doi.org/10.51891/rease.v12i7.29109

ARTIFICIAL INTELLIGENCE AND INTELLIGENT PLATFORMS IN ANIMAL PRODUCTION: CURRENT ADVANCES AND FUTURE PERSPECTIVES

INTELIGÊNCIA ARTIFICIAL E PLATAFORMAS INTELIGENTES NA PRODUÇÃO ANIMAL: AVANÇOS RECENTES E PERSPECTIVAS FUTURAS

INTELIGENCIA ARTIFICIAL Y PLATAFORMAS INTELIGENTES EN LA PRODUCCIÓN ANIMAL: AVANCES RECIENTES Y PERSPECTIVAS FUTURAS

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ABSTRACT:This review aimed to synthesize current advances in artificial intelligence (AI) and intelligent digital platforms applied to animal production, highlighting their main techniques, applications, challenges, and future perspectives. Recent developments in digital agriculture have accelerated the adoption of AI-based tools capable of supporting data-driven decision-making in livestock systems. Among the available technologies, Machine Learning, Deep Learning, and Computer Vision have become the most established approaches for predicting productive performance, monitoring animal health and welfare, optimizing nutrition and reproduction, and improving management efficiency. More recently, intelligent platforms integrating AI, the Internet of Things, cloud computing, and sensor networks have enabled continuous monitoring and real-time decision support across multiple production systems. Emerging technologies, including large language models and explainable AI, are expected to further enhance knowledge management and decision support, although challenges related to interoperability, data quality, model validation, and producer adoption remain. Overall, AI is no longer an emerging technology but an essential component of Precision Livestock Farming, with increasing potential to promote more efficient, sustainable, and evidence-based animal production.

Keywords: Precision Livestock Farming. Animal Science. Data Science. Digital Agriculture. Decision Support Systems.

RESUMO: Esta revisão teve como objetivo sintetizar os avanços recentes da inteligência artificial (IA) e das plataformas digitais inteligentes aplicadas à produção animal, destacando suas principais técnicas, aplicações, desafios e perspectivas futuras. A transformação digital da agropecuária impulsionou a adoção de ferramentas baseadas em IA capazes de apoiar a tomada de decisão em sistemas de produção animal. Entre as tecnologias disponíveis, Machine Learning, Deep Learning e Computer Vision consolidaram-se como as principais abordagens para predição de desempenho produtivo, monitoramento da saúde e do bem-estar animal, otimização da nutrição e da reprodução, além do suporte ao manejo de precisão. Mais recentemente, plataformas inteligentes integrando IA, Internet das Coisas, computação em nuvem e redes de sensores passaram a permitir monitoramento contínuo e suporte à decisão em tempo real. Tecnologias emergentes, como Large Language Models e Explainable Artificial Intelligence, tendem a ampliar o gerenciamento do conhecimento e o suporte às decisões, embora desafios relacionados à interoperabilidade, qualidade dos dados, validação dos modelos e adoção pelos produtores ainda persistam. De forma geral, a IA deixou de representar uma tecnologia emergente e passou a constituir um dos principais pilares da Precision Livestock Farming e da produção animal sustentável.

Palavras-chave: Pecuária de Precisão. Zootecnia. Ciência de Dados. Agricultura Digital. Sistemas de Apoio à Decisão.

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RESUMEN: Esta revisión tuvo como objetivo sintetizar los avances recientes de la inteligencia artificial (IA) y de las plataformas digitales inteligentes aplicadas a la producción animal, destacando sus principales técnicas, aplicaciones, desafíos y perspectivas futuras. La transformación digital de la agricultura ha impulsado la adopción de herramientas basadas en IA para apoyar la toma de decisiones en los sistemas pecuarios. Entre las tecnologías disponibles, Machine Learning, Deep Learning y Computer Vision se han consolidado como las principales estrategias para predecir el rendimiento productivo, monitorear la salud y el bienestar animal, optimizar la nutrición y la reproducción, y mejorar la gestión de precisión. Más recientemente, las plataformas inteligentes que integran IA, Internet de las Cosas, computación en la nube y redes de sensores han permitido el monitoreo continuo y el apoyo a la toma de decisiones en tiempo real. Tecnologías emergentes, como los Large Language Models y la Explainable Artificial Intelligence, amplían aún más estas posibilidades, aunque persisten desafíos relacionados con la interoperabilidad, la calidad de los datos, la validación de los modelos y la adopción por parte de los productores. En conjunto, la IA ha dejado de ser una tecnología emergente para convertirse en un componente esencial de la Precision Livestock Farming y de la producción animal sostenible.

Palabras clave: Ganadería de Precisión. Ciencia Animal. Ciencia de Datos. Agricultura Digital. Sistemas de Apoyo a la Decisión.

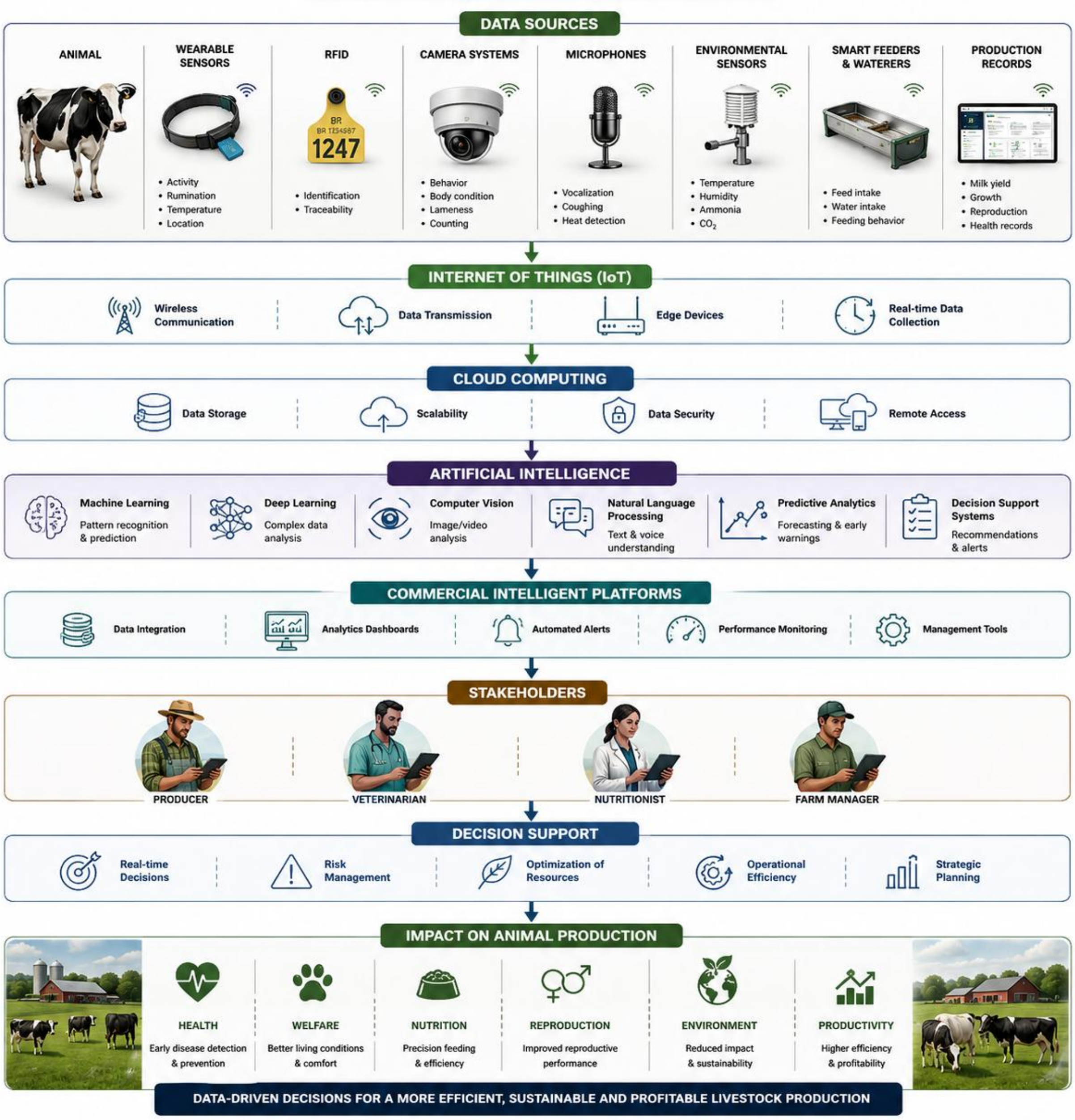
1. INTRODUCTION

Livestock production is undergoing a rapid digital transformation driven by the increasing demand for efficient, sustainable, and welfare-oriented production systems. Modern farms generate large volumes of biological, environmental, and productive data, creating opportunities for more accurate and evidence-based management while addressing challenges related to resource efficiency, animal health, and food security (BACKMAN et al., 2023; BAO e XIE, 2022).

This transformation has been accelerated by the development of Agriculture 4.0, which integrates technologies such as the Internet of Things (IoT), cloud computing, robotics, sensor networks, and big data analytics into agricultural systems (Figure 1). Within this context, Precision Livestock Farming (PLF) has emerged as a management approach based on the continuous monitoring of animals and production environments through automated data collection and intelligent analytical tools (WOLFERT et al., 2017; KLEEN e GUATTEO, 2023).

Artificial intelligence (AI) has become one of the main technologies supporting this transition by enabling the interpretation of complex datasets and the generation of predictive information for decision-making. Machine Learning (ML), Deep Learning (DL), and Computer Vision (CV) are currently the most widely adopted approaches, supporting applications such as disease detection, behavioural monitoring, reproductive management, precision nutrition, weight estimation, and welfare assessment across different livestock species (Figure 1) (BAO e XIE, 2022; TEDESCHI et al., 2025).

Figure 1. Intelligent digital ecosystem for Artificial Intelligence applications in animal production.



Source: MACÁRIO MS e OLIVEIRA IRS; 2026; based on BAO and XIE (2022), ROSATI (2025), MENEZES, et al. (2025), TEDESCHI, et al. (2025), TEDESCHI, et al. (2026), and SIACHOS, et al. (2024).

More recently, intelligent digital platforms have expanded these capabilities by integrating sensors, cameras, farm records, and AI models into unified decision-support

ISSN: 2675-3375

systems. In parallel, emerging technologies such as Large Language Models and Explainable Artificial Intelligence are creating new opportunities for knowledge management, technical assistance, and data interpretation in animal production (Figure 1) (MENEZES et al., 2025; ROSATI, 2025).

Despite the rapid expansion of scientific publications, available evidence remains dispersed among specific species, isolated technologies, or individual production stages. Therefore, this review summarizes recent advances in AI and intelligent platforms applied to animal production, discussing the main computational techniques, their practical applications, current limitations, and future perspectives for digital livestock systems.

2. DIGITAL TRANSFORMATION OF ANIMAL PRODUCTION: FROM AGRICULTURE 4.0 TO PRECISION LIVESTOCK FARMING

The digital transformation of animal production has shifted livestock management from experience-based practices toward continuous, data-driven decision-making. Traditionally, production systems relied on periodic visual inspections and manual records, which often limited the timely detection of health disorders, reproductive events, and management inefficiencies. The incorporation of digital technologies has progressively overcome these limitations by enabling continuous monitoring of animals and production environments (BACKMAN et al., 2023; WOLFERT et al., 2017).

This transformation is closely associated with the concept of Agriculture 4.0, which integrates the Internet of Things (IoT), cloud computing, wireless communication, sensors, robotics, and data analytics into agricultural systems. In livestock production, these technologies support the collection, transmission, and analysis of large volumes of biological, productive, and environmental data, providing the technological basis for Precision Livestock Farming (PLF) (DA SILVEIRA et al., 2021; JAVAID et al., 2022).

Within PLF, wearable sensors, radio-frequency identification systems, automated feeders, environmental sensors, cameras, and milking robots continuously generate information on animal performance and farm conditions. These heterogeneous data are integrated into digital platforms capable of supporting real-time monitoring and evidence-based management, as illustrated in Figure 1 (MORRONE et al., 2022; KLEEN e GUATTEO, 2023).

The rapid expansion of digital data has also stimulated the incorporation of AI into livestock systems. By combining predictive models with automated data acquisition, AI enables early disease detection, precision feeding, reproductive monitoring, welfare assessment, and production forecasting. Consequently, livestock management has evolved from a reactive approach, based on visible production losses, to a proactive strategy focused on prediction and prevention (BAO e XIE, 2022; TEDESCHI et al., 2025).

Although the adoption of digital technologies continues to expand, important challenges remain, including interoperability among platforms, data standardization, internet connectivity in rural areas, implementation costs, and producer training. Nevertheless, continuous advances in sensors, cloud computing, and AI are expected to make intelligent livestock systems increasingly accessible and scalable, supporting more sustainable and efficient animal production (ROSATI, 2024; DISTANTE et al., 2025).

3. ARTIFICIAL INTELLIGENCE TECHNIQUES APPLIED TO ANIMAL PRODUCTION

Artificial Intelligence (AI) comprises a group of computational approaches capable of extracting patterns from complex datasets to support prediction, classification, recognition, and decision-making. In livestock production, AI has become an essential component of digital farming by transforming large volumes of data generated from sensors, cameras, wearable devices, and management software into actionable information for producers and technical advisors (BAO e XIE, 2022; DISTANTE et al., 2025).

Several AI techniques are currently employed in animal production, each presenting distinct strengths according to the type of available data and the production objective. As summarized in Table 1, Machine Learning (ML) remains the preferred approach for structured numerical datasets, including productive, reproductive, nutritional, and environmental records. These algorithms are widely used to predict productive performance, feed efficiency, reproductive outcomes, and disease occurrence while requiring relatively low computational resources (BAO e XIE, 2022; CASTRO et al., 2025).

Table 1 - Main Artificial Intelligence techniques applied to animal production, representative algorithms, applications, livestock species, and selected studies.

AI technique	Representative algorithms/models	Main applications	Livestock species	Selected studies
Machine Learning (ML)	Random Forest, Support Vector Machine (SVM), Decision Trees, XGBoost, K-Nearest Neighbors	Productive performance prediction, feed efficiency, reproductive performance, disease occurrence, mortality risk	Cattle, pigs, poultry, sheep	BAO e XIE (2022); CASTRO et al. (2025); CONDOTTA e TEDESCHI (2026)

AI technique	Representative algorithms/models	Main applications	Livestock species	Selected studies
Deep Learning (DL)	Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU)	Behaviour recognition, disease detection, image analysis, activity monitoring	Cattle, pigs, poultry	TEDESCHI et al. (2025); MENEZES et al. (2024); XIAO et al. (2025)
Computer Vision (CV)	YOLO, Faster R-CNN, Mask R-CNN, EfficientNet, Vision Transformers (ViT)	Animal identification, body condition scoring, lameness detection, weight estimation, welfare assessment	All livestock species	GUARNIDO-LOPEZ et al. (2024); MA et al. (2024); TEDESCHI et al. (2025)
Natural Language Processing (NLP)	BERT, BioBERT	Literature mining, veterinary records, farm reports, technical documentation	Multispecies	ROSATI (2024); MENEZES et al. (2024)
Large Language Models (LLMs)	ChatGPT, Gemini, Claude, Llama	Literature synthesis, decision support, educational content, technical assistance	Multispecies	ROSATI (2024); MENEZES et al. (2024)
Generative AI	GPT-4, Gemini, Claude	Scientific writing support, protocol development, knowledge synthesis	Multispecies	ROSATI (2024); XIAO et al. (2025)
Explainable Artificial Intelligence (XAI)	SHAP, LIME	Model interpretation, transparency, decision support, producer confidence	Multispecies	CONDOTTA e TEDESCHI (2026); ROSATI (2024)

Source: Developed by the authors (MACÁRIO MS & OLIVEIRA IRS, 2026), based on the scientific literature reviewed and cited in this table.

In contrast, Deep Learning (DL) has become the main alternative for analysing unstructured data, particularly images, videos, and continuous sensor streams. Within this field, Computer Vision (CV) has experienced the fastest expansion in livestock research due to its ability to perform automated animal identification, behaviour recognition, body condition scoring, lameness detection, weight estimation, and welfare assessment without direct animal handling (TEDESCHI et al., 2025; MA et al., 2024).

Recent advances have also expanded AI beyond predictive modelling. Natural Language Processing (NLP), Large Language Models (LLMs), Explainable Artificial Intelligence (XAI), and Generative AI are increasingly supporting scientific literature analysis, technical documentation, decision support, and knowledge management. Although these technologies are not yet directly involved in animal monitoring, they are becoming valuable tools for researchers, veterinarians, extension agents, and farm managers by facilitating information retrieval and communication (ROSATI, 2024; XIAO et al., 2025).

The selection of an AI technique depends primarily on the production objective and the nature of the available data rather than algorithm complexity. While ML generally performs better for structured production databases, DL and CV are more suitable for image- and video-based applications. Emerging approaches such as LLMs and XAI complement these technologies by improving human–computer interaction and model interpretability, contributing to more transparent and efficient decision-support systems (Table 1) (MENEZES et al., 2024; CONDOTTA e TEDESCHI, 2026).

4. EMERGING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN ANIMAL PRODUCTION

Although ML, DL, and CV currently represent the most consolidated AI approaches in livestock production, recent technological advances are expanding the capabilities of intelligent farming systems. Large Language Models (LLMs), Generative AI, Explainable Artificial Intelligence (XAI), Digital Twins, and multimodal AI are increasingly being incorporated into research and commercial platforms, enabling more efficient knowledge management, predictive modelling, and decision support (ROSATI, 2024; NIU et al., 2026).

Among these technologies, LLMs have gained particular attention due to their ability to process technical documents, summarize scientific evidence, generate management reports, and assist extension services through conversational interfaces. In parallel, Generative AI is facilitating the development of educational materials, technical protocols, and automated documentation, while XAI improves model transparency by identifying the variables that contribute most to AI predictions, thereby increasing user confidence in decision-support systems (XIAO et al., 2025; CONDOTTA e TEDESCHI, 2026).

Another promising development is the application of Digital Twins, which create virtual representations of animals or production systems continuously updated with real-time data. By integrating biological, environmental, and management information, these systems allow producers to simulate production scenarios, evaluate management alternatives, and anticipate potential health or productivity issues before they occur. Although still in the early stages of adoption, these technologies are expected to become increasingly relevant as digital infrastructure continues to evolve (SUBEESH e CHAUHAN, 2026; GUO et al., 2026).

Rather than replacing established AI methods, these emerging technologies complement existing analytical tools and are expected to strengthen future intelligent livestock platforms by improving automation, interoperability, and knowledge-based decision-making.

5. ARTIFICIAL INTELLIGENCE APPLICATIONS ACROSS ANIMAL PRODUCTION SYSTEMS

The rapid expansion of AI has resulted in practical applications across virtually all sectors of animal production. Current systems integrate sensors, imaging technologies, predictive algorithms, and intelligent platforms to support routine management activities while improving productivity, animal welfare, and resource efficiency. The principal applications currently reported in livestock production are summarized in Table 1.

5.1 HEALTH MONITORING

Health monitoring represents one of the most mature applications of AI in livestock production. Intelligent systems continuously analyse behavioural, physiological, and environmental information to detect diseases before clinical signs become evident, allowing earlier interventions and reducing economic losses. Applications include lameness detection, mastitis diagnosis, respiratory disease surveillance, thermal stress assessment, and mortality risk prediction using data obtained from sensors, cameras, and automated monitoring systems (TEDESCHI et al., 2025; LI et al., 2024).

Recent advances in CV have substantially improved non-invasive health assessment by enabling automated analysis of posture, locomotion, facial expressions, and behavioural changes associated with disease. When integrated into intelligent digital platforms, these technologies generate real-time alerts that support veterinarians and producers in preventive herd management (Table 1) (GUARNIDO-LOPEZ et al., 2024; SHEN et al., 2025).

5.2 ANIMAL WELFARE

AI has also become an important tool for objective welfare assessment by enabling continuous monitoring of animal behavior under commercial production conditions. Image analysis, wearable sensors, and environmental monitoring systems can identify behavioral changes associated with stress, discomfort, aggression, or reduced activity, allowing producers to evaluate welfare indicators without frequent animal handling (PAPAKONSTANTINOU et al., 2024; DAWKINS, 2025).

Beyond individual monitoring, AI contributes to the optimization of housing conditions by integrating environmental variables such as temperature, humidity, ventilation, and stocking density. These systems support management decisions aimed at improving thermal comfort, reducing stress, and promoting sustainable production practices (Table 1) (VLAICU et al., 2024; ROSATI, 2024).

5.3 NUTRITION

Precision nutrition has increasingly benefited from AI through the integration of production records, feeding behaviour, and environmental information. ML algorithms are widely used to predict feed intake, estimate nutritional requirements, optimise diet formulation, and improve feed efficiency, allowing nutritional management to be continuously adjusted according to production conditions (CONDOTTA e TEDESCHI, 2026; BAO e XIE, 2022).

In dairy and intensive production systems, AI-based feeding platforms combine sensor data with predictive models to support precision feeding strategies and reduce feed waste. These approaches improve nutrient utilisation while contributing to production efficiency and environmental sustainability, reinforcing the role of intelligent systems in modern livestock management (Table 1) (FUENTES et al., 2022; TEDESCHI et al., 2025).

5.4 REPRODUCTION

AI has become an important tool for reproductive management by supporting the early detection of estrus, prediction of calving, and monitoring of reproductive performance. Data generated by wearable sensors, activity monitors, and behavioural analyses are integrated with ML models to identify reproductive events with greater accuracy than traditional visual observation, reducing labour demands and improving reproductive efficiency (GIORDANO e LAPLACETTE, 2026; CONDOTTA e TEDESCHI, 2026).

More recently, intelligent reproductive monitoring systems have combined sensor data with predictive analytics to identify animals requiring intervention before reproductive losses occur. These approaches contribute to improved herd fertility while supporting more precise reproductive management in dairy cattle and swine production systems (Table 1) (KLEEN e GUATTEO, 2023).

5.5 GROWTH AND PRODUCTIVE PERFORMANCE

AI has also expanded the capacity to monitor productive performance through automated estimation of body weight, growth rate, feed efficiency, and production indicators.

CV systems combined with DL algorithms enable continuous, non-invasive evaluation of body dimensions and productive traits, reducing the need for manual measurements and minimizing animal handling (MA et al., 2024; XU et al., 2025).

These technologies have been successfully applied to cattle, poultry, swine, and aquaculture, supporting precision phenotyping and performance prediction under commercial production conditions. The integration of predictive models with production databases further contributes to more accurate management decisions throughout the production cycle (Table 1) (CASTRO et al., 2025; TEDESCHI et al., 2025).

5.6 INTELLIGENT DECISION SUPPORT

The integration of multiple AI techniques has led to the development of intelligent decision-support systems capable of combining production records, sensor information, environmental data, and predictive models into a single management platform. Rather than analysing isolated variables, these systems provide real-time recommendations that assist producers in identifying health risks, optimizing feeding strategies, improving reproductive management, and evaluating productive performance (DISTANTE et al., 2025; NIU et al., 2026).

By centralizing information from different sectors of the farm, intelligent platforms simplify decision-making and contribute to more efficient, sustainable, and evidence-based livestock management. As AI models continue to evolve, these systems are expected to become increasingly autonomous and capable of supporting complex production decisions (Table 1) (ROSATI, 2024; VLAICU et al., 2024).

6. INTELLIGENT PLATFORMS AND COMMERCIAL AI SOLUTIONS FOR ANIMAL PRODUCTION

The rapid development of AI has accelerated the commercialization of digital platforms designed to support livestock management. Unlike isolated analytical tools, these platforms integrate data acquisition, predictive analytics, and management recommendations into unified systems that assist producers in routine decision-making. Commercial solutions are currently available for dairy cattle, beef cattle, swine, poultry, and aquaculture, demonstrating that AI has progressed from experimental research to practical on-farm applications (**Table 2**) (MENEZES et al., 2024; DISTANTE et al., 2025).

6.1 COMMERCIAL PLATFORMS CURRENTLY AVAILABLE

Current commercial platforms combine AI algorithms with sensors, CV, wearable devices, and cloud computing to automate monitoring activities and generate real-time alerts. Depending on the production system, these technologies support health surveillance, reproductive management, behavioural monitoring, environmental control, and precision feeding. Representative examples currently available for different livestock sectors are presented in **Table 2** (KLEEN e GUATTEO, 2023; TEDESCHI et al., 2025).

Table 2. Representative commercial intelligent platforms currently available in animal production

Platform	Developer Country	Livestock Species	Main AI approach	Main Applications	Selected studies
Connecterra (Ida)	Netherlands	Dairy cattle	ML + Intelligent platform	Estrus detection, health monitoring, feeding behavior, production alerts	KLEEN e GUATTEO (2023); MENEZES et al. (2024)
Cainthus	Ireland	Dairy cattle	CV + DL	Body condition scoring, feeding behavior, barn occupancy, individual animal monitoring	TEDESCHI et al. (2025); GUARNIDO-LOPEZ et al. (2024)
CattleEye	Ireland	Dairy cattle	CV	Automated lameness detection, locomotion monitoring, mobility scoring	TEDESCHI et al. (2025); LI et al. (2024)
Smartbow	Austria	Dairy and beef cattle	Wearable sensors + ML	Animal localization, rumination monitoring, estrus detection, health alerts	KLEEN e GUATTEO (2023); GIORDANO e LAPLACETTE (2026)
CowManager	Netherlands	Dairy cattle	Ear sensors + ML	Rumination, feeding behavior, heat detection, health monitoring	KLEEN e GUATTEO (2023); MENEZES et al. (2024) (cowmanager.com)
SoundTalks	Belgium	Swine	Bioacoustics + ML	Early detection of respiratory diseases through cough recognition	NEETHIRAJAN (2025); DISTANTE et al. (2025) (PMC)
Fancom One	Netherlands	Poultry and swine	AI + IoT	Environmental monitoring, climate control, ventilation management	MORRONE et al. (2022); COLLINS e SMITH (2022)
BirdBox	China	Poultry	CV	Broiler behavior analysis, flock distribution, welfare assessment	DAWKINS (2025); PANERU et al. (2026)
eYeGrow	China	Broiler chickens	CV + DL	Automatic body weight estimation and growth monitoring	XU et al. (2025); MA et al. (2024)
Aquabyte	Norway	Atlantic salmon	CV + DL	Biomass estimation, fish counting, sea lice detection	FUENTES et al. (2022); LI et al. (2024) (ScienceDirect)

Platform	Developer Country	Livestock Species	Main AI approach	Main Applications	Selected studies
Taranis*	Israel	Integrated farming systems	AI + Remote sensing	Farm monitoring, environmental assessment, decision support	JAVAID et al. (2022); DA SILVEIRA et al. (2021)
Connected Farm Platforms**	Multiple countries	Multi-species	AI + IoT + Cloud computing	Integrated farm management, predictive analytics, real-time decision support	DISTANTE et al. (2025); NIU et al. (2026); ROSATI (2024)

Source: Developed by the authors (MACÁRIO MS e OLIVEIRA IRS, 2026), based on the scientific literature reviewed and cited in this table.
Commercial platforms are presented as representative examples of currently available market solutions. References support the broader technological categories and applications, rather than serving as product-specific validation for each proprietary platform.
*Although Taranis was originally developed for crop production, its digital monitoring architecture has potential applications in integrated crop–livestock systems.
**Generic term referring to integrated livestock management platforms described in the scientific literature.

6.2 INTEGRATION WITH PRECISION LIVESTOCK FARMING

Commercial AI platforms represent one of the most advanced applications of PLF by integrating heterogeneous datasets into centralized decision-support systems. Biological, productive, environmental, and behavioural information collected from multiple sources can be processed simultaneously, allowing continuous monitoring of farm performance and rapid identification of management priorities (WOLFERT et al., 2017; DISTANTE et al., 2025).

Cloud-based infrastructures further facilitate data sharing among producers, veterinarians, nutritionists, and extension services, promoting collaborative decision-making and improving traceability throughout livestock production systems (DA SILVEIRA et al., 2021; JAVAID et al., 2022).

6.3 CURRENT LIMITATIONS FOR LARGE-SCALE ADOPTION

Despite considerable technological advances, several barriers still limit the large-scale adoption of AI in livestock production. High implementation costs, limited internet connectivity in rural areas, interoperability among digital platforms, lack of standardized data, and the need for technical training remain important challenges, particularly for small and medium-sized farms (BACKMAN et al., 2023; ROSATI, 2024).

Additional concerns include data privacy, cybersecurity, and the need for transparent AI models capable of supporting reliable decision-making under commercial production conditions. Overcoming these limitations will require continued technological development together with investments in digital infrastructure, extension services, and producer training (NEETHIRAJAN, 2025; DAWKINS, 2025).

7. FINAL CONSIDERATIONS

Artificial intelligence has become a fundamental component of modern animal production, supporting more accurate, automated, and evidence-based management across multiple livestock systems. Current applications demonstrate that ML, DL, CV, and intelligent digital platforms are no longer experimental technologies but practical tools capable of improving animal health, welfare, nutrition, reproduction, productive performance, and farm management.

Although important challenges remain regarding interoperability, data quality, infrastructure, and large-scale adoption, recent advances indicate that AI will play an increasingly strategic role in the evolution of PLF. Future livestock systems are expected to integrate predictive analytics, intelligent platforms, and emerging AI technologies into comprehensive decision-support environments, contributing to more efficient, sustainable, and resilient animal production.

REFERÊNCIAS

BAO J, XIE Q. Artificial intelligence in animal farming: a systematic literature review. Journal of Cleaner Production, 2022;331:129956. https://doi.org/10.1016/j.jclepro.2021.129956

COLLINS LM, SMITH LM. Review: Smart agri-systems for the pig industry. Animal, 2022;16:100518. https://doi.org/10.1016/j.animal.2022.100518

CONDOTTA ICFS, TEDESCHI LO. ASAS-NANP Symposium: Mathematical modeling in animal nutrition: revolutionizing animal farming with artificial intelligence: trends, challenges, and opportunities. Journal of Animal Science, 2026;104:skaf441. https://doi.org/10.1093/jas/skaf441

DA SILVEIRA F, et al. An overview of Agriculture 4.0 development: systematic review of descriptions, technologies, barriers, advantages, and disadvantages. Computers and Electronics in Agriculture, 2021;190:106405. https://doi.org/10.1016/j.compag.2021.106405

DAWKINS MS. Smart farming and Artificial Intelligence (AI): how can we ensure that animal welfare is a priority? Applied Animal Behaviour Science, 2025;283:106519. https://doi.org/10.1016/j.applanim.2024.106519

DISTANTE D, et al. Artificial intelligence applied to precision livestock farming: a tertiary study. Smart Agricultural Technology, 2025;11:100889. https://doi.org/10.1016/j.atech.2025.100889

FUENTES S, et al. The livestock farming digital transformation: implementation of new and emerging technologies using artificial intelligence. Animal Health Research Reviews, 2022;23(1):59-71. https://doi.org/10.1017/S1466252322000051

GIORDANO JO, LAPLACETTE AL. Present and future opportunities for artificial intelligence applications in dairy cattle reproduction. Animal Frontiers, 2026;16(2):86-98. https://doi.org/10.1093/af/vfaf019

GUARNIDO-LOPEZ P, et al. Computer vision algorithms to help decision-making in cattle production. Animal Frontiers, 2024;14(6):11-22. https://doi.org/10.1093/af/vfae052

GUO C, et al. Navigating AI deployment in precision livestock farming: current trends and future prospects. Animal Frontiers, 2026;16(2):14-25.https://doi.org/10.1093/af/vfaf011

JAVAID M, et al. Enhancing smart farming through the applications of Agriculture 4.0 technologies. International Journal of Intelligent Networks, 2022;3:150-164. https://doi.org/10.1016/j.ijin.2022.09.004

KLEEN JL, GUATTEO R. Precision Livestock Farming: what does it contain and what are the perspectives? Animals, 2023;13(5):779. https://doi.org/10.3390/ani13050779

LI Q, et al. A novel lameness detection method for dairy cows based on temporal gait and spatial post features. Computers and Electronics in Agriculture, 2024;224:109172. https://doi.org/10.1016/j.compag.2024.109172

MA J, et al. Toward smart health monitoring: multimodal sensing and intelligent disease diagnosis in poultry and livestock. Animal Frontiers, 2026;16(2):51-62. https://doi.org/10.1093/af/vfaf060

MENEZES GL, et al. Artificial intelligence for livestock: a narrative review of the applications of computer vision systems and large language models for animal farming. Animal Frontiers, 2024;14(6):42-53.
https://doi.org/10.1093/af/vfae048

MORRONE S, et al. Industry 4.0 and Precision Livestock Farming (PLF): an up-to-date overview across animal productions. Sensors, 2022;22(12):4319. https://doi.org/10.3390/s22124319

NEETHIRAJAN S. Safeguarding digital livestock farming: a comprehensive cybersecurity roadmap for dairy and poultry industries. Frontiers in Big Data, 2025;8:1556157. https://doi.org/10.3389/fdata.2025.1556157

NIU M, et al. Artificial intelligence for animal science: from applications to integrated knowledge systems. Animal Frontiers, 2026;16(2):26-33. https://doi.org/10.1093/af/vfaf010

PANERU B, et al. Artificial intelligence in precision poultry farming: opportunities, challenges, and future features. Animal Frontiers, 2026;16(2):41-50. https://doi.org/10.1093/af/vfag004

PAPAKONSTANTINOU GI, et al. Precision Livestock Farming technology: applications and challenges of animal welfare and climate change. Agriculture, 2024;14(4):620. https://doi.org/10.3390/agriculture14040620

ROSATI A. Guiding principles of AI: application in animal husbandry and other considerations. Animal Frontiers, 2024;14(6):3-10. https://doi.org/10.1093/af/vfae045

SHEN Y, et al. An algorithm for detecting cow lameness based on ensemble learning of keypoint motion features. Journal of Dairy Science, 2025;108(10):11520-11534. https://doi.org/10.3168/jds.2025-26846

SUBEESH A, CHAUHAN N. Agricultural digital twin for smart farming: a review. Green Technologies and Sustainability, 2026;4(2):100299. https://doi.org/10.1016/j.grets.2026.100299

VLAICU PA, et al. Advancing livestock technology: intelligent systemization for enhanced productivity, welfare, and sustainability. AgriEngineering, 2024;6(2):1479-1496. https://doi.org/10.3390/agriengineering6020085

WOLFERT S, et al. Big data in smart farming: a review. Agricultural Systems, 2017;153:69-80. https://doi.org/10.1016/j.agsy.2017.01.023

XIAO S, et al. Review of applications of deep learning in veterinary diagnostics and animal health. Frontiers in Veterinary Science, 2025;12:1511522. https://doi.org/10.3389/fvets.2025.1511522