and 17.57%, 4.93, 4.58, and 5.18%, in young, intermediate, and mature, respectively. In contrast, the GRA decreased to 1.56, 1.34, and 0.98%. These results indicate that agave leaves have low nutritional value and high levels of indigestible fiber. **Conclusion:** Agave *tequilana* leaves can be used as a supplementary ingredient in cattle diets owing to their high fiber content and low nutritional value.

Keywords: Agave, fiber, forage

Palabras clave: Agave, fibra, forraje

Isolation and Probiotic Potential of Lactic Acid Bacteria from Human Milk for Animal Use

Aislamiento y potencial probiótico de bacterias ácido-lácticas de leche materna para uso animal

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Introduction: Human breast milk, as well as milk from domestic mammals, constitutes a primary source of early intestinal microbial colonization in neonates and a reservoir of microorganisms with probiotic potential. Given that the mechanisms underlying early microbiota establishment and host-microorganism interactions exhibit functional similarities across species, lactic acid bacteria (LAB) isolated from human milk may represent a reservoir of strains with probiotic properties potentially transferable to animals of productive interest, such as cattle, swine, and small livestock species. **Objective:** To evaluate the probiotic potential of lactic acid bacteria (LAB) isolated from human breast milk as a bioprospecting model for the development of probiotics applicable to nursing animal species and livestock production systems under a One Health approach. **Methods:** Breast milk samples from 20 women from the eastern region of the department of Antioquia (Colombia) were analyzed. Bacterial diversity was assessed using culture-independent techniques, and LAB strains were isolated and evaluated through safety tests, tolerance to gastrointestinal conditions, adhesion capacity, and antimicrobial activity against relevant pathogens. **Results and Discussion:** A high bacterial diversity was observed, with the genera *Streptococcus* and *Staphylococcus* being predominant. A total of 151 LAB strains were isolated, of which four (*Ligilactobacillus salivarius*, *Limosilactobacillus fermentum*, *Pediococcus acidilactici*, and *Pediococcus pentosaceus*) exhibited a remarkable

probiotic profile, characterized by the absence of virulence factors, antibiotic susceptibility, resistance to gastrointestinal conditions, adhesion capacity, and antimicrobial activity against *Escherichia coli*, *Staphylococcus aureus*, *Listeria monocytogenes*, and *Salmonella enterica*. **Conclusion:** From an applied perspective, the methodology employed enables the establishment of robust criteria for the selection of LAB with potential use in animal nutrition (neonatal mammals), where the inclusion of probiotics has demonstrated positive effects on productive efficiency, gut health, and immune response. In livestock production systems, these microorganisms may contribute to improved weight gain, feed conversion, reduction of enteric diseases, optimization of reproductive performance, and decreased antibiotic use, particularly during critical stages such as growth and weaning.

Keywords: Antimicrobial, bioprospecting, microbiota, one health, safety

Palabras clave: Antimicrobiano, bioprospección, microbiota, one health, seguridad

Inhibition of Bacterial Quorum Sensing by Metabolites Produced by Probiotic Bacteria

Inhibición de la comunicación bacteriana empleando metabolitos de bacterias probióticas

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Introduction: Bacterial communication mediated by quorum sensing (QS) enables the coordination of collective responses that depend on cell density through the production and detection of signaling molecules. Interference with these systems, known as quorum quenching (QQ), represents a promising strategy for modulating bacterial behavior without exerting direct selective pressure on bacterial growth. **Objective:** To evaluate the ability of metabolites produced by probiotic bacteria belonging to the genera *Lactobacillus* spp. and *Pediococcus* spp. to interfere with communication systems dependent on acyl-homoserine lactones (AHLs). **Methods:** The biosensor strain *Chromobacterium violaceum* CV026 and the signaling molecules C4-HSL, C6-HSL, and C8-HSL were used. The metabolites evaluated were obtained from cell-free supernatants of *Lactobacillus* spp. and *Pediococcus* spp. cultures, and QS-associated activity was determined by quantifying violacein production. The assays were performed in three independent biological replicates, each with technical triplicates. **Results and Discussion:** The controls induced

with C6-HSL and C8-HSL showed the highest levels of violacein production, whereas C4-HSL generated a lower response. The addition of supernatants from both genera consistently reduced pigment production to values close to the basal level of the biosensor. In the case of *Lactobacillus* spp., this decrease was accompanied by a marked reduction in growth, indicating that the observed effect may involve both interference with signaling and physiological or metabolic alterations in the biosensor. In contrast, the supernatants of *Pediococcus* spp. produced a greater decrease in violacein production than in bacterial growth, particularly in response to C6-HSL and C8-HSL, suggesting a potentially more specific modulatory activity on AHL-dependent QS systems. **Conclusion:** The results provide preliminary evidence of quorum-quenching-like activity in metabolites derived from probiotic bacteria. The differential pattern observed between *Lactobacillus* and *Pediococcus* suggests distinct mechanisms of action. Further studies involving fractionation and chemical characterization are required to identify the compounds responsible and to establish the specificity of their mechanism of action.

Keywords: AHL, *Chromobacterium violaceum* CV026, *Lactobacillus*, *Pediococcus*, probiotic bacteria, Quorum Quenching, Quorum Sensing

Palabras clave: AHL, *Chromobacterium violaceum* CV026, *Lactobacillus*, *Pediococcus*, bacterias probióticas, interrupción del quorum, percepción de quórum

Analysis of the Adoption of Enteric Methane Mitigating Feed Additives in Two Regions of Colombia Análisis de adopción de aditivos alimenticios mitigadores de metano entérico en dos regiones de Colombia

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Introduction: The use of additives is a promising strategy to reduce methane emissions in livestock systems by modulating ruminal fermentation and improving productive efficiency. However, in Colombia, information on their adoption and producer's perceptions of their benefits remain limited. **Objective:** To evaluate the perception and intention to adopt feed additives

in highland livestock systems in the municipalities of San Pedro de los Milagros (SPM, Antioquia) and Tenjo (Cundinamarca). **Methods:** The analysis included a total of 59 producers, with 42.4% of SPM and 57.6% of Tenjo. Events were conducted to disseminate and implement the method "Evaluation of emerging additives to reduce methane emissions in livestock" developed by the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) within the framework of the Global Research Alliance (GRA). Differences between locations in perception variables and future use were assessed using the Mann–Whitney U test, and effect size (r) was calculated to estimate the magnitude of differences using R software. The association between location and current use of additives (yes/no) was evaluated using the chi-square test. **Results and Discussion:** Current use of additives was similar between locations (28 vs. 32.4%; $P = 0.942$). Producers in SPM showed higher perceptions than those in Tenjo in 9 out of 10 evaluated variables (Health, Feed Efficiency, Cost, Environment, Gas Mitigation, current use, and future use at 1, 5, and 10 years), with medians of 5 in SPM compared to values between 2 and 4 in Tenjo ($P < 0.01$). The exception was perception of animal production ($P = 0.491$), where both locations showed similar ratings (median = 5). Effect size ranged from small to moderate ($r = 0.15–0.32$). In Tenjo, intention to use increased progressively over future time horizons (median: current = 3, 1–10 years = 4). **Conclusion:** The use of additives in the evaluated livestock systems remains low, with more favorable perceptions in SPM. Willingness for future use indicates an opportunity to implement technology transfer strategies that promote greater adoption of these mitigation technologies.

Keywords: Disposition, livestock, perception, rumen modulators, sustainability

Palabras clave: Disposición, ganadería, percepción, moduladores ruminales, sostenibilidad

Effects of High-Andean Forage and Metabolite Diversity on *in vitro* Ruminal Fermentation and Methanogenesis Efectos de la diversidad de forrajes y metabolitos altoandinos sobre la fermentación ruminal y metanogénesis *in vitro*

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Introduction: Forage and metabolite diversity influences ruminal fermentation, energy efficiency, gas production, and methanogenesis. Laboratory methods and mathematical modeling enable the characterization of dynamics and interactions, and the prioritization of plant species with the potential to optimize cattle production and reduce enteric emissions. **Objective:** To characterize the nutritional and bioactive diversity of forages from the High-Andean region of Cundinamarca, Colombia, and evaluate their *in vitro* ruminal fermentation, gas production, and methanogenesis using kinetic modeling to select promising materials. **Methods:** A total of 1,318 forage samples were collected from 83 dairy farms of the High-Andean region of Cundinamarca, Colombia. Nutrient composition was determined using near-infrared spectroscopy (NIRS), and secondary metabolites using conventional wet chemistry methods. Clustering methods (K-means, Ward, and DBSCAN) were used to select 200 representative samples from 57 species ($n \geq 3$). *In vitro* fermentation and gas production were performed using an automated ANKOM RF system for 72 h; methane was quantified using a laser detection system (LMD), and substrate digestibility was determined gravimetrically. Total gas and methane production were described using the Gompertz model, and the goodness of fit was evaluated using the coefficient of determination (R^2), the concordance correlation coefficient (CCC), and the root mean square error of prediction (RMSEP). Kinetic parameters and digestibility were compared using one-way ANOVA and Tukey's test ($\alpha=0.05$). Analyses were conducted in R version 4.5.2. **Results and Discussion:** The Gompertz model adequately described the production kinetics of total gas ($R^2=0.97$; CCC = 0.98; RMSEP = 0.71) and methane ($R^2=0.97$; CCC = 0.98; RMSEP = 7.34). Parameterization identified significant differences between forage species and functional groups ($P<0.05$). Species such as *Pinus patula* and *Holcus lanatus* showed distinct profiles associated with their chemical composition. Legumes and herbs exhibited higher fermentation rates. The integrated analysis enabled the prioritization of forage species such as *Tithonia diversifolia*, *Sambucus nigra*, and *Digitalis purpurea* to optimize ruminal fermentation and modulate emissions. **Conclusion:** Forage diversity of the High-Andean region of Cundinamarca offers opportunities to design local feeding strategies. Mathematical modeling provides a robust tool for selecting materials to develop sustainable production systems.

Keywords: Biology, chemistry, gas, modeling, nutrition, quality

Palabras clave: Biología, química, gas, modelamiento, nutrición, calidad

Cornmeal's Water or Whey Rehydration Effect on Insoluble Nitrogen and *in vitro* Dry Matter Digestibility
Efecto de la rehidratación de harina de maíz con agua o suero sobre el nitrógeno insoluble y la digestibilidad *in vitro* de la materia seca

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Introduction: In cattle production systems, corn is the main source of energy due to its high starch content. However, the bioavailability of this carbohydrate in the rumen can be limited by the grain structure, especially by the presence of prolamins surrounding the endosperm, which restrict enzymatic and microbial access to the starch. **Objective:** the objective was to evaluate rehydrating cornmeal with water or whey on the concentration of insoluble nitrogen, crude protein, and *in vitro* dry matter digestibility. **Methods:** Cornmeal to 1 mm was used in a completely randomized 2 × 2 factorial design with an additional control group, with two types of liquid (water or whey) and two rehydration levels (35 and 40%), resulting in five treatments: 1) WA35, rehydrated with water to 35%; 2) WA40, rehydrated with water to 40%; 3) WH35, rehydrated with whey to 35%; 4) WH40, rehydrated with whey to 40% and; 5) Control, cornmeal without water or whey. The cornmeal was homogeneously rehydrated and ensiled in mini-silos for 60 days. Samples were then taken from each mini-silo to estimate the concentrations of dry matter, ash, organic matter (OM), crude protein (CP), ether extract, neutral detergent insoluble fiber (NDF), non-fibrous carbohydrates (NFC), non-protein nitrogen (NPN), true protein (TP), neutral detergent insoluble protein (NDIP), and acid (ADIP). The *in vitro* digestibility of the dry matter (IVDDM) was quantified after a 48-hour incubation in Ankom Daisy^{II} incubator. The results were subjected to ANOVA and orthogonal contrast sum decomposition and significance was considered at $P \leq 0.05$ ($P \leq 0.05$). **Results and Discussion:** No differences ($P>0.05$) were observed between rehydration with water or whey. However, rehydration with water or whey increased ($P<0.05$) the content of OM, CP, NPN, TP, and IVDDM. Conversely, it reduced the levels of ash, NDIP, ADF, ADIP, and hemicellulose. Furthermore, the rehydration level reduced ($P<0.05$) the ADF and ADIP content, which was lower for the 40% treatment. **Conclusion:** Rehydrating cornmeal with water or whey, followed by a 60-day ensiling process, decreases the concentration of neutral detergent insoluble protein and acid detergent insoluble protein, increasing the level of CP and *in vitro* digestibility of dry matter.

Keywords: Cornmeal silage, crude protein, lactic fermentation

Palabras clave: Ensilado de maíz, proteína bruta, fermentación láctica

Potential *In vitro* Methane Emission from Three Food Ingredients

Potencial de emisión de metano *in vitro* de tres ingredientes alimenticios

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Introduction: Estimating methane (CH_4) emission potential is the basis for formulating feed supplements that reduce the capacity to emit this gas. **Justification:** CH_4 is a greenhouse gas with an effect 28 times greater than that of carbon dioxide (CO_2), and it is emitted in significant quantities by domestic cattle. Its reduction by more than 50% is a target established in Colombia for the year 2030, which requires the evaluation and implementation of different strategies such as the formulation of supplements with low methane emission potential. **Objective:** To estimate the *in vitro* CH_4 emission potential of three ingredients used in ruminant diet formulation and their mixtures. **Methods:** Fecal

liquor was prepared from fecal samples of three goats mixed 1:3 with artificial saliva. Sixty milliliters of this liquor were placed into 20 glass bottles, which were randomly assigned to three ingredients (ground corn: GC; soybean meal: SM; and corn distiller's grains: CDG) (4 bottles/ingredient) and two mixtures (50:50) of these ingredients (GC:SM and GC:CDG). One gram per treatment was incubated in a nylon bag in each bottle. The bottles were flushed with CO_2 , sealed with rubber stoppers, and placed in a water bath at 39.5°C for 24 hours. At the end of the incubation period, gas production was measured volumetrically and CH_4 content was determined. The bags containing the residue were removed, and the percentage of degraded dry matter (DDM) was determined. The ingredients were analyzed under a completely randomized design, and the mixtures were evaluated using a quality T-test. **Results and Discussion:** Ground corn showed the highest methane emission potential (98.6 mL DDM^{-1}), whereas corn distillers grains showed the lowest value (10.2 mL DDM^{-1}) ($P < 0.001$). The methane emission potential of the evaluated mixtures did not differ from the estimated values ($P > 0.37$), suggesting that no interaction exists among them. **Conclusion:** The methane emission potential of individual ingredients can be used to formulate optimized supplements with low emissions.

Keywords: Feces, fermentation, foods, formulation

Palabras clave: Heces, fermentación, alimentos, formulación

SALUD PREVENTIVA Y BIOSEGURIDAD ANIMAL

Molecular Frequency of Vector-borne Hemotropic Agents in Ruminants from Different Departments of Colombia Frecuencia molecular de agentes hemotrópicos transmitidos por vectores en rumiantes de diferentes departamentos de Colombia

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Introduction: Hemotropic pathogens are important infectious agents in domestic ruminants and are commonly associated with vector-borne transmission in tropical and subtropical regions such as Colombia. A wide range of these agents can cause diseases that lead to significant economic losses. These infections can be subclinical or have mild to fatal complications, depending on the infectious agent and the host's immune status, and can result in decreased productivity and reproductive disorders, including abortion. **Objective:** Evaluate the frequency of hemopathogens in ruminants using qPCR and determine the association of infection by these agents with different demographic variables. **Methods:** A retrospective study was conducted using databases with results of ruminant samples sent to the TestMol SAS laboratory for molecular diagnosis of hemotropic agents by qPCR during 2024 and 2025. A descriptive and bivariate statistical analysis of the presence of the infection with demographic variables was performed using Jamovi 2.3.21 ($P < 0.05$). **Results and Discussion:** Two hundred and nine (209) records were evaluated, revealing that 91% of individuals were infected, with 62% of the animals being coinfecting. The most frequent agents were *Mycoplasma* spp. (72%) and *Anaplasma* spp. (53%), with the main coinfection being *Mycoplasma* spp. + *Trypanosoma* spp. (25%). Eighty-seven percent (87%) of the positive cases were cattle and eleven percent (11%) were buffalo, of which 68% were female. Antioquia and Caquetá accounted for 44% and 29% of the cases, respectively. The *Bos indicus* breed was the most frequent (36%) among the infected animals, and the age group with the most positive results was adults (43%). Bivariate analysis showed an association between infection with sex and age group variables, and in the case of coinfections, with department, breed, sex, and age group. **Conclusion:** A higher frequency of *Mycoplasma* spp. was observed in monoinfection and in coinfection with *Trypanosoma* spp. Monitoring these pathogens in cattle populations is crucial in the livestock sector, as is strengthening control and prevention strategies

for vector-borne diseases that affect herd health and, consequently, their productivity.

Keywords: Cattle, frequency, hemopathogens, qPCR
Palabras clave: Bovinos, frecuencia, hemopatógenos, qPCR

Role of TNF- α Genetic Variants and Differential Receptor Gene Expression in the Pathogenesis of BLV Variantes genéticas de TNF- α y expresión diferencial de sus receptores en la patogénesis del BLV

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Introduction: Bovine leukemia virus (BLV) is a single-stranded RNA retrovirus whose persistence in infected cattle indicates that innate immune responses, particularly antiviral cytokines, are insufficient to control infection. Tumor necrosis factor alpha (TNF- α) is a key proinflammatory cytokine that may contribute to antiviral defense, acting through two membrane-bound receptors: TNF- α receptor I (TNF- α RI) and TNF- α receptor II (TNF- α RII). Both receptors participate in apoptotic and immune-regulatory pathways. **Objective:** This study aimed to investigate the -824 A/G polymorphism in the promoter region of the TNF- α gene and to quantify TNF- α RI and TNF- α RII transcript levels, assessing their association with proviral load and persistent lymphocytosis (PL) in Holstein cattle. **Methods:** Blood samples from 140 cows were analyzed for TNF- α genotypes and receptor mRNA expression. Data were normalized and analyzed using one-way ANOVA followed by post hoc *t*-tests. **Results and Discussion:** The TNF- α G/G genotype was significantly associated with increased susceptibility to BLV infection, suggesting that this SNP in the promoter region may alter TNF- α expression and host antiviral responses. BLV-positive cows exhibited elevated TNF- α RI transcript levels compared with uninfected controls ($P < 0.0001$), whereas TNF- α RI and RII expression did not differ significantly between aleukemic (AL) and PL-positive animals. Notably, TNF- α RI expression was consistently higher than TNF- α RII in infected cows. No correlation was found between receptor transcript levels and either lymphocyte counts or proviral load. **Conclusion:** These findings suggest that both viral and host genetic factors modulate the progression of BLV infection and that TNF- α signaling may play a pivotal role in disease pathogenesis. Further studies are needed to elucidate the molecular

mechanisms linking TNF- α regulatory polymorphisms and BLV persistence.

Keywords: Cytokine, dairy herds, gene expression, proviral load, SNP

Palabras clave: Citocina, hatos lecheros, expresión génica, carga proviral, SNP

Is Subclinical Mastitis in Specialized Dairy Systems Associated with Bovine Leukemia Virus Infection? ¿La mastitis subclínica en lecherías especializadas se aumenta por la infección con virus de leucosis bovina?

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Introduction: In specialized dairy systems, viral infections such as Bovine Leukosis Virus (BLV) may influence the occurrence of subclinical diseases that compromise productivity. BLV has been associated with immunomodulatory effects that may impair host immune responses, potentially increasing susceptibility to intramammary infections such as subclinical mastitis. **Justification:** Evidence on this association (Bovine Leukosis Virus (BLV) – sub-clinical mastitis) in high-altitude tropical systems in Antioquia, Colombia, remains limited. **Objective:** This study aimed to evaluate the association between BLV and the presence of subclinical mastitis in specialized dairy herds. **Methods:** A cross-sectional study was conducted on 200 cows from 20 herds located in the high-altitude tropics of Antioquia (North, East, and Aburrá Valley), all enrolled in a dairy herd improvement program. Ten animals per herd were randomly selected. Blood samples were collected to determine the BLV serostatus using ELISA. Subclinical mastitis was assessed on the same day using somatic cell count (SCC) by flow cytometry and the California Mastitis Test. Statistical comparisons between seropositive and seronegative animals were performed using inferential analysis. **Results and Discussion:** A significant association was observed between BLV seropositivity and increased SCC ($P=0.00129$). Seropositive cows showed higher SCC values ($571,640 \text{ cells mL}^{-1}$) compared to seronegative animals ($241,800 \text{ cells mL}^{-1}$), indicating a higher likelihood of subclinical mastitis in BLV positive animals. These findings suggest that BLV infection may exert an immunosuppressive effect that increases susceptibility to intramammary infections. **Conclusion:** BLV seropositivity is associated with a significant increase in somatic cell count and with greater susceptibility to

subclinical mastitis. These results highlight the importance of integrating BLV control strategies into udder health and herd management programs in specialized dairy systems.

Keywords: Health, infection, production, susceptibility

Palabras clave: Sanidad, infección, producción, susceptibilidad

Cross-sectional Evidence of Bovine Venereal Pathogens in a Tropical Production System from Putumayo, Colombia

Evidencia transversal de patógenos venéreos bovinos en un sistema de producción tropical del Putumayo, Colombia

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Introduction: Venereal infections may silently affect productive performance and the sustainability of tropical cattle systems. In the department of Putumayo (Colombia), recent epidemiological information on the presence of *Tritrichomonas foetus* and *Campylobacter* spp. is limited, hindering the understanding of regional reproductive sanitary risk. **Objective:** To determine the frequency of *Tritrichomonas foetus* and *Campylobacter* spp. in breeding cattle in order to provide cross-sectional epidemiological evidence on the presence of venereal pathogens in a tropical cattle production system from Putumayo. **Methods:** A cross-sectional study was conducted in 199 breeding cattle, belonging to a tropical production system, recording age, breed type, and diagnostic results for both agents; descriptive analysis and comparative evaluation of demographic variables were performed. **Results and Discussion:** The observed prevalence was 1.01% (95% CI: 0.12–3.59%) for *Tritrichomonas foetus* and 8.04% (95% CI: 4.72–12.64%) for *Campylobacter* spp. Confidence intervals (95%) were calculated using the Wilson method. *Campylobacter*-positive cases were distributed among *Bos indicus*, *Bos taurus*, and crossbred animals, with no evidence of breed predominance. *Tritrichomonas foetus* was detected using culture in commercial InPouch™ TF medium, while *Campylobacter* spp. was isolated through bacteriological culture on selective media under microaerophilic conditions. Descriptive and comparative analyses of demographic variables were performed. Animals positive for *Tritrichomonas foetus* showed a higher mean age, consistent with the described persistence of the agent in adult bulls. These findings demonstrate the presence of venereal pathogens in the evaluated system, suggesting a potential reproductive sanitary risk, although without evidence of active outbreaks. **Conclusion:** This study provides cross-sectional epidemiological evidence on the presence of venereal

pathogens in a regional context. Although the observed frequency does not indicate the presence of active outbreaks, the results highlight the importance of implementing systematic diagnostic surveillance, sanitary control of breeding animals, and targeted reproductive management as key components for risk mitigation and optimization of productive performance in tropical cattle systems. Furthermore, these findings constitute a baseline for the development of longitudinal studies aimed at evaluating transmission dynamics and their actual impact on reproductive indicators.

Keywords: Diagnosis, epidemiology, health, livestock, prevalence, reproduction

Palabras clave: Diagnóstico, epidemiología, sanidad, ganadería, prevalencia, reproducción

Factors that Affect the Quality and Safety of Bovine Milk in Municipalities of Cesar

Factores que afectan la calidad e inocuidad de la leche bovina en municipios del departamento de Cesar

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Introduction: The quality of bovine milk may be conditioned by various factors, some of them difficult to quantify; among the most common are poor milking practices. The correct application of procedures, hygienic habits, and technical controls before, during, and after milking directly influences

the prevention of diseases and the preservation of the physicochemical and microbiological characteristics of milk. On the other hand, milk production in Cesar constitutes a fundamental axis for the regional economy and food security. Evaluating the degree of knowledge and application of Good Milking Practices (GMP) by cattle farmers makes it possible to identify gaps and to guide training, infrastructure, and sanitary control strategies, in order to guarantee safety and improve the competitiveness of the sector. **Objective:** To diagnose the factors that affect the quality and safety of bovine milk produced in municipalities of the department of Cesar. **Methods:** Observational, cross-sectional, and descriptive-analytical study, based on a survey. For this purpose, 312 cattle farmers were selected through non-probabilistic sampling. The instrument was oriented toward identifying milking practices, hygienic-sanitary management, infrastructure, mastitis prevention, and storage conditions. **Results and Discussion:** 50.8% of the surveyed cattle farmers stated that they have knowledge of GMP; 37.8% expressed interest in improving the infrastructure of their milking pens, and 40.5% indicated carrying out the washing of the udder and teats with clean water. These results reflect a growing concern for animal welfare, milk quality, and the prevention of subclinical mastitis. However, it was evidenced that 87% of producers perform mastitis tests only when they suspect the disease, which represents a risk both for the animal and for the consumer, since it is not possible to timely control subclinical infection. The discussion suggests that, although there is awareness of GMP, limitations still persist in the systematic implementation of preventive practices and sanitary control. **Conclusion:** The findings highlight the need to strengthen training and infrastructure in order to guarantee safety and improve productivity in cattle farming systems in Cesar.

Keywords: Animal welfare, good milking practices

Palabras clave: Bienestar animal, buenas prácticas de ordeño

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Climatic Conditions Affecting Milk Production of Dairy Cows in the Brazilian Cerrado

Condições climáticas que afetam a produção de leite das vacas leiteiras no Cerrado brasileiro

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Introduction: In tropical environments, milk production is constrained by thermal stress, which disrupts physiological homeostasis and necessitates the partitioning of metabolic energy away from lactation to support thermoregulation. Milk production in the Brazilian Cerrado faces increasing challenges due to climate seasonality and high air temperatures. **Objectives:** To evaluate the seasonal variation in milk production of $\square$ Girolando cows reared in an intensive compost-bedded pack barn (CBP) system and a semi-extensive center-pivot grazing (CP) system. **Methods:** Milk yield (MY) data were obtained from a dairy farm located in Morrinhos, Goiás, Brazil, throughout 2025. The annual means for the systems were 37.1 $\pm$ 5.50 kg/cow/day with 84 $\pm$ 58.08 days in milk (DIM) for the CB system, and 26.2 $\pm$ 5.40 kg/cow/day with 211 $\pm$ 124.22 DIM for the CP system. Data were categorized by season according to the Southern Hemisphere: summer (December, January, February), autumn (March, April, May), winter (June, July, August), and spring (September, October, November). Climatic data were extracted from the local meteorological station database, followed by seasonal grouping. Air temperature (t_{air} , °C) and relative humidity (RH, %) were evaluated and integrated using the Temperature-Humidity Index (THI). Seasonal milk yield means were compared using the Scott Knott test ($\alpha = 0.05$) in a randomized complete block design, performed with R® software. **Results and Discussion:** The maximum recorded THI was 87 in November, with a minimum of 44 in August. THI values above 74 represent an alert threshold for milk yield and animal welfare. Spring production was highest ($P < 0.001$), followed by winter and autumn seasons. MY was lowest in summer due to the increased prevalence of high-THI days. Results indicate that 5/8 Girolando yields varied in both

systems—regardless of the different DIM and the controlled microclimate of the CB. **Conclusion:** These data serve as a guide for selecting climate-resilient animals and offer a regionalized framework for improving farm management and informing public policy.

Keywords: Animal welfare, climate change, heat stress, seasonality, tropical climate

Palabras clave: Bienestar animal, cambio climático, estrés por calor, estacionalidad, clima tropical

Thermal Environment of Compost Barn Facilities for Dairy Cows Under Climate Change Scenarios in Brazil Ambiente térmico de instalações tipo Compost Barn para vacas leiteiras sob cenários de mudança climática no Brasil

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Introduction: Milk production in tropical regions is strongly constrained by thermal stress, which adversely affects animal welfare and productive efficiency, which is expected to intensify under climate change. **Objectives:** Evaluate Compost-bedded pack barn (CBP) facilities for dairy cows in tropical conditions, considering the internal microclimate and the current and future impacts of heat stress on animal welfare and milk production. **Methods:** The study was conducted on a dairy farm in Gameleira de Goiás, Brasil, using a CBP housing lactating Holstein cows. Air temperature and relative humidity were measured on a regular spatial grid during morning and afternoon periods. The Temperature-Humidity Index (THI) was calculated, and spatial maps were generated to identify heat stress zones. Future climate impacts were assessed using dynamically downscaled projections from the Eta regional climate model under the RCP4.5 scenario, estimating changes in the frequency of extreme THI events and their potential effects on animal welfare and milk production. **Discussion and Results:** The results revealed pronounced spatial heterogeneity of the internal microclimate, with THI values frequently exceeding the critical threshold, particularly during the afternoon, indicating heat stress and

insufficient ventilation in specific areas of the facility. Thermal maps highlighted localized zones of thermal discomfort, under mechanical ventilation. Climate projections indicated a substantial increase in the frequency of days with extreme THI, which is expected to intensify heat stress, compromise animal welfare, and result in milk production losses. **Conclusion:** These findings suggest that, under tropical conditions and future climate scenarios, current CBP designs and management practices may require adaptive strategies to ensure dairy production. Although the CBP system shows potential in tropical regions, thermal heterogeneity and the projected increase in extreme THI highlight the need for adaptive strategies to ensure animal welfare and milk production under climate change.

Keyword: Heat stress, livestock, microclimate, THI, welfare

Palabras clave: Estrés por calor, ganado, microclima, THI, bienestar

Oxidative Stability and Fatty Acid Profile in Grass-fed Beef, Grain Fed Beef, and Other Meats

Estabilidad oxidativa y perfil de ácidos grasos en res grass-fed, grain-fed y otras carnes

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Introduction: The growing global interest in sustainable livestock systems has positioned grass-fed certification as a key quality differentiator, supported by scientific evidence on its nutritional benefits (Daley et al. 2010). **Justification and Objective.** This study, part of the SATREPS project in Colombia in cooperation with the Government of Japan, preliminarily validated the differential advantages of beef covered under the Colombian Grass-fed seal—an initiative by FEDEGAN-FEP and ProColombia—through the evaluation of physicochemical parameters and oxidative stability, comparing it with meats from other systems and species. **Methodology:** The samples of buffalo loin, pork loin, pork top sirloin cap, grass-fed beef top sirloin cap (Brahman), and imported grain-fed beef top sirloin cap were analyzed, obtained under retail conditions or directly from the slaughterhouse. pH, color (Chroma), MDA (lipid oxidation), and the complete fatty acid profile were determined. For statistical analysis, one-way ANOVA with multiple comparisons using the Tukey-Kramer test ($\alpha = 0.05$) was performed. **Results:** showed significant differences in color (Chroma: $P < 0.0001$), where Grass-fed beef presented the most intense color (29.74); in pH ($P = 0.0077$: 5.50); and in lipid oxidation (MDA: $P < 0.0001$), where Grass-fed beef showed significantly lower levels

(0.11 mg kg⁻¹) compared to grain-fed beef (0.68 mg kg⁻¹), demonstrating superior oxidative stability that translates into longer shelf life. In the fatty acid profile, significant differences ($P < 0.05$) were found in bioactive compounds: grass-fed beef showed higher content of CLA (0.63 g 100 g⁻¹ fat), DPA (C22:5 n-3: 0.44 g 100 g⁻¹ fat), and alpha-linolenic acid (C18:3 n-3: 0.96 g 100 g⁻¹ fat), with a more balanced n-6/n-3 ratio (2.65), compared to grain-fed beef (14.14). In global lipid quality, pork and chicken exhibited the lowest atherogenicity indices (0.43 and 0.39), while buffalo presented the highest proportion of saturated fatty acids (56.70 g 100 g⁻¹ fat), highlighting Grass-fed beef for its unique bioactive profile. **Conclusion.** Colombian Grass-fed beef possesses differential advantages in oxidative stability (more attractive color) and lipid profile, fundamental for its certification and promotion in premium markets. Ongoing studies are further investigating the dynamics of lipid and myoglobin oxidation in this meat during shelf life.

Keywords: Beef, color, lipid profile, MDA

Palabras clave: Carne de res, color, perfil lipídico, MDA

Impact of Silvopastoral Systems; *Brachiaria humidicola* S. and *Pinus caribaea* M. on Soils of Las Delicias Farm

Impacto de sistemas silvopastoriles; *Brachiaria humidicola* S. y *Pinus caribaea* M. en suelos de finca Las Delicias

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Introduction: Conventional livestock production has generated significant environmental impacts, particularly soil degradation, erosion, and compaction; therefore, these challenges highlight the need to implement Silvopastoral Systems (SPS) as a sustainable strategy to enhance productivity, promote animal welfare, and improve soil quality. **Objective:** In this context, the present study evaluated the influence of an SPS composed of *Pinus caribaea* and *Brachiaria humidicola* on the physicochemical structure of the soil at Las Delicias farm, located in the Guarumo rural area of the District of Barrancabermeja. **Methods:** The research was conducted within an 11-hectare rotational grazing system containing nine-year-old pine trees, 31 grazing strips, and a density of 350 trees per hectare arranged in double rows. Methodologically, a random sampling procedure was implemented, collecting three soil samples per system (SPS and *Brachiaria* pasture) during the low-precipitation season in order to compare the systems with respect to the physical variable bulk density (BD) and the chemical variables pH, organic matter (OM), phosphorus (P), potassium (K), calcium

(Ca), magnesium (Mg), and nitrogen (N). **Results and Discussion:** The results indicated that the bulk density in the SPS (Silvopastoral System) was 1.12 g cc^{-1} , slightly higher than that of the pasture system (1.05 g cc^{-1}). Regarding chemical properties, the SPS exhibited higher values for calcium ($0.72 \text{ meq } 100 \text{ cc}^{-1}$), magnesium ($0.12 \text{ meq } 100 \text{ cc}^{-1}$), potassium ($0.06 \text{ meq } 100 \text{ cc}^{-1}$), and phosphorus (5 ppm) compared to the *Brachiaria* monoculture, which recorded 0.62, 0.10, 0.05 meq 100 cc^{-1} , and 2 ppm, respectively. Conversely, the sole pasture system showed slightly higher levels of pH (4.52), organic matter (4.07%), and total nitrogen (0.204%) than the SPS (4.30, 4, and 0.200%, respectively). In both cases, there were no statistically significant differences in the variables between systems. **Conclusion:** A notable numerical disparity was observed, particularly in bulk density and phosphorus levels, suggesting that the integration of arboreal components alters nutrient dynamics and soil physical structure without drastically compromising chemical stability over the medium term under the specific conditions of the Barrancabermeja District.

Keywords: Grass, minerals, pine, silvopastoral, soil

Palabras clave: Gramínea, minerales, pino, silvopastoral, suelo

Carbon Immobilization in Silvopastoral Systems with Buffalo in the Bajo Cauca Antioqueñan Subregion Inmovilización de carbono en silvopastoreo con búfalos en la subregión del Bajo Cauca Antioqueño

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Introduction: silvopastoral systems play an important role in carbon sequestration in soils, aboveground woody biomass, and the root systems of pastures and trees. Silvopastoral systems (SPS) have the potential to immobilize and store carbon in their different compartments, establishing themselves as a viable strategy for climate change mitigation and sustainability in various livestock systems. **Objective:** to estimate organic carbon immobilization in different compartments of a silvopastoral system in the municipality of Cáceres. **Methods:** at the Los Ángeles farm ($7^{\circ}46'23'' \text{ N}$; $75^{\circ}16'20'' \text{ W}$), in a Tropical Humid Forest (bh-T), with an average temperature of 25.8° C and an average annual rainfall of 3,500 mm, in an alley-strip silvopastoral system with *Acacia mangium* and *Tectona grandis* trees planted in a triangular pattern at a distance of three m between trees and 30 m between tree strips, with a density of 342 trees ha^{-1} , with

Urochloa brizantha pasture associated with kudzu (*Pueraria phaseoloides*), established 7 years ago and managed under rotational grazing with dairy buffalo. The treatments were silvopastoral systems (SPS) vs. pasture alone. Four plots (60 m^2) were delimited: rectangular plots for silvopastoral systems (SPS) and circular plots for associated pasture. Soil organic carbon (SOC) was measured at three depths; root carbon (ROC) was measured using an Eijkelkamp Root Auger; and aboveground carbon was estimated using allometric equations. A randomized complete block design (RCBD) with two treatments, four replications, and Tukey's test for mean comparisons was used. **Results and Discussion:** the silvopastoral system with teak had higher ($P<0.05$) soil organic carbon (SOC) compared to acacia and pasture alone (99.9, 87.9, and 85.9 TOC ha^{-1} , respectively). Root carbon (RC) was similar for teak and acacia, and both were higher ($P<0.05$) than pasture alone (5.08, 5.15, and 2.57 TOC ha^{-1} , respectively). Aboveground biomass carbon was higher ($P<0.05$) in acacia (26.5 TOC ha^{-1}) compared to teak (12.5 TOC ha^{-1}). Total carbon immobilization was higher in the acacia (119.6) and teak (117.5) SOC systems compared to pasture alone (88.5 TOC ha^{-1}). **Conclusion:** silvopastoral systems proved to be significantly more efficient in total carbon storage compared to traditional pasture systems without trees.

Keywords: Aboveground carbon, root carbon, soil organic carbon

Palabras clave: Carbono aéreo, carbono en raíces, carbono orgánico del suelo

Composition and Functional Diversity of Fatty Acids in Beef from the Colombian High Tropics Composición y diversidad funcional de ácidos grasos en carne bovina del trópico de altura colombiano

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Introduction: The fatty acid composition of meat determines several attributes associated with product quality and functionality, providing a stronger analytical foundation in the context of pasture-based production systems under tropical conditions. **Objective:** The objective of this study was to analyze the effects of sex, altitude, and animal biotype on the fatty acid composition of four commercial beef cuts under homogeneous grazing conditions in the Colombian highlands. **Methods:** Thirty-eight cattle over three years of age were used, yielding 152 samples from four commercial cuts (biceps femoris, longissimus dorsi, semitendinosus, and shoulder) obtained from farms located between 1,800 and 3,300 meters above sea level (masl) in the Andean region of Colombia.

The animals corresponded to the biotypes *Bos taurus* (T), *Bos indicus* (I), and crossbred (T × I), with sex categories including bulls and steers. Statistical analysis was performed using a Generalized Linear Model, and differences were considered significant at $P < 0.05$. **Results and Discussion:** The results showed that bulls had higher concentrations of polyunsaturated fatty acids (PUFAs) (17.355 vs. 10.969, $P < 0.001$), saturated fatty acids (SFAs) (50.10 vs. 45.32, $P < 0.002$), omega-3 fatty acids (5.54 vs. 3.44, $P < 0.001$), and omega-6 fatty acids (11.81 vs. 7.52, $P < 0.001$) compared to steers. The *B. indicus* biotype showed a higher concentration of beneficial omega-3 fatty acids (linolenic acid: 2.62 vs. 2.00, $P < 0.04$; DHA: 0.69 vs. 0.17, $P < 0.02$). Very high altitude increased monounsaturated fatty acids (42.29 vs. 35.20, $P < 0.008$) and reduced saturated fatty acids (44.32 vs. 50.62, $P < 0.002$). Regarding the cut, the shoulder showed a higher concentration of DHA (0.52 vs. 0.22, $P < 0.043$). **Conclusion:** High-altitude grazing systems produce beef with fatty acid profiles that are beneficial to human health, particularly with an omega-6: omega-3 ratio below 3, especially in *B. indicus* animals and at higher altitudes.

Keywords: Grazing, health, height, omega 3, functionality, quality

Palabras clave: Pastoreo, salud, altura, omega 3, funcionalidad, calidad

Enteric Methane Emission Factor of Holstein Dairy Cows in Antioquia Factor de emisión del metano entérico de vacas Holstein productoras de leche en Antioquia

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Introduction: An enteric methane emission factor (EF) is a measure used to calculate the amount of methane a ruminant expels through its eructation's. EFs with direct measurements (Tier 3) are necessary to reduce inventory uncertainty by avoiding default EF assumptions. **Objective:** To determine the EF in Holstein dairy cows grazing kikuyu grass (*Cenchrus clandestinus*) in the Andean region. **Methods:** Five cows were used, located in Medellín (Santa Elena), at an altitude of 2,200 m, with a temperature of 14.2 °C, annual rainfall of 2,500 mm, and an ecological zone of bh-MB. Descriptive statistics were used with daily measurements over six days. The cows were multiparous Holsteins, with a live weight of 524±48 kg, a lactation period of 110±15 days, and an average milk production of 31.3 L/cow/day. The experimental area was 1.9 ha divided into nine paddocks of 2,111 m² each. Fertilized

(420 kg N; 50 kg P₂O₅ and 180 kg K₂O ha year⁻¹). Grazing management with a mobile electric fence (PO = 1 and PD = 42 days). Forage availability was determined using the double sampling regression technique. Individual intake was quantified using external and internal markers. Supplement (5.5 kg/cow/day). Milk production and compositional quality were measured. Daily CH₄ emissions were measured using the SF₆ technique. SF₆ permeation tubes, with a permeability of 5.4318±0.0426 mg SF₆ day⁻¹, were deployed in the reticulum of the animals. **Results and Discussion:** Forage availability was 3699 kg DM ha⁻¹, with a forage canopy height of 40 cm. Intake under grazing was 16.57±0.72 kg DM/cow/day, with 17.7% CP, 65.7% NDF, 27.4% ADF, 1.98% lignin; 91.28% organic matter; and 67.4% IVDMD. Milk production was 31.6±0.7 L/cow/day, with the following composition: protein (3.32%); fat (3.15%); lactose (4.82%); and MUN (18.42 mg dL⁻¹). Methane emissions were 513.9±98.7 g CH₄/cow/day, with a coefficient of variation of 19.2% (N = 30), an emission efficiency (EF) of 187.5 kg CH₄/cow/year, and an emission efficiency of 16.3 g CH₄ L⁻¹ of milk. **Conclusion:** Determining the EF allows for improved accuracy of the country's enteric methane inventories and provides a baseline for future mitigation programs.

Keywords: Emission efficiency, grazing consumption, SF₆ technique

Palabras clave: Eficiencia emisiones, consumo en pastoreo, técnica SF₆

Seasonal Influence on Physicochemical and Microbiological Parameters of Bovine Milk in the Department of Cesar Influencia estacional en parámetros fisicoquímicos y microbiológicos de la leche bovina en el departamento de Cesar

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Introduction: The quality of bovine milk is influenced by multiple environmental and management factors, among which climatic variations between dry and rainy seasons play a determining role. In regions such as the department of Cesar, characterized by dual-purpose production systems and marked seasonality, it is essential to understand how these conditions affect the physicochemical and microbiological composition of milk. Studying the seasonal influence on milk quality makes it possible to identify patterns associated with feeding and livestock management, providing key information

to improve safety and productivity in dual-purpose bovine systems. **Objective:** To evaluate the seasonal influence on the physicochemical and microbiological parameters of bovine milk produced in the department of Cesar. **Methods:** A total of 1,328 raw milk samples collected between 2014 and 2023 during two seasons (dry and rainy) were analyzed. The samples originated from dual-purpose cattle farms located in various municipalities of Cesar. An exploratory factor analysis was applied to identify patterns of variability and associations among parameters, reducing dimensionality and grouping the most representative variables. Subsequently, a comparison of means was conducted using significance tests (ANOVA and Student's t-test) between the two evaluated seasons, in order to determine significant differences between treatments. **Results and Discussion:** Comparative analyses showed that the rainy season presented greater dispersion in protein, fat, total solids, non-fat solids, lactose, and density values, with statistically significant differences ($P < 0.05$), suggesting a seasonal influence. In contrast, somatic cell count ($P = 0.08$), acidity ($P = 0.08$), and cryoscopy ($P = 0.18$) did not show relevant effects ($P > 0.05$). These findings confirm the impact of climate on milk composition and reveal consistent correlations among several physicochemical parameters. **Conclusion:** Seasonal changes can influence bovine milk composition, mainly due to variations in feeding practices between rainy and dry periods, providing valuable information for production management and quality improvement in dual-purpose livestock systems.

Keywords: Compositional stability, multivariate analysis, quality
Palabras clave: Estabilidad composicional, análisis multivariado, calidad

Effect of Lactation Days on Enteric Methane Emissions in Dual-Purpose Cows Efecto de los días de lactancia en las emisiones de metano entérico en vacas doble propósito

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Introduction: Enteric methane, produced during the digestive process of ruminants, has a much more intense global warming effect than CO₂ in the short term. It accounts for approximately 30% of the increase in global temperature since the pre-industrial era. Reducing these emissions without radically altering the livestock model in extensive systems where animals graze freely is a major challenge for research in tropical conditions. **Objective:** To compare enteric methane emissions from dual-purpose cows grazing tropical forages at different stages of lactation. **Methods:** At

the Porce farm, in the municipality of Cáceres, under Tropical Humid Forest (bh-T) conditions, at an altitude of 1,420 m, with an average temperature of 31 °C and 1,911 mm of annual rainfall, lactating cows of the Girolando genetic cross (Holstein x Gyr, in different proportions) grazed on pastures composed of *Urochloa decumbens* and *Urochloa brizantha*. Two groups of animals were formed (6 cows/group), T1 = 119.6±7.4 and T2 = 241.7±10.8 days of lactation. Daily CH₄ emissions for five days were determined using the SF₆ technique. SF₆ permeation tubes, with permeability rates of 3.2000±0.32753 mg SF₆ day⁻¹, were deployed in the reticulum of the animals 20 days prior to the study. The use of external (Ti₂O₃) and internal (FDNi) markers allows for the estimation of forage consumption. A randomized complete block design was used, with Tukey's test for mean comparison ($\alpha = 0.05$). **Results and Discussion:** Dry matter intake (DM) was higher ($P < 0.05$) in T2 = 13.60±0.25 kg DM/cow/day compared to T1 = 12.24±0.20 kg DM/cow/day. CH₄ emissions were similar for T1 and T2 ($P > 0.05$), with 193.06±57.8 and 173.63±26.8 g CH₄/cow/day, respectively. Methane production efficiency was the same ($P > 0.05$) for T1 = 15.77 and T2 = 12.76 g CH₄ kg⁻¹ DM consumed. **Conclusion:** Lactation length in Girolando dairy cows affects DM intake but not methane emissions under grazing conditions on tropical pastures.

Keywords: Emission production, grazing consumption, SF₆ technique

Palabras clave: Producción de emisiones, consumo en pastoreo, técnica SF₆

Nitrous Oxide Emissions in Feces and Urine by Dual-Purpose Cows in Cáceres Emisiones de óxido nítrico en heces y orina por vacas doble propósito en Cáceres

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Introduction: Nitrous oxide (N₂O) is a greenhouse gas (GHG) with a global warming potential 265 times greater than CO₂ and a long atmospheric lifetime (up to 150 years). The random deposition of urine and feces by cattle on pastures due to daily grazing is a significant source of N₂O in livestock farming in warm climates. **Justification:** Knowing the actual on-farm values of these emissions allows for the design of different mitigation strategies under tropical conditions. **Objective:** To measure N₂O emissions from the urine and feces of dual-purpose cows grazing unfertilized tropical forages. **Methods:** At the Porce farm, in the municipality of Cáceres, under Tropical Humid Forest (bh-T) conditions, at an

altitude of 1,420 m, with an average temperature of 31 °C and 1,911 mm of annual rainfall, lactating Girolando crossbred cows (Holstein x Gyr, in different proportions) grazed on pastures composed of *Urochloa decumbens* and *Urochloa brizantha*. During grazing, fresh feces (500 g) were collected from four different animals, and 0.5 L of urine was collected at milking time. The urine and feces were then placed inside four Static Closed Flow Chambers (25 cm in diameter x 30 cm in height) constructed of PVC (Landcare Research, New Zealand). After sealing, individual samples were taken from the interior of the chambers at 20, 40, and 60 minutes, and at 2, 4, 6, and 24 hours after uniform application of urine and feces to each chamber. Sampling of the N_2O produced inside each chamber was performed using syringes with a volume of 60 cm³, deposited into completely vacuumed vials. The N_2O concentration was measured by gas chromatography with an electron capture detector (ECD). Descriptive statistics were used for data analysis. **Results and Discussion:** On average for the four animals and chambers, the amount of N_2O in urine was 8.37 ± 3.41 kg N_2O /ha/year and in feces 1.17 ± 0.13 kg N_2O /ha/year. This resulted in a total (urine + feces) of 9.54 ± 3.49 kg N_2O /ha/year, equivalent to 2528 ± 925 kg CO_2 eq/ha/year. **Conclusion:** Nitrous oxide emissions from Girolando cows, through urine and feces deposited on the soil as a result of direct grazing on biodiverse pastures in the Lower Cauca region of Antioquia (as a baseline), are high and variable among animals.

Keywords: CO_2 equivalent, GHG in grazing,

Palabras clave: Equivalente de CO_2 , GEI en pastoreo

Carbon immobilization in silvopastoral systems in the Urabá subregion

Inmovilización de carbono en silvopastoreo en la subregión Urabá

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Introduction: Carbon sequestration is frequently used to reduce emissions due to its efficiency in controlling and stabilizing the concentration of greenhouse gases (GHG) in the atmosphere. In silvopastoral systems (SPS), the carbon stored in the soil, through the accumulation of organic matter, is considered the largest carbon reservoir with immense potential for increase over time, as a result of optimal management. **Objective:** To estimate the immobilization of soil organic carbon (SOC) in different compartments of a silvopastoral model in the municipality of Necoclí, in the Urabá region of Antioquia. **Methods:** At the La Cabaña

farm (8°32'41" N; 76°41'58" W), in Tropical Humid Forest (bh-T), altitude 90 meters above sea level (masl), average temperature 24.3 °C, rainfall 3,300 mm year⁻¹, silvopastoral arrangement in alleyways with oak (*Tabebuia rosea*) timber trees, planted in a triangular pattern at a distance of three m between trees in strips 6 m wide and 30 m between strips of trees, with a density of 342 trees ha⁻¹, with *Megathyrus maximus*, cv Mombaza pastures of seven years of age, with rotational management of 6 days PO and 40 PD, in a dual-purpose cattle operation, with an animal carrying capacity (0.9 UGG ha⁻¹). Treatments: SSP vs Pasture alone. Six plots (60 m²) were delimited, rectangular for SSP and circular for the associated pasture. Soil carbon (SCO) was measured at three depths; root carbon (RC) was measured using an Eijkelkamp Root Auger; and aboveground carbon was estimated using allometric equations. A randomized complete block design (RCBD) was used, with two treatments, six replications, and Tukey's test for mean comparisons. **Results and Discussion:** SCO stock was similar ($P > 0.05$) in the silvopastoral system (96.11 TCO ha⁻¹) compared to the pasture alone (81.9 TCO ha⁻¹). RC was higher ($P < 0.05$) for the silvopastoral system with oak trees than for the pasture alone (5.15 and 2.36 TCO ha⁻¹, respectively). Aboveground carbon in tree biomass was 13.13 TCO ha⁻¹. Total carbon immobilization was higher ($P < 0.05$) in the silvopastoral system (114.3 TCO ha⁻¹) compared to the pasture alone (84.3 TCO ha⁻¹). **Conclusion:** SSP with seven-year-old oak trees stores 35.5% more carbon than pastures of Guinea grass alone (*M. maximus*).

Keywords: Root carbon, soil organic carbon, tree aboveground carbon

Palabras clave: Carbono radicular, carbono orgánico del suelo, carbono aéreo de árboles

Evaluation of Fertilization on the Yield and Nutritional Quality of Kikuyu Grass

Evaluación de la fertilización, sobre el rendimiento y calidad nutritiva del pasto kikuyu

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Introduction: The efficient use of fertilizers, resulting in high yields of superior nutritional quality forage from kikuyu grass, points to optimal pasture management and utilization. Inefficient application, indiscriminate use, and application of inappropriate levels of chemical fertilizers contribute to low milk production efficiency, significantly impacting the

productive, economic, and social sustainability of the sector. **Objective:** To evaluate the effect of different types and doses of fertilization based on the balance of main nutrients (N, P and K), on the response in yield and nutritional quality. **Methods:** 1 m² plots with four replications of kikuyu were used in the municipality of San Pedro de los Milagros, at an altitude of 2,550 m, temperature 13.2 °C, precipitation 1,715 mm year⁻¹, ecological zone bh-MB. Nine treatments were tested: T1 = Control, zero fertilization; T2 = 129 kg ha⁻¹ of 31-8-8-2-3; T3 = 194 kg ha⁻¹ of 31-8-8-2-3; T4 = 258 kg ha⁻¹ of 31-8-8-2-3; T5 = 125 kg ha⁻¹ Nitrox-S + 45 kg ha⁻¹ YM Hydrocomplex; T6 = 195 kg ha⁻¹ Nitrox-S + 50 kg ha⁻¹ YM Hydrocomplex; T7 = 250 kg ha⁻¹ Nitrox-S + 90 kg ha⁻¹ YM Hydrocomplex; T8 = 175 kg ha⁻¹ Nitrox-S + 60 kg ha⁻¹ YM Hydrocomplex + 30 kg ha⁻¹ YL Nitabor; T9 = 175 kg ha⁻¹ Nitrox-S + 60 kg ha⁻¹ YM Hydrocomplex + 30 kg ha⁻¹ YL Nitabor + 1.5 L ha⁻¹ YV Zintrac MGB (Foliar). The amounts were applied per cutting, with a 30-day regrowth period. The response variables were forage yield (kg DM ha⁻¹) and nutritional quality. A randomized complete block design was used, with Tukey's test for mean comparisons ($\alpha = 5\%$). **Results and Discussion:** Forage yield was highest ($P < 0.05$) in T9 (3,122 kg DM ha⁻¹) compared to T2 (2,115), T7 (1,922), and T3 (1,870) kg DM ha⁻¹, and these were higher ($P < 0.05$) than T8 (1,548), T4 (1,297), and T5 (1,222) kg DM ha⁻¹. The lowest yields were observed in T1 (774) and T6 (894) kg DM ha⁻¹. Nutritional quality showed crude protein (CP) between 15.1 and 17.6%; neutral detergent fiber (NDF) between 60.2 and 62.0%; and acid detergent fiber (ADF) between 23.2 and 24.5%. Treatment T2 exhibited the best nutritional quality. **Conclusion:** The best treatments are T2 and T9, due to high yields and high nutritional quality.

Keywords: Biomass quantity, chemical composition, complete fertilization

Palabras clave: Cantidad biomasa, composición química, fertilización completa

Characterization of Holstein-Friesian Cattle Production Systems in the Northern Sierra of Ecuador

Caracterización de sistemas de producción de bovinos Holstein Friesian en la Sierra norte de Ecuador

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Introduction: Small-scale milk producers in developing countries lack the skills to manage farms as businesses. There are no studies characterizing cattle production systems registered by breed in Ecuador, except for general studies. **Objective:** To characterize the Holstein Friesian cattle

production systems registered in the northern highlands of Ecuador. **Methods:** A questionnaire consisting of 38 multiple-choice questions was structured and applied to 30 farmers registered with the Holstein-Friesian Association of Ecuador in the provinces of Cotopaxi, Pichincha, and Carchi. The variables were coded using multiple response categories and organized into a categorical data matrix that was entered into the R statistical package. Rare categories with frequencies ≤ 2 observations were recoded as "Others", and quasi-constant variables with frequencies greater than 90% were eliminated, reducing the dataset to 31 active qualitative variables for the application of multiple correspondence analysis, followed by hierarchical cluster analysis using Euclidean distance and the Ward method. **Results and Discussion:** The multiple correspondence analysis determined that five dimensions explain 37.54% of the cumulative variance. The first dimension associated total farm area, pasture area, irrigation system, and forage production; the second dimension related larger pasture area and paddock size, production and purchase of conserved forages, organized calf rearing, and involvement of specialized personnel for artificial insemination; the third dimension linked more efficient reproductive ages and specialized feeding of calves; the fourth dimension addressed the use of reproductive biotechnologies, higher milk production, and the academic level of the producer; and the fifth dimension grouped producer age, paddock management, and use of natural mating. The cluster analysis identified four groups with different levels of technological advancement: high ($n = 11$), medium-high ($n = 7$), medium-low ($n = 8$), and low ($n = 4$). **Conclusion:** The Holstein Friesian production systems in the northern highlands of Ecuador exhibit marked heterogeneity in scale, management, and technological level. The study constitutes an important scientific basis for designing technical assistance strategies, productive improvement, and sustainability of milk production.

Keywords: Cluster analysis, livestock, management, multiple correspondence analysis, reproduction

Palabras clave: Análisis de conglomerados, ganadería, manejo, análisis de correspondencia múltiple, reproducción

Vegetation Index, Precipitation, and Cattle Production and Reproductive Performance Using Sentinel-2 Geospatial Imagery

Índice de vegetación, precipitación y desempeño productivo-reproductivo bovino mediante imágenes de Sentinel-2 geoespaciales

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Introduction: In beef cattle systems, climatic variability and vegetation dynamics determine forage availability and influence productive and reproductive performance. The integration of satellite, climatic, and herd data remains limited, hindering the understanding of temporal relationships between environmental conditions and animal responses. NDVI is widely used; however, it may present saturation in dense vegetation cover. **Objective:** To evaluate the relationship between NDVI, precipitation, and productive and reproductive performance in a Colombian beef cattle system. **Methods:** Data from a farm in Montería, Córdoba, were analyzed. NDVI was derived from Sentinel-2 imagery in Google Earth Engine (2019–2025; ~10–12.5 m resolution; 5-day frequency), applying Scene Classification Layer (SCL) masks to remove clouds and shadows, and aggregating the information at a monthly scale to mitigate cloud cover. Birth weight and weights at 4, 7, 12, 18, and 24 months were evaluated, along with calving interval (CI), age at first calving (AFC), and services per conception (SPC). Exploratory analyses, correlations, and cross-correlation functions (CCF) were performed in R to assess temporal lags. **Results and**

Discussion: NDVI showed marked seasonality (0.25–0.40 in the dry season; 0.70–0.80 in rainy periods; 150–300 mm per month), reflecting forage dynamics. CCF analysis revealed moderate associations and temporal lags. Precipitation showed stronger associations with postnatal weights (lag = -2; $r \approx 0.43$), while NDVI was mainly significant for birth weight (lag = -12; $r \approx 0.27$). Increases in precipitation (>200 mm) and NDVI (~0.75) were associated with weight gains of 15–30 kg at 4 months and 40–60 kg at 7 months. Reproductive variables showed weak associations ($r < 0.25$), although both NDVI and precipitation presented significant relationships at specific lags (-4 to 6 months), indicating cumulative effects. **Conclusion:** The integration of satellite, climatic, and productive data allowed the identification of temporal relationships between environment and animal performance, highlighting delayed climatic effects. Precipitation showed more consistent associations with productive performance, while both NDVI and precipitation were related to reproductive variables.

Keywords: Beef cattle, grazing systems

Palabras clave: Ganado de carne, sistemas en pastoreo

EXTENSIÓN RURAL

Perception of Small Sugarcane Producers Regarding the Use of Their By-Products in Animal Feed Percepción de pequeños productores de caña panelera, sobre uso de sus subproductos en alimentación animal

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Introduction: The sugarcane agroindustry in Colombia operates across much of the country and directly benefits nearly 350,000 families, mostly small and medium-sized producers. Approximately 76% of production consists of byproducts such as bagasse, sugarcane tops, molasses, and cachaza. Sugarcane farming is often integrated with dual-purpose livestock and small ruminants. It is important to develop technologies for the valorization of these byproducts; their potential use in animal feed could be an alternative to strengthen circular economy schemes at the peasant, family, ethnic, and community levels-CFEC. **Objective:** To understand the perceptions of small and medium-sized sugarcane producers regarding the use of these byproducts in livestock feed. **Methods:** In 2025, as part of the project: Agrifood Engagement Plan, implemented by AGROSAVIA, a survey-type data collection instrument was administered, both online and in person, to 106 small and medium-scale producers, 74% of whom were from Boyacá, Santander, and Norte de Santander; in the latter, the survey focused on the Catatumbo region, accounting for 28% of the total participants. The data was organized, and a descriptive and cross-sectional analysis with a quantitative approach was conducted using R (v. 4.3.2; R Core Team-2023). **Results:** It was found that 82% of producers have come to use sugarcane byproducts in animal feed, with bagasse (78%), sugarcane tops (62%), and molasses (60%) being the most readily available, respectively. The livestock species receiving these byproducts as feed supplements are primarily: horses and mules (56%), cattle (40%), and pigs (31%). The different byproducts are mainly supplied fresh (58.5%) or chopped (49.1%), as well as in silage and nutritional blocks (12.3 and 8.5%), respectively. The main obstacle reported in the implementation of technologies for the utilization of sugarcane byproducts in animal feed is a lack of training. 97% of respondents expressed a desire to acquire knowledge in this area. **Conclusion:** the greatest barrier to the incorporation of sugarcane byproducts into animal feed by small and medium-

sized producers in the surveyed sugarcane-growing regions is the limited integration of technologies and knowledge.

Keywords: Circular economy, food security, innovation, PDET territories, sustainable livestock farming

Palabras clave: Economía circular, seguridad alimentaria, innovación, territorios PDET, ganadería sostenible

Standard Costing of Milk Production in Colombia Costeo estándar de producción de leche en Colombia

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Introduction: Calculating production costs is crucial for performance analysis and decision-making in livestock production systems. **Justification:** Knowing the economic outcome of production serves as a basis for farmers to plan and monitor the implementation of technical practices. **Objective:** To estimate the standard production cost per liter of milk in livestock production systems in Colombia. **Methods:** Accounting and production data were collected from 410 dairy farms distributed across the eight departments with the highest milk production volume in Colombia, using stratified sampling by herd size. The standard costing method was applied to estimate the cost per liter of milk in these production systems. **Results and Discussion:** A standard milk production cost structure per cow/year was constructed, including the classification of resources according to accounting designation and identification. Based on the technical information collected, production costs were estimated at market prices. The average standard cost per liter of milk was USD 0.35, with feed, labor, and pasture management representing the most significant costs at 49, 21, and 16%, respectively. Third-party services, including maintenance, electricity, and technical assistance, accounted for 1%. **Conclusion:** although most participating producers have access to technical information, there is low adoption of accounting data calculation and analysis. This situation limits farmers' ability to make informed decisions, hindering the analysis of herd competitiveness, the sustainability of production systems in the market, and the improvement of family finances.

Keywords: Agribusiness, economics, information, knowledge
Palabras clave: Agronegocios, economía, información, conocimiento

SOSTENIBILIDAD

Sustainable Livestock Farming Potential for Climate Action in High-Mountain Territories: The San Félix (Caldas) Case

Potencial de una ganadería sostenible para la acción climática en territorios de alta montaña: el caso de San Félix, Caldas

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Introduction: San Félix, a high mountain district located in the municipality of Salamina (Caldas, Colombia), is a strategic territory due to its water resources, biodiversity, and agrotourism potential. Colonized by people from Antioquia, in the mid-20th century it received a wave of migrants from Cundinamarca and Boyacá who promoted potato cultivation. However, in the 1980s, due to a crisis in production and prices, dairy farming became the main local economic activity. Between 1999 and 2006, San Félix became a territory of armed conflict. Depopulation and traditional dairy production models have led to social and environmental vulnerability.

Objective: To identify the components of a proposal for productive transformation geared towards climate action, linking sustainable livestock farming and agrotourism as synergistic strategies for rural development. **Methods:** Applying the LEADER approach, two territorial laboratories (LABTER) were carried out with the participation of local actors, using participatory methodologies that allowed the perspectives and potential of the territory to be identified. This information was supplemented with secondary sources on land cover and livestock systems. Subsequently, the LifeSim Dairy model was used to simulate methane production in a 38-hectare dairy system with 36 Normande cattle, in a semi-intensive dual-purpose system, with milk production of 7 L/cow/day and very low supplementation. **Results and Discussion:** The results indicate the possibility of producing milk with a lower environmental footprint, promoting a regenerative system with positive emissions balance, through the implementation of a sustainable dairy system based on silvopasture, rational grazing management, protection of water sources, and livestock aqueducts. The analysis, carried out with the participation of local actors, points to a preference for tourism that offers authentic rural experiences, has a low environmental impact, and is in direct contact with local communities. **Conclusion:** The San Félix case illustrates how

livestock farming can be an ally of conservation, contributing to the construction of more sustainable territories. Likewise, the analysis indicates that a sustainable livestock system is a magnet with the potential to position San Félix as a competitive, inclusive, resilient, and sustainable tourist destination.

Keywords: Emissions, heritage, modeling, silvopasture, territory, tourism

Palabras clave: Emisiones, patrimonio, modelación, silvopastoreo, territorio, turismo

Biodiversity, Land Use, and Health Perceptions in a Colombian Livestock Region: A Qualitative Approach

Percepciones sobre biodiversidad, uso del suelo y salud en una región ganadera colombiana: estudio cualitativo

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Introduction: Tropical rural territories are undergoing socio-ecological transformations driven by productive intensification, climate change, and extractive activities, which generate novel interaction dynamics among humans, animals, and ecosystems and favor the emergence of zoonotic and vector-borne diseases. **Objective:** Understanding local perceptions of these transformations is essential to design eco-social interventions and public health prevention strategies grounded in integrated approaches such as One Health. **Methods:** A qualitative study based on grounded theory was conducted at a livestock ranch located in Montelibano, Córdoba (Colombia). Participants included agricultural workers, residents, students, and teachers linked to the territory. Sixteen semi-structured interviews and three focus groups were carried out. Transcripts were coded through open, axial, and selective analysis using ATLAS.ti v.25 software until theoretical saturation was reached. **Results and Discussion:** Community narratives reveal an integrated understanding of the territory in which environmental degradation, agrochemical

use, mining, and land-use change are perceived as factors associated with increased disease incidence. In parallel, sustainability-oriented local practices emerge, including reforestation, reduced hunting, and prudent management of natural resources. However, substantial knowledge gaps persist regarding transmission mechanisms and prevention of zoonotic and vector-borne diseases. Local perceptions reflect a systemic reading of the territory in which human health, animal welfare, and ecosystem functionality are conceived as interdependent dimensions. **Conclusion:** Findings reveal tensions between productive dynamics and socio-ecological health, while also identifying local capacities for adaptation and sustainability. The study provides an interpretive baseline to guide participatory educational interventions and territorial management strategies that integrate scientific knowledge and local knowledge systems, thereby strengthening socio-ecological resilience in tropical livestock systems.

Keywords: Biodiversity, education, perceptions, sustainability, zoonoses

Palabras clave: Biodiversidad, educación, percepciones, sostenibilidad, zoonosis

An Estimate of the Carbon Footprint of Dairy Farms in the Andean Region of Ecuador **Estimación de la huella de carbono de las ganaderías de leche de la zona andina del Ecuador**

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Introduction: The dairy sector is responsible for approximately 3.3% of global greenhouse gas (GHG) emissions; however, it has the potential to play an important role in climate change mitigation through changes in management practices. **Objective:** Therefore, this study aimed to estimate GHG emissions from dairy farms in two provinces of the north-central Andean region of Ecuador. **Methods:** The research was conducted in the provinces of Pichincha and Cotopaxi. In these two provinces, 58% of national milk production is concentrated. A total of 24 dairy farms were sampled and classified as: large farms (semi-stabled system, on average 3.8 AU and 26,132 L milk ha⁻¹ year⁻¹), medium-sized farms (grazing system, on average 1.01 AU and 2,085 L milk ha⁻¹ year⁻¹), and small farms (grazing system, on average 2.1 AU and 7,898 L milk ha⁻¹ year⁻¹). To quantify and analyze emissions, the Cool Farm Tool program was used. The required information was collected through field visits and interviews with producers. Results were analyzed using a completely randomized design and Fisher's parametric test ($P < 0.05$). **Results and Discussion:** Enteric fermentation was

the main source of GHG emissions (5.27 t CO₂-eq ha⁻¹ year⁻¹, 43.39%), followed by feed or forage production (2.86 t CO₂-eq ha⁻¹ year⁻¹, 34.8%) and pasture management (2.35 t CO₂-eq ha⁻¹ year⁻¹, 19.3%). Medium-sized farms emitted the highest amount of emissions per liter of milk produced (2.3 CO₂-eq L⁻¹ milk), which were 50 and 84% higher than those produced by small and large farms, respectively. This was due to low stocking rates and low milk production per unit area, indicating the need to improve productivity and efficiency. **Conclusion:** It is concluded that large dairy farms produce a greater amount of CO₂-eq ha⁻¹ year⁻¹ compared to medium and small farms. However, they are more efficient, as they generate fewer CO₂-eq emissions per liter of milk produced. Finally, small farms produce lower amounts of GHG emissions and show medium efficiency in CO₂-eq per liter of milk.

Keywords: Carbon footprint, dairy farming, greenhouse emissions

Palabras clave: Huella de carbono, producción lechera, emisiones de gases de efecto invernadero

Knowledge Management and Digital Technologies for Sustainable Cattle Extension Services in Colombia

Gestión del conocimiento y tecnologías digitales para servicios de extensión ganadera sostenible en Colombia

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Introduction: Sustainable cattle production requires strengthening producers' capacity to access, interpret, and apply technical-scientific knowledge in decision-making. **Justification:** Conventional extension services show limitations in transforming the effective use of knowledge and promoting the adoption of sustainable practices; therefore, the integration of knowledge management and 4.0 technologies constitute a promising alternative. **Objectives:** To evaluate the effect of an extension service that articulated knowledge management and 4.0 technologies on tacit and explicit knowledge sources, knowledge level, and knowledge use in cattle producers from Cundinamarca, Colombia. **Methods:** A longitudinal before-and-after study with paired measurements was conducted in 68 dairy and beef cattle producers over 12 months. Likert-type surveys were applied at the beginning and end of the intervention, and scores were compared using the Wilcoxon signed-rank test for paired samples. The process included workshops structured on the knowledge creation matrix, following the knowledge spiral at micro, meso, and macro levels, in addition to monthly visits and the use of DJI Mavic Mini 2 drones, RGB spectroscopy, and TaurusWebs®

software for digital pasture analysis and data management. **Results and Discussion:** Explicit knowledge sources increased from 3.10 to 3.82 ($P<0.05$), whereas tacit knowledge sources showed no differences between measurements (4.00 vs 3.91; $P>0.05$). Knowledge level increased from 3.43 to 4.26 ($P<0.05$), and knowledge use from 3.63 to 4.29 ($P<0.05$). In addition, adoption of practices such as pasture rotation at the optimal harvest point, precision fertilization, data recording and analysis, nutritional balancing with minerals and concentrate, and genetic improvement was evidenced.

Conclusion: The integration of knowledge management and 4.0 technologies strengthened the producers' technical-scientific base and promoted decisions and practices aligned with the sustainability of cattle systems.

Keywords: 4.0 technologies, cattle extension services, cattle producers, knowledge management, knowledge use, sustainability

Palabras clave: Tecnologías 4.0, servicios de extensión ganadera, productores ganaderos, gestión del conocimiento, uso del conocimiento, sostenibilidad

Current Status and Outlook for Zootechnics in Colombia: SWOT Analysis by ANZOO Estado actual y proyección de la zootecnia en Colombia: Análisis DOFA desde ANZOO

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Introduction: Colombia faces significant sustainability challenges in livestock production systems, requiring the active involvement of animal science professionals. In this context, the National Association of Animal Scientists (ANZOO), with 16 years of experience, aims to provide advisory and consultative support on issues related to the profession. Given these challenges, it is necessary to develop a strategic diagnosis to understand the current situation and project the future of animal science in the country. ANZOO and its regional chapters provide a key platform for this analysis. **Objective:** To analyze the current status and future

perspectives of animal science in Colombia using a SWOT approach from the ANZOO perspective, identifying strategic factors to strengthen professional practice and contribute to sector sustainability. **Methods:** Data were collected through participatory SWOT matrices developed in virtual meetings with six regional chapters (Boyacá, Antioquia, Santander, Valle del Cauca, Cundinamarca, and Coffee Region). The process included identification, discussion, and prioritization of strengths, weaknesses, opportunities, and threats, integrating regional perspectives into a national sustainability-oriented diagnosis. **Results and Discussion:** A total of 34 strengths, 17 weaknesses, 11 opportunities, and 9 threats were identified. Strengths were mainly related to research (STI) and academic quality, supported by infrastructure, qualified human resources, and efficient management models, with emphasis on inclusion and sustainability. Key weaknesses included limited linkage with the productive sector, gaps in teaching capacities and internationalization, and lag in digital transformation. Opportunities focused on internationalization, relevant academic programs, virtual education, and access to funding. Main threats included economic uncertainty, rapid technological changes, and global risks. **Conclusion:** The methodology provided key inputs for strengthening ANZOO and its mission. Although animal science in Colombia has strong foundations, it faces challenges in improving articulation, adaptability, and innovation. Strengthening knowledge management, strategic communication, alumni engagement, and extension activities are essential, as well as enhancing organizational resilience to increase its national and international impact.

Keywords: Animal science, professional development, strategic analysis

Palabras clave: Ciencia animal, desarrollo profesional, análisis estratégico

Social Perception and Prioritization of Ecosystem Services in Mountain Grazing Systems Percepción social y priorización de servicios ecosistémicos en pastizales ganaderos de montaña

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Introduction: Grasslands are globally dominant ecosystems and constitute complex and multifunctional socioecological systems that are essential for the provision of ecosystem services (ES). In mountain livestock landscapes, these systems integrate productive, regulatory, and sociocultural

functions whose understanding requires incorporating the social perception of multiple stakeholders. **Justification:** Although several studies have examined the biophysical supply of ES, a gap remains in understanding how social actors value and prioritize them, as well as the narratives that guide management decisions. **Objective:** To analyze social perception, prioritization, and narratives associated with ES in mountain livestock grasslands. **Methods:** A structured survey was conducted with 121 social actors (42.6% livestock producers, 29.8% institutional actors, 21.3% farmers, and 6.4% general community members; ages 20–76 years). The perceived importance of eighteen ES was assessed using a Likert scale, prioritization was evaluated through forced-choice selection, and landscape narratives were examined based on open-ended responses. Statistical analysis included the Kruskal–Wallis test and Dunn’s multiple comparisons (Bonferroni adjustment), association tests (χ^2 and Cramer’s V), principal component analysis (PCA), and generalized linear mixed models (GLMM) with random effects by ecosystem service. **Results and Discussion:** Perceived importance was high and convergent among actors, with no significant differences after adjustment for multiple comparisons ($P>0.05$). However, prioritization showed significant differences for forage nutritional quality

($\chi^2 = 18.16$; adjusted $P = 0.0049$; $V \approx 0.43$) and cultural landscape value ($\chi^2 = 17.54$; adjusted $P = 0.0049$; $V \approx 0.42$). PCA explained 60.9% of total variability, revealing in PC1 (52.2%) a functional gradient mainly associated with provisioning and regulating services, whereas PC2 (8.8%) reflected a gradient related to cultural services. Although these services were positively valued, they tended to be prioritized less than productive services. GLMM results indicated that the probability of prioritizing an ecosystem service increased significantly with its perceived importance ($\beta \approx 0.82$; OR ≈ 2.26 ; $P<0.001$), and that approximately 22% of the variability was explained by structural differences among services (ICC ≈ 0.22). Lexical analysis identified three landscape narratives: productive–food, ecological–regulatory, and socio-territorial. **Conclusion:** Social perception structures prioritization patterns and functional gradients in ecosystem services of mountain grasslands, highlighting the importance of integrating sociocultural dimensions into the planning and sustainable management of livestock territories.

Keywords: Agroecosystems, governance, multifunctionality, narratives, socioecological, territory

Palabras clave: Agroecosistemas, gobernanza, multifuncionalidad, narrativas, socioecológico, territorio

ZOOTECNIA DE PRECISIÓN

Estimation of Live Weight in Cattle by Processing Images Obtained by Unmanned Aerial Vehicles (UAVs) Estimación del peso vivo en ganado bovino mediante procesamiento de imágenes obtenidas por vehículos aéreos no tripulados (VANT)

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Introduction: Estimating bovine weight using image processing from UAVs can facilitate monitoring in traditional animal production systems with limited access to corrals and scales. **Objective:** To construct and evaluate a supervised dataset for estimating bovine weight from aerial images, using the weight estimated with a bovine measuring tape as the operational reference. **Methods:** The study was conducted at the Agricultural Sciences campus of the University of Sucre, located at km 7 on the Sampedes road, Sucre, on nine crossbred female *Bos taurus indicus* cattle. Thoracic girth (133–184 cm) and weight were recorded using a bovine measuring tape (188–475 kg). Twenty observations were obtained in three sessions. Since scales were unavailable, the bovine measuring tape was used as the operational reference. Images were obtained with a DJI Mini 2 drone at a height of approximately 4 m and a 90° camera angle. The analysis was performed in Python with OpenCV, using GrabCut-based segmentation, defining the torso as the region of interest and extracting pixel values and raw and normalized areas. Preliminary multivariable linear regression models were evaluated with leave-one-out validation. **Results and Discussion:** The image-derived variables showed weak associations with reference weight, without a sufficiently stable structure to support robust prediction. In the exploratory regression models evaluated with leave-one-out validation, the set of raw geometric variables produced a mean absolute error (MAE) of 66.3 kg, a root mean square error (RMSE) of 83.2 kg, and $R^2 = -0.27$, while the set of normalized variables produced an MAE of 77.3 kg, an RMSE of 93.9 kg, and $R^2 = -0.62$. The negative R^2 values indicate inferior performance compared to a predictor based on mean weight, suggesting low generalizability. This may be explained by the small sample size and the high ratio of predictors to observations. **Conclusion:** This study demonstrates the feasibility of

constructing a database and a reproducible workflow for extracting variables from overhead views, but a larger sample size, standardized data capture, and validation with actual weight measurements on a scale are needed to strengthen the automated estimation.

Keywords: Perimeter, pixels, regression, segmentation, video

Palabras clave: Perímetro, píxeles, regresión, segmentación, video

Machine Learning for Estimating Dry Matter Intake in Colombian Grazing Beef Cattle Aprendizaje automático para estimar el consumo de materia seca en ganado de carne en pastoreo

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Introduction: accurate dry matter intake (DMI) estimation is essential for defining nutrient requirements and optimizing productivity in grazing beef systems, which is critical in Colombian tropical contexts, while direct measurements are costly and impractical. Since traditional equations often fail to capture complex animal - forage interactions, machine learning (ML) offers a robust alternative to model nonlinear relationships. **Objective:** this study evaluated the performance of ML methods to predict DMI in Colombian grazing beef cattle. **Methods:** data (n=191) were sourced from multiple Colombian studies covering different breeds, locations, and tropical grazing conditions, representing a subset of the Latin America and Caribbean dataset. Eighteen combinations of nine predictors (body weight – BW, average daily gain – ADG, neutral and acid detergent fiber – NDF, ADF, respectively, crude protein - CP, ether extract - EE, ASH, and gross energy - GE) were evaluated. The dataset was split into training (80%) and testing (20%) sets. Models included multiple linear regression (MLR), LASSO regression (LS), ridge regression (RR), random forest (RF), and an artificial neural network (ANN) with one hidden layer, and nine neurons. To mitigate overfitting risks and ensure generalization despite the limited sample size, a five folds cross validation approach was implemented. Performance was assessed using Mean

Absolute Error (MAE), Root Mean Square Prediction Error (RMSPE), and Predictive Correlation (PC), and Predictive Ability (PA, calculated as the ratio of RMSE to the sample mean of the response variable). Analyses were carried out in RStudio (v.4.3.3). **Results and Discussion:** mean DMI was 7.7 ± 2.7 kg day⁻¹. ANN and RF models, particularly those integrating BW and key forage components (NDF, CP), achieved the highest accuracy (PA < 0.20; PC > 0.85). These findings provide a practical tool for farm decision making, including forage budgeting, precision feeding strategies, and smart farming applications. **Conclusion:** the synergy of forage quality, and animal traits using ANN and RF provided moderate predictive performance with the current dataset, future work will explore multi layered deep learning structures as more data becomes available for further enhanced predictive power in tropical systems.

Keywords: Cross-validation, grazing systems, predictive modeling

Palabras clave: Validación cruzada, sistemas en pastoreo, modelado predictivo

Improved Fecal-NIRS Equations to Estimate TiO₂ as Intake Marker in Cattle from Colombia and Argentina Robustecimiento de ecuaciones NIRS-fecal para estimar TiO₂ como marcador para consumo en bovinos de Colombia-Argentina

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Introduction: Titanium dioxide (TiO₂) is widely used as an external marker to estimate intake in ruminants due to its safety and high fecal recovery. However, laboratory determination methods such as ICP-OES or UV-Vis colorimetry can be costly and labor-intensive. Fecal NIR spectroscopy (fNIRS) may be a non-destructive and accurate tool to indirectly estimate TiO₂, since it does not exhibit defined IR bands, although its presence may be associated with spectral changes directly linked to the matrix. **Objective:** To improve the robustness of fNIRS equations for determining titanium in ruminant feces using samples from Argentina. **Methods:** A total of 51 bovine fecal samples were used from bioassays in which TiO₂

was applied as an external marker in intake and digestibility studies at the INTA Experimental Center in Balcarce, Buenos Aires. Dried and ground fecal samples were scanned using an NIR reflectance instrument in the 400-2,500 nm range at 2 nm intervals, recording the average of three spectra expressed as log (1/R). These spectra were incorporated into the original database and processed using modified partial least squares regression (MPLS) and standard normal variate with detrending (SNV and Detrend) for scatter correction, along with cross-validation to prevent model overfitting. Spectra were correlated with Ti values obtained by ICP-OES as the reference method. Four mathematical treatments based on first and second derivatives were evaluated; samples with GH values greater than 3 were considered outliers and excluded from the analysis. **Results and Discussion:** The final model for inorganic titanium in feces achieved R²c ≈ 0.87 in calibration and R²vc ≈ 0.85 in cross-validation, with a standard error of cross-validation (SECV) of 423.13 mg TiO₂ kg⁻¹ DM. This represents an improvement over previous calibrations (R²c ≈ 0.78; R²vc ≈ 0.70; SECV = 362.64 mg TiO₂ kg⁻¹ DM) and is sufficient to classify the model as suitable for sample screening and categorization. **Conclusion:** Expanding the database improved the precision and robustness of fNIRS equations for TiO₂ by approximately 15%.

Keywords: Digestibility, feces, grazing, ICP-OES, prediction, ruminants

Palabras clave: Digestibilidad, heces, pastoreo, ICP-OES, predicción, rumiantes

Pose Estimation in Brahman Cattle to Support Objective Phenotypic Classification Estimación de pose en bovinos Brahman para apoyar la clasificación fenotípica objetiva

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Introduction: The Brahman breed is strategic for beef production in Colombia due to its adaptation to tropical conditions. Linear classification allows the evaluation of morphostructural traits; however, under field conditions it shows variability due to evaluator effects, animal posture, lighting, and background, limiting its standardization. **Objective:** To develop and evaluate a computer vision and deep learning system for anatomical keypoint detection in Brahman cattle under field conditions. **Methods:** A dataset of 2,421 lateral-view images of Brahman cattle was collected from four farms located in Montería (Córdoba), Obando (Valle del Cauca), Santafé de Antioquia, and Puerto Berrio (Antioquia). Images were annotated with bounding boxes

and anatomical keypoints. Data augmentation was applied using controlled variations in brightness ($\pm 20\%$), exposure ($\pm 12\%$), and slight blur (≤ 1.5 px), resulting in 6,542 images. The dataset was split into 80% for training and 20% for validation. A YOLO-based pose estimation model was trained for 200 epochs using 640 px images. Model performance was evaluated using precision, recall, mAP50, and mAP50-95, along with precision-recall and F1 curves. Analyses were performed in Python. **Results and Discussion:** The model achieved high performance, with mAP@0.5 values close to 0.995 and mAP50-95 above 0.98 for both detection and pose estimation. Precision reached 1.0 and recall approximately 0.995. Performance curves showed stability across a wide range of confidence thresholds, with maximum F1 values close to 1.0 achieved at a confidence threshold of approximately 0.48. The confusion matrix showed 200 correct predictions and 3 errors ($>98\%$ accuracy). Loss functions decreased progressively and performance metrics stabilized early, indicating good generalization capacity. Results demonstrate consistent detection of anatomical keypoints, providing a basis for objective morphostructural measurements. **Conclusion:** The proposed approach showed consistent performance in anatomical keypoint detection in Brahman cattle, supporting its potential as a tool for objective phenotypic evaluation. Further validation under broader conditions is recommended to confirm its robustness for practical applications.

Keywords: Animal science, artificial intelligence, livestock farming, morphology, phenotype

Palabras clave: Ciencia animal, inteligencia artificial, ganadería, morfología, fenotipo

Morphometric Indices Based on Pose Estimation as Indicators of Growth in Brahman Cattle Índices morfométricos basados en estimación de pose como indicadores del crecimiento en bovinos Brahman

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Introduction: Phenotypic data collection in cattle systems requires efficient and non-invasive methods to characterize animal conformation. Computer vision and pose estimation enable the extraction of morphometric information from images, improving productive evaluation, reducing costs, and increasing standardization. **Objective:** To evaluate the usefulness of morphometric indices derived from pose estimation to describe variations associated with age and weight in Brahman cattle. **Methods:** A total of 1,566 images of Brahman cattle were analyzed, of which 1,021 had valid pose estimations, corresponding to a single record per animal. Images were collected from four farms located in

Montería (Córdoba), Obando (Valle del Cauca), Santafé de Antioquia, and Puerto Berrio (Antioquia), with ages ranging from 1.38 to 289.77 months. Pose estimation was performed using a previously trained YOLO-based model, considering valid those detections with consistent identification of anatomical keypoints and animals correctly positioned in lateral view. Based on these points, three indices were calculated: length-depth, length-height, and depth-height. Variables such as sex, conception method, and parity were analyzed exploratorily. Independent linear models were fitted for each index, using age and weight as explanatory variables and compared using AIC. Pose estimation was conducted in Python and statistical analysis in R. **Results and Discussion:** Indices ranged between ~ 0.95 – 1.10 (length-height), ~ 2.00 – 2.40 (length-depth), and ~ 0.43 – 0.52 (depth-height). The length-height index was positively associated with weight ($\beta = 0.00024$; $P < 0.001$), while depth-height was associated with weight ($\beta = 0.00017$; $P < 0.001$) and age ($\beta = 0.00126$; $P = 0.005$). In contrast, length-depth showed a negative association with weight ($\beta = -0.00030$; $P = 0.045$). These results suggest that heavier animals exhibit greater development in depth and height, reflecting changes in body conformation. Exploratory analysis showed higher values of length-height and depth-height in animals from embryo transfer and in males. **Conclusion:** Pose-estimation-derived indices captured morphometric variation associated with growth, with the depth-height index showing the greatest sensitivity to age and weight. Further analyses are required to validate its applicability in production systems.

Keywords: Cattle, computer vision, imaging, morphometry, phenotype

Palabras clave: Bovinos, visión por computadora, imagenología, morfometría, fenotipo

Body Conformation Indices and Neural Networks for Predicting Weight in Brahman Cattle Índices de proporción corporal y redes neuronales para predecir peso en bovinos Brahman

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Introduction: Predicting live weight in cattle from images represents an alternative for digital data capture in animal production systems. The use of computer vision and machine learning can reduce reliance on direct measurements and facilitate productive monitoring under field conditions. **Objective:** To evaluate the predictive capacity of a neural network to estimate the weight of Brahman cattle from morphometric indices derived from images and animal- and system-level variables. **Methods:** A total of 112 records of

Brahman cattle with weight and image information were analyzed, obtained from four farms located in Montería (Córdoba), Obando (Valle del Cauca), Santafé de Antioquia, and Puerto Berrío (Antioquia). From a previously trained pose-estimation model, three body indices were calculated: length–height, length–depth, and depth–height. Predictor variables included these indices, sex, breeding method, age at the time of the image, and farm. Categorical variables were encoded as dummies and numerical variables were standardized. A multilayer neural network with two hidden layers (32 and 16 neurons), ReLU activation, dropout regularization, and early stopping was fitted. Data were split into training (80%) and testing (20%) sets, and performance was evaluated using RMSE, MAE, and R^2 . **Results and Discussion:** The model showed stable convergence, with validation loss decreasing from 0.72 to approximately 0.42. In the test set, RMSE was 38.61 kg, MAE 34.45 kg, and R^2 0.76, indicating moderate

predictive ability. Permutation importance analysis showed that age had the greatest influence (Δ RMSE = 17.28 kg), followed by sex (7.12 kg), embryo transfer breeding method (5.39 kg), and the length–height index (3.08 kg). These results suggest that weight prediction depends mainly on biological factors, while morphometric indices provide complementary information. Interpretation should be made with caution due to possible correlations among predictors. **Conclusions:** The neural network showed promising ability to predict weight in Brahman cattle using morphometric and animal-level variables. Additional data are needed to improve model robustness and generalizability.

Keywords: Cattle, morphometry, neural networks, phenotype, weight

Palabras clave: Bovinos, morfometría, redes neuronales, fenotipo, peso

RESÚMENES
AVICULTURA
(POSTURA, ENGORDE Y COTURNICULTURA)

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Effects of Cannabidiol on the Behavior, Welfare and Egg Production of Caged Laying Hens Efectos del Cannabidiol sobre el comportamiento, bienestar y producción de gallinas ponedoras de jaula

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Introduction: Cannabidiol (CBD), a phytocannabinoid derived from *Cannabis sativa*, has, among other properties, anxiolytic effects. Although its use in veterinary medicine has increased, evidence in production of animals remains limited. In poultry science, welfare is assessed through stress and behavioral indicators. Some studies have reported positive effects of *Cannabis sativa* derivatives in birds. However, there is limited information regarding the effect of CBD on stress modulation and its impact on productivity in laying hens.

Objective: Evaluate the effects of CBD on welfare, behavior, and productivity in caged laying hens. **Methods:** A pilot study was conducted using 15 Hy-Line Brown laying hens, 86 weeks of age, distributed into three groups (n=5): vehicle (olive oil 0.1 mL kg⁻¹), CBD 0.2 mL kg⁻¹, and CBD 0.4 mg kg⁻¹,

administered orally for 41 days. Tonic immobility, behavioral ethogram, and egg quality parameters (egg weight and Haugh units) were evaluated. A non-parametric statistical approach was used, applying a negative binomial regression model and a zero-inflated model. **Results and Discussion:** CBD-treated birds showed a progressive decrease in tonic immobility time, indicating reduced stress, with better results observed at the lower dose. The ethogram revealed a significant reduction in stereotypic behaviors in treated groups (high dose vs. vehicle: $P=0.0103$; low dose vs. vehicle: $P=0.0008$), along with an increase in behaviors associated with welfare. Regarding productivity, the vehicle group showed a decline in laying rate and egg quality by weeks 6 and 7, whereas treated groups remained stable. These findings suggest that CBD may modulate the stress response, reflected in behavioral improvements and productive stability. The association between increased stereotypies and reduced performance in the vehicle group supports the negative impact of stress in caged hens. **Conclusion:** CBD showed a potential positive effect on welfare and productivity in laying hens. However, studies involving younger birds, larger sample sizes, and controlled conditions are required to confirm these findings.

Keywords: Animal welfare, cannabis, egg quality, ethology, poultry, stress

Palabras clave: Bienestar animal, cannabis, calidad de huevo, etología, avicultura, estrés

REPRODUCCIÓN

Seminal Kinematics of Creole Roosters Under Replacement Diets with *Morus alba* and *Trichantera gigantea*

Cinémática Seminal De Gallos Criollos Bajo Dietas De Sustitución Con *Morus alba* Y *Trichantera gigantea*

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Introduction: Sperm kinematics is a reference for semen quality, and one factor that can affect its parameters is the type of diet provided. **Objectives:** To compare sperm kinematics in Creole roosters under a diet including 20% arum and mulberry. **Methods:** The study was conducted at the Santa Lucía Research Center-Reproductive Biotechnology Laboratory, owned by UNIPAZ. Two experimental groups (T1 and T2) were used, each consisting of 5 roosters (*Gallus domesticus subspecies eucadatus*), kept in individual cages with a commercial balanced feed ration of 96 g/bird/day (80%) and mulberry substitutions of 20% (24 g/bird/day) for T1 and arum of 20% (24 g/bird/day) for T2. The evaluation period was 30 days, following a 15-day adaptation period. Semen was obtained individually from each rooster by non-invasive dorso-abdominal massage. Twenty-five ejaculates were obtained with weekly sampling for a total of five collections and 25 samples per treatment. The following characteristics were analyzed: VCL (Curvilinear Velocity), VSL (Rectilinear Velocity), VAP (Average Velocity/Trajectory), LIN (Linearity Index), and STR (Straightness Index). The samples were analyzed on computerized semen analysis equipment (CASA) (SCA®-Microptic Sperm Class Analyzer) in its avian module. A completely randomized, one-way design was used, with diet and the variables as the evaluation factors. Non-parametric statistics and the Mann-Whitney U test were used, and the data were processed using IBM SPSS Statistics 22. **Results and Discussion:** The mean values describe the sperm velocities, with the following results for mean and standard deviation: (T1) VCL 68.61 $\mu\text{m s}^{-1}$; ± 22.85 . VSL 23.24 $\mu\text{m s}^{-1}$; ± 8.35 . VAP 40.8 $\mu\text{m s}^{-1}$; ± 14.96 . LIN 34.17%; ± 3.83 . STR 55.42%; ± 4.34 . (T2) VCL 57.08 $\mu\text{m s}^{-1}$; ± 28.65 . VSL 18.97 $\mu\text{m s}^{-1}$; ± 8.14 . VAP 33.67 $\mu\text{m s}^{-1}$; ± 15.86 . LIN 32.88 %; ± 5.95 . STR 55.63 %; ± 7.35 . **Conclusion:** a difference was observed between VCL, VSL, VAP and LIN where T1 had a higher mean; in STR the higher mean was for T2, however, there were no statistically significant differences ($P \leq 0.05$).

Keywords: creole rosters, semen quality, sperm kinematics
Palabras clave: gallo criollo, calidad del semen, cinemática espermática

Supplementation with Aro, False Sunflower and its Effect on Sperm Kinetics in Creole Rosters Suplementación con Aro, falso girasol y su efecto sobre la cinética espermática en gallo criollo

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Introduction: Feeding and nutrition based on alternative forages, such as Mexican sunflower (*Tithonia diversifolia*) and Nacadero (*Trichanthera gigantea*), represent a viable alternative to improve the reproductive performance of Colombian Creole chickens while maintaining sperm quality and reproductive efficiency. **Objective:** To compare the effect of supplementation with Mexican sunflower and Nacadero on the sperm kinetics of Colombian Creole roosters. **Methods:** Two groups were formed, each consisting of five roosters. The animals underwent a 15-day dietary adaptation period. Parameters evaluated included motility, hyperactivity, fast, medium, and slow spermatozoa, curvilinear velocity (VCL), straight-line velocity (VSL), average path velocity (VAP), linearity index (LIN), and straightness index (STR). Analyses were performed using the Microptic Sperm Class Analyzer (SCA) software (poultry module), with weekly sampling over one month. All animals were kept under identical environmental and management conditions. The total feed intake per bird was 120 g, consisting of 80% commercial feed and 20% leaf meal supplementation: T1 received 20% Mexican sunflower leaf meal, and T2 received 20% Nacadero leaf meal. Statistical analysis was conducted using the non-parametric Mann-Whitney U test, and data were processed using IBM SPSS Statistics 22. **Results and Discussion:** Mean values obtained for Mexican sunflower and Nacadero were, respectively: VCL (76.45 $\mu\text{m s}^{-1}$ vs. 57.08 $\mu\text{m s}^{-1}$); VSL (25.55 $\mu\text{m s}^{-1}$ vs. 18.97 $\mu\text{m s}^{-1}$); VAP (45.40 $\mu\text{m s}^{-1}$ vs. 33.67 $\mu\text{m s}^{-1}$); LIN (34.26 vs. 32.88%); and STR (55.63 vs. 55.63%). Significant differences ($P < 0.05$) were observed for VCL, VSL, and VAP in favor of Mexican sunflower. No significant differences were found for LIN and STR. These results indicate that Mexican sunflower yielded superior outcomes for sperm kinetics. **Conclusion:** Supplementation

with 20% Mexican sunflower (*Tithonia diversifolia*) leaf meal significantly improves sperm kinetics (VCL, VSL, and VAP) in Colombian Creole roosters, outperforming the results obtained with Nacedero (*Trichanthera gigantea*). Given that no differences were observed in linearity and straightness, Mexican sunflower establishes itself as a superior and sustainable nutritional alternative to optimize seminal quality and reproductive efficiency in the Colombian Creole rooster.

Keywords: Motility, nacedero, nutrition, semen

Palabras clave: Motilidad, nacedero, nutrición, semen

Effect of Semen Collection Time on Seminal Cleaning in Creole Roosters

Efecto del tiempo de recolección de semen en la limpieza seminal de gallos criollos

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Introduction: Semen quality depends on the collection technique and time, guaranteeing hygiene to preserve the germplasm and ensure fertility. **Objective:** To evaluate the effect of semen collection time on sample cleanliness in Creole

breed roosters under confinement conditions at the Santa Lucia Research Center. **Methods:** Two groups each with five roosters were formed, treatment one (T1) had samples taken in the morning, treatment two (T2), the semen sample was taken in the afternoon after feeding, with an adaptation period of 45 days. The variables analyzed were dirt, leukocytes, bacteria and agglutination. Carrying out weekly evaluations for a month. The information on the nominal variables was processed through cross tables using the SPSS STATISTICS 22.0 program. **Results and Discussion:** The values were worked out in terms of percentages; The results for the presence of dirt in the samples were 70% in the morning, and 85% in the afternoon. For bacterial presence, it is highlighted that all AM and PM samples resulted with bacterial presence, in a moderate presence of bacteria in the morning of 45%, and in the afternoon of 40%, in an abundant presence in the morning of 15% and in the afternoon of 20%; For agglutination, all the am and pm samples presented some degree of agglutination, for high agglutination in the morning it occurred in 5% of the samples and in the afternoon in 15%; In the leukocyte variable, these cells were present in all samples; in the morning, 5% of the samples presented more than three cells per focus ($>3 \times C$), and in the afternoon in 10% of the samples. **Conclusion:** A marked percentage difference is not generated, but a decrease in the contamination of the sample is seen when the semen is collected in the morning.

Keywords: Collection time, dorso-abdominal massage, sample taking, seminal cleaning

Palabras clave: Limpieza seminal, masaje dorso abdominal, toma de muestra, tiempo de recolección

GENÉTICA Y MEJORAMIENTO

The LDB2 Gene Affects the Growth and Carcass Yield of the Colombian Creole Chicken

El gen LDB2 afecta el crecimiento y el rendimiento de canal del pollo criollo colombiano

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Introduction: Colombian Creole chickens are a valuable genetic resource for rural production systems, as they can withstand adverse environmental conditions and contribute to food security. However, information on the genetic basis explaining variation in characteristics related to growth and carcass quality is limited.

Justification: Identifying candidate genes associated with these characteristics would improve our understanding of the biological mechanisms that regulate productive performance, facilitating the development of marker-assisted selection strategies in native chickens. **Objective:** To evaluate the association of a polymorphism in the LDB2 gene with growth and carcass quality traits in Colombian native chickens. **Methods:** Two hundred

birds, distributed across different families, were evaluated. Growth variables were recorded from birth to slaughter age, as well as carcass parameters including slaughter weight, carcass weight and commercial cuts. Genotypes were obtained using the Illumina Chicken 60K SNP BeadChip panel, and the effects of polymorphisms were analyzed using general linear models that included the effects of genotype, sex, family and their interactions. **Results and Discussion:** Only two genotypes (TT = 0.9; TC = 0.1) were found in the studied population. Significant associations were found with live weight and weight gain at 8 and 10 weeks of age. There was also a relationship with slaughter weights, excluding feathers and viscera. The TT genotype showed better values in all cases ($P < 0.05$). This pattern suggests that the gene may be associated with genetic regulatory mechanisms involved in early growth and body development. **Conclusion:** The consistency of the observed effects on multiple production variables supports the potential of LDB2 as a relevant candidate marker for genetic improvement programmes, particularly in native populations, where marker-assisted selection could improve production performance without compromising local adaptation.

Keywords: Animal genetic resources, chicken meat, creole chicken, SNPs, weight gain

Palabras clave: Recursos genéticos animales, carne de pollo, aves criollas, SNPs, ganancia de peso

NUTRICIÓN Y ALIMENTACIÓN

Effect of Corn Oil in Broiler Diets on Carcass Yield and Commercial Cuts

Efecto del aceite de maíz en la dieta de los engordes sobre el rendimiento de canales y los cortes comerciales

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Introduction: Corn ethanol byproducts have been evaluated as substitutes for ingredients conventionally used for farming in modern broiler chicken. In this context, corn oil emerges as a possible energy alternative with competitive prices. **Objective:** To evaluate how corn oil in diet influences carcass yield and commercial cuts of broiler. **Methods:** 432 Cobb 500 chicks were distributed in a completely randomized design with three treatments with eight replicates and 18 birds/replicate. Treatments evaluated included degummed soybean oil, poultry by-product oil, and degummed corn oil, with a dietary inclusion level of 2%. The corn oil was obtained from a corn ethanol producer. Broilers were housed in 24 pens of 1.44 m² containing nipple drinkers and a tubular feeder, and reused rice husk bedding, in a climate-controlled shed with exhaust fans and evaporative cooling pads. Isonutritive diets were used for each phase: pre-starter (1-7 days); starter (8-21 days); grower (22-35 days); and finisher (36-42 days), according to Rostagno et al. (2017). At 42 days, 24 birds (eight per treatment) were selected according to the average weight of the replicates and slaughtered by exsanguination after electronarcosis. Before slaughter, the body live weight of each bird was recorded. After slaughter, the breast, back, thigh and drumstick, wings, abdominal fat, and feet, neck, and head were separated and weighed individually. The carcass yield was calculated in relation to the eviscerated body weight of the warm carcass (without feet, head, neck, viscera, intestines, pancreas, spleen, gizzard, liver, heart and abdominal fat). The data were subjected to analysis of variance and compared using Tukey's test ($P \leq 0.05$). **Results and Discussion:** Body live weight and carcass yield were not statistically different between the groups ($P > 0.05$). Broilers fed a diet containing degummed soybean oil had lighter feet, neck, and head when compared to animals fed poultry byproduct oil and degummed corn oil ($P = 0.02$). The yield of the breast, back, thigh and drumstick, wings, and the amount of abdominal fat were not affected by the type of oil in the diet ($P > 0.05$). **Conclusion:** Degummed corn oil from ethanol producers is an efficient nutritional alternative for broiler's diets.

Keywords: Coproduct, ethanol, meat, poultry

Palabras clave: Coproducto, etanol, carne, avicultura

Effects of Probiotics on Performance, Intestinal Health and Uniformity in Broiler Chickens

Efectos de los probióticos sobre el rendimiento, la salud intestinal y la uniformidad en pollos de engorde

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Introduction: the search for alternatives to the use of antibiotics as growth promoters has driven the adoption of probiotics in industrial poultry production. However, information on the effects of different probiotic strains on productive performance, flock uniformity, and intestinal health of broiler chickens remains limited. **Objective:** this study aimed to evaluate the effects of different probiotic preparations, in association with antibiotic use, on performance, flock uniformity, excreta quality, and intestinal morphology of broiler chickens. **Methods:** the experiment was conducted with Cobb® broiler chickens distributed into treatments containing different commercial probiotics. Zootechnical performance parameters, flock uniformity, fecal morphological characteristics, incidence of muscle abnormalities, and histomorphology of the small intestine were evaluated at 21 and 42 days of age. **Results and Discussion:** probiotic supplementation reduced excreta viscosity and improved flock uniformity, especially at 35 and 42 days of age. The c. bs is composed exclusively of *Bacillus subtilis*, whereas c. mix consists of anaerobic lactic acid-producing bacteria and mannanoligosaccharide-producing microorganisms that colonize the intestine and help control enterobacteria, supporting improved performance. Both probiotic formulations, in synergism with antibiotics, showed a positive additive effect on body weight and uniformity. Improvements in intestinal morphology were also observed, with increased villus height and a better villus-to-crypt ratio in specific intestinal segments. No significant effects of the treatments were observed on the incidence of muscle abnormalities. **Conclusion:** the use of probiotics showed potential to improve flock uniformity and intestinal health of broiler chickens, representing a viable strategy to optimize productive performance and animal welfare in intensive production systems.

Keywords: Antibiotic alternatives, flock homogeneity, growth rate, nutrition

Palabras clave: Alternativas a los antibióticos, homogeneidad de la parvada, tasa de crecimiento, nutrición

Inclusion of *Tenebrio molitor* Meal in Broiler Chicken Diets: Effects on Growth and Zootechnical Parameters
Inclusión de harina de *Tenebrio molitor* en dietas para pollos de engorde: efectos sobre el crecimiento y parámetros zootécnicos

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Introduction: The role of insects, primarily in the feeding of birds and fish, has gained relevance in recent years due to their high biological and energetic value. *Tenebrio molitor* appears to be a promising source of protein and energy to replace plant-based protein such as soy and corn, which is widely used in poultry diets (Rumpold and Schlüter 2013). **Objective:** To evaluate the use of *T. molitor* larva meal (larval stage) in broiler diets, through partial substitution of the protein and energy fraction, on productive parameters such as weight gain, feed intake, and feed conversion. **Methods:** A completely randomized design with a 3x3 factorial arrangement was implemented. The control treatment (T1) consisted of a conventional corn and soy-based diet. Treatments T2 and T3 included 5 and 10% *T. molitor* larva meal, respectively, substituting protein and energy from the control diet. Growth phases (0–21, 21–35, and 0–35 days) were evaluated. Performance data were analyzed using the GLM and ANOVA procedure, with mean comparison by Tukey's test ($P < 0.05$), using SAS software. **Results and Discussion:** The variables feed intake, weight, and conversion showed no significant differences ($P > 0.05$) for any of the treatments, suggesting that the inclusion of *T. molitor* larva meal up to 10% does not negatively affect the productive performance of broilers. **Conclusion:** The partial substitution of protein and energy from corn and soy with *T. molitor* larva meal at 5 and 10% in poultry diets does not alter the evaluated productive parameters. These findings support the potential of *T. molitor* as a viable alternative ingredient in broiler feed. Furthermore, its progressive and adapted use may offer relevant zootechnical benefits in prolonged production contexts.

Keywords: Alternative feed, Broiler, insects, performance, poultry nutrition, protein nutrients

Palabras clave: Alimento alternativo, pollo de engorde, insectos, desempeño, nutrición avícola, nutrientes proteicos

Influence of Corn Oil on the Productive Performance of Commercial Laying Hens
Influencia del aceite de maíz en el rendimiento productivo de las gallinas ponedoras comerciales

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Introduction: Lipid sources increase the energy density of the diet without compromising feed intake, thus improving poultry performance. The use of vegetable oils, such as corn oil, can be a strategic tool to optimize results in egg production. **Objective:** The study aimed to evaluate the productive performance of commercial laying hens fed diets containing degummed corn oil from the ethanol industry. **Methods:** 256 Lohmann LSL laying hens at 85 weeks of age were distributed in a completely randomized design with four treatments and eight replicates of eight birds each. The treatments were: Degummed soybean oil, Chicken viscera oil, Degummed corn oil, and diet without oil. The dietary inclusion of oil was 2% to perform the treatments. The corn oil was obtained from a corn ethanol producer. The laying hens were housed in laying cages equipped with nipple drinkers and linear feeders. Feed and water were provided *ad libitum*. The experimental diets followed nutritional levels according to Rostagno et al. (2017) and the birds were monitored over a 28-day cycle. For the productive performance analysis, the following parameters were evaluated: egg production (EP, %), feed intake (FI, g/bird/day), egg weight (EW, g), feed conversion ratio per mass (FCR, kg kg⁻¹) and FCR per dozen eggs (kg dz⁻¹). The data were subjected to analysis of variance and compared using Scott Knott's test ($P \leq 0.05$). **Results and Discussion:** The FI differed statistically among all groups evaluated ($P = 0.03$). The laying hens fed with diet without oil showed the higher FI (108,6 g). Laying hens fed with corn oil showed higher FI than those fed with chicken viscera oil. The EP, EW and FCR (kg dz⁻¹) and FCR (kg kg⁻¹) were not affected by the type of oil used in the diet ($P > 0.05$) and the mean values were respectively 88%, 62,3 g, 1,453 and 1,944. **Conclusion:** The use of degummed corn oil as an alternative lipid source in the diet of laying hens preserves productive performance levels, establishing itself as a viable and efficient substitute for conventional oils.

Keywords: Conversion, egg, nutrition, poultry

Palabras clave: Conversión, huevo, nutrición, aves de corral

Vitamins in Ovo on the Initial Performance of Broiler Chicks

Vitaminas en ovo sobre el rendimiento inicial de los pollitos de engorde de engorde

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Introduction: *In ovo* nutrient supplementation has been investigated as a strategy to promote early development of broiler chicks. Antioxidant vitamins C and E show potential to reduce oxidative stress during embryonic development and improve early performance. **Objective:** To evaluate the effects of *in ovo* supplementation with vitamins C, E, and C+E on hatching rate and early performance of broiler chicks. **Methodology:** A total of 400 fertile eggs with 444 hours of incubation from Cobb breeders were inoculated in the amniotic cavity and distributed in a hatcher. Treatments were 0.0 mg of placebo; 40 mg of DL- α -tocopherol acetate (vitamin E); 10 mg of ascorbic acid (vitamin C); and the combination of the two vitamins, diluted in 0.5 mL of saline solution. After hatching, birds were assigned to a completely randomized design with four treatments, six replicates, and 14 birds per unit. Performance was evaluated from 1–7, 1–14, and 1–21 days. Data were analyzed by ANOVA and Tukey's test (5%). **Results and Discussion:** After the 504-hour birth window, it was observed that *in ovo* supplementation did not interfere ($P=0.105$) with the hatching rate in treatments placebo (98.25%); vitamin E (89.47%); vitamin C (96.49%) and C+E (94.74%), indicating that the application of vitamins did not compromise embryonic development. In the period from 1 to 7 days, chicks from eggs inoculated with the combined vitamins C+E ($P=0.045$) showed higher feed consumption (135 g) when compared to chicks from the vitamin E treatment (120 g). At 14 days, chicks hatched from eggs inoculated with placebo ($P=0.028$) showed better feed conversion (1.16) when compared to chicks treated with vitamin E (1.43), and at 21 days ($P=0.030$), chicks hatched from eggs inoculated with vitamin E maintained the highest conversion (1.48) when compared to chicks treated with vitamin C (1.28). **Conclusion:** *In ovo* supplementation with vitamin E worsens feed conversion in the initial phase of broiler chicks. Supplementation with vitamin C, alone or in combination with vitamin E, shows consistent productive results, indicating potential for application as a nutritional strategy in the embryonic phase.

Keywords: Antioxidants, embryo, hatching, incubation, poultry farming

Palabras clave: Antioxidantes, embrión, eclosión, incubación, avicultura

Relative Bioavailability of Phosphorus of Selected Inorganic Sources in Broilers Biodisponibilidad relativa del fósforo de algunas fuentes inorgánicas en pollos

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Introduction: In animal nutrition, phosphorus (P) is essential for several metabolic processes associated with physiological status and production: In broiler diets, phosphate sources are key ingredients and therefore a focus of nutritional evaluation.

Objective: To characterize and evaluate the relative phosphorus bioavailability (RPB) of five phosphate sources in 384 male Cobb 500 broilers from 21 to 28 (F1) and from 35 to 42 (F2) days of age. **Methods:** Five phosphate sources were characterized and evaluated: monosodium phosphate (MSP), dicalcium phosphate 1 (DCP1) and 2 (DCP2), monocalcium phosphate (MDCP), and tricalcium phosphate (TCP). Characterization included determination of ash, Ca, P, As, Cd, Hg, and Pb, and P solubility in 2% citric acid. RPB was assessed based on body weight (BW) and tibia ash and P deposition, using MSP as the reference source. A factorial design was used with five P sources and three inclusion levels (0.08, 0.16, and 0.32%) in a basal diet without P. Treatments were assigned in a complete randomized design. **Results and Discussion:** All phosphate sources met Colombian regulations for P content. MSP, DCP1, and MDCP complied with both European and Colombian limits for As, Cd, Hg, and Pb, whereas DCP2 and TCP showed As values above the maximum permitted levels. High variability was observed in P solubility among sources. No differences in BW were detected among treatments in either phase ($P>0.10$); however, differences in RPB were observed ($P<0.05$). In F1, DCP1 and DCP2 showed higher RPB values, with DCP1 presenting the highest value based on P deposition (130.61) and DCP2 based on ash deposition (123.79) ($P<0.05$). In F2, the highest values were observed for DCP2 (110.20 and 227.27 for ash and P, respectively) ($P<0.05$). Across sources in F1, RPB based on ash ranged from 65.20 to 123.79 and from 48.98 to 130.61 based on P. In F2, RPB based on ash ranged from 40.31 to 110.20 and from 27.73 to 227.27 based on P. **Conclusion:** Tibia ash and phosphorus deposition, as well as RPB, remain reliable indicators for estimating P availability in broilers. The solubility criterion requires further evaluation due to its variable relationship with the other parameters assessed.

Keywords: Birds, evaluation, phosphate, quality, tibia

Palabras clave: Aves, evaluación, fosfatos, calidad, tibia

Metabolizable Energy of Three Types of Palm Oil and Soybean Oil in Broiler Chicken Energía metabolizable de tres tipos de aceite de palma y de soya en pollo de engorde

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Introduction: The design of feeds requires information on the metabolizable energy (ME) of the ingredients that will be used. In poultry feeding, oils and fats have not represented a notable level of inclusion, but the maintenance of production goals, the use of cereals for other activities and the pressure for competitive diets make it necessary to review the possibility of higher levels of use. **Objective:** Estimate the apparent ME without and with correction for nitrogen balance (AME; AMEn) of four types of oil in growing chickens. **Methods:** 384 Ross 308 AP males were used until day 21 of life, randomly distributed in 13 diets: one reference diet without oil (DR) and 12 from the combination of three types of palm oil: commercial, low in oleic (hopo) and high in oleic (HOPO) and one of soy, with three levels of inclusion (3, 6 and 9 kg kg⁻¹). The ME was estimated with total collection (RT) or with Cr₂O₃ (I) using a linear and a quadratic regression model. **Results and Discussion:** HOPO oil had a high content of oleic acid (53.8%) compared to commercial oil (44.0%), hopo (46.4%) and soybean (29.90%), but low compared to oils from other hybrids and even non-hybrid plants. With RT with increasing inclusion level, EMA and EMAn decreased, there was no effect of the type of oil or the interaction. With I there was an effect of the source, level of inclusion and the interaction. Unlike results for other ingredients, the study showed some similar values AME and AMEn and even higher values of AMEn. With both techniques there were ME values higher than the gross calorific values, with I, but not with RT, there were three negative ME values, with RT the linear regression model presented fit for all oils, but with I both this model and the quadratic were not adequate to estimate the ME. **Conclusion:** The results confirm previous findings: oils and fats present greater difficulties in estimating their ME compared to other ingredient.

Keywords: Birds, energy, evaluation, ingredients

Palabras clave: Aves, energía, evaluación, ingredientes

Evaluation of the Inclusion of *Sacha inchi* Cake in Laying Hens in the Colombian Amazon Evaluación de la inclusión de torta de *Sacha inchi* en gallinas ponedoras en la Amazonía colombiana

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Introduction: Poultry farming in Colombia is a robust industry; in 2025 alone, per capita egg consumption reached

365. In the Amazon region, this production is an economic alternative for marginalized rural areas, contributing to food security. The Hy-Line Brown breed of hen is widely used for its adaptability and productive efficiency. Its feed represents approximately 60% of production costs; therefore, utilizing byproducts such as *Sacha inchi* cake (SIC) (*Plukenetia volubilis* L.) presents an opportunity to enrich animal-based foods, promoting sustainable production systems. **Objective:** To analyze the zootechnical parameters of different levels of SIC inclusion in laying hens. **Methods:** The study was carried out at the Poultry Unit of the University of the Amazon, including 120 hens (10 per replicate) in four treatments with inclusion of 0, 5, 10 and 15% TSI (T1, T2, T3, and T4, respectively), the statistical analysis was developed with ANOVA (5%), verifying normality and homoscedasticity with Levene's method, and Tukey's test ($P < 0.05$) in R version 4.3.1. **Results and Discussion:** An inverse relationship was observed between SIC inclusion and productivity. In T3 and T4, the number of eggs per week decreased by 18 and 40.7%, respectively, while in T2, it remained within the range of T1. Furthermore, the birds' physical condition deteriorated. In T4, feed intake decreased by 17.5%, as did body mass by 11.2%. This coincides with studies that attribute this effect to the presence of antinutritional factors and reduced nutrient bioavailability when SIC inclusion increases. The decrease in feed consumption is related to changes in palatability caused by residual phenolic and lipid compounds characteristic of SIC. **Conclusion:** The inclusion of 5% SIC maintains productive performance, feed conversion efficiency, and the physiological state of the birds without significant alterations. These factors decrease when SIC inclusion exceeds 10%, suggesting metabolic limitations.

Keywords: Laying hens, nutrition, *Plukenetia volubilis*, poultry, sustainability

Palabras clave: Gallinas ponedoras, nutrición, *Plukenetia volubilis*, avicultura, sostenibilidad

Essential Oil (*Lippia origanoides*) Enhances Amount and Type of Mucin in Broilers Under Intestinal Inflammation Model (Lipopolysaccharide)

Aceite esencial (*Lippia origanoides*) aumenta cantidad y tipo de mucinas en pollos bajo un modelo de inflamación intestinal (lipopolisacárido)

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Introduction: Intestinal morphology is a useful physiological marker for estimating the digestive and absorptive capacity, as well as the health of the intestine. Broilers have secretory cells (goblet cells) that produce mucus (mucins) in the villi and crypts. Mucins serve as a barrier against pathogenic bacteria and toxic substances present in food and the intestinal lumen. However, the mucins production can be disrupted in the intestinal mucosa by various factors, leading to infections through the release of toxins or bacterial compounds (lipopolysaccharides—LPS) and subsequently causing inflammatory diseases. In broiler chicken production, antibiotics have been used successfully as growth promoters to improve intestinal health. Nevertheless, poultry production faces the challenge of adequately replacing the prophylactic use of growth-promoting antibiotics (GPA) with products of natural origin that fulfill the role of growth promoters. **Objective:** To evaluate the effects of adding *Lippia organoides* essential oil (OEO) to the feed on the amount and type of mucin produced in the duodenum of birds exposed to *in vivo* intestinal inflammation model induced by *E. coli* LPS. **Methods:** A total of 1200 ROSS308 chickens were allocated in six dietary treatments: D1: basal diet (BD) or balanced commercial diet without adding GPA, OEO, or LPS; D2: D1+150ppm GPA (Avilamycin); D3: D1+150 ppm OEO; D4: D1+1.0 LPS (1.0 ppm)+GPA; D5: D1+LPS(1.0 ppm)+GPA; D6: D1+LPS(1.0 ppm)+OEO. Measurements were taken on days 21 and 42 (except for zootechnical parameters). The experiment was conducted using a randomized block design. **Results and Discussion:** The mucins in the duodenum showed higher values (both in amount and type) in D3 for both villi and crypts. A reduction in the amount and types of mucins was observed in the villi and crypts of diets containing LPS; however, among these, D6 was the least affected ($P<0.05$). The highest mucin content in the duodenum, in both villi and crypts, was observed in older animals (42 days), with statistically significant differences ($P<0.05$) recorded among all age groups for all staining methods. **Conclusion:** The addition of OEO has a positive effect on intestinal morphometry (mucins) and zootechnical parameters, particularly in increased AWG and FE in broilers.

Keywords: Antibiotic, chicken, crypt, LPS, phytobiotic, villi
Palabras clave: Antibiótico, pollos, criptas, LPS, fitobióticos, vellosidad

***In vitro* evaluation of a probiotic additive on feed degradability for broiler chickens in gastrointestinal simulators**

Evaluación *in vitro* de un aditivo probiótico en la degradabilidad de alimento para pollos de engorde en simuladores gastrointestinales

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Introduction: The poultry industry faces significant challenges related to food safety and public health, which has driven the search for sustainable strategies to improve productivity without compromising animal welfare. In this context, the excessive use of antibiotics has raised concerns about antimicrobial resistance, promoting interest in alternatives such as probiotics, which can enhance gut health, nutrient utilization, and productive performance. **Objective:** To evaluate the effect of a microencapsulated probiotic additive on feed degradability for broiler chickens using *in vitro* gastrointestinal tract simulators. **Methods:** A completely randomized design with repeated measures over time was employed, including three treatments (0, 300, and 1000 mg kg⁻¹) with three replicates per treatment ($n = 9$ reactors). Reactors were inoculated with fresh broiler chicken feces and operated under semicontinuous feeding for 20 days. Physicochemical parameters such as pH, total solids, volatile solids, dissolved solids, short-chain fatty acids (SCFAs), and soluble protein concentration were evaluated. Data were analyzed using two-way ANOVA with repeated measures, considering treatment and time, followed by post hoc tests for multiple comparisons ($P<0.05$). **Results and Discussion:** Probiotic supplementation did not show a statistically significant effect on overall feed degradability ($P = 0.222$), although the 1000 mg kg⁻¹ dose showed a consistent improvement trend compared to the control. Total, volatile, and dissolved solids were mainly influenced by incubation time. In contrast, pH significantly decreased in probiotic treatments ($P = 1.27 \times 10^{-9}$), indicating greater acidification of the medium. Additionally, an increase in SCFA production (propionic, butyric, isobutyric, and valeric acids) was observed at the highest dose, particularly in later stages. Soluble protein concentration also increased significantly ($P=0.047$), suggesting improved nutrient availability. **Conclusion:** Microencapsulated probiotic supplementation shows potential as a functional strategy in broiler nutrition by improving the fermentative environment, increasing beneficial metabolite production, and enhancing nutrient availability, supporting its use as a sustainable alternative to antibiotics.

Keywords: broilers, feed degradability, gastrointestinal tract, *in vitro*, probiotics

Palabras clave: pollos de engorde, degradabilidad del alimento, tracto gastrointestinal, *in vitro*, probióticos

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Backyard Poultry Evaluation in Juárez, Chihuahua, Mexico Evaluación avícola de traspatio en Juárez, Chihuahua, México

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Introduction: Poultry farming in Mexico is one of the country's most dynamic and strategic livestock activities due to its economic contribution and role in food security. However, backyard poultry farming is the most traditional in Mexico, consisting of raising small, non-specialized flocks (meat or eggs) fed with various feeds (kitchen scraps, crops, or commercial feed). Approximately 80% of households in rural and peri-urban areas contribute to family sustenance and the genetic diversity of domestic birds. **Objective:** To study the main production parameters, incubation, and egg quality, as well as the diseases present in backyard poultry farms in the northern area of ciudad Juárez, Chihuahua,

Mexico. **Methods:** A total of 85 birds (72 females, 12 males), including adults and pullets, were used. They were housed in rustic chicken coops located in the backyards of the peri-urban areas in the northern part of Ciudad Juárez. Fertile eggs from these hens were counted for incubation monthly. Hatching rates, early embryonic mortality, and post-hatching mortality were calculated from March 2024 to June 2025. Daily feed consumption (g/a/d), number of eggs per week (n), and mortality (%) were also evaluated. Descriptive statistics were used for analysis. **Results and Discussion:** A total of 215 fertile eggs were incubated; 54.88% (n = 118) hatched, and 45.12% (n = 97) experienced embryonic death. Post-hatching viability was 86.98% (n = 187). The egg lost 5.32±2.02 g (14 days post-incubation), and the chick's weight represented 77.38±6.54% of the fertile egg weight, a percentage higher than that reported in the literature. Backyard hens had a body weight of 1.98±0.15 kg, a feed consumption of 121.67±2.50 g/hen/day, and laid 4.17±1.03 eggs/week. **Conclusion:** Management, feeding, and health control have a direct and decisive influence on production and reproduction. The low hatching rate and high embryonic mortality are due to a lack of knowledge regarding fertile egg management. Implementing basic measures such as biosecurity and proper selection of fertile eggs are the main challenges for backyard poultry farming.

Keywords: Fertile egg, food consumption, hatching, mortality
Palabras clave: Huevo fértil, consumo alimento, eclosión, mortalidad

EXTENSIÓN RURAL

Raising Small Livestock with an Inclusive Approach: Experiences with Indigenous Youth and Women in Caldas

Cría de especies menores con enfoque inclusivo: Experiencias con jóvenes y mujeres indígenas de Caldas

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Introduction: Indigenous women and youth play a fundamental role in strengthening food sovereignty, yet this role has generally been undervalued. In small-scale livestock farming, women contribute their labor and preserve traditional knowledge, while youth take on this legacy, incorporating technological changes without undermining traditional knowledge. **Objective:** To recognize the role of indigenous women and youth in small-scale livestock farming within the Cañamomo Lomaprieta Indigenous Reserve of Colonial Origin-RICL. **Methods:** In 2025, the RICL and Agrosavia launched the Territorial Innovation System (STI) in Riosucio and Supia-Caldas to strengthen local agri-food systems. Focus groups, semi-structured interviews, and field transects were conducted. The information was triangulated and analyzed participatively. Priority was given to the breeding of smaller species as a setting for co-innovation, with the

establishment of livestock production units. Participants were selected based on their prior involvement and membership in organizational groups. The process took place in the communities of Santa Ana and Tabuyo, and with the Indigenous Guard. Approximately 35 women participated, 50% of whom were heads of household, ranging in age from 15 to 75 as well as some men, including partners and children of the participating women. **Results and Discussion:** It was found that pigs, and especially poultry, are key to food sovereignty because of their protein content. Three participatory Laying hen raising units were established, in which women demonstrated leadership in decision-making, caring for the hen, and passing on agroecological knowledge. Strategies were created for the marketing of organic eggs to strengthen family and community food security, as well as women's economic autonomy. Young people were involved throughout the co-innovation process and played a key role in areas such as information systematization and social media marketing strategies. **Conclusion:** small-scale farming constitutes an important link for the food sovereignty of the RICL; women possess natural leadership, although greater visibility is still needed; with young people, it is important to establish strategies that strengthen their continued presence in the territory, for the conservation of these legacies.

Keywords: agroecology, animal protein, co-innovation, ethnic communities, food sovereignty, indigenous knowledge

Palabras clave: Agroecología, proteína animal, co-innovación, comunidades étnicas, soberanía alimentaria, conocimientos propios

SALUD PREVENTIVA Y BIOSEGURIDAD ANIMAL

Essential Oils Reduce Avian Influenza Replication in Cells and Chicken Embryos Aceites esenciales reducen la replicación de influenza aviar en células y embriones de pollo

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Introduction: Avian influenza remains a constant threat to poultry production and poses an imminent risk to human health. Alternative control measures are needed to contain potential outbreaks. Essential oils exhibit broad-spectrum antiviral activity; however, their effectiveness against strains such as H7N3 requires further validation. **Objective:** To evaluate an essential oil formulation against avian influenza H7N3 using *in vitro* and *in ovo* models. **Methods:** A nanoformulation containing *Lippia* spp., *R. officinalis*, and *E. globulus* was tested against two H7N3 strains. In MDCK cells, cytotoxicity was assessed by MTT assay, and antiviral activity was evaluated using a focus reduction assay to determine CC₅₀, IC₅₀, and the selectivity index (SI). In chicken embryos, antiviral activity was evaluated under prophylactic

treatment and co-treatment conditions with the virus. Viral replication was quantified by hemagglutination, EID₅₀, and qPCR. Nonlinear regression, Kaplan–Meier analysis with the log-rank test, and one-way ANOVA followed by Tukey's test ($P < 0.05$) were applied. **Results and Discussion:** The formulation reduced infection in a dose-dependent manner, with IC₅₀ values of 20.4 ppm for the vaccine strain and 38.3 ppm for the field strain, with SI values of 9.6 and 5.1, respectively (CC₅₀: 196 ppm), and inhibition greater than 80% at 100 ppm. In embryos, 1,500 ppm was the highest concentration that did not cause treatment-related mortality. At 48 h, both treatments reduced mortality, reaching 20% with prophylactic treatment and 40% with the virus mixture, compared with 80% in the control group. At 72 h, prophylactic treatment showed the lowest viral replication, with 1 hemagglutination unit, 5.28 log₁₀ EID₅₀ mL⁻¹, and 11.39 log₁₀ copies mL⁻¹. These findings suggest an antiviral effect at the treatment times evaluated, which was more pronounced when administration occurred before infection. **Conclusion:** The formulation exhibited antiviral activity against H7N3 *in vitro* and *in ovo* and showed potential as a complementary control strategy. Further *in vivo* studies are required to confirm its safety, dosage, and applicability under production conditions.

Keywords: Cytotoxicity, hemagglutination, nanoemulsion, prophylaxis, replication, virucidal

Palabras clave: Citotoxicidad, hemaglutinación, nanoemulsión, profilaxis, replicación, virucida

RESÚMENES

**PEQUEÑOS RUMIANTES
(OVINOS Y CAPRINOS)**

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Stimulation of Physiological Self-healing Processes in a Goat with Asthenia in Thoracic Limbs

Estimulación de procesos fisiológicos de autocuración en una cabra con astenia en miembros torácicos

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Introduction: The nervous system can suffer dysfunctions caused by infections, physical or chemical trauma, and even emotional factors. This system is responsible for coordinating every process in the body; therefore, when this system presents a dysfunction in its network of nerves, nerve impulses cannot be transmitted correctly, resulting in abnormalities in some processes. However, these dysfunctions can be restored through neural therapy, which seeks to restore harmony to the nervous system so that it can reorganize the abnormal events that are occurring. Such is the case of an eight-day-old goat born from a multiple birth but rejected by its mother, which caused asthenia. This goat was treated with neural therapy. Asthenia consists of a subjective feeling of fatigue or lack of energy that is not adequately relieved by rest. **Objective:** To evaluate the capacity of neural therapy to restore the physiology of the nervous system so that a goat with asthenia regains its strength and can stand. **Methods:** In El Carmen de Chucuri, an eight-day-old goat, fed with milk replacer, was diagnosed with asthenia of the thoracic limbs, preventing it from standing. It underwent a single treatment with neural therapy (diluted lidocaine), consisting of three injections of 0.4 milliliters in each limb at the skin level of the carpus. **Results and Discussion:** Twelve hours after the diluted lidocaine treatment, the goat was running normally, and this continued five months later. This result is significant because there is no literature on the use of this therapy in small ruminants. Furthermore, the level of improvement achieved by the therapy suggests that lidocaine was able to repolarize the neuronal membrane by triggering signal transduction in G protein-coupled receptors located on the cell membrane, thereby suppressing the expression of inflammatory mediators. **Conclusion:** Neural therapy was able to stimulate self-healing processes.

Keywords: Disruptors, nerves, repolarization

Palabras clave: Disruptores, nervios, repolarización

Erythrocytic Characterization of the Prenatal and Postnatal Periods in Colombian Hair Sheep

Caracterización eritrocitaria de los periodos prenatal y postnatal en ovinos de pelo colombianos

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Introduction: Considering the lack of references in the literature for the hematological variables in the Colombian hair sheep (OPC) - a basal breed for sheep production in Colombia due to its great adaptability - it is important to determine reference values for these parameters. **Objective:** To determine the erythrogram values in the prenatal and postnatal periods in Colombian hair sheep in the department of Córdoba and to establish the reference laboratory values for this breed. **Methods:** Fifty pregnant OPC sheep (Sudan variety) between 90 and 110 days of pregnancy, averaging 1.5 to 2.5 years of age, were studied. Blood samples were collected by venipuncture of the jugular vein every 15 days from 60 days prepartum to 60 days postpartum, 9 samples per animal in total. Samples were analyzed using the ABX Micros ESV 60 Hematology Analyzer. The erythrogram consisted of erythrocytes ($\times 10^6 \mu\text{L}^{-1}$), hemoglobin (g dL⁻¹), hematocrit (%), mean corpuscular volume (μm^3), mean corpuscular hemoglobin (pg), mean corpuscular hemoglobin concentration (g dL⁻¹), and platelets ($\times 10^3 \text{ mm}^{-3}$) counts. An ANOVA was performed using SAS (9.0) to identify differences between the prenatal and postnatal periods, adopting a probability level of 0.05. **Results and Discussion:** The values found for the prenatal and postnatal periods, respectively, were: erythrocytes: 7.52 ± 1.65 and $5.88 \pm 1.73 \times 10^6 \text{ mm}^{-3}$; hemoglobin: 9.01 ± 1.64 and $6.60 \pm 1.62 \text{ g dL}^{-1}$; hematocrit: 30.92 ± 6.50 and $26.97 \pm 8.93\%$; mean corpuscular volume: 40.00 ± 5.22 and $45.43 \pm 6.19 \mu\text{m}^3$; mean corpuscular hemoglobin: 11.95 ± 1.23 and $11.39 \pm 1.71 \text{ pg}$; mean corpuscular hemoglobin concentration: 30.28 ± 4.48 and $25.01 \pm 1.91 \text{ g dL}^{-1}$; and platelets: 360.20 ± 156.75 and $320.51 \pm 222.67 \times 10^3 \text{ mm}^{-3}$. The values for erythrocytes, hemoglobin, mean corpuscular volume, and mean corpuscular hemoglobin concentration were significantly different ($P < 0.05$). **Conclusion:** The values established in this work may be helpful for subsequent

research in this field and may also be useful in clinical practice for this breed and in the same environment conditions.

Keywords: Erythrogram, gestation, sheep

Palabras clave: Eritrograma, gestación, oveja

Winter Prepartum Shearing Stress in Ewes with and Without Maternal Experience Using Global Positioning System

Estrés de esquila preparto invernal en ovejas con y sin experiencia materna usando sistema de posicionamiento global

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Introduction: Winter prepartum shearing (WPS) is a significant stressor in sheep. It is unknown whether WPS affects behavior differentially in ewes with and without prior maternal experience, and whether GPS can be used to assess the response to WPS. **Objective:** To determine the response to WPS in ewes with and without prior maternal experience using GPS. **Methods:** Twelve Finnish-Landrace*Polwarth ewes were used to evaluate WPS performed one month prior to parturition, six with maternal experience (previous pregnancies and parturitions) and six without maternal experience (first pregnancy). Two days before (the preceding days were grouped as Day - 1) and two days after (Days 1 and 2) WPS, the animals were assessed using GPS, with recordings every 10 minutes. A mixed procedure (GLIMMIX procedure of SAS) was performed to evaluate distance (m) and speed (m s^{-1}), including the fixed effects of treatment (maternal experience), time (days), and their interaction, with the animal considered as a random effect. **Results and Discussion:** Sheep with maternal experience (ME) traveled a

greater distance than those without (SM) (726.5m vs. 634.7 m, $P = 0.05$). Day affected distance traveled ($P = 0.002$), with the distance being greater on Day -1 (795.8 m) than on Day 1 (614 m) and Day 2 (631.6 m) ($P < 0.01$). There was no interaction between treatment and day on distance traveled ($P = 0.144$). There was no effect of treatment ($P = 0.719$) or of the interaction between treatment and day on speed ($P = 0.456$). There was a trend in the Day effect ($P = 0.06$), which tended to increase from Day -1 to Day 1 (0.304 m s^{-1} vs. 0.354 m s^{-1} , $P = 0.058$, respectively). The EPI affected behavior, which was evidenced by GPS through a shorter distance traveled, but with a higher speed towards Day 1. Furthermore, the distance traveled showed a differential response according to maternal experience. **Conclusion:** The EPI affected the distance and speed of the sheep, and those with maternal experience traveled a greater distance. Therefore, the use of GPS allows for the evaluation of the behavioral response to the EPI in sheep, and thus their welfare, which can be a good non-invasive tool for producers to use.

Keywords: Behavior, sheep, welfare

Palabras clave: Comportamiento, ovinos, bienestar

Winter Prepartum Shearing Stress in Ewes with and Without Maternal Experience: Rumination and Walking Behavior

Estrés de la esquila preparto invernal en ovejas con y sin experiencia materna: Comportamiento de rumia y caminar

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Introduction: Winter pre-lambing shearing (WPS) is an important management tool that has improved production

rates by favorably impacting the birth of heavier and more vigorous lambs. However, WPS generates a significant stress response. Although WPS causes stress, because it is performed during gestation, ewes with different maternal experience may respond differently, which could imply long-term changes in the offspring. **Objective:** To determine the behavioral response of rumination and walking to WPS in ewes with and without maternal experience. **Methods:** Twelve Finnish-Landrace*Polwarth ewes with maternal experience-ME (previous pregnancies and lambings) and twelve without maternal experience-WME (first gestation) were used to evaluate the stress response to WPS during the month prior to lambing. Three days before (grouped as Day -1) and four days after (Days 1, 2, 3, and 4) the EPI, rumination and walking behaviors were assessed by visual scanning every 10 minutes (8 hours daily). A mixed procedure (GLIMMIX procedure of SAS) was performed, including group, time, and their interaction as fixed effects, and sheep as a random effect. **Results and Discussion:** There was an interaction between group and day ($P=0.007$). EM ewes ruminated less frequently than WME ewes on day 2 (8.3 ± 4.9 vs. $17.1\pm 4.9\%$, $P=0.002$, respectively). There was a group-day interaction in the frequency of walking ($P=0.02$). On day 1 post-shearing, ME ewes walked more than WME ewes (11.8 ± 1.3 vs. $6.7\pm 1.3\%$, $P=0.008$, respectively). Since ME ewes ruminated less on day 1 post-shearing and walked more on day 2, compared to WME ewes, it is possible to speculate that they exhibit a greater stress response. **Conclusion:** Maternal experience affected the behavioral response to shearing stress, with ME sheep showing a greater response by ruminating less and walking more than WME sheep. Therefore, maternal experience should be considered when planning shearing, and differential management strategies may be required to minimize stress and its potential effects on productivity and welfare.

Keywords: Behavior, sheep, welfare

Palabras clave: Comportamiento, ovinos, bienestar

Exploratory Analysis of Diurnal Behavioral Patterns in Goats at the Aprisco UNAL, Medellín Inspección exploratoria de patrones diurnos de comportamiento en caprinos del Aprisco UNAL, Medellín

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Introduction: The analysis of the temporal organization of behavior in goats allows for the understanding of functional patterns associated with welfare and management in confined or semi-confined systems. At the goat facility (*aprisco*) of

the Universidad Nacional de Colombia, Medellín campus, the characterization of the diurnal behavioral cycle provides empirical evidence on the structuring of activity and its possible relationship with local environmental conditions. **Objectives:** To describe the diurnal dynamics of 27 goat behaviors, classified as states and events, and to compare their expression between two observation periods conducted in July and December 2025. **Methods:** Non-invasive direct observation was carried out using random focal sampling during daytime sessions (08:00–18:00 h), with a temporal resolution of 1 min per session lasting 1 h. A total of 1,800 behavioral records were obtained and subjected to descriptive statistical analysis. For each session, the hourly relative frequency of each behavior was estimated and its recurrence throughout the day was evaluated. Additionally, average diurnal cycles of air temperature and relative humidity were calculated from hourly records obtained at a nearby meteorological station, in order to contextualize the observed patterns. **Results and Discussion:** In both periods, grazing constituted the dominant behavior, accounting for 813 of the 1,800 records (45.2%), followed by behaviors such as walking (229) and chewing/ruminating (147), which represented a high proportion of the behavioral budget. In December, a relative increase in browsing was observed, along with a greater temporal concentration of several behaviors, suggesting a more defined structuring of the diurnal cycle. The hourly distributions revealed a non-random organization, characterized by alternation among feeding, locomotion, exploration, and resting behaviors. From a biometeorological perspective, July presented relatively warmer and drier conditions than December, which coincides with a higher frequency of feeding behavior in July and a greater behavioral diversity in December. **Conclusion:** The goats at the facility exhibit well-defined diurnal cycles, dominated by feeding behaviors and organized according to functional sequences of activity and rest, with monthly variations consistent with modulation by local environmental conditions.

Keywords: Animal welfare, ethology, heat stress, stereotypies, thermal comfort

Palabras clave: Bienestar animal, etología, estrés ambiental, estereotipias, confort térmico

Temperament and Response to Vaccination in Lambs Temperamento y respuesta a la vacunación en corderas

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Introduction: Animal temperament affects the behavioral and physiological response to an external or stressful stimulus. More nervous animals respond with a higher level of stress than calm animals. Stress can affect the animal's immune function and reduce its welfare. Vaccination is characterized by fever, discomfort, or a temporary reduction in feed intake. Although temperament influences the stress response, there is no information in sheep regarding the relationship between temperament and the physiological response to vaccination.

Objectives: To compare the physiological response (rectal temperature: RT; and live weight: LW) to vaccination of calm and nervous ewe lambs. **Methods:** Twenty-eight Australian Merino ewe lambs aged 5-6 months (LW = 23 kg) were used, selected by temperament (calm, n = 14 and nervous, n = 14), grazing on native pasture with free access to water and shade. They were vaccinated (day 0; 1 mL per animal) against *Clostridium* (UltraChoice®8). RT was recorded every 8 hours on days -1, 0, 1, and 2. LW was recorded on days

-1, 14, and 28. Mixed procedures for repeated measures were performed, including the fixed effects of temperament (calm vs. nervous), time (hours), and their interaction, with the ewe lamb as the random effect. **Results and Discussion:** RT was higher in calm ewe lambs (40.0 °C) than in nervous ones (39.8 °C) ($P = 0.047$) and varied over time ($P < 0.0001$), showing a fever peak 24 hours after vaccination. There was no interaction between temperament and time ($P = 0.66$). LW changed over time ($P < 0.0001$), showing a decrease from day -1 to day 14, followed by an increase on day 28 ($P < 0.0001$). LW showed no effect of temperament ($P = 0.12$) or interaction ($P = 0.41$). **Conclusion:** Temperament affected the physiological response to vaccination, evidenced by a greater increase in RT in calm ewe lambs than in nervous ones, with no differences in the evolution of LW. Based on the results obtained, it may be that calm ewe lambs present a better immune response to vaccination than nervous ones.

Keywords: Behavior, *Clostridium*, ethology, immunity, stress

Palabras clave: Comportamiento, *Clostridium*, etología, inmunidad, estrés

REPRODUCCIÓN

Sperm Morphology and Testicular Development in Hair Sheep Morfología espermática y desarrollo testicular en ovinos de pelo

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Introduction: Testicular parenchyma integrity is a key determinant of reproductive capacity and results from age-appropriate testicular development. **Justification:** This study is justified by the need to establish reference reproductive parameters for hair sheep in Ciénaga de Oro, Córdoba, Colombia. By characterizing sperm morphology and testicular dimensions, the study validates the species' suitability under local conditions and provides an essential technical tool for selecting rams, optimizing the efficiency and competitiveness of the regional sheep sector. **Objective:** To study sperm morphology and testicular development in adult hair sheep. **Methods:** The presence of sperm abnormalities in the head, neck, midpiece, and tail, as well as individual testicular

dimensions and their average values, were recorded in different breeding rams in the municipality of Ciénaga de Oro, Córdoba, Colombia. Once the normal distribution of the variables was determined (Shapiro-Wilk test), a Student's t-test was used to establish the mean value of the abnormalities. **Results and Discussion:** Major sperm abnormalities were found in $5.7 \pm 1.9\%$ of cases, minor abnormalities in $3.7 \pm 1.0\%$, and a percentage of normal sperm in $90.7 \pm 2.7\%$. Semen quality showed a sperm concentration of $2051.8 \pm 796.5 \times 10^6$ sperm mL^{-1} , a vitality (Vb) of 84.2 ± 4.6 , and a rapid progressive individual motility (RPIM) of $78.9 \pm 5.6\%$. The mean morphometric measurements were: 31.6 ± 3.5 cm for CE, 6.2 ± 0.6 cm for AD, and 9.4 ± 1.3 cm for LT. The positive traits observed in the evaluated specimens are significant and provide a valuable tool for selecting breeding stock. The use of these parameters allows local producers to improve the competitiveness of the regional sheep sector. **Conclusion:** The average behavior of the variables suggests optimal reproductive performance. The results obtained are physiologically normal and comparable to those reported in previous research for hair sheep, consolidating the technical viability of these rams in the region.

Keywords: Low tropics, reproductive efficiency, semen quality, testicular biometry, veterinary andrology

Palabras clave: Trópico bajo, eficiencia reproductiva, calidad seminal, biometría testicular, andrología veterinaria

GENÉTICA Y MEJORAMIENTO

Behavior Test in Pelibuey Sheep in the Highlands of Jalisco, Mexico

Prueba de comportamiento en ovinos Pelibuey en Los Altos de Jalisco, México

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Introduction: Sheep farming is a significant livestock activity in the Highlands of Jalisco, Mexico. The Pelibuey breed is known for its hardiness, docility, adaptability to warm climates, and good reproductive efficiency, making it a key maternal breed in production systems. However, there is limited regional data on growth indicators, daily weight gain, and feed efficiency during the development stage, which hinders the objective selection of rams and the genetic improvement of herds. **Objective:** To evaluate the productive performance of male ewes intended for breeding. **Methods:** The trial was conducted at the facilities of the Livestock Association of Tepatitlán in Jalisco, Mexico. The animals were housed in individual pens and received a uniform diet of commercial feed. The following variables were evaluated: initial weight (IW), final weight (FW), weight gain (WG), head width (HW),

neck length (CL), height at the withers (HW), longitudinal diameter (LD), rump length (LG), rump width (WW), thoracic circumference (TC), cannon bone circumference (CB), dorsal sternal diameter (DSD), and testicular diameter (TD). The evaluation period was 30, 60, and 90 days long. A staged analysis of variance (ANOVA) was applied, and regression and correlation analyses were performed using SAS (v 9.0). Differences were considered significant at $P < 0.05$. **Results and Discussion:** ANOVA showed significant differences ($P < 0.05$) in all variables evaluated, except HW and WW. The IW and FW were 18.2 ± 2 and 49.2 ± 20 kg, respectively. Similarly, a variation range of 1.68–13.31% was observed for these variables. PF was significantly correlated with AC, LC, ALT, DL, and PT ($P < 0.05$). The daily weight gain ranged from 224 to 355 g day⁻¹, a range that reflects significant biological differences attributable to genetic variation among the evaluated animals. **Conclusion:** Variability in productive performance was identified, allowing for the selection of the best animals. The correlation between morphometric and productive variables supports the use of these variables in the genetic improvement of the Pelibuey breed in sheep farming systems in the Highlands of Jalisco, Mexico.

Keywords: Jalisco Highlands, Pelibuey sheep, productive traits

Palabras clave: Altos de Jalisco, ovinos Pelibuey, características productivas

NUTRICIÓN Y ALIMENTACIÓN

Does Energy Supplementation Influence the Bioefficiency of Male Lambs Under a Grazing System? ¿Influye la suplementación energética en la bioeficiencia de corderos machos en un sistema de pastoreo?

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Introduction: Sorghum is an energy-rich food with a low tannin content, high digestibility, and a moderate amount and quality of crude protein. **Objective:** the objective was to evaluate the influence of ground sorghum supplementation on productive and metabolic performance of male lambs in grazing system. **Methods:** Eight weaned Dorper × Katahdin lambs were used, with a mean initial body weight (BW) and age of 18 ± 2.32 kg and 3 months, respectively. The animals were distributed according to a completely randomized design into two treatments: US – unsupplemented and SU – supplemented with 0.5% BW in ground sorghum. The supplement was offered daily at 08h00 in an individual feeder during 60 grazing days. For growth performance evaluation, at the beginning and end of the experiment, body measures were taken using a hipometer. The heart girth was measured with a flexible tape. Diurnal behavior was monitored on days 15, 30, and 45 of the experimental periods by direct observation for 12 hours. On the other hand, on days 15 and 60 of the experimental period, blood samples were collected from animals to quantify the concentration of urea (BUN), total proteins, albumin, globulins, creatinine and glucose. Data were executed to an ANOVA, and significance was considered at $P \leq 0.05$. **Results and Discussion:** There was no supplementation effect ($P > 0.05$) on height at withers, rump height, rump width, rump length, rib depth, heart girth, and body length. Similarly, the supplementation did not affect ($P > 0.05$) the grazing, water intake, standing and lying ruminating, total rumination time, standing and lying inactive, and total inactivity time during the experiment. Similar values between treatments ($P > 0.05$) on the productive performance of the lambs was detected for US lambs compared to SU lambs (average of 18.4 vs 18.3 kg BW, respectively). However, there was an interaction effect ($P < 0.05$) between treatment × collection day on total protein concentrations, where SU lambs showed higher concentrations at the second collection. There was no effect ($P > 0.05$) of supplementation was observed on blood

levels of albumin, globulins, creatinine, BUN, and glucose. **Conclusion:** Ground sorghum supplementation does not influence growth performance; nevertheless, blood protein levels improve of grazing male lambs.

Keywords: Male lambs, total proteins, *Urochloa humidicola*
Palabras clave: Corderos machos, proteínas totales, *Urochloa humidicola*

Estimation of the Gas Composition of *in vitro* Fermentation by Gas Densitometry Estimación de la composición de gases de fermentación *in vitro* utilizando densitometría gaseosa

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Introduction: Carbon dioxide (CO₂), methane (CH₄), and hydrogen (H₂) are the main gases produced during the fermentation of organic matter. Among other properties, they have different densities that can be used for their identification. **Justification:** The analysis of gas concentrations by gas chromatography is a time-consuming and costly procedure. However, differences in gas density allow for the estimation of individual concentrations in a gas mixture. **Objective:** To estimate the concentration of CH₄, CO₂, and H₂ through gas densitometry in an *in vitro* gas mixture using fecal liquor. **Methods:** Fresh fecal samples were collected from three goats (approximately 100 g per goat) and mixed (1:3) with artificial saliva at 39.5 °C. The fecal liquor was extracted, and 60 mL were placed into each of 20 glass bottles randomly assigned to five feed ingredients (4 bottles per ingredient). In each bottle, 1.0 g of the ingredient was incubated, flushed with CO₂, sealed with a rubber stopper and aluminum cap, and placed in a water bath at 39.5 °C for 24 hours. At the end of the incubation period, each bottle was weighed, the gas mixture produced was extracted and its volume measured by volumetry; the bottle was then reweighed, and the density of the gas mixture was estimated. Based on this, the proportions of CH₄, CO₂, and H₂ were estimated using the general gas equation through the SIMPLEX method with three constraints. Data were analyzed using ANOVA. **Results and Discussion:** Using gas densitometry, the average concentration of CO₂ was found to be $52.9 \pm 9.0\%$, that of CH₄ was $45.9 \pm 8.4\%$, while that of H₂ was $1.14 \pm 1.23\%$ ($P < 0.01$). Correlations

between gas concentrations and experimental density were significant ($P < 0.01$). **Conclusion:** The analysis of the density of fermentation gas mixtures can be used to estimate their composition based on the general gas equation. However, it requires constraints based on assumptions that need to be validated.

Keywords: Feces, ingredients, SIMPLEX

Palabras clave: Heces, ingredientes, SIMPLEX

Maternal Feeding and its Effect on Early Growth in Colombian Hair Lambs (OPC)

Alimentación materna y su efecto en el crecimiento temprano en corderos de pelo colombiano (OPC)

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Introduction: Sheep production in Colombia faces limitations under traditional production systems. **Justification:** Evaluating maternal feeding strategies associated with offspring development may contribute to strengthening the sector. **Objective:** To determine the effect of maternal supplementation strategies during late gestation and lactation on the postnatal growth dynamics (0–90 days) of Colombian hair sheep (OPC) lambs. **Methods:** Twenty-seven OPC ewes (36.78 ± 4.61 kg) were assigned by age to three treatments:

T1, no supplementation; T2, maternal supplementation during the last third of gestation with a supplement containing 33% CP and 80% TDN; and T3, supplementation during the last third of gestation with the same supplement used in T2, followed by supplementation during lactation with a supplement containing 18% CP and 80% TDN. Animals grazed on 1.2 ha (11 paddocks) dominated by *Panicum hispidifolium* and *Urochloa decumbens* and additionally received chopped *Cenchrus purpureus* in confinement (17:00–07:00 h). Supplementation was adjusted to 0.6% of BW to exceed protein requirements by 25% during gestation and to meet energy requirements during gestation and lactation. Lambs were weighed biweekly until 90 days of age. Data were analyzed using nonlinear mixed-effects models (NLME) in R, fitting body weights to the Brody growth model. **Results and discussion:** The model adequately described growth trajectories ($R^2 > 0.95$). Lambs from T2 showed the highest maturation rate ($k = 0.013$; $P = 0.038$), indicating that maternal prepartum supplementation accelerated postnatal precocity, whereas lambs from T3 reached the highest estimated asymptotic weight ($A = 21.79$ kg), suggesting that continued supplementation during lactation enhanced growth potential. Lambs from T1 showed the lowest growth rate ($k = 0.008$), evidencing maternal nutritional limitations under grazing conditions. **Conclusion:** Maternal supplementation during late gestation improves growth precocity in OPC lambs, while its continuation during lactation promotes greater growth potential at weaning.

Keywords: Growth, precocity, sheep, strategies, supplementation

Palabras clave: Crecimiento, precocidad, ovinos, estrategias, suplementación

SALUD PREVENTIVA Y BIOSEGURIDAD ANIMAL

Effect of Supplementation with *Tithonia diversifolia* on Hematocrit and Parasite Load in Sheep

Efecto de la suplementación con *Tithonia diversifolia* sobre el hematocrito y carga parasitaria en ovinos

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Introduction: Sheep are susceptible to gastrointestinal parasites, primarily the nematode *Haemonchus contortus* (Hc). This hematophagous parasite inhabits the abomasum, causing anemia, high morbidity, and mortality in herds across tropical and subtropical regions. **Justification:** Supplementation with bioactive plants, particularly *Tithonia diversifolia* (TD), constitutes a viable alternative for controlling gastrointestinal nematodes. **Objective:** To evaluate the effect of TD supplementation on hematocrit (HCT) and eggs per gram (EPG) of fecal matter in a group of pregnant Katahdin sheep located in a Colombian low-tropic region. **Methods:** Fifteen adult ewes in their first and second trimesters of pregnancy, naturally infected with Hc larvae, were selected. During a 45-day experimental period, they received a daily additional supplementation of 200 g of fresh TD leaves per animal. The ewes grazed in radial-patterned pastures predominantly covered with *Brachiaria brizantha* under a semi-confinement system. At baseline and at the conclusion of the 45-day period, blood samples were collected via jugular vein puncture to determine HCT using the microcentrifugation technique (11,000 rpm for 5 min). Additionally, fecal samples were obtained directly from the rectum for EPG counting using the McMaster technique. Data analysis was performed using descriptive statistics, correlation coefficient (r), and the paired Student's t -test to compare the results at the beginning and the end of the experiment. **Results and Discussion:** The initial and final mean values were 25.26 ± 7.92 and $36.93 \pm 4.90\%$ for HCT, and 1270 ± 988.46 and 353.33 ± 318.17 for EPG counts, showing statistically significant differences ($P < 0.05$). A significant negative correlation coefficient ($r = -0.74$; $P < 0.05$) was determined between the variables, indicating an inverse relationship between HCT and EPG. **Conclusion:** Supplementation with TD had a positive effect on HCT levels and significantly reduced EPG counts, likely due to the anthelmintic effect attributable to the presence of secondary metabolites in the plant, specifically tannins, flavonoids, and saponins.

Keywords: Anemia, anthelmintic, metabolites, nematodes, supplementation

Palabras clave: Anemia, antihelmíntico, metabolitos, nematodos, suplementación

Parasitic Load and *in vitro* Larval Unsheathing Kinetics of Gastrointestinal Nematodes in Katahdin Sheep

Carga parasitaria y cinética del desenvaine larvario *in vitro* de nematodos gastrointestinales en ovinos Katahdin

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Introduction: Gastrointestinal nematodes in tropical ruminants cause severe economic losses. Their mitigation requires integrated management, including genetic selection, rotational grazing, and the disruption of parasitic life cycles. **Objective:** To evaluate the parasitic burden and the *in vitro* larval exsheathment kinetics of gastrointestinal nematodes in Katahdin sheep. **Methods:** The research was conducted at CISL-Unipaz (Barrancabermeja), utilizing 20 Katahdin sheep (average weight: 50 kg) under semi-confinement and grazing conditions (*Brachiaria brizantha*). Parasitic burden was determined using the McMaster technique (EPG), and coprocultures were prepared with 10 g of feces from animals with ≥ 1000 EPG. Coprocultures were supplemented with 10 g of sawdust and 40 mL of distilled water, incubated for 9 days at $28 \pm 2^\circ\text{C}$ in darkness. Recovered L_3 larvae were washed or three times (1,500 rpm for 5 min) and adjusted to $40 \pm 10 L_3$ $50 \mu\text{l}^{-1}$ via dilution. Exsheathment was evaluated by exposing larvae to 50 μl of NaClO at concentrations of 0.15, 0.20, and 0.30% for 10, 20, and 30 minutes. Measurements were performed in triplicate for each concentration in 96-well plates. Microscopic readings (10x) were conducted on five 20 μl aliquots per well. A 3x3 factorial design was used, employing descriptive statistics and Pearson's correlation test via SPSS Statistics 23.0 software. **Results and Discussion:** The parasitic burden showed high dispersion ($\bar{x} = 1008$ hpg, $M_e = 300$ hpg and $M_o = 100$ hpg). Exsheathment kinetics demonstrated a strong positive linear relationship ($r = 0.95$) between exposure time and exsheathment rate across all doses. The NaClO 0.30% concentration exhibited the highest response rate, with an average of 31 exsheathed larvae (77.5%)

at 10 minutes, reaching 43 larvae at 30 minutes. The 0.15% dose showed a slower progression slope, with an average of only 9 larvae (22.5%). **Conclusion:** The high susceptibility observed in the in vitro exsheathment kinetics, combined with McMaster monitoring and coproculture, identifies larval exsheathment as a strategic point for biological control. These findings support the need to develop methods that disrupt the parasite's life

cycle, thereby reducing anthelmintic reliance and advancing toward clean and ethical production models in the low tropics.

Keywords: Biological cycle, coproculture, haemonchosis, small ruminants, tropical lowlands

Palabras clave: Ciclo biológico, coprocultivo, haemoncosis, pequeños rumiantes, tierras bajas tropicales

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Identification of Physicochemical Quality Characteristics of Sheep Meat in Five Regions of Colombia Identificación de características de calidad fisicoquímica de la carne ovina en cinco regiones de Colombia

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Introduction: Global population growth has increased the demand for efficiently and sustainably produced food, amidst the challenges of climate change and the search for healthier options. **Justification:** In this context, sheep meat stands out for its nutritional value, organoleptic properties, and a production system with environmental, social, and economic benefits. **Objective:** The objective of this study was to characterize the physicochemical composition of sheep meat produced in five regions of Colombia, evaluating the following variables: water-holding capacity (WHC), moisture (M), color (C), shear force (SF), pH, protein (P), fat (F), fatty acid profile (saturated fatty acids – SFAS, monounsaturated fatty acids –

MUFAS, and polyunsaturated fatty acids – PUFAS), and ash content (AC). **Methods:** 1,109 sheep from Cundinamarca, Boyacá, Santander, Tolima, and Huila were analyzed under different climatic conditions (high tropics – CLTA and low tropics – CLTB), coat type (wool – CUTL, hair – CUTP), breed (Romney Marsh – TRRM, Hampshire – TRH, Criolla – TRC, Katahdin – TRK, Pelibuey – TRP, and Santa Inés – TRSI), and feeding system (confined – SAE, semi-confined – SASe, and grazing – SAP). Descriptive statistics and inferential analyses (one-way ANOVA, non-parametric tests, and post-hoc comparisons) were performed using SAS software (v. 9.4). **Results and Discussion:** Significant differences were found according to climate (a^* , b^* , pH), region (C, pH, P), coat type (a^* , b^* , pH, PUFAs), breed (CRA, L*, a^* , b^* , pH, F, PUFAs), and feeding system (C, pH, P, CA). In the mixed models, no significant differences were found for fat content; however, only pH showed significant effects in the interaction between climate and feeding system ($P < 0.01$). **Conclusion:** The physicochemical composition characteristics of sheep meat produced in five regions of Colombia were determined, showing that they correspond to reference values found worldwide. Further studies are needed on the specific characteristics regarding the presence of fatty acids and their relationships to expand knowledge in this area of research, given the nutritional importance of this meat and its potential impact on human health.

Keywords: Acids, composition, meat, omega, quality, sheep
Palabras clave: Ácidos, composición, carne, omega, calidad, ovinos

ZOOTECNIA DE PRECISIÓN

Evaluation of a Computer Vision Algorithm for Classifying Sheep Feeding Behavior Evaluación de un algoritmo de visión por computador para clasificar el comportamiento alimentario ovino

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Introduction: Precision animal science in complex agroecosystems is a strategy to optimize sustainability and efficiency in forage resource use. In this context, sheep grazing aimed at biological control of weeds in tea plantations (*Camellia sinensis*) constitutes an innovative model that requires technological validation. **Objective:** To evaluate the agreement between an expert human observer (EHO) and a computer vision algorithm (CVA) in classifying feeding behaviors (FB) and to determine the effect of crop management practices on ingestive behavior patterns. **Methods:** The research was conducted in a production system under two management regimes (MR): harvest and pruning. In 14 animals, the FBs of tea browsing (TB), weed browsing (WB), and weed grazing

(WG) were evaluated, along with the time dedicated to each. Assessments were performed at 6:30 a.m., during the first 10 minutes of foraging, over three consecutive days. The CVA was trained in 664 images, and its performance was compared with that of the EHO using standardized recordings. The Cohen's Kappa coefficient, McNemar's test, and diagnostic performance metrics were estimated. The time spent on each FB was analyzed using a mixed linear model. **Results and Discussion:** A good agreement was found between methods ($\kappa = 0.61$; 95% CI: 0.37-0.84; $P < 0.001$). McNemar's test revealed a systematic bias ($P = 0.035$) in the CVA misclassifying browsing as grazing. The CVA showed a sensitivity of 65.0% and a specificity of 95.5%. The analysis of FBs revealed an effect of management practice ($P = 0.019$) and an interaction between management and behavior type ($P = 0.002$). Proportionally, TB accounted for 48% of total time in harvest compared to 24% in pruning, while WG increased from 37 to 60% between the two management practices. **Conclusion:** The CVA allows for an objective characterization of sheep behavioral responses to different tea crop management practices, highlighting the potential of precision animal science as a tool for decision-making in sustainable production systems.

Keywords: Agroecosystems, artificial intelligence, *Camellia sinensis*, ingestive behavior

Palabras clave: Agroecosistemas, inteligencia artificial, *Camellia sinensis*, comportamiento ingestivo

RESÚMENES EQUINOS

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Perception of the Use of Equids and other Species: Agricultural Sciences Students vs. other Faculties Percepción del uso de équidos y otras especies: estudiantes de Ciencias Agrarias vs. otras facultades

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Introduction: For approximately 5,000 years, humans have used equids to advance their evolutionary process, consolidating a historical bond that grants them a particular status in the social imaginary. **Justification:** Understanding the perception of students from the Faculty of Agricultural Sciences regarding their use, compared with other species, is relevant because these future professionals will participate in productive, sanitary, and ethical decision-making. **Objective:** To analyze the perception of equid, use according to its purpose and to compare it with other species, as well as between students of Agricultural Sciences and those from other faculties. **Methods:** A descriptive, cross-sectional, and comparative study with a quantitative approach was conducted, involving 171 students, 93 from Animal Science and 78 from other disciplines. Attitudes were assessed using the (APQ) questionnaire adapted to the institutional context. **Results and Discussion:** In medical research, equids showed ambivalence (38% acceptance; 32% rejection; 30% neutrality); when comparing faculties, Agricultural Sciences showed higher acceptance (40% combining “agree” and “strongly agree”) compared to other faculties (18%), and lower relative rejection, suggesting a more utilitarian technical perspective. For euthanasia due to terminal illness, acceptance exceeded 80% in Agricultural Sciences (84%) and was lower in other faculties (59%), showing that the criterion of suffering is transversal but more pronounced among those with agricultural training. For human consumption, disagreement predominated for equids, especially in other faculties (59% rejection vs. 41% in Agricultural Sciences), while in pigs and chickens’ acceptance exceeded 75%, confirming a species-based hierarchy. In sanitary control, Agricultural Sciences showed higher acceptance (58%) compared to other faculties (23%), reflecting greater understanding of the population-based approach. In cultural use, high rejection persisted in both groups (55% Agricultural Sciences; 68% others), although more pronounced outside Agricultural

Sciences. **Conclusion:** The perception of equid use reveals an intermediate moral hierarchy compared to other species; although they share transversal ethical criteria such as suffering, Agricultural Sciences students show greater acceptance of scientific and sanitary uses, whereas other faculties adopt more restrictive positions, especially regarding consumption and cultural use.

Keywords: Attitudes, equids, ethics, euthanasia, production, zootechnics

Palabras clave: Actitudes, équidos, ética, eutanasia, producción, zootecnia

Erythrocyte Reference Values in Colombian Creole Horses in the Magdalena Medio Region, Barrancabermeja-Santander Valores eritrocitarios de referencia en caballos criollos colombianos en el Magdalena medio, Barrancabermeja- Santander

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Introduction: The Colombian Creole Horse (CCH) represents an exceptional genetic resource, evolutionarily adapted to diverse national ecosystems. Despite its socio-economic relevance and its value in exhibitions due to the elegance of its gait, there is a significant documentary gap regarding its specific hematological profile. Although the complete blood count (CBC) is a diagnostic pillar of equine internal medicine for early diagnosis and therapeutic monitoring, the absence of standardized values for the breed hinders clinical monitoring. Given that the extreme bioclimatic conditions of the Magdalena Medio region can alter homeostasis, it is imperative to establish local erythrocyte reference values. This characterization will allow for accurate clinical interpretation and strengthen preventive medicine in the tropical lowlands. **Objective:** To determine erythrocyte values in Colombian Creole Horses in Barrancabermeja, Santander. **Methods:** Samples were taken from 39 females and 25 apparently healthy males, aged 8 months to 9 years; a total of 64 samples were collected across different farms in the municipality of Barrancabermeja, Santander. The variables evaluated were hematocrit (HCT), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), hemoglobin (HGB), and

red blood cell count (RBC). Blood was obtained from the jugular vein and collected in purple-top tubes; samples were processed using a Mindray BC-2800VET automated veterinary analyzer. Descriptive statistics were performed, and data were processed in IBM SPSS Statistics 22. **Results and Discussion:** For Males: MCH (pg) mean 15.75 and standard deviation 1.85; HCT (%) mean 35.28, standard deviation 9.37; HGB (g L⁻¹) mean 11.79, standard deviation 2.39; RBC (10¹² L⁻¹) mean 7.76, standard deviation 1.43; MCV (fL) mean 45.53, standard deviation 10.14. In Females: MCH (pg) mean 15.18 and standard deviation 1.48; HCT (%) mean 35.05, standard deviation 6.90; HGB (g L⁻¹) mean 11.49, standard deviation 1.44; RBC (10¹² L⁻¹) mean 7.34,

standard deviation 1.14; MCV (fL) mean 45.88, standard deviation 6.88. **Conclusion:** These findings establish the first erythrocyte reference baseline for the Colombian Creole Horse in the tropical lowlands. The observed variability reflects physiological adaptation to extreme bioclimatic conditions. This characterization closes a critical diagnostic gap, providing essential data to improve clinical precision and therapeutic monitoring for the breed.

Keywords: Colombian creole horse, equine physiology, erythrocytes, hematology, lowland tropics

Palabras clave: Caballo criollo colombiano, fisiología equina, eritrocitos, hematología, trópico bajo

SALUD PREVENTIVA Y BIOSEGURIDAD ANIMAL

Molecular Frequency of Hemotropic Agents in Horses from Different Departments of Colombia Frecuencia molecular de agentes hemotrópicos en equinos de diferentes departamentos de Colombia

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Introduction: Equines in the country are used as companion animals in some regions and as working animals in others for various activities (high-performance competitions, cattle ranching, transportation). Because they are frequently exposed to the outdoors and due to their constant geographic redistribution, they have a high risk of exposure to vectors and, consequently, to hemotropic infections. Although there is a large population of horses and mules in the country, there is limited information on the epidemiology of the diseases that affect them. **Objective:** Evaluate the frequency of hemotropic agents in horses using qPCR and determine the association of infection by these agents with different demographic variables. **Methods:** A retrospective study was conducted using databases with results of horse samples

sent to the TestMol SAS laboratory for molecular diagnosis of hemotropics by qPCR during 2025. A descriptive and bivariate statistical analysis of the presence of the infection with demographic variables was performed using Jamovi 2.3.21 ($P < 0.05$). **Results and Discussion:** A total of 293 individuals were evaluated, revealing an 88% infection rate and 43% of animals with coinfections. Females accounted for 59% of positive cases and 85% of infected animals belonged to light breeds. Young adults and foals (65 and 17%, respectively) showed the highest frequency of infection. The main identified agents were *Anaplasma* spp. (91%) and *Mycoplasma* spp. (42%), with mixed infection by both pathogens being the most frequent coinfection (69%). Most positive cases came from Antioquia (66%), followed by Valle del Cauca (10%). Bivariate analysis found a significant association between infection and the department of Antioquia ($P = 0.038$). **Conclusion:** A higher frequency of *Anaplasma* spp. was observed in horses, mainly in coinfection with *Mycoplasma* spp., and with association according to the department. These findings highlight the need to strengthen epidemiological surveillance of hemotropic agents in the country, in order to mitigate their spread and optimize control and prevention strategies, as well as to identify the main risk factors associated with their detection.

Keywords: Equines, frequency, hemopathogens, qPCR

Palabras clave: Equinos, frecuencia, hemopatógenos, qPCR

RESÚMENES PORCINOS

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Stimulation of Physiological Processes to Restore Balance in a Piglet with Epitheliogenesis Imperfecta Estímulo de procesos fisiológicos para restaurar el equilibrio en un lechón con epiteliogénesis imperfecta

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Introduction: Epitheliogenesis imperfecta (EPI) is a condition in which piglets lack skin in certain areas of their bodies. These areas can vary in size and may resolve spontaneously, require medical attention, or, depending on the severity, necessitate euthanasia. This condition occurs in approximately 0.1% of piglets, resulting in significant economic losses. This report presents the case of a piglet with EPI treated with neural therapy, a low-cost, minimally invasive treatment that stimulates the body's own healing processes. **Objective:** To evaluate the effectiveness of neural therapy in stimulating self-healing processes in a piglet with EPI. **Methods:** In Carmen de Chucuri, a 10-day-old piglet with a single focus of epitheliogenesis imperfecta on its left flank was treated with neural therapy, consisting of four injections applied perilesionally to the single lesion. Each injection contained 0.3 ml of lidocaine without epinephrine and saline solution. **Results and Discussion:** The treated piglet began to heal gradually, to the point that the area with epitheliogenesis imperfecta began to be covered with skin. In fact, five months after treatment, the patient remains healthy. This finding fills the information gap regarding the use of this medication for this type of dermatological problem in piglets. Furthermore, the study highlights the capacity of diluted lidocaine to stimulate physiological self-healing processes in the animal. Neural therapy views these organic problems as physiological dysfunctions; therefore, a balanced nervous system is capable of reorganizing any organic problem affecting the animal. In other words, lidocaine was able to "reset" the dysfunctional nerves because it triggered signal transduction in $G\alpha_q$ protein-coupled receptors located in the cell membrane, thus reducing the expression of inflammatory mediators. It is noteworthy that there was no need to use antibiotics or healing creams. **Conclusion:** The therapy proved effective because it resolved this case.

Keywords: dermatopathy, lidocaine, physiology, self-healing
Palabras clave: dermatopatía, lidocaína, fisiología, autocuración

Characterization of Growth Curves in Three DanBred Breeds of Boars in Antioquia Caracterización de las curvas de crecimiento de tres razas de verracos DanBred en Antioquia

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Introduction: The DanBred genetic program offers three high-performance breeds that have been evaluated by CIPA S.A. in Colombia since 2019. Most commercial genetic programs worldwide are based on two typical maternal breeds and different terminal breeds or lines. It is essential to validate their zootechnical productivity under Antioquia conditions, as tropical climate and local management practices differ from Danish production standards. This characterization enables the optimization of nutritional programs and selection criteria according to the animals' actual biological potential. **Objective:** To characterize the growth curves of Landrace (LL), Yorkshire (YY), and Duroc (DD) boars under the environmental conditions of Antioquia using a variant of the Gompertz model (Zwietering parameterization). **Methods:** A total of 6,180 records from 457 boars housed in two Artificial Insemination Stations (AISs), designated SR and TM, were analyzed between 2023 and 2026, considering their origin (C-SR or C-FR). Data were curated using Generalized Additive Models (GAM), filtering out observations beyond ± 3 SD. Body weights were predicted at key ages: weaning (P25), end of nursery phase (P75), selection (P95), entry into the AIS (P140), training (P190), onset of production (P240), and maturity (P280). Age at Maximum Daily Weight Gain (AMDWG) was calculated as an indicator of precocity. **Results and Discussion:** Gompertz models showed a strong goodness-of-fit (R^2 ranging from 0.94 to 0.97, $P < 0.001$). DD boars from the SR AIS with C-SR origin exhibited superior performance across all evaluated stages. Analysis of growth rate curves indicated that DD animals were the most precocious (AMDWG = 128 days), while among maternal lines, LL showed greater precocity (130 days). Among maternal breeds, YY reached the highest mature body weight (179.34 kg). Mean body weight at P240 was 174.48 kg

for DD, 157.91 kg for LL, and 157.18 kg for YY. **Conclusion:** Boar growth performance is influenced by both the AIS of residence and the farm of origin. While C-FR origin favors higher initial body weights, the SR AIS environment enhances the expression of maximum growth potential toward maturity across all breeds.

Keywords: Artificial insemination stations, Gompertz function, productivity, sigmoidal function, weight gain

Palabras clave: Centros de inseminación artificial, función Gompertz, productividad, función sigmoide, ganancia de peso

Effects of Meteorological and Productive Factors Affecting Growth in DanBred Breeding Boars in Antioquia, Colombia

Efectos de factores meteorológicos y productivos que afectan el crecimiento de verracos reproductores DanBred en Antioquia, Colombia

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Introduction: The growth of breeding boars is critical for productivity in artificial insemination stations (AIS); body weight directly influences productive lifespan and overall productivity.

Justification: In tropical regions, variable meteorological conditions and productive factors are key determinants of growth dynamics, an aspect poorly documented in the commercial swine breeding sector. **Objective:** To evaluate the influence of meteorological and productive factors (intrinsic and extrinsic) on mean body weight per growth stage in breeding boars from two commercial AIS in Antioquia, Colombia. **Methods:** A total of 6,227 weight records from 462 DanBred breeding boars of the Yorkshire, Landrace, and Duroc breeds (2023–2026), originating from two genetic breeding farms and allocated to two commercial AIS, were analyzed. Six growth stages were evaluated. Meteorological variables included mean (T2M), maximum (T2M_MAX), and minimum (T2M_MIN) temperature, and relative humidity (RH2M), obtained using the NASA POWER package in R. A temperature coefficient of variation (TCV) was constructed as an indicator of thermal variability. Multivariate linear models were used to simultaneously control for the variability inherent to productive factors (breed, farm of origin, age, and previous stage weight), thereby isolating the net effect

of meteorological variables. Models were fitted in RStudio using a stepwise selection approach, with stage-specific body weight as the response variable; corresponding ANOVAs were subsequently performed. **Results and Discussion:** Age and previous stage weight were significant determinants across all growth stages ($P < 0.001$), with adjusted R^2 values ranging from 0.24 to 0.86. Breed significantly influenced growth from the nursery phase onward; Duroc exhibited the highest body weight, modulating the overall response of the group. T2M positively influenced growth during early stages; in later phases, TCV and RH2M emerged as significant effects, indicating increased thermal sensitivity as growth progressed. The adjusted models revealed climatic patterns that were not apparent in raw data without control for productive factors. **Conclusion:** Boar growth is determined by the interaction of meteorological and intrinsic factors. TCV and RH2M exert a measurable effect on animal development under tropical conditions, conditioned by genetic background and management practices.

Keywords: Body weight; meteorology; temperature; thermoregulation

Palabras clave: Peso vivo, meteorología, temperatura, termorregulación

Design and Construction of a Low-Cost IoT System for Monitoring in Animal Production Systems Diseño y construcción de un sistema IoT de bajo costo para monitoreo en sistemas de producción animal

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Introduction: Precision animal production requires continuous monitoring systems capable of recording environmental and operational variables relevant to animal welfare assessment, facility management, and data-driven decision-making. **Justification:** In many livestock systems, the available instrumental solutions present limitations associated with cost, scalability, spatial coverage, and flexibility integration, which hinders their adoption in applied research and productive environments. In this context, the development of low-cost IoT boxes constitutes a promising technological alternative to expand the distributed monitoring of variables of interest in animal production. **Objective:** To evaluate the operational feasibility of a low-cost IoT

system for monitoring environmental variables in animal production systems through its design, assembly, and initial implementation under real swine production conditions.

Methods: A prototype based on ESP32 was developed and integrated with low-cost electronic modules, including BME280 for measuring temperature, relative humidity, and barometric pressure; GY-49 for quantifying light intensity; ADMP401 for acquiring environmental acoustic signals; DS3231 for system time synchronization; ADS1115 for digitizing analog signals; and TCA9548A for I²C bus multiplexing during the integration of multiple sensors. The system was assembled in a physical enclosure designed for component protection.

Results and Discussion: As part of the project progress, the first monitoring boxes were assembled and an initial test was carried out in a swine production system, in which the basic electronic and functional integration of the prototype was verified, as well as its physical feasibility for operation

in a productive environment. This phase made it possible to identify adjustment requirements in assembly, reading stability, system protection, internal component distribution, and the calibration process, showing that the development is currently in an active stage of optimization prior to metrological validation and extended field evaluation. **Conclusion:** The developed IoT box represents a viable technological basis for monitoring in animal production, with potential applications in environmental assessment, animal welfare, and decision-making support, although stages of calibration, field validation, and performance analysis under real operating conditions are still required.

Keywords: Calibration, electronics, environment, pigs, sensors, welfare

Palabras clave: Valibración, electrónica, ambiente, porcinos, sensores, bienestar

GENÉTICA Y MEJORAMIENTO

Early Ultrasound Indicators of Backfat Thickness to Predict Carcass Quality in Pigs Indicadores ultrasonográficos precoces de grasa dorsal para la predicción de calidad de canal en cerdos

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Introduction: Accuracy in predicting final fat deposition is critical for profitability in pig production, as carcass finishing is a key determinant in carcass classification. Identifying precise prediction windows allows for animal segregation and dietary adjustments to maximize the proportion of high-quality carcasses. **Objective:** To determine the ultrasonographic measurement points with the greatest predictive value for slaughter classification and their impact on carcass quality.

Methods: A total of 412 pigs from four genetic lines were evaluated using ultrasonography: 109 from the Commercial line, 94 from the F1 line, 111 from the LM1 line, and 98 from the LM2 line. Two variables were obtained for each individual: Backfat Thickness at the Last Rib (BF-LR) and Backfat Thickness at the Tenth Rib (BF-TR), measured biweekly from weeks 9 to 23 of age. Chi-square tests, multiple

correspondence analysis, and standardized residual analysis were used to determine associations between genetic lines, measurement weeks, and backfat ranges. Associations were considered significant at $p \leq 0.05$. **Results and Discussion:** The highest predictive correspondence window was identified between weeks 15 and 17. During this period, the Commercial line showed the highest probability of achieving superior carcass quality at slaughter, with standardized residuals greater than 2.0, indicating significant statistical inertia with Category A. In contrast, the LM1 and LM2 lines showed standardized residuals lower than -2.0 for Category A and greater than 2.0 for Categories C and D from week 19 onward, confirming a significant inertia toward fat accumulation at slaughter. Statistical significance supported consistent biological patterns. This early detection enables the identification of animals likely to achieve better classifications before feed costs exceed profit margins, allowing for early marketing or nutritional adjustments aimed at shifting carcasses toward higher quality grades. **Conclusion:** Backfat Thickness at the Last Rib measurements at weeks 15 and 17, interpreted through standardized residuals, function as an early warning system, enabling producers to mitigate the negative impact of excessive fat deposition and optimize economic returns through carcass quality-based segregation.

Keywords: Correlation, fat-free lean percentage, multiple correspondence analysis, standardized residual analysis

Palabras clave: Correlación, porcentaje de carne magra libre de grasa, análisis de correspondencias múltiples, análisis de residuos estandarizados

NUTRICIÓN Y ALIMENTACIÓN

Influence of Backfat Thickness on Biological Parameters in Lactation of Swine Lines

Influencia del espesor de grasa dorsal sobre parámetros biológicos en lactancia de líneas porcinas

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Introduction: The sow has a high demand for nutrients due to its productive efficiency, mobilizing body reserves in response to fetal growth and mammary gland development during lactation. It is necessary to evaluate dorsal fat thickness in its reproductive phases to ensure optimal biological parameters.

Objective: To establish the behavior and influence of dorsal fat thickness on biological parameters (sow weight, litter weight, and number of piglets) at the start of lactation and at weaning. **Methods:** Experimental, longitudinal, descriptive, and inferential study, supported by a completely randomized design (CRD). Three treatments were formulated based on genetic lines and breeds: T1 – synthetic line 1 (10 sows), T2 – synthetic line 2 (10 sows), and T3 – F1 Landrace x Large White genetics (9 sows). Measurement of dorsal fat at farrowing and weaning was performed at point 2 using real-time ultrasonography (ultrasound scanner). For data analysis, non-parametric statistics were used due to the number of females per treatment (less than 30), supported by descriptive and inferential statistics via the Kruskal-Wallis test, after previously determining data normality and homoscedasticity, using Stata 14.0 statistical software. **Results and Discussion:** The behavior of dorsal fat thickness, sow weight, and litter weight showed no statistically significant difference ($P>0.05$) between the synthetic lines and the F1 genetics at the start of lactation and at weaning; however, such a difference existed ($P = 0.0446$) in the number of piglets between T2 – synthetic line 2 and T3 – F1 genetics. This is probably due to the high correlation of dorsal fat thickness with sow weight ($r = 0.749$) and litter weight ($r = 0.727$), and the low correlation with live piglets ($r = 0.191$), at the start and end of lactation. **Conclusion:** The parallel decrease in female weight and dorsal fat thickness at the end of lactation is related to the negative energy balance due to the mobilization of body reserves directed toward milk production, reflected in the increase in litter weight.

Keywords: genetics, lactation, nutrition, piglets, productive efficiency

Palabras clave: genética, lactancia, nutrición, lechones, eficiencia productiva

Characterization of Hindgut Microbiota in Probiotic-Supplemented Weaned Pigs Using Culture-Dependent and Metagenomic Techniques

Caracterización de microbiota intestinal posterior en cerdos destetados con adición probiótica utilizando técnicas metagenómicas y dependientes del cultivo

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Introduction: Early weaning (≤ 21 d) imposes a significant physiological challenge and disrupts the establishment of the intestinal microbiota, compromising gastrointestinal function. Determining microbial diversity and abundance is essential to assess host health; however, traditional methods often lack the required sensitivity. **Objective:** This study evaluated hindgut bacterial populations using two distinct approaches: a) culture-dependent techniques (MRS and Chromocult agar) and b) 16S rRNA gene sequencing (Illumina platform) with metagenomic bioinformatic analysis, in weaned pigs supplemented with various probiotic strains. **Methods:** A total of 80 crossbred castrated male piglets, weaned at 21 d of age, were randomly assigned to five experimental diets: D1) commercial basal diet (BD) without antibiotics; D2) BD + antibiotics; D3) BD + *Lactobacillus acidophilus*; D4) BD + *Lactobacillus casei*; and D5) BD + *Enterococcus faecium*. No solid feed or antibiotics were administered during the lactation period. On days 15 and 30 post-weaning, eight piglets per treatment were euthanized to collect hindgut (cecum and colon) digesta. Samples were either refrigerated for culture-based analysis or immediately snap-frozen in liquid nitrogen for metagenomic sequencing. **Results and Discussion:** Significant discrepancies ($P<0.01$) were observed between the identification techniques across all treatments. Culture-based analysis revealed that probiotic supplementation significantly reduced *Escherichia coli* counts ($P<0.01$) compared to the antibiotic group (D2). Conversely, metagenomic sequencing demonstrated that probiotics decreased the relative abundance of *Citrobacter* and *Enterobacter* ($P<0.01$) relative to D2. Consequently, the detectable effect of each probiotic strain on pathobiont populations is highly dependent on the analytical technique employed. **Conclusion:** Molecular techniques provide superior sensitivity and specificity for characterizing the intestinal microbiota, particularly as approximately 95% of microbial populations remain unculturable. These findings underscore the necessity of high-throughput sequencing for an accurate assessment of the porcine gut ecosystem.

Keywords: *Enterococcus faecium*, illumina sequencing, microbial identification, post-weaning stress, weaned pigs

Palabras clave: *Enterococcus faecium*, secuenciación de Illumina, identificación microbiana, estrés postdestete, lechones destetados

Jejunal Microbiota of Pigs Weaned at two Ages and Supplemented with Antimicrobial Alternatives Microbiota intestinal (yeyuno) en cerdos destetados a dos edades y alimentados con diferentes alternativas antimicrobianas

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Introduction: Early weaning (<21 d) induces intestinal dysbiosis, compromising mucosal integrity and increasing the incidence of post-weaning diarrhea and growth retardation. While natural antimicrobial alternatives are being explored, their interaction with weaning age remains poorly understood.

Objective: This study aimed to characterize the jejunal microbiota of pigs weaned at two different ages (21 and 28 d) and supplemented with various antimicrobial alternatives.

Methods: A total of 160 crossbred barrows were utilized, with 80 piglets weaned at 21 d and 80 at 28 d of age. No solid feed or antibiotics were provided during the lactation period. Animals were assigned to one of five experimental diets: D1) commercial basal diet (BD) without antibiotics; D2) BD + antibiotics; D3) BD + *Bacillus subtilis*; D4) BD + oregano essential oil (*Lippia origanoides*); and D5) BD + organic acids. On days 15 and 30 post-weaning, eight piglets per treatment were euthanized to collect proximal jejunum and digesta samples. Samples were immediately snap-frozen in liquid nitrogen for microbial diversity analysis using 16S rRNA gene sequencing and bioinformatic processing. The statistical analysis of microbial communities was performed through the "Phyloseq" package of RStudio software to carry out the comparison between the species richness of microbial community (alpha diversity) of each diet was made using the Shannon diversity index, to subsequently make comparison between diets by means of the ANOVA test. **Results:** At both 15 and 30 d post-weaning, pigs fed D4 exhibited the highest number ($P<0.05$) of enriched taxa, specifically *Oscillibacter* spp., compared to the other groups. Regardless of the sampling day, *Megasphaera* was the characteristic genus in the antibiotic group (D2), while D5 showed no distinctive taxa. Furthermore, pigs weaned at 28 d displayed significantly higher values ($P<0.05$) for taxonomic diversity and richness

compared to those weaned at 21 d, irrespective of the dietary treatment. **Conclusion:** Dietary inclusion of natural alternatives, such as oregano essential oil (*L. origanoides*), promotes microbial diversity and enriches beneficial taxa like *Oscillibacter* spp., a key indicator of intestinal health. Additionally, delaying weaning to 28 d significantly enhances the maturation and stability of the porcine gut ecosystem.

Keywords: Gut health, *Lippia origanoides*, microbial diversity, weaned pigs, weaning age

Palabras clave: Salud intestinal, *Lippia origanoides*, diversidad microbiana, cerdos destetados, edad de destete

Dietary Probiotic Supplementation Modulates Gut Microbiota and Enhances Growth Performance in Early-Weaned Pigs

Adicionar cepas probióticas modula la microbiota intestinal y su relación con el desempeño productivo en lechones destetados

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Introduction: Early weaning (≤ 21 d) imposes severe physiological stress due to maternal separation and abrupt dietary transitions. These factors often trigger reduced feed intake, gastrointestinal dysfunction, and dysbiosis, resulting in post-weaning diarrhea and impaired growth. **Objective:** This study aimed to characterize the intestinal microbiota and evaluate its relationship with growth performance in early-weaned pigs supplemented with various probiotic strains. **Methods:** A total of 80 crossbred barrows, weaned at 21 d of age, were assigned to five experimental diets: D1) commercial basal diet (BD) without antibiotics; D2) BD + antibiotics; D3) BD + *Lactobacillus acidophilus*; D4) BD + *Lactobacillus casei*; and D5) BD + *Enterococcus faecium*. No solid feed or antibiotics were provided during the lactation period. Clinical indicators, including rectal temperature (RT) and diarrhea severity index (DSI), along with average daily gain (ADG) and feed conversion ratio (FCR), were monitored daily for 30 d. On days 15 and 30 post-weaning, eight piglets per treatment were euthanized. Proximal jejunum and digesta samples were collected and immediately snap-frozen in liquid nitrogen for 16S rRNA gene sequencing and metagenomic analysis. **Results and Discussion:** Pigs receiving the D5 diet exhibited the lowest RT and DSI ($P<0.05$), coupled with the highest overall ADG ($P<0.05$). In contrast, D5 pigs showed lower feed intake ($P<0.05$) and a more efficient FCR. Although *Lactobacillus* was the predominant genus across all experimental groups, D5 supplementation increased the

relative abundance of *Oscillibacter*, while D2 was characterized by a higher abundance of *Butyrivibrio*. **Conclusion:** Dietary inclusion of probiotics, specifically *E. faecium*, effectively mitigates the incidence of diarrheal episodes and enhances zootechnical parameters, particularly weight gain and feed efficiency. These findings suggest that targeted probiotic intervention modulates the porcine gut ecosystem to optimize health during the critical post-weaning transition.

Keywords: *Enterococcus faecium*, growth performance, gut health, post-weaning stress, weaned pigs

Palabras clave: *Enterococcus faecium*, desempeño productivo, salud intestinal, estrés posdestete, cerdos destetados

Impact of Antimicrobial Alternatives and Weaning Age on Jejunal Disaccharidase mRNA Expression in Pigs Impacto de alternativas antimicrobianas y la edad de destete sobre la expresión de disacaridasas intestinales (yeyuno) en lechones destetados

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Introduction: The porcine intestinal mucosa facilitates carbohydrate breakdown and absorption through the activity of brush border enzymes. However, post-weaning transition requires significant morphological and enzymatic adjustments, particularly in mRNA expression, to overcome nutritional and sanitary challenges, especially in early-weaned piglets (<21 d).

Objective: This study aimed to quantify the mRNA abundance of jejunal disaccharidases, specifically lactase-phlorizin hydrolase (LPH), maltase-glucoamylase (MgA), and sucrase-isomaltase (SI), in pigs weaned at two ages and supplemented with various antimicrobial alternatives. **Methods:** A total of 150 crossbred barrows were used, with 80 piglets weaned at 21 d and 80 at 28 d of age. During lactation, no solid feed or antibiotics were provided. Animals were fed one of five experimental diets: D1) commercial basal diet (BD) without antibiotics; D2) BD + antibiotics; D3) BD + *Bacillus subtilis*; D4) BD + oregano essential oil (*Lippia origanoides*); and D5) BD + organic acids. On days 15 and 30 post-weaning, eight piglets per treatment/weaning age were euthanized to collect proximal jejunum samples, which were immediately snap-frozen in liquid nitrogen. The mRNA abundance of intestinal disaccharidases was quantified using real-time PCR (qPCR). For the analysis, a model of repeated measures over time was carried out under a completely randomized experiment: five

treatments (diets) and three repetitions (5 piglets) and two ages. The statistical analysis was performed according to the *Proc Mixed* procedure of the SAS® program. **Results and Discussion:** At 15 and 30 d post-weaning, pigs receiving the D4 diet exhibited significantly higher ($P<0.05$) relative mRNA expression of disaccharidases compared to all other groups, regardless of weaning age. Additionally, pigs weaned at 28 d showed higher ($P<0.05$) values for all molecular variables than those weaned at 21 d, irrespective of the dietary treatment. These results indicate that both supplementation and weaning age independently modulate the transcriptional activity of digestive enzymes. **Conclusion:** Dietary inclusion of natural alternatives, such as *L. origanoides* essential oil, enhances the relative mRNA expression of jejunal enzyme genes in weaned pigs. Furthermore, delaying weaning to 28 d promotes a more robust enzymatic profile, potentially improving nutrient utilization and gut maturation during the post-weaning period.

Keywords: Brush border enzymes, carbohydrate digestion, gene expression, *Lippia origanoides*, weaned pigs

Palabras clave: Enzimas bordes en cepillo, digestión carbohidratos, expresión génica, *Lippia origanoides*, lechones destetados

Maternal Programming of Piglet Microbes Through High Zinc Supplementation

Programación materna de microorganismos de lechones a través de una alta suplementación con Zinc

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Introduction: The maternal environment plays a critical role in establishing the primordial microbiome, yet how maternal nutrition modulates early microbial succession to influence offspring health remains poorly understood. **Objective:** To investigate if supplementation of maternal diets with high Zn doses during gestation increases the survivability of pigs while modulating the microbiome in both mothers and offspring. **Methods:** 30 sows were randomly assigned to three gestational dietary Zn treatments: 1) 125 ppm Zn from breed to farrow (Control); 2) 266 ppm Zn from breed to farrow (Br); and 3) 2,840 ppm Zn from day 110 to Farrow (D110). Pig survivability at farrowing and pre-weaning were measured. The microbiome in maternal seeding sources (vagina, milk, feces) and in the feces of $n = 30$ piglets per sow

treatment group was sequenced via shotgun metagenomics at birth and day five of age. After bioinformatics processing (Kraken2, Human3), the taxonomic and functional repertoire in sows and piglet microbiomes from each Zn treatment was compared and tested using diverse ecological diversity metrics (alpha-beta diversity), in tandem with multivariate and machine learning techniques for group prediction and feature selection. **Results and Discussion:** Piglets farrowed from Br sows exhibited greater % of pigs born alive and surviving pre-weaning. Limited broad effects of high Zn supplementation in mother milk and vaginal microbiomes were observed (alpha and beta diversity, ($P>0.5$)). However, Zn modulated specific taxonomic and functional traits associated with active colonic fermentation and intestinal hydrogen balance in the sow gut microbiome, particularly in sows under the Br treatment ($P<0.05$). Maternal supplementation with high Zn doses had the strongest deterministic effect on the piglet gut microbiome, including increased functional diversity, significant modulation of microbial traits typically associated by maternal milk and greater prevalence of antimicrobial resistance genes, particularly in pigs farrowed from Br sows. **Conclusion:** Maternal supplementation with high Zn doses throughout gestation impacted fermentative traits in sow microbiomes and modulated the microbial functional repertoire of piglets, which could be associated with increased pig survivability. However, the results caution that high Zn supplementation in maternal diets can induce antimicrobial resistance in the primordial and developing pig microbiome.

Keywords: Gestation, maternal milk, microbiome, weaning, Zn

Palabras clave: Gestación, leche materna, microbioma, destete, Zn

Digestive Antimicrobial Resistance Gene Profile in Piglets Fed Microencapsulated Probiotics During Pre-Fattening

Caracterización metagenómica del resistoma intestinal en cerdos bajo diferentes estrategias nutricionales

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Introduction: Antimicrobial resistance (AMR) is a critical global challenge, particularly in swine production, where the

use of antibiotic growth promoters (AGPs) has contributed to the dissemination of antimicrobial resistance genes (ARGs) in the gut microbiome. This phenomenon compromises animal health and poses risks to public health and the sustainability of livestock systems. In this context, and aligned with the One Health approach, microencapsulated probiotics have emerged as a promising alternative to modulate the gut microbiome and reduce selective pressure exerted by antibiotics. **Objective:** To evaluate the ARG profile in piglets during the pre-fattening phase under different dietary strategies and to assess its relationship with productive performance. **Methods:** An experimental study was conducted with piglets assigned to four dietary treatments (D1 and D2 with probiotics, D3 with antibiotics, and D4 with copper sulfate) for 49 days post-weaning. Fecal samples were collected at different time points, DNA was extracted, and shotgun metagenomic sequencing was performed. Data were normalized as counts per million (CPM). Statistical analyses were conducted using R software; normality was assessed, and differences between treatments were evaluated using the Kruskal–Wallis test. Spearman correlation, co-occurrence network analysis, and principal component analysis were also performed to evaluate associations between the resistome and zootechnical variables. **Results and Discussion:** Fourteen ARG classes were identified, with aminoglycosides, tetracyclines, and macrolides being the most abundant. No statistically significant differences were observed among treatments; however, the antibiotic group showed greater variability. ARG abundance increased with age, and moderate correlations indicated that higher ARG levels were associated with poorer productive performance. Probiotic groups showed reduced selective pressure and improved performance. **Conclusion:** Microencapsulated probiotics represent a promising strategy to modulate the intestinal resistome and maintain productive performance, supporting their use as a sustainable alternative to AGPs in swine production.

Keywords: Antimicrobial resistance, metagenomics, microbiome, probiotics, swine

Palabras clave: Resistencia antimicrobiana, metagenómica, microbioma, porcinos, probióticos,

Impact of a Microencapsulated Probiotic Consortium on Lactose Digestion and Intestinal Health in Piglets Impacto de un consorcio probiótico microencapsulado en la digestión de lactosa y la salud intestinal en lechones

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Introduction: During weaning, piglets experience a decline in intestinal lactase activity, which compromises lactose digestion and can lead to osmotic diarrhea, intestinal dysbiosis, and poor zootechnical performance. The intestinal microbiota can compensate for the decrease in lactase through microbial metabolic pathways for lactose and galactose. However, the low viability of conventional probiotics limits their efficacy, making microencapsulation a key strategy to protect them and enhance their effect on lactose digestion and intestinal health. **Objective:** This study evaluated the impact of two microencapsulated probiotic consortia on intestinal microbiota, digestive enzyme expression, and productive performance, compared to conventional antibiotic and copper sulfate treatments. **Methods:** A total of 108 piglets, weaned at 21 days, were randomly assigned to four treatments: D1 (Probiotic Consortium 1), D2 (Probiotic Consortium 2), D3 (sub-therapeutic antibiotics), and D4 (copper sulfate). The microbial profile was evaluated via 16S sequencing and metagenomics, alongside the expression of lactose metabolic pathways and productive parameters. Data were analyzed using ANOVA and post-hoc tests ($P < 0.05$).

Results and Discussion: The global architecture of microbiota remained stable across treatments; however, relevant taxonomic and functional modulations were observed. Microencapsulated probiotics, particularly treatment D2, promoted a microbiota enriched in Firmicutes, with a higher abundance of beneficial genera such as *Lactobacillus* and *Prevotella*, and a marked suppression of *Escherichia coli*. Functionally, D2 showed superior activation of intracellular lactose metabolism pathways (tagatose-6-phosphate pathway) and higher glycolytic flux, suggesting more efficient carbohydrate utilization. In contrast, the antibiotic treatment showed a significant reduction in genes associated with lactose degradation and glycolysis, evidencing functional impairment of the microbiota. Although no statistical differences were detected in feed conversion, D2 showed a tendency to maintain growth with lower feed intake. **Conclusion:** Supplementation with microencapsulated probiotics improved lactose digestion and optimized post-weaning productive performance. These results support their use as a sustainable alternative to the use of antibiotic growth promoters in animal production.

Keywords: Gut microbiota, lactose digestion, Leloir and tagatose-6P pathways, microencapsulated probiotics, weaned piglets

Palabras clave: Microbiota intestinal, digestión de lactosa, vías de Leloir y tagatosa-6P, probióticos microencapsulados, lechones destetados

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Effect of the Supernatant of *Lactiplantibacillus plantarum* on the Quality of Cooked Ham Efecto del sobrenadante de *Lactiplantibacillus plantarum* en la calidad del jamón cocido

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Introduction: Pork ham is highly perishable due to its high moisture; biopreservation through metabolites of lactic acid bacteria emerges as an alternative to chemical preservatives. **Objective:** To compare the effect of the cell-free supernatant of *Lactiplantibacillus plantarum* versus lactic acid and a commercial control on the microbiological, physicochemical, and sensory quality of cooked ham. **Methods:** *L. plantarum* ATCC® 8014 was cultured in MRS medium, the supernatant was obtained, and its *in vitro* activity against *Listeria monocytogenes* and *Escherichia coli* was evaluated. Three treatments were applied (T1: control, T2: lactic acid, T3: supernatant) to ham samples, analyzing pH, acidity, water-holding capacity, and sensory attributes over 21 days of refrigeration. **Results and Discussion:** The supernatant showed *in vitro* inhibition with halos up to 9.2 mm, reduced after filtration and heating, confirming the involvement of heat-sensitive bacteriocins and organic acids. In T3, no pathogens were detected throughout storage, while pH (5.82–6.16), acidity (0.109–0.108%), and water-holding capacity (72–71%) remained stable ($P>0.05$), without affecting texture or color. Sensory-wise, the odor attribute was better preserved in T3 compared to T1 and T2, indicating control of volatile compounds associated with spoilage. The effectiveness of the supernatant is attributed to the combined action of bacteriocins, organic acids, and antimicrobial metabolites, which act without causing excessive acidification or altering technological properties, unlike some chemical acidulants. The physicochemical and sensory stability supports its compatibility with industrial processes and its potential to reduce nitrite use. **Conclusion:** The supernatant of *L. plantarum* constitutes a viable strategy to extend the shelf life of cooked ham, ensuring microbiological safety and sensory quality, and represents a sustainable alternative for the meat industry.

Keywords: Food safety, human and animal health

Palabras clave: Inocuidad alimentaria, salud humana y animal

Stability Assessment of *Lactobacillus gasseri* Microencapsulated in Cocoa Mucilage Under Simulated Gastrointestinal Conditions

Evaluación de estabilidad de *Lactobacillus gasseri* microencapsulado en mucílago de cacao bajo condiciones gastrointestinales simuladas

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Introduction: The viability of probiotics during gastrointestinal transit is a key challenge to their effectiveness. Microencapsulation has emerged as a strategy for protecting probiotics, with cocoa mucilage standing out as an innovative material. **Objective:** The ability of the probiotic powder to withstand gastrointestinal conditions *in vitro* was evaluated. **Methods:** Once the probiotic powder was obtained from a suspension consisting of cocoa mucilage (CM) + inulin + maltodextrin (ED 10) and bacterial biomass (3×10^{15} CFU g⁻¹), viability testing (CFU g⁻¹) was conducted under simulated gastrointestinal conditions (gastric and intestinal phases), as well as water activity (a_w) and moisture content; subsequently, adhesion assays to intestinal mucosal cells were performed using a slide-fixation method with human mucin tissue. **Results and Discussion:** The viability parameter yielded significant values of 3×10^{11} CFU g⁻¹, a_w values of 0.567, and a moisture content of 12%. Meanwhile, the evaluation of intestinal adhesion showed a positive response, i.e., the presence of the microorganism in the powder. **Conclusion:** The results demonstrate that microencapsulation in a cocoa mucilage-based matrix improves the stability and viability of *Lactobacillus gasseri*. This suggests its potential as an encapsulating material in the development of functional probiotic systems, providing an innovative and sustainable alternative for the food industry.

Keywords: Human health, microencapsulation, mucilage, viability

Palabras clave: Salud humana, microencapsulación, mucílago, viabilidad

ZOOTECNIA DE PRECISIÓN

Formal Comparison of Two-Way Anova and Ancova Models Under a Particular Data Structure: CH Designs Comparación formal de los modelos Anova a dos vías y Ancova bajo una estructura de datos particular: Diseños CH

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Introduction: In any linear model, the vector space spanned by the design matrix columns (MS) determines many inferential features like model equivalence and parameter identifiability.; thus, studying the MS properties is of paramount importance. In certain experimental designs requiring local control, there are two approaches: grouping experimental units into homogeneous groups (blocking) and observing concomitant variables (covariates) on each one of them (covariance analysis). **Rationale:** This study was motivated by statistical consultancies from pork and poultry operations where operative or physical setups induced conditions on the design matrix termed CH: complete homogeneity, and there was interest in comparing models using blocking or covariates to perform local control. Most model comparisons rely on real or simulated data analysis, but they lack reproducibility and are not completely conclusive; a theoretical approach is more general. **Objective:** To develop a theoretical framework for model comparison in this problem. **Methods:** The focus was on a complete-blocks design or its generalized version. The CH conditions correspond to each one of p covariates having the same value within each block or within each block-treatment subclass. Three linear fixed effects models with Gaussian independent and homocedastic errors were considered: Two-way Anova with (TWA) or without interaction (TWA) and the Ancova (AC). We followed a projective approach, which is based on the theory of vector spaces and orthogonal projections onto subspaces of interest. The comparison was performed in terms of precision assessed by the estimator of error variance. We used a real pork dataset from an ongoing experiment to illustrate the developed theory. **Results and Discussion:** We proved three theorems and two corollaries establishing conditions under which: 1) the TWA is equivalent to AC, 2) the TWA is equivalent to AC, 3) the TWA and TWA yield higher precision than the AC. Some conditions are asymptotic (rely on large samples). **Conclusion:** This theory answers the question regarding the performance of

the studied models and leads to the conclusion that, under the CH conditions, there is no gain in precision by measuring covariates, which means that the associated economic and logistic effort is not worth.

Keywords: Linear algebra, linear models, precision, projection matrices, subspaces, vector spaces

Palabras clave: Álgebra lineal, modelos lineales, precisión, matrices de proyección, subespacios, espacios vectoriales

Identification of Key Performance Indicators in Swine Farrowing Systems Using Network Analysis Identificación de indicadores clave de desempeño mediante análisis de redes en sistemas de maternidad porcina

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Introduction: Swine farrowing systems generate multiple productive indicators that reflect different biological processes, from birth to weaning. However, evaluating these indicators in isolation makes it difficult to identify which ones determine the overall performance of the system. The identification of key performance indicators (KPIs) helps guide production decision-making in complex systems. Network analysis constitutes a useful tool to explore the interactions among variables and determine which indicators occupy structurally dominant positions within the system. **Objective:** To identify KPIs in swine farrowing systems using correlation-based network analysis. **Methods:** Records corresponding to the 2023–2025 period were analyzed, including 13 variables associated with prolificacy, lactation mortality, and weaning performance. From a correlation matrix, an undirected weighted graph was constructed in Gephi® 0.10.1, applying a threshold of $\geq |0.4|$ to retain correlations of greater magnitude. **Results and Discussion:** The resulting network consisted of 13 nodes and 25 edges, with an average degree of 3.846, a density of 0.321, and an average clustering coefficient of 0.704, indicating moderate connectivity and a tendency toward the formation of functional groups, suggesting the presence of functional subsystems within the farrowing system. Within this structure, total born showed high connectivity with variables

associated with neonatal survival and weaning performance, as well as high betweenness centrality, suggesting its role as a structural indicator of the system and as a bridge node between the interconnected functional subsystems related to birth and growth. Additionally, average birth weight showed relatively high closeness and betweenness values, indicating its influence within the neonatal growth subsystem. **Conclusion:** Network analysis allowed the identification of key indicators that structure performance in swine farrowing systems. In particular, total born emerges as a central KPI that articulates variables related to survival and growth, enabling the evaluation of the performance of specific productive subsystems. This approach provides a useful analytical tool to prioritize indicators and guide decision-making in swine production systems.

Keywords: Complex systems, decision-making, reproductive performance, swine production system, weaning

Palabras clave: Sistemas complejos, toma de decisiones, desempeño reproductivo, sistema de producción porcina, destete

Bioeconomic Assessment of Pig Lactation Performance Using Hierarchical Models and Monte Carlo Simulation Evaluación bioeconómica del desempeño en lactancia porcina mediante modelos jerárquicos y simulación Monte Carlo

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Introduction: Precision livestock production requires analytical tools capable of transforming production records into quantitative decision-making criteria. In the swine lactation phase, comparison among genetic lines using simple averages may be insufficient when unequal sample sizes, high biological variability, and multiple traits of interest are present. **Justification:** Data analytics applied to livestock systems enables integration of uncertainty, biological performance, and economic consequences within a single analytical framework. In this context, hierarchical Bayesian models and Monte Carlo simulation offer a robust alternative for genetic and bioeconomic evaluation under real farm conditions. **Objective:** To preliminarily evaluate the usefulness of a bioeconomic approach based on hierarchical Bayesian models and Monte Carlo simulation to analyze lactation performance in three paternal genetic lines anonymized as A, B, and C.

Methods: A total of 192 litters were analyzed using hierarchical Bayesian models for weaned piglets, average weaning weight, and lactation mortality. Continuous variables were modeled as $y_{ij} \sim N(\mu_j, \sigma^2)$, with line effects $\mu_j \sim N(\mu_{global}, \tau^2)$, allowing partial pooling. Mortality was modeled as $M_{ij} \sim \text{Binomial}(n_{ij}, p_j)$, with $p_j \sim \text{logit}^{-1}(\text{logit}(p_j))$ hierarchically distributed. Posterior distributions generated Monte Carlo scenarios to estimate expected utility and integrate traits into a composite bioeconomic decision index, defined as a weighted combination of productive performance (weaned piglets and weaning weight) and mortality penalization, standardized through z-transformations and evaluated under posterior uncertainty. **Results and Discussion:** The methodology allowed identification of trade-offs between prolificacy, weaning weight, mortality, and statistical robustness. Line A showed the highest posterior mean of weaned piglets, line C the highest average weaning weight, and line B the lowest estimated mortality. Under economic simulation, line A showed the highest expected utility; however, when incorporating a sample size penalty and an integral decision index, line C emerged as the most conservative alternative. This demonstrates that best performance in an individual trait does not necessarily coincide with the most robust option under uncertainty. **Conclusion:** This preliminary evaluation suggests that integrating hierarchical Bayesian models and Monte Carlo simulation represents a promising methodology for livestock data analytics, enabling transparent, traceable, and context-adapted decision-making within the biological and economic complexity of precision swine lactation.

Keywords: Inference, models, prolificacy, risk, simulation, uncertainty

Palabras clave: Inferencia, modelos, prolificidad, riesgo, simulación, incertidumbre

Bioclimatic Evaluation in Typological Pig Production Barn in the Department of Antioquia Evaluación bioclimática en un galpón tipológico de porcicultura en el departamento de Antioquia

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Introduction: In pig production systems, the environment in the farrowing barn is crucial for the welfare and productive performance of sows and piglets, especially under tropical conditions. However, there is marked spatial heterogeneity in the microclimate, mainly due to differences in thermal requirements between the two: while sows require temperatures around 20 °C on average, piglets need much warmer environments (34 °C on average). This variability makes it difficult to identify areas at risk of thermal stress and can affect productive efficiency if not responsibly managed. In a previous analysis of the barn, a thermal assessment was conducted, leading to changes in its infrastructure. The aim of this new assessment was to evaluate the effects of these changes on the productivity of sows and piglets. **Objective:** To perform a preliminary diagnosis of the thermal environment in a pig production barn using spatial analysis. **Methods:** A spatial map of the barn was created, and a grid of 56 points was systematically established (1 m along the transverse axis and 2 m along the longitudinal axis). At each point, variables such as temperature, relative humidity, air velocity, and lighting were recorded at animal height. The data were processed through an automated workflow developed in a programming environment based on Python, assisted by artificial intelligence(chatgpt) tools, which enabled the transformation of alphanumeric coordinates, data cleaning, and the generation of continuous temperature surfaces, yielding results comparable to software such as Surfer. **Results and Discussion:** A heterogeneous thermal distribution was observed within the barn, with thermal accumulation cores in intermediate zones reaching temperatures between 23.9 and 25.1 °C, exceeding the upper critical temperatures required by sows; these were therefore identified as critical points. In contrast, peripheral areas showed lower temperatures of 19 to 19.2 °C, associated with greater heat dissipation. **Conclusion:** The preliminary assessment confirmed significant improvements in the thermal environment resulting from the modifications made to this construction type.

Keywords: Microclimate, swine, temperature, thermal stress, welfare

Palabras clave: Microclima, porcinos, temperatura, estrés térmico, bienestar

Interactive Web Tool for Gompertz Curve Projection and Strategic Feeding Plans in Pigs Herramienta web interactiva para proyección de curva Gompertz y planes de alimentación dirigidos en cerdos

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Introduction: Inter-individual growth variability in swine production represents one of the major challenges for profitability and environmental sustainability, given that it largely depends on feeding, which constitutes the most significant cost within the production system. Conventional static nutritional programs assume homogeneous batch development, disregarding actual biological growth trajectories. This lack of precision leads to inefficiencies, nutrient wastage, and an increased carbon footprint, thereby making the transition toward dynamic and individualized nutrition imperative. **Objective:** To develop an interactive computational application to evaluate body growth trajectories and recommend targeted feeding schemes using a variant of the Gompertz model (Zwietering parameterization). **Methods:** A web-based tool was developed in R using the Shiny framework. The system integrates a modified Gompertz mathematical model to establish a reference asymptote. Animals are categorized based on their standard deviation relative to the mean growth curve. A proportional scaling algorithm was designed to project body weight toward a defined target by applying a weighting factor ($k = \Delta W / \Delta G$). This factor adjusts the daily gain of the reference curve, ensuring attainment of the target weight at the desired age while preserving biological nonlinearity. Finally, the algorithm integrates absolute age, weight categorization, and lactation duration to dynamically recommend a specific daily diet. **Results and Discussion:** The software “CIPA | Growth Monitoring and Feeding” enables bulk importation of weight records and their real-time visualization. The calculated trajectories are mathematically aligned with predefined production targets without compromising the physiological integrity of the base curve. The nutritional module assigns feeding allowances that advance or delay phase transitions according to the animal’s growth rate, optimizing feed utilization and automatically mitigating batch variability. **Conclusion:** The implementation of this algorithmic tool facilitates data-driven zootechnical decision-making, enabling the execution of precision feeding strategies tailored to individual growth patterns, thereby supporting more efficient, profitable, and sustainable production systems.

Keywords: Informatics, mathematical model, nutrition, prediction, R Shiny, software

Palabras clave: Informática, modelo matemático, nutrición, predicción, R Shiny, software

RESÚMENES PISCICULTURA

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Critical Real-Time Water Quality Parameters During Red Tilapia Fry Transport

Parámetros críticos de la calidad del agua en tiempo real durante el transporte de alevines de tilapia roja

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Introduction: Global aquaculture depends on efficient transport protocols to ensure the survival and welfare of red tilapia (*Oreochromis* sp.) fry. Inadequate conditions during transport can induce physiological stress, compromise immune function, and impair epidermal integrity. **Objective:** To evaluate in real time the changes in water quality parameters during the transport of red tilapia fry and assess their impact on epidermal integrity. **Methods:** A total of 250 individuals per bag were transported under three treatments: 5 hours (T1), 12 hours (T2), and 20 hours (T3), with mean body weights of 0.6 ± 0.2 g, 0.6 ± 0.35 g, and 0.6 ± 0.25 g, respectively. Each bag contained 2.5 L of water and 6.5 L of oxygen (99.5%); fish were fasted for 48 h prior to transport. Water quality parameters (pH, DO,

temperature) were recorded every five minutes using HOBO sensors, and epidermal samples were examined by scanning electron microscopy (SEM). Statistical analyses: included descriptive measures and a generalized linear model (GLM) with transport duration as fixed factor; differences among treatments at the initial measurement points were assessed with Tukey's test (95% confidence). All analyses were performed with R Project, version 4.4.0.). **Results and Discussion:** Survival was 100% in all treatments, demonstrating the effectiveness of the protocol, particularly supplemental oxygenation. DO increased over time, reaching mean values of 7.86 ± 4.15 mg L⁻¹ (5 h), 9.76 ± 3.17 mg L⁻¹ (12 h) and 11.29 ± 3.39 mg L⁻¹ (20 h). pH showed a slight but significant decrease, from 6.00 ± 0.19 to 5.77 ± 0.17 , reflecting progressive acidification due to CO₂ accumulation. Final temperatures remained within the tolerance range reported for the species (26.56 ± 0.77 to 29.47 ± 1.74 °C). SEM revealed a homogeneous epidermis, without structural damage, and the presence of goblet cells (4–5 µm), confirming preservation of epidermal integrity. **Conclusion:** Continuous monitoring of water quality is essential to optimize transport protocols in aquaculture. Adequate oxygenation and control of acidification minimize stress, ensure high survival, and maintain the epidermal integrity of red tilapia fry, contributing to more sustainable and efficient production systems.

Keywords: Aquaculture, goblet cell, water quality, welfare

Palabras clave: Acuicultura, célula caliciforme, calidad de agua, bienestar

NUTRICIÓN Y ALIMENTACIÓN

Effect of Commercial Bioadditives on the Productive Performance of Juvenile *Oreochromis* sp. Efecto de bioaditivos comerciales sobre el desempeño productivo de *Oreochromis* sp. en fase juvenil

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Introduction: Plant-derived functional additives are increasingly used in aquaculture to improve productivity and sustainability, particularly in species such as red tilapia. **Objective:** To evaluate the effect of dietary supplementation with additives based on *Lippia origanoides* on the productive performance of juvenile *Oreochromis* sp. **Methods:** A completely randomized design was used with two treatments and one control (C): diet supplemented with a powdered product containing *Lippia origanoides* (LO) at 1,000 g ton⁻¹ of feed, and diet supplemented with the same product combined with sodium humates (LOS). Each treatment had four replicates. A total of 240 fish (1±0.2 g) were randomly

distributed into 12 plastic tanks (500 L) with 20 fish per unit and fed a commercial diet containing 40% crude protein for 130 days. Productive variables evaluated included weight gain, feed intake, apparent feed conversion ratio, final biomass, survival, and hepatosomatic index. Data were analyzed using ANOVA followed by Tukey's test ($P<0.05$). **Results and Discussion:** No significant differences were observed among treatments for weight gain, feed conversion ratio, or final mean weight. Survival was 80.0±4.64% in C, 95.0±4.64% in LO, and 97.5±4.64% in LOS. Final biomass was higher in supplemented groups, reaching 12.58 kg (LO) and 13.13 kg (LOS) compared with 11.25 kg in the control. The hepatosomatic index showed significant differences ($P = 0.005$), with values of 2.50±0.10% (C), 1.80±0.10% (LO), and 2.00±0.10% (LOS). Fish were euthanized using thermal shock (-4 °C) followed by eugenol anesthesia prior to sampling. All procedures were conducted under approval of the institutional bioethics subcommittee. **Conclusion:** Dietary supplementation with *Lippia origanoides*-based additives did not negatively affect productive performance and significantly influenced the hepatosomatic index. Higher survival and biomass in supplemented groups suggest potential benefits for tilapia production.

Keywords: Aquaculture, hepatosomatic index, *Lippia origanoides*, productive

Palabras clave: Acuicultura, índice hepatosomático, *Lippia origanoides*, productivo

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Gill Alterations Associated with a Hydrocarbon Contamination Event in Rainbow Trout (*Oncorhynchus mykiss*)

Alteraciones branquiales asociadas a un evento de contaminación por hidrocarburos en trucha arcoíris (*Oncorhynchus mykiss*)

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Introduction: Accidental hydrocarbon spills represent a significant environmental risk for aquaculture systems, particularly in regions where productive activities and fuel transportation converge, potentially affecting water quality and fish tissue integrity. The integrated evaluation of limnological parameters and gill histopathology allows the identification of early sublethal effects associated with contaminant exposure, providing key information for sanitary and environmental management in fish production systems. **Objective:** To evaluate water quality conditions and describe histological alterations in the gills of rainbow trout (*Oncorhynchus mykiss*) following a confirmed hydrocarbon contamination event at a commercial farm in the department of Santander, Colombia. **Methods:** A technical field visit was conducted at a trout farm operating under an open-flow system to assess physicochemical water parameters. Five hydrocarbon-affected fish (juvenile and adult) were sampled for gill histology. Tissues were processed using conventional techniques and stained with hematoxylin and eosin. Statistical analysis was descriptive, reporting mean $\pm$ standard deviation for water quality and qualitative lesion characterization for histology. **Results and Discussion:** Water quality parameters were within optimal ranges for rainbow trout production, with adequate dissolved oxygen concentrations (6.5 ± 1 mg L⁻¹), neutral pH (7.3 ± 0.1), stable temperature (15°C), and absence of detectable nitrogenous compounds. However, histological analysis of the gills revealed severe inflammatory lesions characterized by lymphocytic infiltration, marked atrophy of primary lamellae, epithelial desquamation of secondary lamellae, diffuse necrosis of the branchial epithelium, hyperplasia of mucous cells, and alterations in lamellar

architecture. These lesions suggest an acute tissue response to an irritant agent, consistent with exposure to contaminants of chemical origin. **Conclusion:** Although water quality parameters remained within suitable ranges for the species, the histopathological findings suggest that the observed gill alterations were likely associated with hydrocarbon exposure.

Keywords: Aquaculture, contamination, diesel, histopathology, quality

Palabras clave: Acuicultura, contaminación, diésel, histopatología, calidad

Similar Growth of Red Tilapia at Two Stocking Densities in Biofloc Farming

Crecimiento similar de la tilapia roja en dos densidades de población en cultivo con biofloc

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Introduction: Biofloc technology (BFT) enables intensive aquaculture production with reduced water exchange; however, information on appropriate stocking densities for red tilapia under large-scale commercial conditions remains limited. Identifying suitable stocking densities is essential to optimize productive performance, water use efficiency, and final product quality in sustainable aquaculture systems. **Objective:** To evaluate the effects of two stocking densities on growth performance, water quality parameters, and chemical and microbiological characteristics of monosex red tilapia reared in a commercial BFT system in eastern Colombia. **Methods:** Six circular commercial tanks (153 m³ each) were used in a completely randomized design with two treatments: 30 fish m⁻³ (T30) and 40 fish m⁻³ (T40), each with three replicates, over a 210-day production cycle. Fish began the study with an initial weight of 1 ± 0.2 g. Feeding was carried out using a commercial balanced diet provided by a private company, following the manufacturer's recommendations. Water quality variables, zootechnical performance, proximate composition, and microbiological quality of fish were assessed. Data were analyzed using an independent sample t-test; percentage data were arcsine-transformed prior to analysis (R software v3.6.3). **Results and Discussion:** Water quality parameters remained within suitable ranges for

the species in both treatments, although dissolved oxygen decreased progressively throughout the production cycle. No significant differences were observed in growth performance or feed conversion ratio (FCR) ($P>0.05$), which reached 1.6 in T30 and 1.7 in T40. Final biomass was higher in T40 due to the greater number of fish. Proximate composition was similar between treatments ($P>0.05$), and *Salmonella* spp. and *Vibrio cholerae* were not detected, confirming product safety. **Conclusion:** Stocking densities of 30 and 40 fish m⁻³

in commercial biofloc systems do not negatively affect productive performance or the nutritional and sanitary quality of red tilapia, allowing producers to select densities according to market demands and water use efficiency.

Keywords: Aquaculture, innocuousness, *Oreochromis*, productive performance, quality

Palabras clave: Acuicultura, inocuidad, *Oreochromis*, desempeño productivo, calidad

RESÚMENES

**ESPECIES PRODUCTIVAS NO TRADICIONALES
(APICULTURA, CONEJOS, CUYES, PATOS,
ENTRE OTROS)**

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Thermal and Behavioral Responses of Reproductive Rabbits to Bottle-Based Thermal Enrichment Respuestas térmicas y conductuales de conejas reproductoras al enriquecimiento térmico con botellas

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Introduction: In rabbit production systems under hot climates, thermal load can compromise the comfort and welfare of reproductive does. **Justification:** Simple and low-cost thermal enrichments may reduce peripheral temperature increase and promote behaviors associated with welfare. **Objective:** To evaluate the effect of a room-temperature water bottle and a frozen bottle on thermal and behavioral variables in

reproductive rabbits. **Methods:** Twelve female rabbits were evaluated over periods of 15 days of use followed by 15 days of rest, and were divided into three groups: control, room temperature water bottle, and frozen bottle. Ear and nose temperatures were recorded before treatment application and at 2, 4, and 6 hours, along with the temperature and humidity of the warren; in the enrichment groups, behaviors were quantified using an ethogram. **Results and discussion:** Vivarium temperature was positively correlated with ear ($r=0.86$) and nose temperature ($r=0.95$), whereas relative humidity was negatively correlated with both variables ($r=-0.82$ and $r=-0.89$). The greatest thermal challenge occurred at 4 h. Relative to baseline, the mean increase in ear temperature was lower in the enriched groups at 4 h (control: $+1.79$ °C; room-temperature bottle: $+0.89$ °C; frozen bottle: $+0.70$ °C) and at 6 h (control: $+1.54$ °C; room-temperature bottle: $+0.51$ °C; frozen bottle: $+0.92$ °C). Behaviorally, both groups showed low stereotypy frequency; the frozen-bottle group showed higher active interaction (1.18 vs 0.83 events/animal/day) and a slightly higher exploratory Likert welfare score than the room-temperature bottle group. **Conclusion:** Bottle-based thermal enrichment attenuated the increase in auricular temperature relative to the control and maintained a behavioral pattern compatible with good welfare, with an overall advantage for the frozen-bottle treatment.

Keywords: Comfort, ear, ethogram, humidity, management, vivarium

Palabras clave: Confort, oreja, etograma, humedad, manejo, vivario

REPRODUCCIÓN

Reproductive Efficiency of Rabbit Genetic Lines Fed a Commercial Concentrate Diet Eficiencia reproductiva de líneas genéticas de conejas alimentadas con concentrado comercial

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Introduction: In the department of Antioquia, rabbit production (*cuniculture*) is emerging as a viable productive alternative for small and medium-scale producers, particularly in regions where rural and gastronomic tourism has increased the demand for differentiated, locally sourced meat products. In this context, improving reproductive efficiency is a key factor in strengthening production systems. **Justification:** Evaluating the reproductive performance of different genetic lines under commercial feeding conditions makes it possible to identify management strategies that optimize productivity in commercial rabbit production systems. **Objective:** To evaluate the reproductive efficiency of two genetic lines of breeding does under a feeding system based on commercial concentrate. **Methods:** Reproductive records corresponding to 38 litters from females belonging to two genetic

lines—Californian Russian (RC) and New Zealand (NZ)—were analyzed. Animals were subjected to natural mating at a ratio of 2 males per-5 females. The evaluated variables included number of pups born (PB) and pups weaned (PW) per litter, pre-weaning survival rate (SR = PB/PW), and calving interval CI). Data were analyzed using descriptive statistics and comparisons between genetic lines in RStudio. **Results and Discussion:** The overall mean values were 8.08 PB and 6.94 PW, with a survival rate of 0.84 and an average CI of 94.4 days. The New Zealand (NZ) line showed a larger litter size (8.35 PB) and a higher number of weaned kits (7.47) compared to the RC line (7.86 and 6.47, respectively). Likewise, the survival rate was higher in NZ (0.88) than in RC (0.81). The CI averaged 96.8 and 92 days for NZ and RC, respectively, corresponding to semi-intensive production systems. Although no statistically significant differences were found between the evaluated lines, the observed trend suggests better reproductive performance of the NZ line under the evaluated feeding system. **Conclusion:** The results indicate that the use of commercial concentrate formulated by Solla S.A. supports adequate reproductive parameters in rabbit production systems. Additionally, productive response may vary depending on the genetic potential of the breeding stock, providing relevant information for feeding programs and genetic selection strategies aimed at improving regional rabbit production.

Keywords: Feeding, productivity, rabbit farming, reproduction

Palabras clave: Alimentación, productividad, cunicultura, reproducción

NUTRICIÓN Y ALIMENTACIÓN

Chemical Characterization of Two Populations of *Hermetia illucens* Fed with Agro-Industrial Waste Caracterización química de dos poblaciones *Hermetia illucens* alimentadas con residuos agroindustriales

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Introduction: BSFL are a value source of protein and energy for animal nutrition. However, their chemical composition presents metabolic versatility influenced by substrate and population origin, factors that condition the standardization of biomass. **Objective:** To analyze the chemical composition of two populations of BSFL (UNAL and CIAT) raised on different substrates for use in animal nutrition. **Methods:** Both populations were evaluated through independent trials (30 experimental units [EU]/population; 700 larvae per EU) for 15 days under controlled conditions. Five substrates were formulated by supplementing base residues: chicken feed (CON), cocoa husk (CH), coffee pulp (CFP), restaurant waste (RW), and a mixture of coffee husk and rice husks (DCHRH). After scalding, samples (n = 3 per diet) were analyzed using proximal analysis (Weende) for dry matter (DM), crude protein (CP), ethereal extract (EE), ash (ASH), and crude fiber (CF). **Results and discussion:** A significant interaction between population and substrate was identified for CP ($P = 0.042$), ASH ($P < 0.001$), and DM ($P = 0.039$). CIAT reached the highest CP in the RW diet ($44.24 \pm 0.18\%$), while UNAL recorded the lowest CP value ($36.10 \pm 0.41\%$); however, it exhibited a higher ASH composition for CON ($5.51 \pm 0.14\%$) compared to CIAT ($2.38 \pm 0.08\%$). DM and EE depended mainly on the substrate ($P < 0.001$); CON maximized DM in both populations ($35.93 \pm 0.07\%$ CIAT; $36.01 \pm 0.61\%$ UNAL), with higher EE levels in CIAT ($33.19 \pm 0.66\%$) compared to UNAL ($24.07 \pm 2.26\%$). In contrast, RW resulted in lower DM (CIAT: $19.85 \pm 0.97\%$; UNAL: $19.09 \pm 0.41\%$) and EE (CIAT: $11.94 \pm 1.78\%$; UNAL: $8.13 \pm 1.42\%$), producing leaner larvae. The highest CF content was observed at UNAL with DCHRH ($17.43 \pm 0.64\%$) and the lowest in CIAT, CON ($7.08 \pm 0.87\%$). **Conclusion:** The nutritional composition of BSFL is determined by the interaction between the population and the substrate, revealing a highly dynamic bromatological profile. The variability in CP, EE, and ASH levels confirms that these nutrients respond to the specific combination of population origin and the substrate provided, validating the metabolic plasticity of the species.

Keywords: Bromatology, larvae, nutrition, protein, substrate

Palabras clave: Bromatología, larvas, nutrición, proteína, sustrato

Productive Performance of Two Populations of *Hermetia illucens* Fed with Agro-Industrial Waste Desempeño productivo de dos poblaciones de *Hermetia illucens* alimentadas con residuos agroindustriales

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Introduction: The productive performance of black soldier fly larvae (BSFL) (*Hermetia illucens*) makes it possible to convert agro-industrial by-products into protein for animal nutrition. However, the efficiency of this process depends on the nutritional quality of the substrate and population physiological variability. **Objective:** To analyze the productive performance of two populations of BSFL (UNAL and CIAT) using substrates based on agro-industrial waste. **Methods:** The performance of both populations was evaluated through independent trials (30 experimental units [EU]/population; 700 larvae per EU) for 15 days under controlled conditions. Five substrates were formulated by supplementing base residues: chicken feed (CON), cocoa husk (CH), coffee pulp (CFP), restaurant waste (RW), and a mixture of coffee husk and rice husks (DCHRH). Larval weight (LBW, mg) was determined individually, bioconversion efficiency (WBE %, biomass gained/substrate consumed) and bioconversion percentage (CR, %, final biomass/total substrate) were calculated at the population/EU level. **Results and Discussion:** A significant interaction between population origin and substrates was identified for all variables ($P < 0.05$). In the CON substrate, CIAT outperformed UNAL in LBW (82.7 ± 11.2 vs. 34.3 ± 6.1 mg), WBE (47.7 ± 7.2 vs. $20.7 \pm 3.6\%$), and CR (34.3 ± 4.6 vs. $14.2 \pm 2.5\%$). In contrast, in agro-industrial waste, the CFP substrate allowed both populations to achieve statistically similar values: LBW (31.0 ± 6.0 vs. 28.9 ± 2.8 mg), WBE (16.4 ± 5.0 vs. $16.8 \pm 2.1\%$), and CR (10.5 ± 2.0 vs. $9.8 \pm 0.9\%$). The UNAL population showed a hierarchical response, with CFP being the most efficient, while CIAT maintained a homogeneous CR in CH ($9.7 \pm 0.9\%$), CFP ($10.5 \pm 2.0\%$), and RW ($9.4 \pm 1.1\%$). Finally, the RW and DCHRH substrates significantly limited performance in both populations. **Conclusion:** The productive performance of BSFL depends on the interaction between population and the substrate. CIAT's superiority on optimal substrates disappears when CFP is used, as this input homogenizes yield regardless of population. Thus, CFP is a viable biotechnological alternative for waste valorization and minimizing the population variability.

Keywords: Biomass, biotechnology, nutrition, performance, substrates

Palabras clave: Biomasa, biotecnología, nutrición, rendimiento, sustratos

SISTEMAS DE PRODUCCIÓN ANIMAL Y AGROINDUSTRIA

Challenges of the Aburrá Valley-Antioquia Metropolitan Agrifood System for Animal Proteins Retos del sistema agroalimentario metropolitano del Valle de Aburrá-Antioquia sobre proteínas animales

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Introduction: The metropolitan agrifood system of the Aburrá Valley, especially in the supply of animal-source proteins—meat, milk, and eggs—is sensitive to logistics, the cold chain, and sanitary risks. Its evaluation is necessary to propose sustainable agrifood innovation ecosystems capable of articulating actors, information, and capacities around public-value solutions. **Justification:** In a metropolis with high population concentration and limited capacity to produce animal proteins, dependence on other subregions of Antioquia and on other departments increases vulnerability to road closures, climatic or sanitary events, and energy costs, while also deepening value asymmetries to the detriment of primary producers. **Objective:** To systematize supply case studies in Girardota, Barbosa, Caldas, and Medellín, focusing on the meat, milk, and egg chains, and to derive guidelines for a proposal for an Agrifood Innovation Ecosystem aligned with Animal Science 5.0. **Methods:** An analytical synthesis was conducted using traceability information compiled over five years, associated with more than 4,000 producers linked to supply, triangulating lessons from agricultural extension, supply-demand mapping, and proximity markets. The analysis adopted the food security framework—availability, access, utilization, and stability—and integrated approaches from innovation systems and digital agrifood ecosystems. **Results and Discussion:** It was evidenced that the chain does not operate as an intelligent system: volumes circulate toward wholesale markets and are then redistributed, even returning close to their origin, increasing costs, environmental footprint, and loss of value. In addition, low value added and limited access to fair markets or to the final consumer keep producer prices low. The presence of subsistence and family farmers who supply third parties with eggs, milk, or meat was identified; however, they face restrictions in meeting sanitary requirements, which puts pressure on food safety and confirms their role as buffers of food security. **Conclusion:** It is necessary to institutionalize information management through BI, spatial analytics, and traceability; strengthen

linkages among actors; and design short proximity circuits, fair markets, and compensated recovery mechanisms to advance triple-impact sustainability and contribute to SDGs 2, 12, 13, and 17.

Keywords: Dairy products, eggs, meats, metropolis, sustainability, traceability

Palabras clave: Productos lácteos, huevos, carnes, metrópolis, sostenibilidad, trazabilidad

Production of Vermicompost with *Eisenia foetida* Using Organic Waste in Caquetá Producción de lombricomposta con *Eisenia foetida* utilizando residuos orgánicos en Caquetá

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Introduction: Vermiculture is a biotechnology for the ecological management of agricultural waste that allows it to be transformed into products of high agronomic value, such as humus and vermicompost, highlighting the Californian red worm (*Eisenia foetida*) for its high efficiency and adaptability. **Justification:** the evaluation of different substrates allows us to identify those that favor the growth, reproduction and production of vermicompost in *Eisenia foetida*. **Objective:** To evaluate the population dynamics of *Eisenia foetida* using different substrates of animal and plant origin. **Methods:** The experiment was carried out in Florencia (Caquetá, Colombia), evaluating four organic substrates: bovine manure, ornamental tree residues and kitchen residues. A randomized complete block design with four treatments and four replications was used. The data were analyzed using ANOVA, after verification of normality and homogeneity of variances; when there were significant differences ($P < 0.05$), Tukey's test was applied. G Poultry manure presented the best performance, with a growth of $195 \pm 12.4\%$, density of 730 ± 45.6 earthworms kg^{-1} and high biomass; bovine

manure showed intermediate growth ($142 \pm 10.1\%$), density of 610 ± 38.2 earthworms kg^{-1} and the highest production of shells (50 ± 4.2 pellets per unit); kitchen waste registered growth of $118 \pm 9.3\%$, density of 540 ± 41.7 worms kg^{-1} and the highest production of vermicompost (4.0 ± 0.35 kg); In contrast, ornamental tree residues presented the lowest performance, with growth of $60 \pm 7.8\%$, density of 390 ± 35.4 earthworms kg^{-1} and reproduction of 21 ± 2.6 cocoons per unit; evidencing what has been reported in previous studies, where the positive relationship between nitrogen content, nutrient availability and population growth of *Eisenia foetida* is highlighted, as well as the influence of substrate quality on the productive and reproductive efficiency of the vermiculture system. **Conclusion:** Manure is consolidated as the most suitable substrate in vermiculture, as it consistently favors the population and productive development of earthworms, which makes it an efficient alternative for the use of organic waste.

Keywords: Humus, compost, vermiculture

Palabras clave: Humus, compostaje, vermicultura

Characterization of Postweaning in Two Rabbit Lines in the State of Antioquia

Caracterización del crecimiento postdestete en dos líneas de conejos en el departamento de Antioquia

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Introduction: Rabbit farming in Colombia is limited, as are studies characterizing post-weaning growth in rabbits, a key stage in production performance. Low productivity is associated with a lack of technical information on growth; therefore, characterizing this phase is essential for improving production efficiency and strengthening the sustainability of the system. **Objective:** To characterize post-weaning growth in rabbits from a production system in the department of Antioquia. **Methods:** Weigh-ins were conducted twice weekly on rabbits from two genetic lines (New Zealand—NZ—and Russian Californian—RC—) from weaning until sale, using a scale (Dubai Kitchen). The data were digitized in Excel and analyzed in RStudio. Descriptive statistics were estimated to evaluate growth according to parity (NP), litter size (TC), genetic line (LG), month of weighing (MP), and sex (SX) at different ages (G). Additionally, a mixed model with repeated measures was used to identify sources of variation in growth.

Results and Discussion: RC rabbits had higher mean initial (853.96 g) and final (1,367 g) weights compared to NZ (780.32 g and 1,197 g, respectively). Daily weight gain (DWG) was higher in RC (23.44 g day^{-1}) than in NZ (21.65 g day^{-1}), with sample sizes of 133 and 99 animals, respectively. Descriptive analysis revealed differences in growth among levels of G, NP, LG, TC, MP, and SX. The mixed model indicated significant effects of G, TC, MP, and NP on growth, with a progressive increase in weight with age and a decrease in animals from large litters. Rabbits from intermediate parities recorded higher weights. In contrast, SX and LG did not show significant effects under the evaluated conditions.

Conclusion: Post-weaning growth is primarily determined by age, litter size, and parity, reflecting the influence of maternal factors on production performance. These results allow for the identification of opportunities to adjust feeding and management according to each factor, contributing to improved production efficiency and the sustainability of rabbit farming in Antioquia.

Keywords: Litter size, parity number, productive performance, rabbit farming

Palabras clave: Tamaño de camada, número de parto, desempeño productivo, cunicultura

Factors Associated with Weaning Weight in Rabbits in a Production System in Antioquia

Factores asociados al peso al destete en conejos en un sistema productivo en Antioquia

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Introduction: Rabbit farming in Colombia is limited, as are studies on the factors influencing weaning weight (WW) variability in rabbits. The low productivity in Colombian rabbit production systems is partly due to the lack of technical information on factors influencing this variable. Identifying them will generate useful information to improve productive efficiency and promote sustainable rabbit farming. **Objective:** To identify determining factors affecting weaning weight in rabbits from the rabbit farming unit of the Universidad Nacional de Colombia, Medellín campus. **Methods:** WW was recorded for rabbits from two genetic lines: New Zealand and Californian Russian, using a scale (Dubai Kitchen) in the morning hours. Data were recorded on physical registration sheets and digitized in Excel. RStudio was used to process and descriptively analyze the information to evaluate WW according to age grouped into two classes (AC), parity number (PN), litter size at weaning (LSW), genetic line (GL), and sex

(SX). Additionally, a linear model including the aforementioned factors as fixed effects was used to identify sources of variation responsible for WW. For significant effects in the model, a means comparison test was performed using Tukey's test.

Results and Discussion: Descriptive analysis and the linear model ($R^2 = 0.34$; adjusted $R^2 = 0.31$) showed that weaning weight is mainly influenced by litter size at weaning (LSW) and parity number (PN), while sex had no significant effect ($P = 0.445$). Tukey comparisons indicated that higher weights were associated with smaller litter sizes, particularly tcd3 (1453 ± 79.2 g), which differed significantly from larger litters such as tcd11 and tcd12 ($P < 0.05$). Parity number showed a non-linear effect, with higher weights in PN9 (1114 ± 65.5 g) and lower values in PN6 (689 ± 51.6 g). These results highlight the importance of maternal and management factors.

Conclusion: Weaning weight varied significantly with litter size at weaning (LSW) and parity number (PN), while sex had no effect. Higher weights were observed in smaller litters and specific parities, indicating a non-linear maternal influence. These findings highlight the importance of optimizing litter size and reproductive management to improve productivity.

Keywords: Litter size, parity number, productive performance, rabbit farming, weaning weight

Palabras clave: Tamaño de la camada, número de partos, rendimiento productivo, cría de conejos, peso al destete

Reproductive Parameters in Relation to Non-Genetic Factors at a Rabbit Farm in Medellín

Parámetros reproductivos de acuerdo con factores no genéticos en una cunícola de Medellín

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Introduction: Rabbit farming in Colombia is underdeveloped, as does the availability of studies focused on characterizing reproductive parameters in rabbits. Therefore, the study of reproductive variables such as fertility and prolificacy will generate technical inputs aimed at strengthening the sustainability of rabbit production systems. **Objective:** To estimate reproductive parameters of the rabbit breeding program at the National University of Colombia, Medellín Campus, based on non-genetic factors. **Methods:** Fertility rate (FR) and the number of kits per litter (NKL) were evaluated in New Zealand and Russian Californian rabbits. The data were recorded in Excel and analyzed in RStudio using descriptive statistics, considering year (YB), parity (P), litter size (LS), and month of parturition (MP). **Results and Discussion:** The overall mean FR were 0.85 ± 0.084 . The months with the highest FR were January, July, and August, and those with the lowest FR were February, March, and May. According to the YB the FR was 0.76 ± 0.23 , 0.87 ± 0.14 , and 0.90 ± 0.10 for 2023, 2024, and 2025, respectively. The overall mean for the LS was 7.8 ± 0.78 . The MP with the highest average LS were February, May, and November, and those with the lowest average LS were July, October, and December. Mean values were obtained LS values of 7.75 ± 2.05 , 7.02 ± 2.33 , and 8.73 ± 1.71 for the YB of 2023, 2024, and 2025, respectively. The mean LS according to parity showed a slight upward trend from parity 1 to parity 7, ranging from 7.05 ± 2.47 to 8.28 ± 1.49 . Depending on the parity (P), it showed a progressive increase, rising from 0.86 ± 0.338 in P1 and P2 to higher values in advanced parities, reaching 0.949 ± 0.223 in P8 and P9. This suggests an improvement in reproductive efficiency as the female's physiological experience increases. **Conclusion:** The factors of P, MP and YB may influence LS. In a future study, the significant influence of these factors on the studied variables should be verified using a statistical procedure appropriate to the characteristics of the variables.

Keywords: Kindling interval, litter size, parity number, rabbit farming

Palabras clave: Intervalo entre partos, tamaño de camada, número de parto, cunicultura

EXTENSIÓN RURAL

Food Security Through the Production of *Cavia porcellus* in Rural Communities of the Orinoquía Piedmont Seguridad alimentaria con la producción de *Cavia porcellus* en comunidades rurales del Piedemonte Llanero

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Introduction: Food security in rural areas of the Orinoquía piedmont faces significant limitations related to access to animal protein, production costs, and dependence on external markets. In this context, the production of *Cavia porcellus* (guinea pig), combined with rural extension processes, emerges as a sustainable alternative for local communities. Guinea pig meat has high nutritional value, and its production system requires low investment, shows broad adaptability, and is easy to manage. Therefore, implementing this system contributes to food security while generating income for rural households.

Objective: To strengthen food security and productive capacities of peasant families through the implementation of guinea pig production systems. **Methods:** The study was conducted under a Participatory Action Research (PAR) approach, structured in

five stages: participatory diagnosis; training in management, feeding, health, and commercialization; implementation of pilot production units; continuous technical support; and the development of local marketing strategies. The study involved 15 families in the Meta Department. **Results and Discussion:** The rural extension process led to the adoption of this alternative by 10 out of the 15 participating families, strengthening knowledge in animal production, economic empowerment, and local marketing processes. The availability of high-quality protein in households increased, and dependence on external markets was reduced through the implementation of guinea pig production. From an agroecological perspective, the use of local resources was optimized, reducing costs and enhancing sustainability. **Conclusion:** The initiative contributed to food security in terms of quality, by providing a high-value animal protein source, and availability, due to the species' high reproductive rate. Furthermore, the implementation of *Cavia porcellus* production systems proved to be an effective strategy to improve food security, strengthen rural economies, and promote sustainable rural development models. The community support process facilitated the appropriation of this alternative and its integration into local productive activities.

Keywords: Agroecology, guinea pig farming, rural development, sustainability

Palabras clave: Agroecología, cuyicultura, desarrollo rural, sostenibilidad

RESÚMENES
ANIMALES DE COMPAÑÍA

FISIOLOGÍA, BIENESTAR Y COMPORTAMIENTO

Characterization of Animal Abuse in Medellín (Colombia) During the Period 2017 – 2024 Caracterización del maltrato animal en Medellín (Colombia) durante el periodo 2017 – 2024

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Introduction: In recent decades animal welfare has gained increasing relevance, which has driven the creation of a robust regulatory framework that ensures the guarantee of this state. In the case of Colombia, legal recognition imposes on the State and society the duty to guarantee conditions of dignified treatment in coherence with the principles of protection, the five domains of animal welfare and social solidarity, as established in Law 1774 of 2016. **Justification:** However, in relation to fauna, critical problems persist, such as: massive abandonment, physical abuse, negligence, among other forms of mistreatment; thus understanding that the existence of a legal framework does not by itself guarantee its effective compliance, and the question arises: What is the dynamic in the District of Medellín in relation to the mistreatment of non-human animals?, and therefore, the need to carry out the present research arises, which has the following **Objective:** To characterize the mistreatment of non-human sentient beings in the District of Medellín during the period 2017 - 2024. **Methods:** It is research of descriptive scope with mixed methodology, whose source of information was obtained through the District Ombudsman's Office of Medellín and delivered by the governmental entities related to the topic. The analyzed data correspond to the petitions, complaints and claims submitted by citizens in relation to cases of animal abuse, taking into account the date of the event, type of abuse (minor/severe), animal species, place, and purpose of the animal; highlighting that the information corresponding to cases of severe abuse in domestic fauna was not possible to obtain. **Results and Discussion:** After the processing and statistical analysis of the information, a significant and sustained increase year after year in citizen participation to report these events was evidenced. The months with the highest number of reports were March, August, October, and December. Regarding wildlife, the main forms of mistreatment identified were roadkill, illegal trafficking, and illegal possession. **Conclusion:** Reports of animal abuse increase in Medellín, associated with festivities, socioeconomic contexts, and illegal possession.

Keywords: Animal ethics, sentience, welfare
Palabras clave: Ética animal, sintiencia, bienestar

Attitudes Towards the Use of Animals for Various Purposes Among Undergraduate Students at UNAL Medellín

Actitudes frente al uso de animales para diversos fines en estudiantes de pregrado UNAL Medellín

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Introduction: Empathy towards the pain and suffering of animals is a central theme in the discussion of animal welfare and ethics in the human-animal relationship, which depends on the purpose for which animals are used and the role they play for human beings. **Justification:** In Colombia, there are still few studies that explore how these attitudes are formed, especially among students in programs such as Animal Science, which poses challenges for advancing towards a more ethical approach to their management. **Objective:** To determine the attitudes of undergraduate students at the Universidad Nacional de Colombia, Medellín campus, regarding the use of animals for various purposes; to compare the attitudes between students of Animal Science and other disciplines; to analyze the influence of gender and place of origin; to identify differences according to the level of academic advancement; and to determine the attitude towards the use of equines compared to other animals. **Methods:** A descriptive, cross-sectional, and comparative study with a quantitative approach was conducted during the 2025-2 academic period with a sample of 171 students. Attitudes were assessed using the adapted Animal Purpose Questionnaire, employing Likert-type scales related to medical and scientific research, nutrition, disease control, cultural interests, and euthanasia for terminal illness in five animal species: pig, mouse, equine, dog, and chicken. Data were processed in R Studio and analyzed using Student's t-tests, ANOVA, linear regression, and chi-square tests, with internal consistency assessed using Cronbach's alpha. **Results and Discussion:** The APQ showed excellent overall reliability ($\alpha = 0.852$). Differences were found between disciplines, demonstrating that training in Animal Science shapes the perception of animal use. Gender and place of origin significantly influenced attitudes, while academic advancement showed a decreasing trend in empathy toward production animals. Differences between species confirmed that empathy toward animals is

not homogeneous. **Conclusion:** Attitudes toward the use of animals are determined by the interaction between academic background, personal factors, and animal species, highlighting the need to strengthen training in animal welfare.

Keywords: Animal purpose questionnaire, animal species, animal welfare, empathy, purpose of use

Palabras clave: Cuestionario sobre la finalidad de los animales, especies animales, bienestar animal, empatía, finalidad de uso

SALUD PREVENTIVA Y BIOSEGURIDAD ANIMAL

Oral Dysbiosis in Canine Periodontal Disease: The Role of Gram-Negative Bacteria

Disbiosis oral en la enfermedad periodontal canina: el papel de las bacterias Gram negativas

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Introduction: Periodontal disease is one of the most common pathologies in dogs, affecting more than 75% of adult dogs. Its development is associated with the accumulation of bacterial plaque, altering the oral microbiome and promoting the growth of Gram-negative bacteria. This dysbiosis generates chronic inflammation, periodontal damage, and a risk of systemic dissemination. Therefore, microbiological characterization is key to understanding the progression and severity of periodontal disease (PD). **Objective:** To identify Gram-negative bacteria associated with periodontal disease in dogs. **Methods:** A descriptive-correlational study was conducted in 29 dogs with periodontal disease treated at the UDES veterinary clinic, selected according to compatible clinical signs. Samples were obtained by swabbing dental

surfaces, enriched in BHI broth at 37 °C for 24 h, and subsequently cultured on blood agar and MacConkey agar, incubated under aerobic conditions for 24–48 h. Colonies were evaluated using Gram staining, and Gram-negative bacteria were identified using the API 20E system. Data analysis was performed using descriptive statistics and correlation tests with SPSS. **Results and Discussion:** The highest proportion of bacterial isolates was observed in Stage 2 periodontal disease (31.25%), followed by Stage 3 (28.13%), indicating that bacterial load is concentrated in intermediate stages of the disease. Stage 1 accounted for 21.88%, while patients without periodontal disease with gingivitis, and in Stage 4 each represented 6.25%. A high bacterial diversity was observed, with *Klebsiella pneumoniae* being the most frequent species (21.88%), followed by *K. oxytoca*, *Serratia ficaria*, and *Pseudomonas fluorescens/putida* (6.25%). Other Gram-negative bacteria were isolated less frequently (3.13%), and 19.75% corresponded to non-enterobacterial bacteria. These findings suggest greater bacterial diversity in moderate stages of the disease. **Conclusion:** An association was observed between the severity of periodontal disease and the increase in Gram-negative bacteria. These findings highlight the need to strengthen oral hygiene and prevention strategies in veterinary practice in order to reduce the zoonotic risk for pet owners.

Keywords: Canine oral health, canine periodontitis, oral microbiota

Palabras clave: Salud oral canina, periodontitis canina, microbiota oral

Índice de autores

A

Adriana L Acosta P 128
 Adriana M Nusspaumer Bouvie 122
 Adrián Félix Medina Montes 163
 Albeiro López Herrera 67, 84, 85 114
 Alejandro La Manna 62
 Alejandra Marín Quitian 89, 92
 Alejandro Strauch Salazar 86, 90
 Alejandro Vidal Montoya 70, 73
 Alexandra E Fajardo-Rojas 95
 Aleyda Judith Pimienta Charry 88, 108
 Álvaro José Uribe 118
 Amir J Serpa Ortega 88
 Ana Caroline Romão da Silva 111, 112
 Ana Cristina Herrera Rios 62, 144, 164, 167
 Ana Delia Arenas Monsalve 173
 Ana Elvira Farfán García 80
 Ana María Calvo Salamanca 101
 Ana M Barreto 96
 Anderson Jhojary Pulgarín Méndez 166
 Anderson Prieto Torres 114, 166
 Andrea C Quique Niño 98
 Andrea M Sierra Alarcón 78, 81, 100
 Andre D'Alessandro Vargas Cupitre 114
 Andrés Felipe Pérez Rojo 76
 Andres Gómez 147
 Andrés Gómez Zapata 145, 146, 147
 Andrés Julian Bermúdez García 69
 Andrés Mauricio Díaz Lopera 142
 Andrés M Ramírez Moreno 167, 168
 Andrés Ochoa 123
 Andrés Rendón Restrepo 146, 147
 Angela R Martínez Agudelo 83, 127, 141, 142, 148, 153
 Angelica Lucia Zuluaga 98
 Angélica María Ruiz Hernández 100
 Ángel María Giraldo Mejía 112, 113
 Antonio Landaeta Hernández 61
 Arnulfo R, Portilla Narváez 75
 Ayda F Barona Rodríguez 95

B

Bayron G Obando Enríquez 117
 Bernardo Rivera-Sánchez 96
 Brainer F Cárcamo Peñates 163

Brayan E Zuleta Hernández 90
 Bryant Santiago Vidales Chavez 72

C

Camila Andrea Chipatecua Santana 141, 142, 153
 Carlos A Delgado Vélez 96
 Carlos A González Sepúlveda 112, 113
 Carlos Alberto Martínez Niño 69, 81, 100, 151,
 Carlos E Ospina Parra 117
 Carlos G. Díaz Sáenz 166
 Carlos Octavio Duque González 39
 Carlos Octavio Larrea-Izurieta 93
 Carlos S Escobar-Restrepo 76
 Carmen E Guevara Saenz 121
 Carolina Ríos Usuga 84, 137
 Catalina M Bedoya Ortiz 148
 Catherine López Sánchez 85
 Clara C Rugeles Pinto 125
 Clara V Rúa- Bustamante 98
 Claudia L Santos León 108, 109
 Constanza Yunda Romero 169
 Cristian C Rúa Giraldo 67, 73, 85
 Cristina Hurtado Gutierrez 98
 Cristina Úsuga Monroy 80, 84, 85

D

Dalia M Rodríguez Jimenez 86, 90
 Damián G González Pino 122
 Daniela A Castiblanco Beltrán 151
 Daniela Ardila Morales 112
 Daniel Alonso Franco Bedoya 65
 Daniela Lourenco 7
 Daniel Cardona Cifuentes 72
 Daniel Leonardo Cala Delgado 158, 159
 Dariana Alvarez Londoño 70, 71
 Darío Andres Hurtado Espinoza 141
 Darío Andrés Hurtado Espinoza 121
 Darly G Jiménez Vélez 90
 Darwin A García Rojas 65, 67, 108, 109, 135
 Darwin Heredia Nava 77, 78, 79, 126
 Darwin Yovanny Hernández Herrera 110, 121, 132, 163
 Deiby A Aguilar 175
 Deilen Paff Sotelo Moreno 75, 77, 127

Deilen P Sotelo Moreno 82
 Deisy Bibiana Camargo Hernández 8, 81, 101
 Delane Ribas da Rosa 87, 111
 Diana Carolina Tacha Morales 131
 Diana C Cediél Devia 79
 Diana C López Álvarez 132
 Diana Marcela Parra Forero 101
 Diana Marcela Valencia Echavarría 101
 Diana María Bolívar Vergara 70, 73, 74, 93, 101, 102
 Diana M Beristain Ruiz 116
 Diana M Maturana Mena 64, 66
 Diana M Parra Forero 8, 81
 Diana M Valencia Echavarría 81
 Diego A Arenas Ramirez 110
 Diego Alejandro Aguilar Vargas 69
 Diego A Medina 78
 Diego F Conejo Rodríguez 165
 Diego Fernando Carrillo González 100, 163
 Diego H Bejarano Garavito 69
 Diego Suárez González 61
 Diomedes DJ Díaz Díaz 95
 Dionisia S Marques 112
 Divier Antonio Agudelo Gómez 71
 Dixon F Florez Delgado 79, 85
 Dubel Reinaldo Cely Leal 79, 85
 Dursun Barrios 95
 Dylan A. Serrano Bedoya 113

E

Edgar Alejo Martínez 77, 82
 Edimer David Jaramillo 56
 Edwin Alejandro Monsalve Castro 141, 142
 Elena de Torres 62
 Elizabeth Batista Martins 112
 Elize T van Lier Sanders 122, 123
 Elkin O Romero Cárdenas 65, 67, 108, 109, 129, 135
 Emilia S Díaz Silva 123
 Emiro R Canchila Asencio 108, 109, 129
 Erica P Salcedo Carrascal 78
 Esteban Valencia Villegas 92
 Estefania Herrera Pasos 142, 152

Estefanía Romaniuk Colman 123
Evangelina Rodero-Serrano 93

F

Fabiana García Scaloppi 159
Fabyola Barros Carvalho 112
Faiber A. Gutiérrez Losada 114, 166
Federico Costa 96
Felipe A Obando Vega 142, 152
Francisco Adolfo Gutiérrez León 75, 97
Francy Zorayda Gómez-Balanta 98
Fredy Rivera Robayo 159

G

Genésio Cássio Souza Cruz 112
Georgget E Banchemo Hunziker 122
Germán A Téllez 89
Giovanni Restrepo Betancur 37, 66
Gloria A Casas Bedoya 151
Gonzalo J Díaz Gonzalez 107
Gonzalo Suárez Veirano 122
Guillermo Peña Chipatecua 165
Gustavo B Gundim 111, 112

H

Héctor Jairo Correa Cardona 63, 83
Héctor J Correa Cardona 127, 141, 142, 153
Heidi V Yepes Gómez 107
Heloisa H de Carvalho Mell 111, 112
Henry A Jurado Gámez 150
Henry Alberto Grajales Lombana 97, 131
Hermes Ordoñez Olivares 145
Hernán Antonio Alzate Díaz 157
Humberto Ramírez Vega 77, 78, 79, 126

I

Ignacy Misztal 23, 26
Ingrid L. Jaramillo Delgado 84, 137
Inkar Castellanos-Huerta 118
Isabella Beltrán Florez 158
Isabella García Gallego 168
Iván M Cortés López 88
Ivonne Catalina Fajardo Argoti 150

J

Jaime A Ángel Isaza 80 114, 118, 146, 147, 158

Jaime E Parra Suescún 114, 145, 146, 147, 150

Jairo A Osorio Saraz 142, 152
Jairo G Carvajal Jiménez 113
Javier A Sarmiento 135
Javier M. Agudelo Rendón 115, 148
Jazmín V Pérez Pazos 78
Jean P. Díaz Paz 142
Jennifer G Aceves Arias 79
Jenny C. Sanmartín Sangama 135
Jerónimo Cárdenas 65
Jesaiás I da Costa 159
Jéssica Tatiana Morales Piñeyrúa 62
Jesús Alfredo Berdugo Gutiérrez 72
Jesús A Mendoza Ibarra 85
Jesús D Corzo Vega 175
Jhon Fredy Osorio Giraldo 65
Johanna Marcela Urán Velásquez 148
John Jairo Hincapié 64
Jorge A Gil Laureiro 122
Jorge E Franco Rodríguez 65, 108 121, 129, 135, 141
Jorge E Rivera Valencia 151, 152
Jorge H Contreras Castro 145
José Alejandro Osorio Posada 81
José Eduardo Escobar 63
José Henrique Stringhini 31, 112, 114
José I Paz Orellana 89, 92
José J. Echeverri Zuluaga 70, 71
José Martín Jáuregui 24, 26, 28
Josué I Paz Orellana 91
Juan Camilo Arroyave Manco 148
Juan Carlos Rincón Flórez 42, 72
Juan C Navas Rodríguez 158, 159
Juan C Pareja Arcila 148
Juan David Cardona Agudelo 70, 73
Juan Duran 141
Juan Esteban Agudelo Giraldo 37, 55
Juan E Vasquez Bustamante 115, 148
Juan Fernando Cadavid Santamaría 50
Juan Fernando Muñoz Santofimio 98
Juan Fernando Naranjo Ramírez 35, 76, 96, 148
Juan F López Rendón 117
Juanita I Clavijo Rodríguez 144
Juan J Eusse Roldan 62
Juan J Ríos Gaviria 167, 168
Juan Leonardo Cardona Iglesias 95, 117
Juan M Bonilla 83, 127

Juan M Bonilla Hernández 141, 142, 153, 167, 168

Juan Pablo Damián Cabrera 28, 122, 123
Juan P. Arismendy Morales 85
Julia M Sousa da Silva 111
Juliana Victoria Bedoya Jaramillo 64, 66
Julio A Narváez Estacio 150
Júlio C. Lopes Brasileiro 111

K

Karen N Avendaño Rodríguez 159
Karol J Celis Hernández 88
Kelly Cristina Torres Angulo 129
Kelsey Hammers 147
Kenneth R Cabrera Torres 93

L

Lady Susatama Acevedo 53
Lascario A Cadavid Gutierrez 110
Laura Bolívar Parra 80
Laura Castaño Gaviria 167, 168
Laura Jineth Acevedo Cuervo 75
Lee Johnston 147
Leonardo Hernández Corredor 61
Letícia A da Silva 87
Ligia J Jaimes Cruz 63, 83, 127, 141, 142, 153
Lina Henao Marín 98
Lina Marcela de los Ríos Morales 48
Lina M Rendón Ramos 84, 137
Lisbeth Campos Arenas 67, 108, 109, 135
Lorena A Aguayo Ulloa 78, 88
Lorena I Mestra Vargas 78
Loufrantz Mendez 118
Lucio Flavio Macedo Mota 30
Luisa F Campos Grijalba 165
Luis Afonso Giraldo Valderrama 76
Luis Alberto de la Cruz Cruz 76
Luis Alejandro Tellez Valderrama 166
Luis Alejandro Vinatea Arana 157
Luis Alfonso Giraldo Valderrama 89, 90, 91, 92
Luis Carlos Chaves Moreno 114
Luis Carlos Ramírez Villa 169
Luis C Veloza Angulo 148
Luis F Cartuche-Macas 93
Luis Gabriel González Herrera 70, 71, 72, 73, 74, 93, 101, 102, 144, 164, 167, 167, 168

Luis M Cohen Teheran 71, 74, 93, 101, 102
 Luis Miguel Vahos Bedoya 65
 Luiz Fernando Brito 21
 Luz Z Duarte Rodríguez 159

M

Mahavisnu Bonza Espinoza 95
 Manuela Liebano Arango 71
 Manuela Valencia Toro 164
 Manuel F Pardo 98
 Marcela Patiño-Murillo 96
 Marcos Barcellos 112
 Marcos B Café 111, 112
 María A Vergara Avilez 125
 María Camila Marzola López 72
 María Fernanda Valencia Guerrero 101
 Mariana J Basurto Vergara 77, 79
 Mariana Parra Cerezo 158
 Mariana Peñuela Vázquez 115
 María Paula Arrieta 73
 María Paula Galán Plata 107
 Maria Paulina Arroyave Serna 168
 Maria Paulina Oquendo Ramírez 70, 71
 María V Escobar Builes 96
 María Victoria Correa Galeano 63
 María V Pons Romero 122
 Marinaldo D Ribeiro 87
 Maritza Ocampo Betancur 66
 Mark Schwartz 147
 Martha I Abaunza Carreño 88
 Martha Rubiela Chipatecua 83, 127
 Martín R Claramunt Tammaro 122
 Mateo Gallego Castrillón 89, 92
 Mateo Itza Ortiz 116
 Matheus Soares Da Silva Ferreira 121
 Matias Bermann 23
 Mayra H Ramírez Amador 123
 Miguel Ángel Alvarado Gardea 76
 Miguel Orlando Suárez Barrera 80
 Mónica Cuéllar Sánchez 113
 Mónica Zayné Torres Cruz 89
 Mónica Z Torres Cruz 97, 131
 Moon-Suhn Ryu 147

N

Naia IP Santos 87
 Naia Isabela Pio Santos 87, 111, 112
 Natalia Andrea Marín-Garzón 53

Natalia Lisboa Bueno da Silva Sousa 112
 Neidy Canchila Roa 108, 109
 Nelson A Cruz Gutiérrez 151
 Nelson Cala Moreno 158
 Nicolás Hernández Gallo 86, 90
 Nicole C Resende Ferreira 87
 Nicole CR Ferreira 87
 Nohelys M Ortega Fernández 64
 Nohora Juliana Rueda Forero 80
 Noor E Huma 147
 Norberto Villa Duque 65, 67, 108, 129
 Norverto Villa Duque 129

O

Olga L Herran Ramírez 144
 Olga Lucia Mayorga Mogollón 78, 81, 100, 101
 Oliver Restrepo Rojas 62, 144, 164, 167
 Oscar Agudelo Varela 77, 82, 127
 Oscar A Mora Pantoja 92
 Oscar A Sáenz Ruíz 148
 Oscar David Múnera Bedoya 62, 144, 164, 167
 Oscar F Ospina Rivera 97
 Oscar O Pérez Rodríguez 89, 91, 92

P

Paola Y Hernández 175
 Paolo C Cano Montero 123
 Patricia Ricci 101
 Patricia Ubaque Rojas 135
 Paula A Fernández Rendón 132
 Paula A Ospina Rojas 125
 Paula Palomino Cadavid 76
 Pedro E Urriola 147
 Perla V Vargas Mora 116
 Piedad M Agudelo Flórez 96
 Piedad Y Martínez Oquendo 81

R

Rafaella R Andrade 87, 111
 Raquel Martínez Loperena 77
 Rene A Crosby Granados 159
 René M Patiño Pardo 128
 René Ramírez García 148
 Renzo Rocha 98
 Ricci Terraza Martinez 65, 67, 108, 109, 129, 135

Richard J Sánchez Jiménez 95
 Rodolfo Ruiz Posada 65, 67, 129
 Rodrigo A Martínez Sarmiento 69
 Roldan I Ortiz-Soto 116
 Román Maza Ortega 75, 127
 Ronnal E Ortiz Cuadros 78, 81, 88
 Ronnal Esneyder Ortiz Cuadros 100
 Rosa H Mira Herrera 117
 Rubén D Higuera Pedraza 90, 91

S

Salomé Sánchez Contreras 92
 Samir J Calvo Cardona 71
 Samuel Correa Roldán 92
 Samuel Restrepo Gómez 92
 Sandra Clemencia Pardo Carrasco 157
 Sandra Sofía Ruíz Díaz 73, 175
 Santiago Henao Villegas 123, 135, 173
 Santiago Mena Velez 83, 127, 141, 142, 153
 Sara Jurado-Díaz 150
 Sara Tapias Vásquez 66
 Satoshi Ohkura 78, 88
 Saúl E Romo Mejía 78
 Sebastián Álvarez Pulgarin 115
 Sebastián García Osorio 128
 Sebastián Villegas Palacino 47
 Sergio Andres Pizarro Cano 135
 Sergio M Betancur Hincapié 89, 90, 91, 92
 Sindi Alejandra Velandia-Cruz 118
 Sofía Ruge Camacho 53
 Sonia D Ospina Hernández 98
 Sorany Milena Barrientos Grajales 165
 Stephania Madrid Gaviria 64, 66
 Stephanie Rutschke 147
 Susana Misas Vargas 70, 73
 Susana Raigosa Echeverri 66
 Suziane AB da Silva 111

T

Tarek N. Mrad Rincon 61
 Tatiana Ruiz Cortés 67
 Tomás Antonio Madrid Garcés 114, 166
 Tomás Tabares Vera 167, 168

V

Vanessa Aguilar Marín 117
 Vanessa De La Mora Villegas 78

Vega Luisa F Navarro Pedrero 175

Verónica González Cadavid 142, 151,
152

Víctor H Herrera Franco 145, 146, 147

Victor H Severino Lendecky 116

Víctor Hurtado Nery 169

Víctor Manuel Gómez Rodríguez 77, 78,
79, 126

Vincent P Reyes 78

Viviana Parada Roa 80

X

Xavier B Lastra Bravo 97

Y

Yasser Y Lenis 100, 163

Yazmin A Calvo Rodríguez 67, 88, 108,
109, 135,

Yeraldín Franco Montoya 164

Yessica V Agudelo Peñuela 151,
152

Yuli Paola Martínez Silva 86, 90

Yulissa A Arias Palencia 128

Yurany M Correa Raigosa 113

Yury T Granja Salcedo 53, 81

Yuxuri Frías Hernández 126