Brazilian Journal of Biology®

ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

Original Article

# Comparative analysis of methods for monitoring the condition of small cattle using modern technologies

## Análise comparativa dos métodos de monitorização do estado dos bovinos de pequeno porte utilizando tecnologias modernas

L. L. Ginoyan[a]*, N. T. Abraimov[a], B. S. Sansyzbayev[a], L. S. Kodabashyan[b], S. S. Eranosyan[b], D. R. Larin[b], A. A. Khomyakov[b], D. Pazylova[a] and A. Tileuberdi[a]*

[a]Private company "Organic and Minerals Limited", Astana, Kazakhstan
[b]MIREA-Russian Technological University, Moscow, Russian Federatian

**Abstract**

For successful animal husbandry, farmers need to monitor the health status of animals on a daily basis, as well as ensure the safety and protection of animals. In this regard, the problem of choosing the optimal system for monitoring the condition of farm animals in the modern market is urgent. The practical value of the scientific article is to analyze the problems of stakeholders and, based on the needs, conduct a comparative analysis of various modern systems for monitoring the condition of small cattle using the weighted sum method. The object of the study was the process of monitoring the condition of small cattle using RFID tags, as well as the ability to monitor their health depending on the chosen approach. The subject of the study was a livestock enterprise that raises small cattle. It was found that the health of small cattle directly affects the financial stability of the farm. In the presented study, the authors analyze the problems of stakeholders and, based on the needs of stakeholders, conduct a comparative analysis of various modern systems for monitoring the condition of small cattle using the weighted sum method. The results obtained will help farmers make informed decisions in the future when choosing the most appropriate monitoring option for more effective and high-quality monitoring of the condition of small cattle, thereby reducing the risk of diseases and increasing profits for companies.

**Keywords:** small cattle, monitoring of the state of small cattle, RFID tags, comparative analysis, weighted sum method.

**Resumo**

Para uma criação animal bem-sucedida, os agricultores têm de monitorizar diariamente o estado sanitário dos animais, bem como garantir a segurança e a protecção destes. A este respeito, o problema da escolha do sistema ótimo de controle do estado dos animais de criação no mercado moderno é urgente. O valor prático deste artigo científico é analisar os problemas das partes interessadas e, com base nas necessidades, realizar uma análise comparativa de vários sistemas modernos de monitoramento da condição de pequenos bovinos usando o método da soma ponderada. O objetivo deste estudo foi comparar os processos de monitoramento da condição de pequenos bovinos usando etiquetas RFID, bem como a capacidade de monitorar sua saúde, dependendo da abordagem escolhida. O assunto do estudo foi uma empresa pecuária que cria gado de pequeno porte. Verificou-se que a saúde dos pequenos bovinos afeta diretamente a estabilidade financeira da exploração. Os resultados obtidos ajudarão os agricultores, no futuro, a tomar decisões embasadas na informação, ao escolherem o sistema de controle mais adequado para uma monitorização mais eficaz e de alta qualidade da condição do gado de pequeno porte, reduzindo assim o risco de doenças e aumentando os lucros para as empresas.

**Palavras-chave:** bovinos de pequeno porte, acompanhamento do estado dos bovinos de pequeno porte, etiquetas RFID, análise comparativa, método da soma ponderada.

## 1. Introduction

Today, agriculture has become one of the key economic sectors in many countries (Dolgov, 2014). Agriculture is one of the main sectors of the economy of many countries and plays an important role in ensuring food security of the population. It is also a source of income for many rural residents and contributes to the development of rural areas (Ilyin, 2018). Problems in the field of agriculture generate social tension and social instability, in this regard, the sustainability and development of this industry is carefully monitored in all countries, in most cases at the state level

*e-mail: 17tile@gmail.com
Received: March 22, 2024 – Accepted: July 18, 2024

(Morozov, 2017). Therefore, the farmer needs to monitor the farm and take care of the health of livestock, as this factor plays an important role in successful operations. In the context of modern industrialization and population growth, the demand for animal products is also increasing, so it is worth emphasizing the importance of effective monitoring of animal health. Many Russian livestock enterprises still use outdated methods of monitoring animal health (Kirsanov et al., 2019). For example, it can be a method of monitoring the condition of animals, which is based on a daily routine examination of animals and monitoring their behavior. The need for farmers to integrate modern technologies for identifying and monitoring the condition of small cattle is obvious. Currently, mostly only foreign companies offer a wide range of systems for monitoring the condition of farm animals.

In Turkey, farmers used to systems that help to track the volume of meat products consumed (Erden et al., 2015). In China, Vietnam, Indonesia, this system used to control pig meat production (Curti et al., 2023). Landless sheep production systems are only found in western Asia and northern Africa (Steinfeld and Mäki-Hokkonen, 2023).

However, in order for farmers to choose the most suitable system, it is necessary to take into account many factors that influence this decision. For example, in order to achieve an optimal level of cow productivity, it is necessary to form a scientifically sound diet, taking into account many factors, including the age of the animals, the level of activity, climatic conditions, etc. (Mikolaichik et al., 2014). Therefore, the search for the most effective monitoring system for small cattle will help to solve one of the key problems in this area - monitoring the health of small cattle. Well-established monitoring and control of animal health will allow you to quickly respond to possible problems and minimize the risks of possible diseases.

## 2. Materials and Methods

In this article, the authors analyze the problems and needs of stakeholders using the project management knowledge base (PMI, 2017), and conduct a comparative analysis of existing systems for monitoring the condition of small cattle on the market using the weighted sum method (Podinovsky and Potapov, 2013). The results of this analysis will help farmers choose the most appropriate method for monitoring the condition of animals, which in turn contributes to improving the efficiency of farming and reducing the cost of treating animals.

## 3. Results

### *3.1. Problem description*

In agriculture, monitoring the condition of small cattle is an urgent task. Often, agricultural enterprises specializing in the cultivation of smallpox face the problem of inability to properly care for livestock.

The analysis of modern methods of livestock care includes the study of various approaches aimed at ensuring the health and welfare of animals, as well as at improving production efficiency.

Using modern technologies in livestock care:

- Monitoring the health of livestock using technologies of recognition and tracking (Sultygova, 2023).

The introduction of a livestock health monitoring system using recognition and tracking technologies can significantly facilitate the work of livestock enterprises, ensure timely identification of problems and take measures to eliminate them. Both companies specializing in the production of monitoring equipment and software developers usually participate in the development of such systems. They are constantly improving their products using the latest technologies and data processing methods.

A request for implementation of such a system was received from a private company Organic and minerals Limited from Astana, Kazakhstan.

When choosing a system for monitoring the condition of small cattle, it is necessary to take into account the opinion of interested parties and their problems. Below is a possible list of stakeholders compiled together with the system customer. This list is presented in a simplified form and is intended only to reflect the essence of the problems. Stakeholders and concerns are subject to change depending on the specific situation. In a concrete example, the following subjects are interested in the effectiveness of the process of monitoring the health of small cattle:

1. Organic and Minerals Limited from Astana, Kazakhstan is the customer of the system, they are interested in the effectiveness and accuracy of monitoring to improve the health of their livestock.
   Problem:
   Insufficient data on the health of livestock, the inability to recognize diseases or problems with animals in a timely manner, which leads to a deterioration in their health and well-being.
2. Owners and managers of livestock enterprises using this system
   Problem:
   Unsatisfactory indicators of animal productivity, insufficient control and monitoring of animal health, which leads to loss of production and animal welfare.
3. Veterinarians - as specialists responsible for the health of livestock
   Problem:
   Lack of an accurate system for monitoring animal health, which reduces the effectiveness of diagnosis and treatment of veterinarians.
4. Manufacturers of equipment and technologies for livestock monitoring
   Problem:
   Insufficient competitiveness of producers of equipment and technologies for monitoring livestock production in the market, which hinders the successful introduction and distribution of their products, as well as slows down the development of new technologies.
5. Government agencies and regulators
   Problem:
   Insufficient control of livestock morbidity monitoring and compliance with zootechnical practice standards,

which complicates the tasks of state bodies and regulators to ensure animal health and compliance with standards.

Limitations to consider when implementing a system for monitoring the health of small cattle:

- Financial constraints: The development and implementation of a monitoring system requires significant financial costs for equipment, software, personnel training, and system support.
- Technical limitations: It is necessary to take into account the limitations in the technical capabilities for data collection, transmission and processing, especially in remote areas where reliable communication may not be available.
- Staff training and participation: It is important to ensure that staff working with the livestock health monitoring system are trained to ensure that data are correctly interpreted and that effective monitoring responses are taken.
- Ethical constraints: Ethical considerations should be taken into account when collecting animal data, such as privacy protection, animal welfare, and ethical issues related to the use of monitoring technologies.
- Legal restrictions: It is important to take into account the legal regulations and laws governing the collection, storage and use of livestock health data to avoid violations of the law.

### *3.2. Modern approach to livestock health monitoring*

The main modern approach to monitoring the health of small cattle is RFID.

RFID (Radio Frequency Identification) is a method of automatic identification of objects, in which data stored in so-called RFID tags (transponders) are read or written by means of radio signals. RFID is a method of automatic identification through a radio signal. An RFID system consists of readers, tags, and software. A label is a chip where data is stored. An external reader scans the tag and processes the received data from it. The software is generally responsible for the operation of the system (Kulikov et al., 2022). Radio frequency identification methods are widely used in many areas, such as access control, animal identification, payment systems, warehouse systems, library systems, automobile immobilizers, with high reading range and speed, used in logistics and accounting for the movement of goods (Grigoriev et al., 2018).

RFID tags for animal identification are often used in agriculture to track herds of animals, control the processes of breeding and cattle breeding, as well as to ensure the safety and protection of animals from theft or loss (Ryzhova, 2015; Shilo et al., 2017).

An RFID tag, also known as a radio frequency identification tag, is a device that consists of two main components:

The first is an integrated circuit for storing and processing information, modulating and demodulating a radio frequency signal, and some other functions.

The second is an antenna for signal reception and transmission (Mishurov, 2014).

The principle of operation is described in a simplified version in Figure 1. In the animal industry, the RFID tag can take many forms, including ear tags, subcutaneous microchips, or bolus capsules that are inserted into the animal's stomach. In this case, the chip type can be used: Mifare S50, ISO14443A standard, operating frequency: 13.56 MHz (Russia, 2021).

An ear tag is the only version of the tag that remains visible after chipping. It is worth noting that this is the cheapest option for RFID identification. The ear tag is the easiest to secure, and chipped animals will always be easy to separate from the entire herd. The disadvantage of tags is a higher level of loss-animals can scratch the ear on which the label is attached (Alpysbay and Baideldinov, 2018; Bogdanov and Ryabtsev, 2022).

The subcutaneous microchip, of course, cannot be lost or replaced specifically, it excludes the substitution of one animal for another at exhibitions, when selling breeding young animals, because it is very difficult to find the crystal and extract it from the animal's body. It consists in a capsule made of biocompatible glass with a coating that eliminates allergic reactions, rejection or movement under the animal's skin (Shevchenko et al., 2013).

The bolus can also not be lost or intentionally removed, but is only suitable for working with ruminants. This is a small ceramic capsule that is inserted into the stomach through the oral cavity and settles in the rumen. It does not cause any harm or distress to the animal. After chipping has been performed in one of the three ways, the unique number of the animal can always be determined using a special reader device. This device makes it possible to

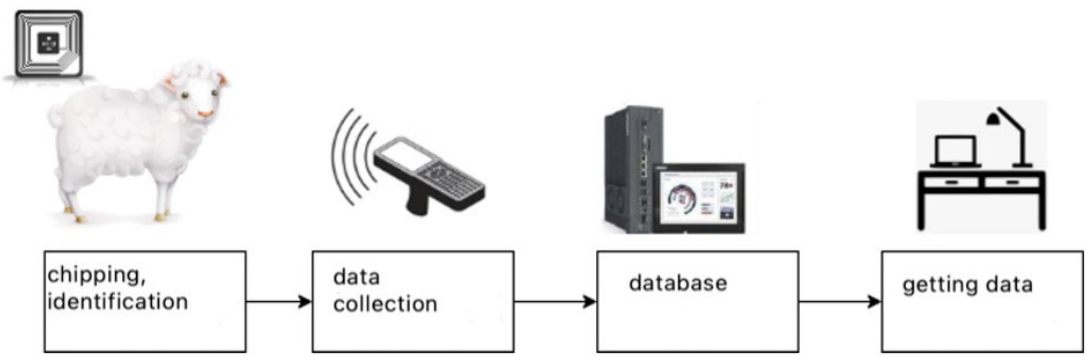


**Figure 1.** Working principle of an RFID tag for animal identification.

enter new data about each animal (inspection results or the fact of vaccination) and then transfer them from the reader to the electronic animal registration program (Irgit and Lushchenko, 2021; Timoshenko et al., 2015).

An RFID tag is a kind of passport for an animal. By quickly calculating it in the database, you can establish all the characteristics of the animal, up to genetics in several generations. In addition, such an identification number will not be lost throughout the life of the animal.

*3.3. Analysis of alternative options*

Below are alternative versions of the solution concepts that could be used to meet the formed requirements of stakeholders, given in the previous stage:

1. Ear tag - Concept A
2. Subcutaneous microchip - Concept B
3. Bolus - Concept C

The factors influencing the choice of a concept accepted by stakeholders are presented below (see Table 1). Next, we will use the weighted sum method to select a concept. A number of factors can be further specified, in particular, the number of obtained physiological indicators of the state of animals can be represented in separate blocks in the form of the location of the animal and its current state. This table is presented in a simplified way and is based on the needs of key stakeholders.

The weighted sum method is a multi-criteria decision-making method where there will be multiple alternatives, and we must determine the best alternative based on multiple criteria. Next, we will arrange the data for each concept relative to the presented factors (Podinovsky and Potapov, 2013; Volokobinsky et al., 2016; Klevets, 2018) (see Table 2).

The next step is to normalize the value for the corresponding attribute depending on the useful and unfavorable attribute (see Table 3). A useful attribute is the one in which the person wants to get the most out of it. An unfavorable attribute is an attribute for which minimum values are desired.

Next, we multiply each parameter by the corresponding weights, add up the components in each row, and calculate a weighted sum that is an estimate of the success of the system and prioritize the concepts.

As a result of the analysis, we can draw conclusions:

1. Concept A

Pros: Low development costs, low system deployment costs.

Cons: There is a low amount of data on the physiological parameters of the state of animals.

2. Concept B

Pros: Highly accurate health data, good viewability.

Cons: Development costs are higher than average.

3. Concept C

Pros: Informative status, average development costs.

**Table 1.** Factors influencing the choice of concept.

| Factor | Weight |
|---|---|
| Cost | 50 |
| Development and purchase costs | 25 |
| Cost of deployment and maintenance | 25 |
| Operational characteristics | 50 |
| The number of obtained physiological indicators of the state of animals | 25 |
| Read chip recognition | 25 |
| The amount | 100 |

**Table 2.** Data set.

| | concept A | concept B | concept C |
|---|---|---|---|
| Development cost, purchases per 300 pcs | ~from 50,000 rubles | ~from 60,000 rubles | ~from 70,000 rubles |
| Cost of deployment and maintenance | ~from 6000 rubles | ~from 15,000 rubles | ~from 30,000 rubles |
| Number of obtained physiological indicators of the state of animals | 2 Animal search, passport | 3 Animal search, passport, data storage | 5 Animal search, passport, data storage, temperature for disease detection, potato pH value for feeding control |
| Read chip recognition | 20-40 cm | 60-80 cm | 60-100 s |

**Table 3.** Matrix of solutions with normalized weight.

| | But the concept | In the concept | With the concept |
|---|---|---|---|
| Development cost, purchases per 300 pcs | 0.375 | 0.25 | 0.125 |
| Cost of deployment and maintenance | 0.85 | 0.625 | 0.25 |
| Number of obtained physiological indicators of the state of animals | 0.4 | 0.6 | 1 |
| Read chip recognition | 0.4 | 0.8 | 1 |

Cons: Limited viewability, higher-than-average deployment costs.

### *3.4. Discussions*

Based on weighted sum analysis, Concept C (bolus) has the highest final score, providing highly accurate data on the condition of animals, as well as providing additional functions for monitoring the health of small cattle. It is worth noting that the concept of C in comparison with alternatives provides the possibility of remote monitoring of the state of the small cattle. However, the development cost for it is higher than for concepts A (ear tags) and B (subcutaneous microchip). The analysis is based on the requirements and limitations of the above-mentioned stakeholders. It is worth noting that the choice between concepts depends on the budget and requirements for the accuracy of health data.

## 4. Discussion

To improve the effectiveness of animal control, businesses need to individually select monitoring systems that match their models. The purpose of this article was to study and analyze modern methods of monitoring the condition of small cattle with the subsequent implementation of the system in the private company "Organic and Minerals Limited".

In the course of the work, the authors analyzed the problems of stakeholders and limitations in the course of the work. In this regard, methods for monitoring the condition of livestock that meet the customer's needs were selected for the company "Organic and Minerals Limited".

Using the weighted sum method, an analysis of alternative options for concepts was carried out, as a result of which it was concluded that the most effective option for a particular enterprise is to consider the C-bolus concept for monitoring the condition of small cattle. The bolus provides highly accurate data on the condition of animals and provides the possibility of remote monitoring. In the future, it is planned to implement the results obtained in the process of monitoring the condition of small cattle in order to reduce the incidence of herd diseases and reduce losses.

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