International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 10 No. 6s, 2024
https://www.theaspd.com/ijes.php

Bibliometric Analysis Of The Integrated Use Of Artificial Intelligence In Precision Livestock Farming

Nicol Conde Monterroza[1], Alexander Pérez Cordero[1], Donicer E. Montes Vergara[1*]
[1]University of Sucre, Faculty of Agricultural Sciences, Colombia
*Corresponding author: donicer.montes@unisucre.edu.co

Abstarct:
Objetive. *Conduct a bibliometric study on the main artificial intelligence (AI) tools applied to livestock production systems, especially ruminants and non-ruminants, in the period 2019-2024.*
Methodology. *A retrospective descriptive cross-sectional study was developed based on the analysis of scientific sources, analytical tools, and content analysis techniques. The corpus was constructed using the Scopus database, selected for its multidisciplinary coverage in areas such as veterinary medicine, animal husbandry and related fields. The search strategy included original articles, systematic reviews, data analyses and brief reports, delimiting the subject matter to title, abstract and keywords. The bibliometric analysis was performed with the statistical software R using the Biblioshiny interface.*
Results. *A total of 726 documents from 208 sources were evaluated. The research showed a growing trend with a confidence level of 97.73% and an annual growth rate of 34.46%. The year 2024 reached a peak with 211 publications. There was a high level of international collaboration, with Italy (499), China (427) and Brazil in Latin America (230) standing out. The most frequent keywords were 'precision livestock farming' (387), "livestock" (195) and 'animals' (180), highlighting topics in machine learning (ML) technologies applied to animal welfare and grazing management.*
Conclusion. *The analysis confirms the strong emphasis on AI and machine learning in precision livestock farming, consolidating it as a key approach to improving efficiency and sustainability. However, adoption faces resistance due to high costs and operational complexity. Some authors recommend inclusion in academia with more accessible commercial approaches for the livestock sector.*
Keywords: *Artificial intelligence, bibliometrics, development, machine learning, precision livestock farming, scientific output.*

INTRODUCTION

Artificial intelligence (AI) has emerged as a disruptive force, driving significant changes in various areas of modern life. (1) In this context, AI has been driving and transforming the agricultural sector, (2) completely changing traditional methods of farming and livestock breeding. The implementation of advanced tools such as ChatGPT, Copilot, DALL·E, (3) along with drones, smart sensors, UAVs and Big Data enables better decision-making and resource management. (4) In the specific case of precision agriculture, AI has greatly benefited farmers, enabling the implementation of these cutting-edge tools to promote sustainable agriculture, increase productivity and strengthen crop resilience. (5) Livestock farming has also been boosted by AI, enabling more efficient use of resources, reducing carbon footprints and promoting animal welfare. (6) However, the implementation of these tools faces major challenges such as the digital divide and a significant initial investment. (5)

The integration of AI into agricultural production systems has made it possible to optimize the management and control of crops and animals in key processes such as sowing, irrigation, fertilization, harvesting, health, breeding, genetic management, reproduction and animal nutrition, etc. (7,8), adapting to the particularities of each system and each species.

In ruminant production systems, the implementation of machine learning techniques has become increasingly important in optimizing production and reproductive parameters, especially in cattle, sheep and goats. Continuous monitoring of physiological and environmental variables using sensors and smart platforms has significantly improved early disease detection, reducing the costs associated with veterinary treatments and minimizing the negative impact on production performance. A specific case is the use of tools such as Machine Learning (ML) in stress analysis, which has proven to be highly effective in identifying complex patterns in large volumes of heterogeneous data, facilitating early interventions that prevent consequences such as sustained weight loss, abortions, immunosuppression and increased susceptibility to infectious or parasitic diseases. (9) Similarly, chips implanted in livestock to record parameters such as individual identification, location, feed intake, and general activity have proven to be key tools for improving management efficiency, strengthening traceability programmers, and promoting sustainable practices in animal production. (10)

Brazil and the world's leading meat-producing countries have been implementing radio frequency identification (RFID) for farm automation. A representative example is the system developed with the ESP32 microcontroller and the RFID-RC522 module, in which each animal carries a chip encoded with a unique identifier that, when read by the system, allows immediate access to its production, reproductive, health, nutritional and even behavioural history, (11) thus ensuring traceability. Similarly, the incorporation of IoT sensors expands the functional scope of the system by enabling the recording of environmental variables such as temperature, humidity and heat stress index, which directly affect the welfare and productive performance of livestock. (11) All this, combined with the automation of administrative processes that are essential to the livestock industry, such as budget management, cost control, and production and operations management, (12) optimizes operational management and strengthens international competitiveness by ensuring compliance with strict quality and sustainability standards in meat production.

Technological progress has not been limited to ruminant production. In the case of systems for non-ruminants, the adoption of digital tools and automated processes has grown significantly, incorporating methods tailored to the specific characteristics of species such as poultry and pigs. In poultry farming, the integration of advanced technologies has transformed production and health management, promoting more efficient, traceable and sustainable production. The combination of automatic weighing sensors, smart feeders and predictive analysis algorithms has optimized feed conversion by adjusting the quantity and composition of feed in real time based on the actual growth of the flock. Computer vision systems allow for continuous assessment of bird uniformity, detection of abnormal behaviour and anticipation of performance declines, while machine learning platforms analyze production, health and environmental data to identify patterns associated with diseases such as Salmonella. (13) In addition, the incorporation of robots for tasks such as data collection, behaviour monitoring, health inspection and automated cleaning reduces the workload, improves biosecurity and ensures faster and more accurate interventions. (14) The synergy between these technological innovations strengthens the ability to respond to production and health risks, increases operational efficiency, and ensures compliance with demanding safety and quality standards in the modern poultry industry.

In pig farming, advances have focused on reproductive management. The use of chips and management platforms connected to biometric sensors allows parameters such as reproductive cycles, intervals between births, conception rates and breeding performance to be recorded and analyzed. In addition, the incorporation of heat monitoring systems using thermal cameras and activity detectors has increased the accuracy of oestrus detection, facilitating artificial insemination at the optimal time and improving prolificacy rates. The evolution of these technologies demonstrates how AI tools have become fundamental pillars of modern livestock production. In this regard, the objective of this article is to conduct a bibliometric study of the main artificial intelligence (AI) tools applied to livestock production systems, especially ruminants and non-ruminants, in the period from 2019 to 2024.

METHODOLOGY

This study uses a bibliometric methodology to analyze the evolution, structure and impact of research on artificial intelligence (AI) applied to livestock production systems, based on scientific sources, analytical tools and content analysis techniques. A retrospective cross-sectional descriptive study was developed, applying a bibliometric analysis of articles published in journals in the field of veterinary medicine and related areas, published worldwide, which were found in the Scopus database in 2019-2024. The bibliometric analysis focused on patterns of production and accumulation of knowledge, using quantitative software tools to analyze large sets of bibliographic data.

The corpus was constructed from the Scopus databases, which were selected for their multidisciplinary coverage in the areas of veterinary medicine, animal husbandry, and related fields. (15,16) The impact and prestige indicator (SCImago Journal Rank), the quartile in which each journal is found, and its respective H-index were taken into account.

The search strategy applied in this study took into account all original articles, systematic reviews, data analyses, and brief research reports on the subject studied. To focus and delimit the subject of study, the title, abstract, and keyword fields were covered, using key terms which are listed in Table 1.

Table 1. Inclusion and exclusion criteria

Criterio	**Election**
Database	***Scopus***
Search term	Precision livestock farming, Artificial intelligence,

	Livestock systems, Precision agriculture, Ruminants, Monogastric animals (non-ruminants).
Excluded documents	Errata

Biblioshiny, the Bibliometrix interface of the statistical software R, was used for its ability to process Scopus data and generate conceptual structure analyses and thematic visualizations. (17) The approach developed made it possible to compile bibliographic information from the dataset, facilitating the analysis of research trends and patterns.

Ethical considerations.

Given that the study is based on the analysis of publicly available scientific publications, approval from an ethics committee was not required. The integrity of all data in its original form was respected, and the procedure can be reproduced and documented.

RESULT AND DISCUSSION

The identification of the documents described in the search regarding the integrated use of artificial intelligence in precision livestock farming can be seen in Table 2. The types of source documents were: article, book, book chapter, conference paper, data paper, editorial, erratum, note, review and short survey.

Table 2. Analysis of results of the integrated use of artificial intelligence in precision livestock farming.

Period	Source	Documents	Annual growth rate
2019-2024	208	726	34,46
Authors	**Authors of works/single author**	**International Co-authorships**	**Co-authors by documents**
2942	24	31,27	5,49
Key words	**References**	**Average age of the document**	**Average number of citations per document**
3158	5299	2,75	25,95

The trend in investigations for the period 2019–2024 was positive, with a confidence level of 97.73% and a peak of 211 investigations in 2024, indicating that this trend may be exceeded in 2025.

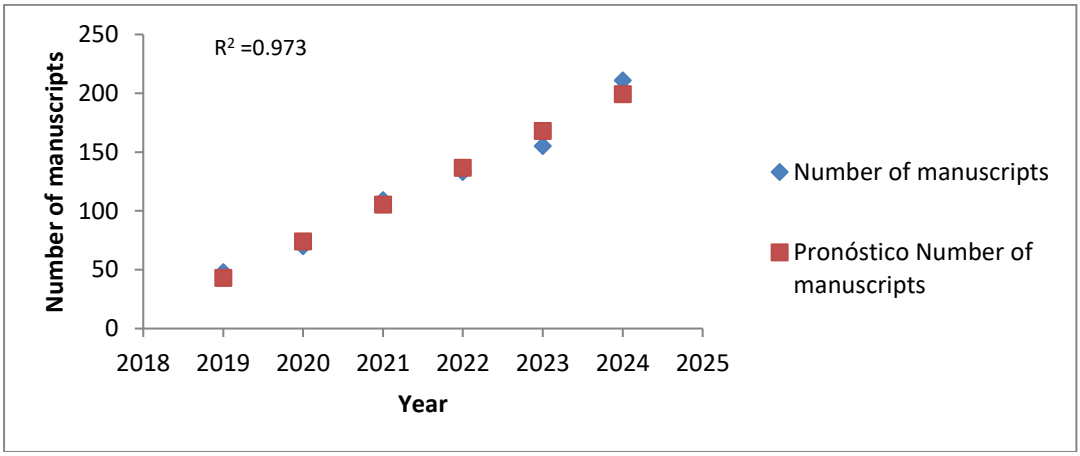

Figure 1. Scientific output per year

Collaborative research was identified in more than 30 countries (Figure 2). Analysis of publications by country showed that Italy (499), China (427), the USA (391), the United Kingdom (293), Germany (212), France (182), Spain (163), Netherlands (134), and Australia (114) were the leading countries in terms of scientific productivity on the subject under investigation. In the Latin American geographical area, Brazil stood out with 230 research projects (Figure 3).

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 10 No. 6s, 2024
https://www.theaspd.com/ijes.php

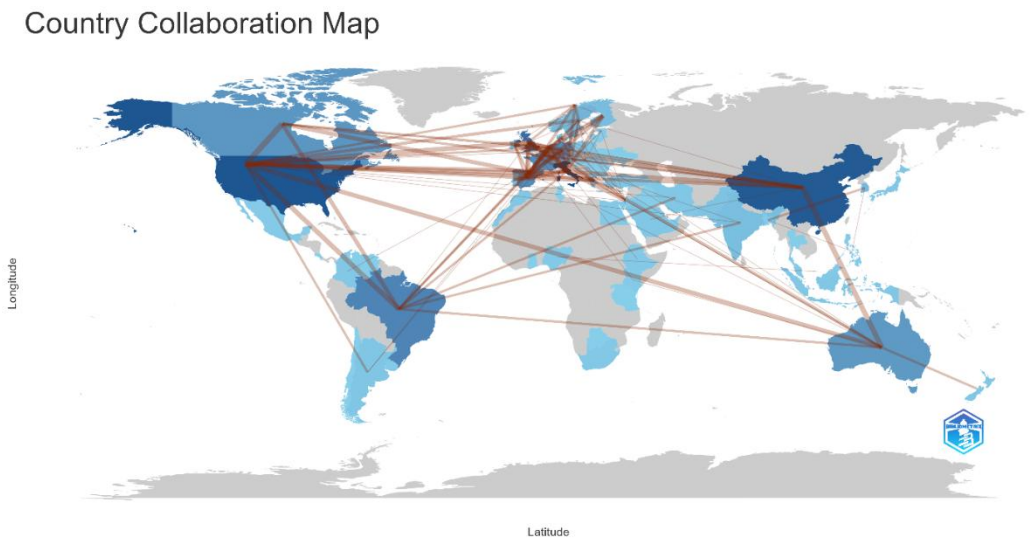

Figure 2. Map of collaboration between countries in research on the integrated use of artificial intelligence in precision livestock farming

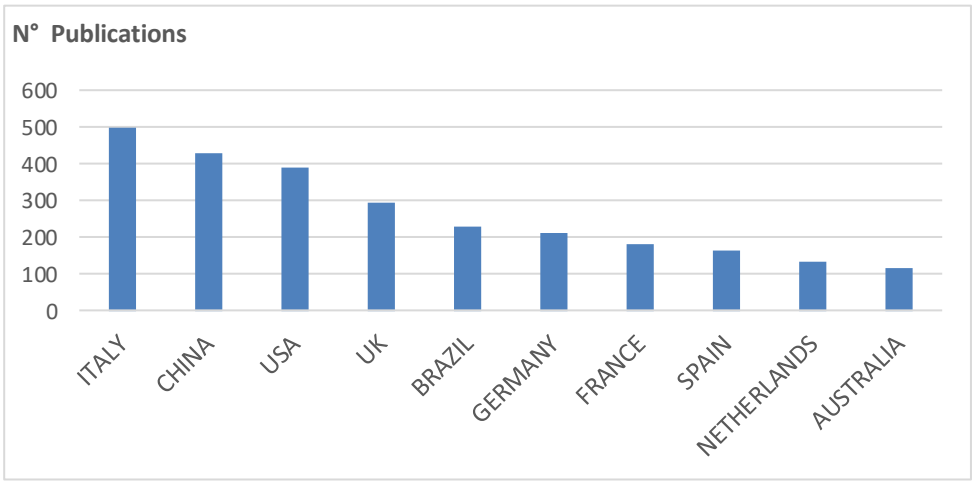

Figure 3. Main countries with publications on the integrated use of artificial intelligence in precision livestock farming.

Figure 4 shows the number of publications per journal globally, listing the main journals with the most articles in the field of study. The year and country of publication were taken into account, as well as the h-index, in order to measure how a scientific article whose order number (from highest to lowest, according to the number of citations) correlates with a lower or equal number of citations. (18) The quartile number (Q) in which the journal is positioned in a specific field and the Scimago Journal Rank (SJR) index show that all the journals presented in Figure 4 are in Quartile 1, with very relevant impacts for the categories and sub-areas in which they are located (Agricultural and Biological Sciences, Animal Science and Zoology).

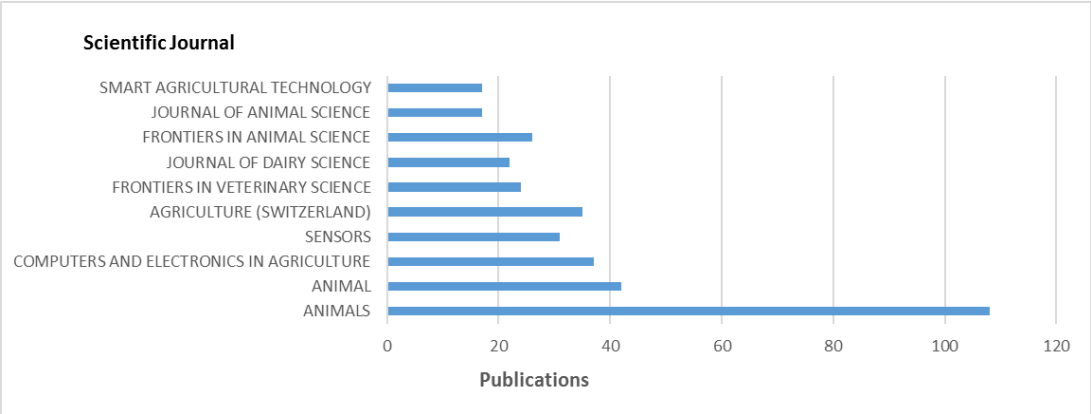

Figure 4. Publications reviewed globally

Among the most productive and cited authors is Neethirajan Suresh, University Research Chair Professor

at Dalhousie University, Canada (Figure 5), who has conducted research focused on precision livestock farming (PLF), using technology such as sensors, cameras and data analysis to monitor individual animals, improving their health, welfare and productive efficiency. By collecting and analyzing data in real time.
Bibliometric impact analysis, based on citations and H-index, confirms that the studies by these authors (Norton Tomas, Remus Aline, Pomar Candido, Guo Leifeng, Rosa Guilherme J.M, Halachmi Ilan, Kaler Jasmeet, Lovarelli Daniela, Niemi Jarkko K) have served as key references in the consolidation of the field.

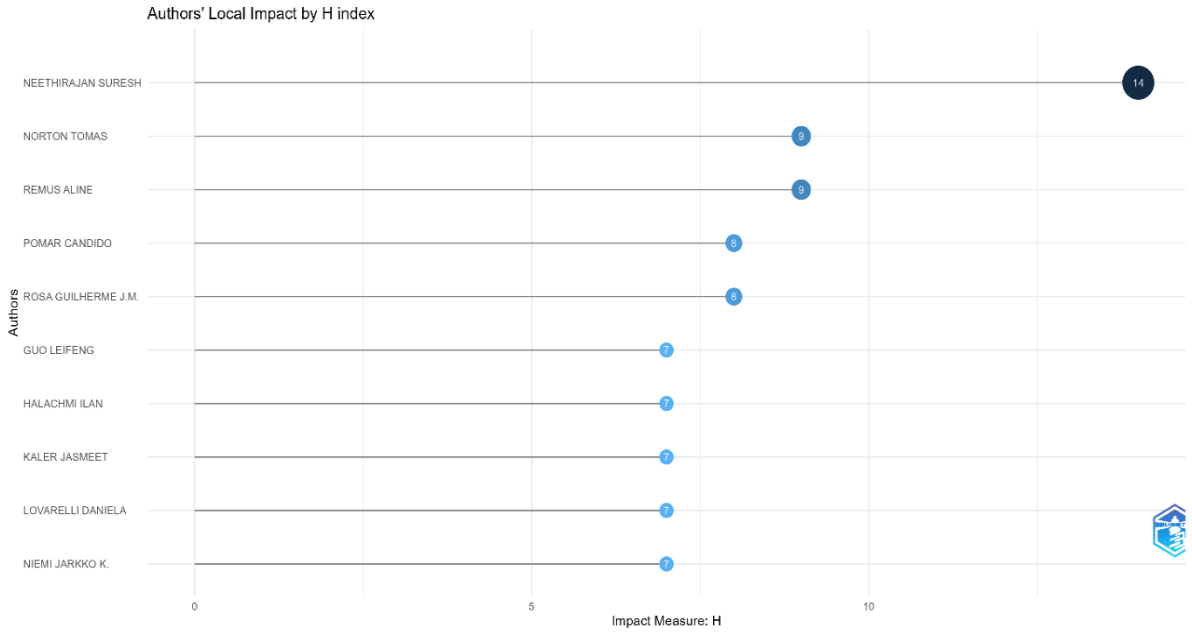

Figure 5. Bibliometric impact of the most influential authors in the field of study

Figure 6 shows the keyword co-occurrence network, with a level between 2 and 21, where three clusters with multiple items were identified. The most relevant keywords in most studies were related to livestock, animal welfare, machine learning, agricultural workers, deep learning, computer vision, dairy cattle, algorithms, among others.

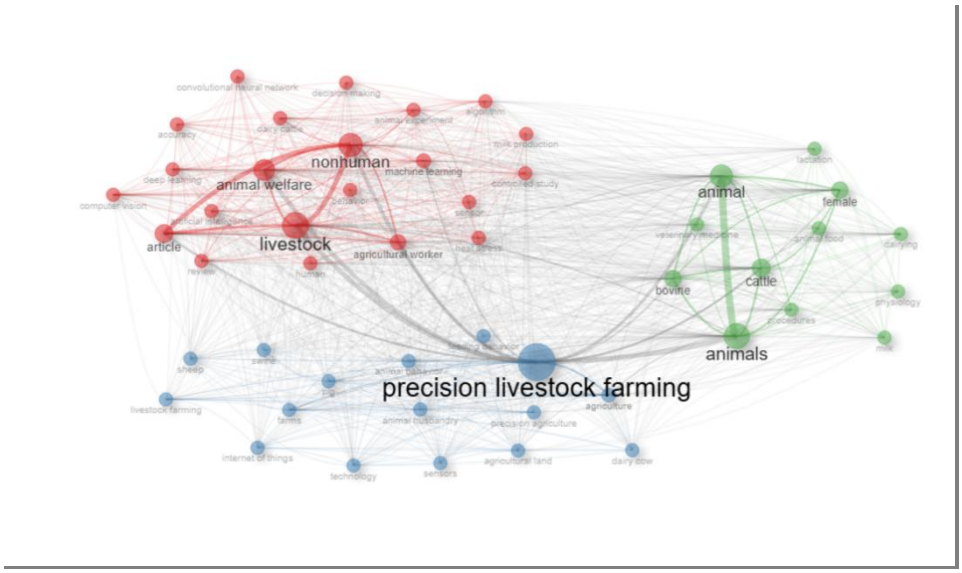

Figure 6. Word co-occurrence analysis.

The analysis of keyword frequency and density (Figure 7) showed the word precision livestock farming as the most repeated (387 times), followed by livestock (195) and animals (180). Studies related to agricultural productivity and the implementation of artificial intelligence in precision agriculture, applications of smart technology as a sustainable strategy in production, and the use of remote sensor systems applied to geo-plots are evident. (19-20-21)
Qualitative analysis of the most influential documents distributed by cluster (Figure 8) revealed that works

focusing on precision livestock farming, machine learning, deep learning with applied technology, animal welfare, and animal grazing, among others, allowed not only for mapping the relationships between authors and topics, but also for interpreting the key content that gives meaning to the current research ecosystem. The analysis of articles revealed that this is an area with many studies, indicating a strong interest in applying innovative technologies to optimize the efficiency of livestock production. (22) The studies used technologies for individualized animal analysis, collective herd analysis, and other mixed approaches. (23–24)

The debate on precision livestock farming is a complex exercise involving advanced technological integration, responsible management and animal welfare. PLF technologies are being adopted not only to increase production efficiency, but also to ensure more ethical and sustainable practices in animal management. (25) Sustainability must seek a balance between health, welfare, environmental preservation, economic and ethical aspects, with the aim of maintaining animal production systems in the long term. Automated monitoring, individual tracking and the use of image monitoring systems are emerging as essential tools for creating a more suitable environment for animals, which benefits animal production. (26)

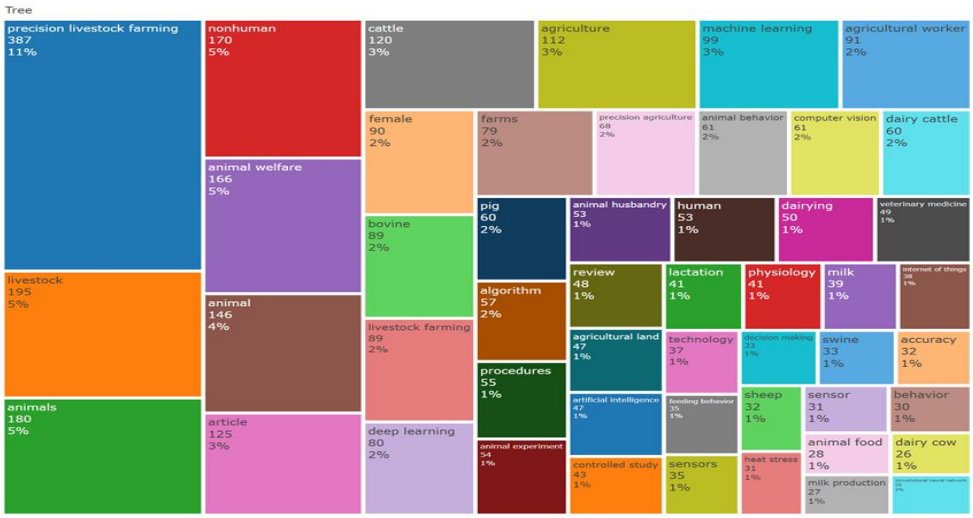

Figure 7. Keyword frequency and density analysis

These approaches highlight a growing trend in the sector towards adopting animal welfare certifications and practices in line with consumer and societal expectations, which demand greater transparency and environmental responsibility. In this context, the relationship between humans and animals, environmental conditions, economic management and new technologies become fundamental pillars for the development of a more zootechnical animal industry with a modern and conscious approach. (27)

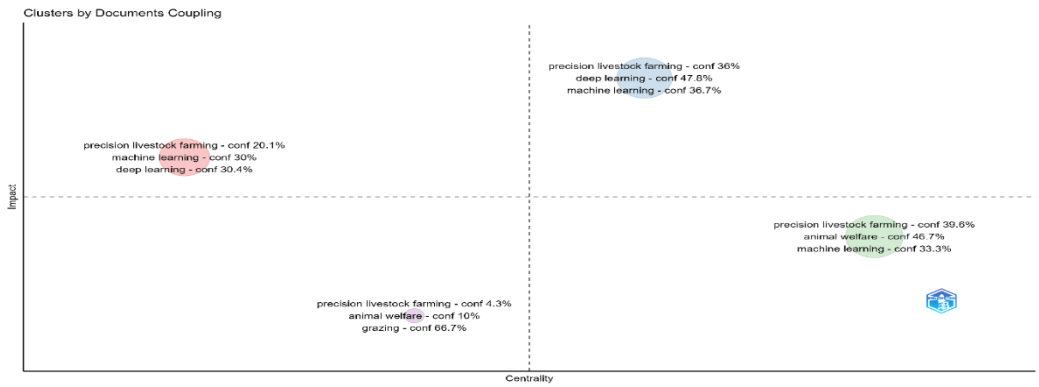

Figure 8. Thematic map of the conceptual groups identified in the analyzed literature (2019-2004).

CONCLUSION

The bibliometric analysis revealed a clear emphasis by researchers on technologies, especially artificial intelligence and machine learning in livestock farming, which have been incorporated into the temporary field of research. A significant increase in scientific publications was identified, as well as a large participation

of countries through citations of works on this research topic. In the context of this bibliometric analysis, it is important to mention the participation of Brazil, which had a significant number of documents, a position that reflects its important presence in research on precision livestock farming.

Precision livestock farming is emerging globally as an essential approach to animal production, highlighting areas of application in animal welfare, production efficiency and environmental sustainability, with the optimization of real-time monitoring becoming increasingly relevant. However, the implementation of these technologies faces resistance from producers due to high costs and operational complexity. Some writings suggest inclusion in academia with commercially more accessible transformative approaches for the livestock sector.

Author contributions

The first author drafted the main manuscript, the second author reviewed the manuscript, and the third author prepared the figures and assisted in the analysis of the topic and style correction.

Funding Declaration

There was no Funding, for both the authors.

REFERENCES

1. González-González CS. El impacto de la inteligencia artificial en la educación: transformación de la forma de enseñar y de aprender. Qurriculum Rev TeoríaInvestigación Práctica Educ. 2023;(36):51-60 https://doi.org/10.25145/j.qurricul.2023.36.03
2. Javaid M, Haleem A, Khan IH, Suman R. Understanding the potential applications of Artificial Intelligence in Agriculture Sector. Adv Agrochem. marzo de 2023;2(1):15-30. https://doi.org/10.1016/j.aac.2022.10.001
3. Bert F. Inteligencia artificial aplicada al agro: ¿Dónde estamos y qué podemos esperar? IICA [Internet]. 2024; Disponible en https://blog.iica.int/blog/inteligencia-artificial-aplicada-al-agro-donde-estamos-que-podemos-esperar
4. Logeshwaran J, Srivastava D, Kumar KS, Rex MJ, Al-Rasheed A, Getahun M, et al. Improving crop production using an agro-deep learning framework in precision agriculture. BMC Bioinformatics. 2024;25(1):341 https://doi.org/10.1186/s12859-024-05970-9
5. Boscán Boscán AC. Agricultura digital: Innovación en las prácticas productivas. Electrónica Arbitrada del Centro de Ciencias Administrativas y Gerenciales. 2024;21(2):77-97.
6. Kenya Murrieta. Inteligencia artificial en el agro para mejorar la productividad sustentable agropecuaria del Ecuador [Internet]. [Ecuador]: UNIVERSIDAD TÉCNICA DE BABAHOYO; 2023. Disponible en: http://dspace.utb.edu.ec/handle/49000/13865
7. Ramírez-Orellana A, Ruiz-Palomo D, Rojo-Ramírez A, Burgos-Burgos JE. The Ecuadorian Banana Farms Managers' Perceptions: Innovation as a Driver of Environmental Sustainability Practices. Agriculture. 5 de marzo de 2021;11(3):213. https://doi.org/10.3390/agriculture11030213
8. Fajardo B, Otálora XDD, Mendez DA, Calvet S, Estellés F. Ganaderia de Precisión: Avances tecnológicos para una producción eficiente Y sostenible. 2024;151:30-5. Disponible en https://www.revistaganaderia.com/Noticias/Noticia/9092/ganaderia-precision-avances-tecnologicos-produccion-eficiente-sostenible
9. Jaramillo Encalada YA, Rios Villacorta PA. Tendencias Tecnológicas con IoT en la Ganadería 4.0 Aplicables en Ecuador. Cienc Lat Rev Científica Multidiscip. 2024;8(6):5947-74. https://doi.org/10.37811/cl_rcm.v8i6.15294
10. Guzman Chavez GE. Sistema basado en internet de las cosas para el monitoreo de ganado vacuno usando una red lorawan [Internet]. Pontifica Javeriana; 2022. Disponible en: http://hdl.handle.net/10554/61871
11. Do Nascimento Galvão I. A utilização do RFID para automatizar fazendas com bovinos de corte [Internet]. [Goiania]: Pontifici UnIversidade Católica de Goiás Escolaa Politécnica e de Artes Engenharia de Computação; 2024. Disponible en: https://repositorio.pucgoias.edu.br/jspui/handle/123456789/8038
12. Sánchez Benítez ER, Suazo Robleto GE, Peñalba Berríos DE, Fernández Obregón MA, López López AJ. Sistema multiplataforma para la sistematización productiva de hatos ganaderos bovino. La Calera [Internet]. 27 de mayo de 2024;24(42). https://doi.org/10.5377/calera.v24i42.17942
13. Ramirez D. Desarrollo de modelos de predicción para identificar y prevenir incidencia de Salmonella en aves utilizando herramientas de machine learning para Agrosuper S.A [Internet]. 2024. Disponible en https://repositorio.uchile.cl/handle/2250/204886
14. Fei JD, Hao W, Jun W, Wei X. Real-Time Recognition Study of Egg-Collecting Robot in Free-Range Duck Sheds [Internet]. 2023. https://doi.org/10.2139/ssrn.4396479
15. Dubey P, Dubey P, Agrawai P, Chourasia H. Bibliometric Analysis of Data Science Research: A Decade of Insights from Web of Science. Proc IEEE Int Conf Smart Technol Com¬putingElectrical Electron. 2023; https://doi.org/10.1109/ICSTCEE60504.2023.10585030
16. Bredahl Laura. The current and evolving landscape of bibliometric tools and technologies. Libr Technol Rep. 2022;58(8):1.25. https://doi.org/10.5860/ltr58n8
17. Massimo Aria, Corrado Cucurullo. Bibliometrix: An R-tool for comprehensive science mapping analysis. J Informetr. 2017;11(4):959-97. https://doi.org/10.1016/j.%20joi.2017.08.007
18. Chinguel Laban DO, Minaya Gutierrez CA. Inteligencia Artificial - Chatgpt: un estudio bibliométrico y su aplicación en el caso de Gases de Efecto Invernadero. Manglar. 2 de abril de 2024;21(1):149-57. https://doi.org/10.57188/manglar.2024.015
19. Mahfuz S, Mun HS, Dilawar MA, Yang CJ. Applications of Smart Technology as a Sustainable Strategy in Modern Swine

Farming. Sustainability. 23 de febrero de 2022;14(5):2607. https://doi.org/10.3390/su14052607
20. Si Q. Advancements in Precision Livestock Farming: Technologies and Applications. Anim Mol Breed. 2024;14(2):187-95. https://doi.org/10.5376/amb.2024.14.0020
21. Vargas-Bello-Pérez E, Espinoza-Sandoval OR, Gonzalez Ronquillo M, Angeles Hernandez JC, Chay-Canul AJ, Lee-Rangel HA, et al. The role of artificial intelligence in Latin American ruminant production systems. Anim Front. 31 de diciembre de 2024;14(6):23-32. https://doi.org/10.1093/af/vfae034
22. Benjamin M, Yik S. Precision Livestock Farming in Swine Welfare: A Review for Swine Practitioners. Animals. 31 de marzo de 2019;9(4):133. https://doi.org/10.3390/ani9040133
23. Papakonstantinou GI, Voulgarakis N, Terzidou G, Fotos L, Giamouri E, Papatsiros VG. Precision Livestock Farming Technology: Applications and Challenges of Animal Welfare and Climate Change. Agriculture. 16 de abril de 2024;14(4):620. https://doi.org/10.3390/agriculture14040620
24. De Oliveira FM, Ferraz GAES, André ALG, Santana LS, Norton T, Ferraz PFP. Digital and Precision Technologies in Dairy Cattle Farming: A Bibliometric Analysis. Animals. 20 de junio de 2024;14(12):1832. https://doi.org/10.3390/ani14121832
25. Norton T, Chen C, Larsen MLV, Berckmans D. Review: Precision livestock farming: building 'digital representations' to bring the animals closer to the farmer. Animal. 2019;13(12):3009-17. https://doi.org/10.1017/S175173111900199X
26. Halachmi I, Guarino M, Bewley J, Pastell M. Smart Animal Agriculture: Application of Real-Time Sensors to Improve Animal Well-Being and Production. Annu Rev Anim Biosci. 15 de febrero de 2019;7(1):403-25 https://doi.org/10.1146/annurev-animal-020518-114851
27. Kaur U, Malacco VMR, Bai H, Price TP, Datta A, Xin L, et al. Invited review: integration of technologies and systems for precision animal agriculture—a case study on precision dairy farming. J Anim Sci. 3 de enero de 2023;101:skad206. https://doi.org/10.1093/jas/skad206