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Automation of cattle weighing as a strategy for reducing logistical bottlenecks in livestock management

Automação da pesagem bovina como estratégia para redução de gargalos logísticos no manejo pecuário

Automatización del pesaje bovino como estrategia para reducir los cuellos de botella logísticos en el manejo ganadero

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Abstract: The modernization of livestock farming has incorporated digital technologies capable of optimizing production processes and increasing the operational efficiency of rural properties. Among the main challenges faced by producers is the periodic weighing of cattle, a fundamental procedure for monitoring zootechnical performance, but one that still depends, in many cases, on intensive handling and physical restraint of the animals. This study aims to analyze the automation of cattle weighing as a strategy for reducing logistical bottlenecks in livestock management. The research was conducted through a literature review of studies on precision livestock farming, radio-frequency identification (RFID), load sensors, and Internet of Things (IoT) applications in herd monitoring. The results indicate that automated weighing systems enable real-time data collection, reduce labor requirements, and minimize animal stress during handling (Costa et al., 2014). In addition, the integration of sensors, microcontrollers, and electronic identification systems enables individual monitoring of cattle production performance, supporting strategic decision-making on the farm. It is concluded that weighing automation is a relevant tool for improving the productive and logistical efficiency of modern livestock farming and contributes to the advancement of precision livestock farming.

Keywords: precision livestock farming. RFID. rural automation. cattle weighing. internet of things.

Resumo: A modernização da pecuária tem incorporado tecnologias digitais capazes de otimizar processos produtivos e aumentar a eficiência operacional das propriedades rurais. Entre os principais desafios enfrentados pelos produtores está a realização da pesagem periódica dos bovinos, procedimento fundamental para o monitoramento do desempenho zootécnico, mas que ainda depende, em muitos casos, de manejo intensivo e contenção física dos animais. O presente trabalho tem como objetivo analisar a automação da pesagem bovina como estratégia para redução de gargalos logísticos no manejo pecuário. A pesquisa foi desenvolvida por meio de revisão bibliográfica em estudos sobre pecuária de precisão, identificação eletrônica por radiofrequência (RFID), sensores de carga e aplicações de Internet das Coisas (IoT) no monitoramento de rebanhos. Os resultados indicam que sistemas automatizados de pesagem permitem a coleta de dados em tempo real, reduzem a necessidade de mão de obra e minimizam o estresse dos animais durante o manejo (Costa et al., 2014). Além disso, a integração entre sensores, microcontroladores e sistemas de identificação eletrônica possibilita o acompanhamento individual do desempenho produtivo dos bovinos, favorecendo a tomada de decisões estratégicas na propriedade. Conclui-se que a automação da pesagem representa uma ferramenta relevante para a melhoria da eficiência produtiva e logística da pecuária moderna, contribuindo para o avanço da pecuária de precisão.

Palavras-chave: pecuária de precisão. RFID. automação rural. pesagem bovina. internet das coisas.

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Resumen: La modernización de la ganadería ha incorporado tecnologías digitales capaces de optimizar los procesos productivos y aumentar la eficiencia operativa de las propiedades rurales. Entre los principales desafíos que enfrentan los productores se encuentra el pesaje periódico del ganado bovino, procedimiento fundamental para monitorear el desempeño zootécnico, pero que todavía depende, en muchos casos, de un manejo intensivo y de la contención física de los animales. Este trabajo tiene como objetivo analizar la automatización del pesaje bovino como estrategia para reducir los cuellos de botella logísticos en el manejo ganadero. La investigación se desarrolló mediante una revisión bibliográfica de estudios sobre ganadería de precisión, identificación electrónica por radiofrecuencia (RFID), sensores de carga y aplicaciones de Internet de las Cosas (IoT) en el monitoreo de rebaños. Los resultados indican que los sistemas automatizados de pesaje permiten recopilar datos en tiempo real, reducen la necesidad de mano de obra y minimizan el estrés de los animales durante el manejo (Costa et al., 2014). Además, la integración de sensores, microcontroladores y sistemas de identificación electrónica permite el seguimiento individual del desempeño productivo de los bovinos, favoreciendo la toma de decisiones estratégicas en la propiedad. Se concluye que la automatización del pesaje constituye una herramienta relevante para mejorar la eficiencia productiva y logística de la ganadería moderna y contribuye al avance de la ganadería de precisión.

Palabras clave: ganadería de precisión. RFID. automatización rural. pesaje bovino. internet de las cosas.

1. Introduction

Brazil occupies a prominent position in the global cattle industry and is one of the world's largest producers and exporters of beef. According to the Brazilian Beef Exporters Association in Beef Report 2025, the country has a herd of more than 230 million head, consolidating its position as the global leader in beef exports. This setting requires growing productive efficiency, traceability, and the use of technologies that provide greater control over production processes, especially herd management and data-based decision-making. It also requires the production sector to adopt strategies that increase productive efficiency, sanitary control, and herd traceability. In this context, monitoring animal performance is essential for production planning on rural properties. Periodic cattle weighing makes it possible to assess important indicators such as average daily gain, feed efficiency, and the herd's genetic performance. Despite its importance, the traditional weighing process still presents significant logistical limitations. In conventional systems, animals must be driven to corrals and restrained in squeeze chutes for weighing, which requires substantial labor and may cause animal stress (Medeiros, 2020). According to Machado and Nantes (2004), traditional methods of animal identification and handling present difficulties related to reading information, the need for physical restraint, and a greater likelihood of recording errors. These limitations may

compromise the efficiency of livestock management and hinder the collection of reliable data. With the advancement of digital technologies applied to agribusiness, new solutions aimed at automating animal monitoring have emerged. These technologies include electronic sensors, radio-frequency identification (RFID) systems, and Internet of Things (IoT) platforms, which allow production data to be collected and analyzed automatically (Gokhale et al., 2018). Their use enables the development of automated weighing systems capable of recording animal weight during natural movement around the property, reducing the need for intensive handling and increasing production-process efficiency (Muniz et al., 2022).

Despite the available technological advances, small and medium-sized rural producers still face difficulties in accessing these solutions, mainly because of high implementation costs, lack of technical knowledge, and infrastructure limitations. This situation reinforces the importance of studies that analyze the feasibility and applicability of these technologies within Brazilian rural conditions.

Given this scenario, this study aims to analyze the use of cattle-weighing automation as a strategy to reduce logistical bottlenecks in livestock management, highlighting its operational and productive benefits.

2. Livestock farming context in the Presidente Prudente region, São Paulo

The Presidente Prudente region, located in western São Paulo State, has a strong beef-cattle industry, predominantly under extensive and semi-intensive systems. Many rural properties in the region are classified as small or medium-sized and face limitations in access to advanced technologies and the mechanization of production processes. In this context, traditional handling practices are still widely used, especially for herd weight control, which generally involves driving animals to fixed corrals. This process requires intensive labor, increases operating time, and may create logistical bottlenecks related to animal movement, handling organization, and resource availability. Thus, the adoption of automated technologies, such as walk-over weighing systems, has the potential to reduce these bottlenecks, improve logistical efficiency, and increase the competitiveness of the region's rural producers.

3. Theoretical framework

Logistics in the agricultural sector plays a fundamental role in organizing production processes and is responsible for optimizing the flow of resources, information, and operations

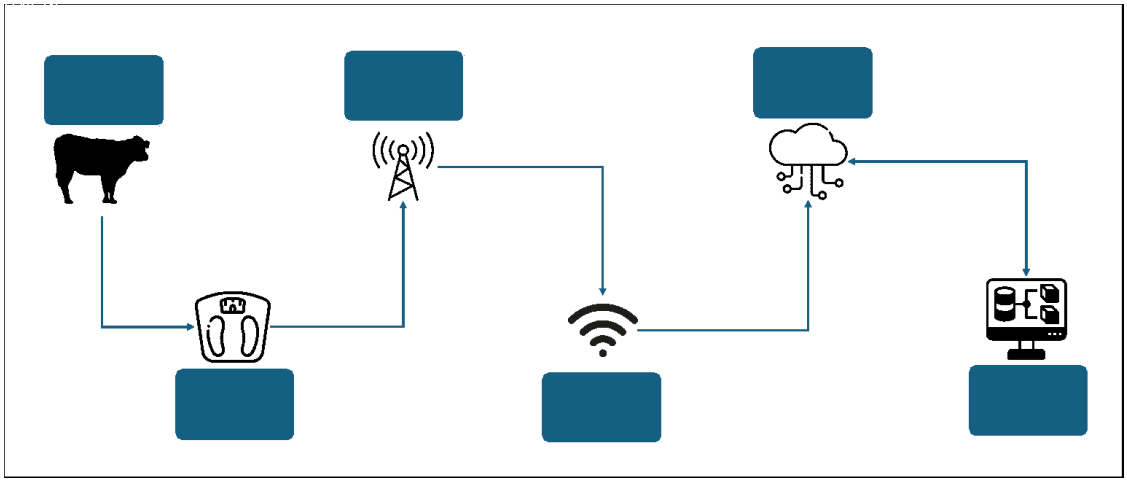
within rural properties. In beef-cattle farming, internal logistics includes activities such as herd handling, sanitary control, feeding, weighing, and animal transport. The efficiency of these activities directly affects productivity and the property's operating costs (BATALHA, 2012). In this setting, one of the main challenges faced by producers is the existence of operational bottlenecks during animal handling. Cattle weighing stands out among these activities as an essential process for monitoring weight gain, nutritional assessment, and managerial decision-making. Traditionally, weighing is performed on scales installed in corrals and requires animals to be driven through alleys and restraint chutes. This procedure demands time and labor, may stress the animals, and increases the risk of accidents involving workers and the herd itself (EMBRAPA, 2019). According to Embrapa, frequent handling in restraint structures may cause behavioral and physiological changes in cattle, affecting productive performance and animal welfare. Therefore, the search for technologies that reduce the need for intensive handling has become a priority in precision livestock farming. In this context, electronic animal identification has emerged as an important tool for modernizing herd management. This technology uses radio-frequency devices known as RFID (Radio Frequency Identification), usually embedded in electronic ear tags or implantable chips. These devices allow animals to be identified individually and automatically without direct physical contact (SILVA; SOUZA, 2019). The RFID system operates through communication between a transponder in the animal's electronic ear tag and a reader antenna installed at strategic points on the property. When the animal passes near the antenna, its identification code is captured and sent to a management system, allowing production data to be recorded and stored automatically (MARTINS; LIMA, 2021). Integrating this technology with automated weighing systems has enabled significant advances in monitoring cattle performance. One of the most relevant examples is walk-over weighing. A walk-over weighing system is installed in corridors that animals must use to access waterers or mineral-supplement feeders, ensuring their voluntary daily passage without intensive handling (Embrapa, 2017; Santos & Oliveira, 2021). Ideally, it is centrally located in the paddock, no more than 200-250 meters from any grazing point (the maximum recommended distance to avoid excessive energy expenditure), with a narrow funnel (70-80 cm wide) to prevent two animals from passing simultaneously. The main technical challenges are:

1. Interference from multiple animals or movement: load sensors generate noise (±2-5 kg). The solution adopted in the literature is a Kalman filter or AI algorithms that validate only stable readings associated with a single RFID. Invalid readings are discarded automatically.

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2. Crowding: prevented with side barriers and a raised platform that forces individual passage. Integration with low-frequency RFID (134.2 kHz) enables simultaneous identification and real-time weight readings, sending data to the cloud via IoT.

Figure 1 - Data flow of the automated cattle-weighing system (Walk-over weighing + IoT)



Source: Prepared by the author.

In this system, as shown above, the scale is installed at locations frequently crossed by the animals, such as access corridors to water or feed, allowing weight to be recorded automatically whenever an animal crosses the platform (SANTOS; OLIVEIRA, 2021). This approach eliminates the need to drive the herd to the corral for periodic weighing, significantly reducing handling time and operating costs. In addition, the system continuously collects data, enabling more accurate monitoring of weight gain and herd production performance over time (COSTA; FERREIRA, 2022). Another relevant aspect of automated weighing is its integration with precision-livestock technologies. Sensors, microcontrollers, and Internet of Things (IoT)-based systems allow collected data to be sent automatically to digital platforms or livestock-management applications, facilitating information analysis and producer decision-making (SANTOS; OLIVEIRA, 2021). Thus, adopting automated cattle-weighing systems represents an important technological innovation for the agricultural sector. In addition to helping reduce logistical bottlenecks in herd management, these technologies promote greater operational efficiency, improved animal welfare, and more accurate production monitoring, all essential factors for the competitiveness of modern livestock farming.

3.1 Precision livestock farming

Precision livestock farming consists of applying digital technologies to monitor and manage herds automatically and based on data. This approach uses electronic sensors, computer systems, and communication devices to collect information on animal behavior, health, and production performance. According to Gokhale et al. (2018), using digital technologies in agriculture has enabled greater operational efficiency, allowing producers to monitor production indicators in real time and make more strategic herd-management decisions. In this context, automating processes such as feeding, health monitoring, and animal weighing represents an important advance in modernizing livestock farming, contributing to increased productivity and improved animal welfare.

3.2 Electronic identification of cattle by RFID

Electronic animal identification is a fundamental element in automated livestock-monitoring systems. Radio-frequency identification, known as RFID, is among the most widely used technologies. According to Machado and Nantes (2004), RFID technology enables individual animal identification through electronic devices called transponders, which store unique codes and transmit information when activated by an electronic reader. These devices can be fitted to animals in different forms, such as electronic ear tags, subcutaneous implants, or intra-ruminal boluses. Each format has specific characteristics regarding durability, reading range, and data-storage capacity (Artmann, 1999). According to Santos et al. (2020), RFID transponders used in cattle generally operate in the low-frequency (LF) range, close to 134.2 kHz, allowing greater penetration through living tissue and more reliable information reading. In addition to individual identification, RFID technology can also monitor animals' physiological parameters, such as body temperature, contributing to herd-health control.

3.3 Automated animal-weighing systems

Automated animal-weighing systems have been developed as an alternative for reducing the operational impacts of traditional handling. These systems use electronic sensors capable of measuring the force exerted by an animal on a weighing platform. According to Oliveira et al. (2023), the load sensors used in these systems convert the applied force into electrical signals, which are processed by microcontrollers responsible for calculating and recording the animal's

weight. When integrated with RFID systems, these devices automatically associate the recorded weight with the individual animal's identification, creating a detailed production history over time (Costa et al., 2014). Furthermore, integration with IoT technologies enables collected information to be sent to digital data-storage and analysis platforms, allowing remote monitoring of herd performance (Gokhale et al., 2018).

3.4 Economic feasibility analysis

The automation of cattle weighing is not limited to reducing logistical bottlenecks: it represents a high-return economic strategy for Brazilian agribusiness. In traditional systems, one weighing session for 200 head requires, on average, 4 to 6 hours of work by 4-5 employees (Muniz et al., 2022). Considering the average cost of rural labor in Brazil at R$15.00-20.00 per hour/person, a single monthly weighing costs approximately R$1,200-2,400 in labor alone. A walk-over weighing system integrated with RFID and IoT requires an initial investment of R$25,000-45,000 (scale + reader + solar gateway), but practically eliminates 100% of the labor dedicated to weighing. International and Brazilian studies indicate a payback period of 12 to 24 months, thanks to a 2-11% reduction in live-weight loss caused by stress and more accurate average daily-gain data that enable nutritional optimization (Muniz et al., 2022). The average ROI in precision livestock farming is around 25-40% per year, making the technology highly attractive to producers seeking competitiveness in export markets.

4. Methodology

This study is characterized as qualitative and exploratory research conducted through a literature review. Scientific articles, academic studies, and technical publications related to livestock automation, electronic animal identification, and automated weighing systems were analyzed. The sources address technologies applied to precision livestock farming, focusing on load sensors, RFID devices, microcontrollers, and Internet of Things applications in animal monitoring. The analysis aimed to understand how these technologies work and assess their impacts on the logistical and productive efficiency of livestock management.

5. Results and discussion

The literature analysis demonstrates that cattle-weighing automation can bring significant benefits to rural-property management. One of the main benefits is reducing animal stress during handling. In automated systems, weighing can occur while animals move naturally around the property, avoiding physical restraint in squeeze chutes or corrals (Muniz et al., 2022). Another important benefit is the reduced demand for labor. Traditional systems require teams to drive and restrain animals, while automated systems continuously and automatically collect data. Automated data collection also increases the accuracy of recorded information. According to Costa et al. (2014), electronic identification integrated with weighing allows the individual production performance of each animal to be monitored, supporting nutritional and health planning. Digital connectivity also allows data to be stored on online platforms, enabling statistical analyses and real-time production reports (Gokhale et al., 2018). Thus, adopting these technologies helps reduce logistical bottlenecks in livestock management and increase production efficiency. In addition to reducing stress during handling, automation directly affects final meat quality - a strategic factor for Brazil, the world's largest exporter. Traditional handling in squeeze chutes raises plasma cortisol levels (up to 108.8 ng/mL), depleting muscle glycogen reserves and resulting in a final carcass pH ≥ 5.8 (DFD - dark, firm, dry). DFD meat has a dark color, greater water loss (2.5%), and a tough texture, reducing export value by as much as 15-20% and increasing rejection in premium markets. Automated walk-over weighing systems eliminate periodic restraint, maintaining low cortisol and an ideal pH (5.5-5.8), thereby producing lighter, more tender meat with a longer shelf life. Thus, this technology is not merely logistical: it is a value-adding strategy that guarantees a premium product for the European Union, China, and the Middle East.

6. Final considerations

The automation of cattle weighing represents an important technological innovation in modern livestock farming. Integrating load sensors, electronic identification systems, and digital platforms enables continuous monitoring of herd production performance. The studies analyzed indicate that adopting these technologies can reduce animal stress, decrease labor requirements, and improve the reliability of production information. Therefore, adopting automation technologies in livestock management represents a significant advance in reducing logistical bottlenecks, especially on small and medium-sized rural properties. In addition to

improving operational efficiency, these technologies help reduce costs, increase productivity, and improve animal welfare. However, challenges related to access to technology still need to be overcome, indicating the need for policies and incentives that facilitate its adoption in rural areas.

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