Management and Control of Cattle Using Identification by RFID Technology

Rogério Teixeira Reis, Bruno Pereira Barella, Marcelo Henrique Stoppa
Programa de Pós-Graduação em Gestão Organizacional
Federal University of Goias

Abstract

Here is presented a survey of the most common cattle identification methods comparing advantages, disadvantages and costs in the utilization of a new Identification model that uses tags with Radio Frequency Identification Devices (RFID). From there, a RFID system of evaluation is proposed for management automated. When the herd pass through a monitored portal, it can be obtained the immediate identification of each animal. Three tests were performed to verify the better position of the RFID reader in order to determine a setting for it and verify that the settings selected for the assembly of the system remains adequate. The use of this system gives the producer an electronic identification, facilitating the management, identification and control of the herd.

Keywords: Cattle; Control; RFID; Management; Identification.

1. Introduction

It can be considered that agribusiness is one of the most important development of any nation, since even the most developed nations started with an agricultural base and only a posteriori, they developed their sectors of industry and services [1]. With approximately 226 million cattle, according to the United States Department of Agriculture and the United Nations Food and Agriculture Organization [2], Brazil owns 22% of the world's commercial herd, since in India exists a low consume by religious questions, however, it is still one of the world's largest exporters of meat, with almost 20% of world exports in 2016 [3], where it has been increasingly used internationally in the use of traceability technology [4].

Despite the importance of livestock in the Brazilian economy, most productive systems are still empirically managed by people with no training in the administrative area and without access to adequate information for decision making. In this way, in the great majority of the rural properties, there are problems generated by the lack of management. For a maximization of the productions in the properties it is necessary to use techniques to identify, monitor and manage the assets, in order to achieve optimal results.

The correct identification of the animals is essential information, since it allows the rural producer to identify the individual performance of each animal, and consequently to improve its production, eliminating unproductive matrices, improving the quality of the herd and facilitating the management of the herd, besides providing security to the herd, besides traceability in the event of outbreaks of disease.

Although livestock farming is an extremely important activity and presents an extremely competitive market and very susceptible to external and internal influences, it is observed that there is a large number of producers, mainly small and medium-sized producers who still manage their businesses in a inproductive or non professional way, without identification or adequate control of the herd.

The development of an economically viable electronic identification system can allow the rural producer informations necessary to facilitate the management and control of the herd, quickly identifying the absence of animals and allowing the selection of the low productivity animals, aiding their disposal and consequent improvement of the quality of the herd. In addition, it can to facilitating the control of animal's ages, vaccines and other measurements. Still be possible to identify the matrices of each animal, as well as to provide security and control over the entire field.

RFID technology has characteristics that possibly allow the development of an economically viable and user-friendly system that allows the product to manage its herd. The use of this system presents several applications to the producer, allowing besides that mentioned previously, date of last childbirth, weight gain, among othes, allowing labor savings, a safer, more practical control and the minimization of errors, that when compared with traditional techniques.

2. Identification Techniques

Iron Marking is one of the oldest methods and although it presents low cost and generally easy visualization, it generates damage of the leather, devaluation of the price and is painful for the bovine. It disagrees with animal welfare practices and can suffer adulteration. If it can't be unrelated to a national registry, there is a risk of duplicity, and different animals may be marked with the same number and the manual reading also provides a greater risk of error. The investment in a marker is approximately $ 20.00 to $ 26.00 and that same amount for a gas forging. The cost of marking per animal is very low, counted only by labor and the consumption of gas from the forge or electrical energy in the case of electrical markers.

The tattoo is usually made in the ear of the animal, it has as an advantage the relatively low cost and the fact of being permanent. But it is painful for the animal and presents difficult visualization, being necessary immobilization of the animal for its reading. The process of accomplishment is also moderately time consuming, since it involves the assembly of the characters in the marker and the immobilization of the animal. Equipment cost can be range from $ 146.00 on a traditional marker to up to $ 1530.00 on a pneumatic model.

The bottle of ink was found with values of $ 20.00 to $ 42.00. This would allow an estimated tagging cost of about $ 0.20 to $ 0.40 per animal.

The identification earring offers the advantage of ease of application, low cost and good visibility, but presents a risk of loss and infection / myiasis at the application site, visualization can be compromised by the accumulation of impurities and presents a risk of duplicity and errors of reading. The applicator was priced from $ 20.00 to $ 56.00 and the earrings ranged from $ 0.40 to $ 0.47.

Bottons are similar to earrings, but because of their size and shape are less likely to be lost, in fences and shrubs or during some kind of corporal dispute. However, printed in small size its reading is only possible with the animal immobilized. The applicator was quoted from $ 20.70 to $ 56.50 and bottons ranged from $ 0.46 to $ 0.55.

Bracelets and necklaces are products of most common use in small animals, and they present complications of use in the extensive production systems. The reading distance is relatively short (0.6 to 0.8 meters). The cost found in the market was $ 0.82 to $ 7.33.

The earrings and electronic bottoms have attached in their interior transponder, offering simpler placement and easier reading. In relation to other electronic devices they have a relatively low cost and during slaughter they are removed and can be reused. The main disadvantage is the risk of loss with indexes that can reach up to 5% in the case of earrings, and a short reading distance (around 0.8 meters). Varying from $ 0.50 to $ 1.30, they need readers with costs between $ 779.70 and $ 1779.17.

The subcutaneous injectable transponder is incorporated into a bio compatible glass capsule where the application subcutaneously, easy, fast and not painful. Besides this, it does not provoke a reaction in the animal organism and accompanies the animal throughout its life with risk of negligible loss. As disadvantages it presents possible migration of the transponder in the animal, difficulties in withdrawal during slaughter, causing problems in food safety and high cost in relation to earrings / bottoms, keeping the same reading distance and requiring association with a method of external identification. Each chip cost $ 2.62 and the reading systems costs between $ 779.70 and $ 1779.17.

In the intra-ruminal bolus, the transponder is incorporated into a ceramic capsule that is swallowed by the animal placing itself in the reticulum, providing negligible losses and easy recovery after slaughter. It is a system free from fraud and do not cause injury. However, require longer application time and an external method of identification under high application cost. Like the other RFID methods, it has reduced reading distance and each chip comes out for $ 2.62 and the entire system costs $ 1779.17. It is important to emphasize that the intra-ruminal bolus is the most complex identification system, since it requires specialized professionals for its implantation, which raises the cost.

Barcode or QR code earrings feature relatively low cost, ease of placement, but disadvantages are the need to immobilize the animal for reading, the impossibility of purely visual identification, and the optical reading can be hampered by dirt or barcode wear; We found products with a unit value of $ 0.50 and readers ranging in price from $ 59.02 to $ 325.69 and even free apps for smartphones.

There are biometric systems perform iris, retina or muzzle patterns, that be unique and intact features throughout life, minimizes the risk of fraud. The disadvantages are the high time for obtaining the reading of the animal, since the agitation of animals makes it difficult to read and the cost of implementing the system that is still under development. The reader costs something next to $ 2616.43.

Laboratory analyzes (DNA analyzes) provide the identification of the genetic material of the animal. It has as characteristics to have the identification to the consumer without using any material, fraud proof, high cost, identification of the animal is not carried out in real time. Cost of $ 30.00 to 91.58 per animal.

Multiple technology earrings can be found on the market and simultaneously offer visual numeric identification, bar code reading and RFID identification. The association of these technologies facilitates identification in case of failure of one of the readings, and can be identified by the others. However, they do not eliminate problems such as those resulting from loss, and can cost of $ 0.50 and $ 1.31.

A Table 1 presents a summary of the different methods of animal identification. The relative costs to the labor for application of the method and the labor of reading the identification are presented.

Table 1 - Summary of costs of different methods of identification

Cost in $ / Identification	Identificator	Aplicator	Manpower Aplication	Reader	Manpower Reader
Iron Marking	0	36.00 to 52.00	Moderate	0	Moderate
Tattoo	0.18 to 0.41	145.82 to 1529.54	High	0	High
Number Earrings	0.41 to 0.47	20.72 to 56.51	Low	0	Moderate
Numerical Bottons	0.37 to 0.50	20.00 to 56.00	Low	0	High
Eletronic Earrings	0.50 to 1.30	20.00 to 56.00	Low	779,70 to 1779.17	Baixa
Bracelets and Necklaces	0.82 to 7.33	0	Low	0	Moderate
Subcutaneous Injection Transponder	2.62	0	Low	779,70 to 1779.17	Moderate
Intra-ruminal bolus	2.62	0	High	1779.17	High
Earrings with Bar Code	0.54 to 0.78	20.72 to 56.51	Low	59.02 to 325,69	Moderate
Biometric System	0	0	0	2616.43	High
Laboratory Analysis	30.00 to 91.58	0	0	0	Low

3. Electronic Identification

The identification systems traditionally used, such as earrings, necklaces, tattoos, hot iron (fire or electric), among others, result in a practical identification of each animal of the herd [5]. However, these systems difficulty in viewing at a distance, need for animal restraint, problems in reading due to character abrasion, dirt and transcription errors, and the possibility of duplication, i.e. two animals with the same identification. In recent years, traditional identification systems have been replaced by systems with RFID technology. The electronic identification of the herd, commonly called RFID (Radio Frequency Identification Devices) has numerous advantages in property management. This system is considered far superior to visual identification with numbers. The main advantages are the elimination of labor costs and reduction of incorrect reading from 6% to 0.1% [6, 7].

Radiofrequency identification starts occurs at the beginning of World War II. The physicist Robert Alexander Watson-Watt in 1935 developed an active identifier to distinguish enemies over long distances. British airplanes have received transponders that worked with radio signal of 2.5 bits of information [8].

In the 50's with the increase in speculation in radio frequency identification technologies, the interest of companies in using an antitheft system arises. The items received a tag that carried 1 bit of information in which it was informed if the merchandise had been paid or not. If the merchandise had not been paid the bit would still be active and then if it was against the sensors these would trigger the alarm [9].

Already in the 1970s speculations on the use of ultra-high frequencies (UHF) began to emerge in the identification systems. Passive tags have been developed, which do not require a battery for their operation. Since the 1980s radio frequency identification technology has been widely applied in a wide range of segments, such as identification of wagons in the USA, based on passive tags operating in the ISM range (Industrial, Scientific and Medical) of 902 to 928 MHz , an automated toll system in Dallas, Texas, in 1989, in 1991 the US Department of Defense began using RFID to locate, identify and protect containers using active transponders.

The main purpose of RFID technology is to send and receive wireless radiofrequency data from a mobile device to a reader. The system is composed of tags, which are inserted or incorporated into the item that is to be identified or monitored, reader, whose function is to receive the tag data and uniquely identify the antenna and communication system usually communicate with management software, this layer is called middleware [10].

For system operation, the information must first be recorded on the tags or also called transponders. Then these are pasted into the items that you want to monitor or identify. The information is then read by a set of sensors (antennas and reader or transceivers) by means of radiofrequency waves.

These are responsible for decoding the information of the tags through an antenna, which emits a radio signal that activates the tag for the exchange of information. After the transceiver receives the information, it must be sent to the middleware which will manipulate it as desired [11].

3.1 Transponder or Tag or RFID Tag

Tags, also called transponders or labels, can be classified as active, passive or semi-passive.

Passive tags do not have an internal battery and operate from the induction principle, responding to the signal emitted by the antenna. They have only the reading function and are usually used only for object identification [11].

The active tags have an internal battery and allow the process of writing and reading, emit a radiofrequency signal that identifies them.

The semi-passive tags are a combination between the two systems (active and passive) have a battery, but also include circuits that read and transmit diagnostics back to your sensor system. Labels monitor environmental conditions, communicate with other items, and collaborate to collect data that no single sensor would be able to detect [12].

3.2 Readers

Also known as transceivers these devices can read and write tag data compatible with systems [13]. The operation of the reader is independent of connection direction with the product since it operates by emitting radio waves that can propagate in the most different materials.

There are two types of readers, which only performs the read function (RO) and the read / write (RW) the selection of which to use depends on the class of tags used. The written function of the equipment functions as a master-slave where the reader assumes as master and the tag as slave.

RFID readers must operate in Full Duplex mode if they communicate with passive or semi-passive tags, thus enabling the tag to reflect the reader's signal. There are configurations that combine several antennas, allowing an improvement in the reading of the tags. This type of antenna configuration of the reader is called bi-static. However, an antenna can be used, forming a monostatic configuration in which the same antenna transmits and receives [8]. There is another configuration called multi-static, which is a mixture of bi-static and mono-static configurations, the antennas work in pairs, that is, at a certain time interval one antenna transmits and the other receives then the function is inverted.

In order to apply an RFID system, some aspects related to the reader should be considered, for example: antenna position, antenna polarization, medium degradation, compatibility between tags and system and electromagnetic interference [14].

3.3 Antennas

RFID system antennas have the role of converting guided data, which is transported by a cable or transmission line, into radiated waves that propagate in space or vice versa [10]. According to [10], the main parameters to be considered in an RFID antenna are: radiation pattern, directivity or gain, impedance, bandwidth, effective aperture and polarization.

The main parameter to be considered in the antenna is its polarization, since if it is not properly determined it can lead to a low signal coupling with the tag. There are two types of polarization to be circular and linear, where the direction of the magnetic field determines its polarization [10].

In Circular Polarization, the electric field rotates around the propagation axis by performing 360 ° at each wavelength traveled on this axis.

In Linear Polarization the direction of the magnetic field is constant with respect to the axis of propagation. For a good coupling between the tag and the signal generated by the antenna, the tag must be aligned with the direction of the magnetic field emitted by the antenna of the reader. If this configuration is not satisfied, the induced current in the antenna of the tag will be minimal, thus generating a low coupling [15].

3.4 Frequency of Operation

Frequency is the number of cycles repeated over a time interval of the wave, which is measured in hertz (Hz). The frequency determines the ability of a wave to propagate in a given material, for example a low frequency is capable of pass through water, while those with a higher frequency are easier to read from a distance [12]. As faster the frequency is faster the transmission of information. Table 2 presents the frequencies and their main characteristics.

Table 2 - Frequencies and key features RFID technology

Frequency	Reach Between Reader and Tag	Cost Tag	Aplication	Type of Tag
Low Frequency LF (135 kHz)	>0.5 m	High	Automation Industrial Control Access	Usually Passive
High Frequency HF (13,56MHz)	>1 m	Medium	Location of various items with books, luggage, clothing, etc.	Usually Passive
Ultra High Frequency UHF (433 e 860 e 930 MHz)	>12 m	Can be Low	Provides the Chain of Supplies and Logistics: Control Inventory	Usually Active
Microwave (2,45 e 5,8GHz)	<10 m	Can be Low	Access control Electronic collection of Tolls Industrial automation	Usually Active

4. Control System

4.1 Software

At the beginning two platforms were studied for software development, Python and Java. Both are widely used for a wide range of solutions. They are object oriented, and have extensive documentation, enabling applications with hardware such as RFID technology.

Initially, using the Python language, it was developed a system for registering and verifying the data of animals that are stored in a database. For manipulation and editing of the database, the SQLite software was used.

For the software exists seven tabs for the manipulation of the data: Simple Cadastre, Filters, Sold Animals, Missing Animals, Confinement Records and Deleted Animals.

The Simple Register tab has been implemented for use by both the administrator and his / her assistants. It is possible to carry out a simple and quick registration with the main information of the animal as Number, Number of the Mother, Description, Sex and Date of Birth. This registration is then added in the system so that the administrator completes the registration with the other information. Figure 1 shows the Simple Register tab.

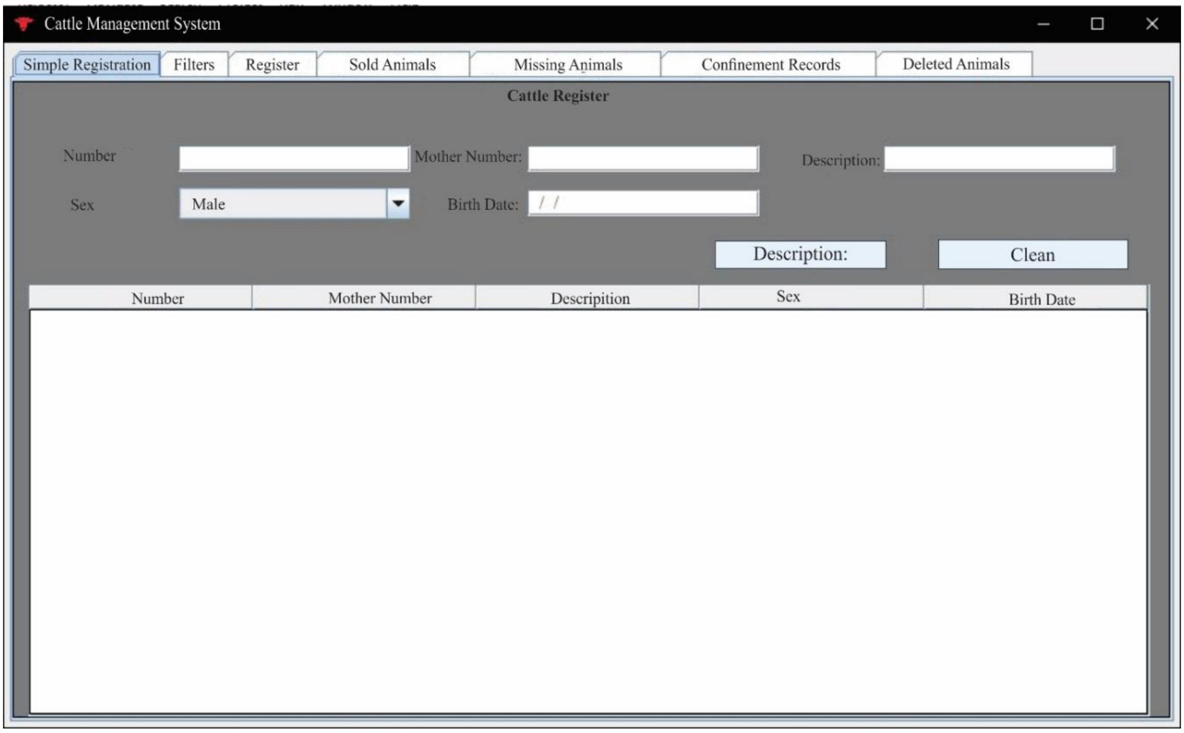

Figure 1 - Simple Registration tab of software developed in Java

Filters are used to organize the animals in a grouped way. The filtered table can be exported to a specific control in the field. By means of the button Statistics one can verify the quantity of animals registered. It is still possible to perform a scan only with the animals filtered through the Verification box. Figure 2 shows the Filters tab.

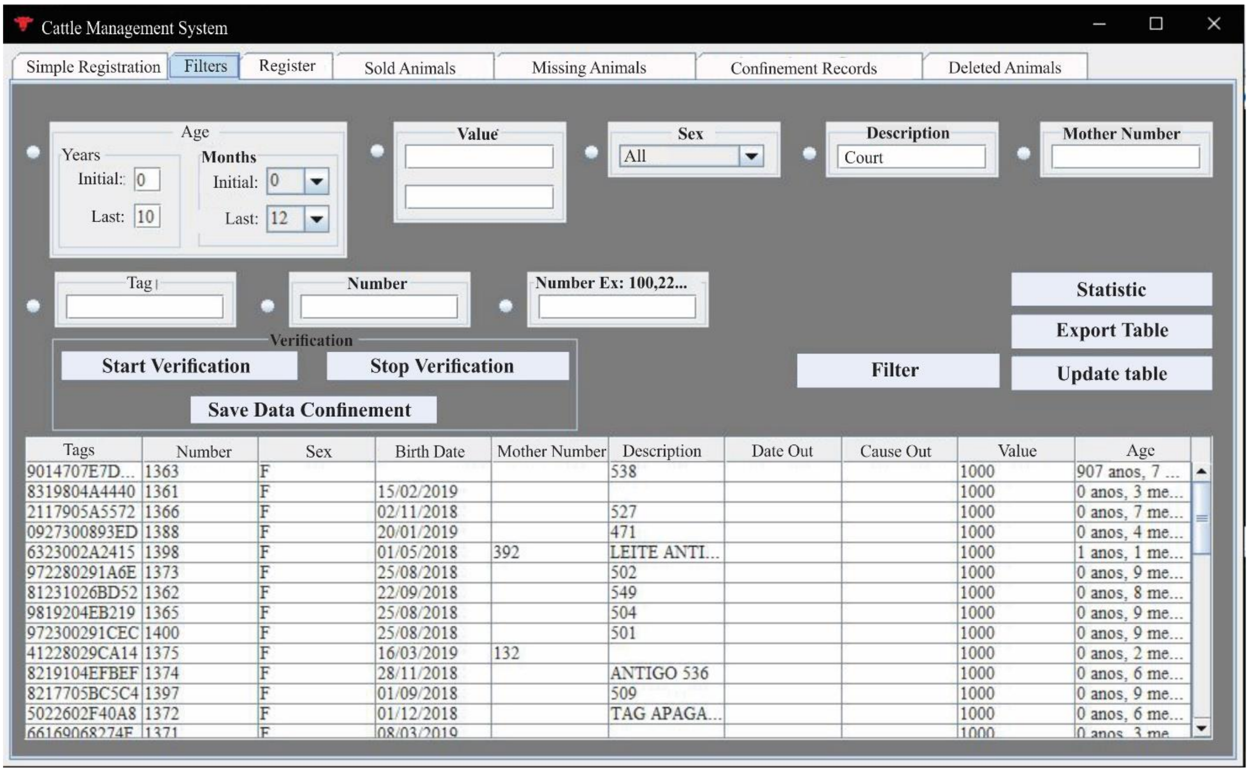

Figure 2 – Filter tab of software developed in Java

For the continuation of the registration of the animals or to start a new registration is used the tab Register. In it is possible to associate the identifier (Id) of the tag with a number, to register the standard data of the animals, to delete animals, to filter quickly and to verify all the animals by the check box. In it can be visualized all the registered and active animals of the property. Figure 3 shows the Register tab.

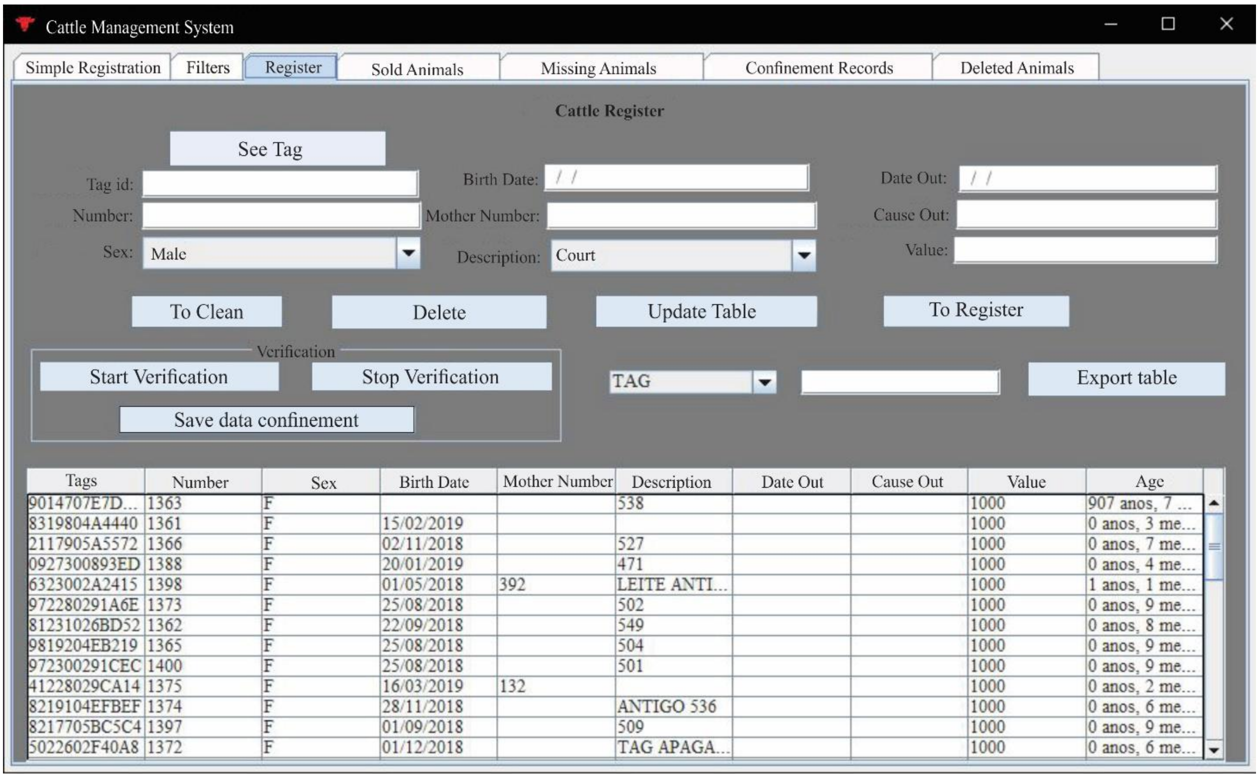

Figure 3 – Filter tab of software developed in Java

The tabs of Sold Animals, Missing Animals and Confinement Records are tables showing the animals according to their status. For the purpose of information security, users of the system do not erase the information in the database, they are stored for a pre-established period until it is discarded. Figure 4 shows the tab of the Deleted Animals.

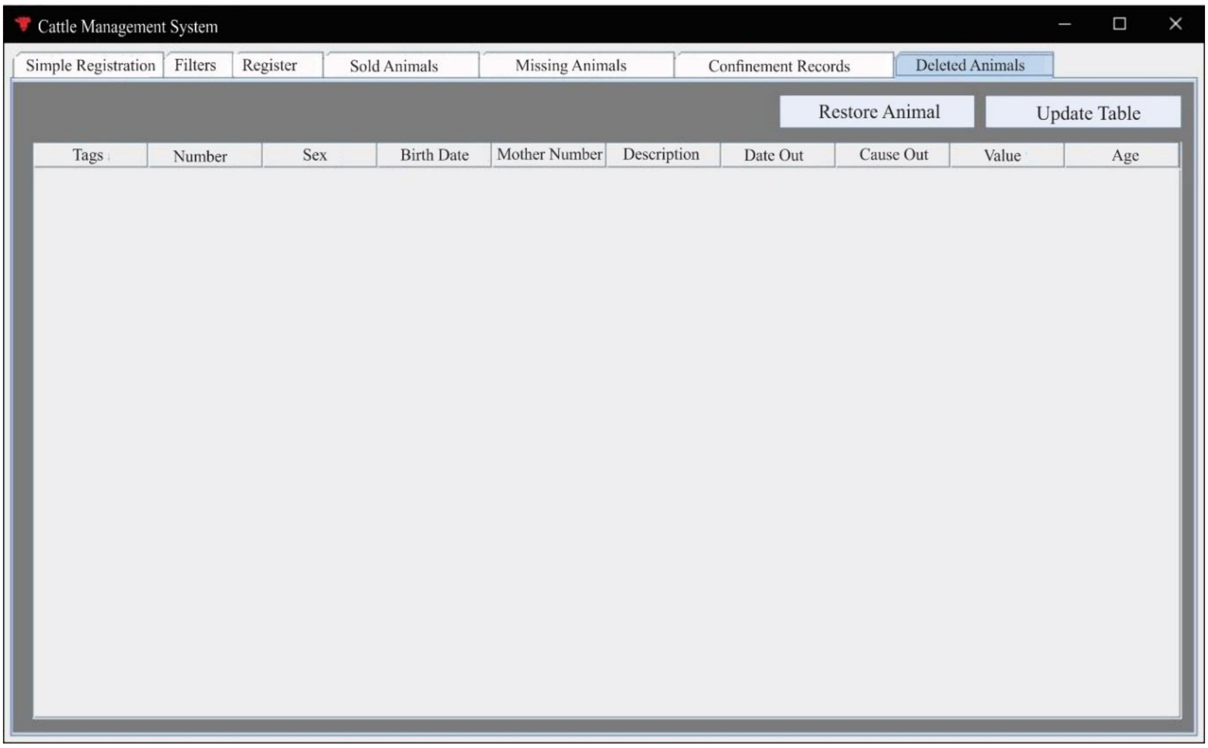

Figure 4 – Deleted Animals tab of software developed in Java

For a better usability of the developed system, an online and a local one database are used, which makes it possible to use them on more than one machine.

4.2 Hardware

It is necessary to use the livestock control system developed here in a more versatile platform for the environment local, such as a smartphone. In order to use the system on a smartphone, it is necessary for a platform to host the screen of the networked system, thus providing the manipulation of this via mobile device. For this, this improvement can be made by using a Raspberry Pi in place of the computer.

In a way like this, in addition to reducing the cost of the system, it contributes to an increased versatility, making the system available on any mobile device. The RFID reader used in this research has a range of three meters and a circular polarization, can be used with both passive and active tags and also has an integrated ID writer for the tags. The reader used in the developed system is presented in Fig. 5.

Figure 5 – Reader RFID

The circuit for the operation of the system consists of a RFID reader, tags and controller, where the controller can be a notebook or a similar platform capable of processing the data received through the reader. Figure 6 shows the diagram of the RFID reader.

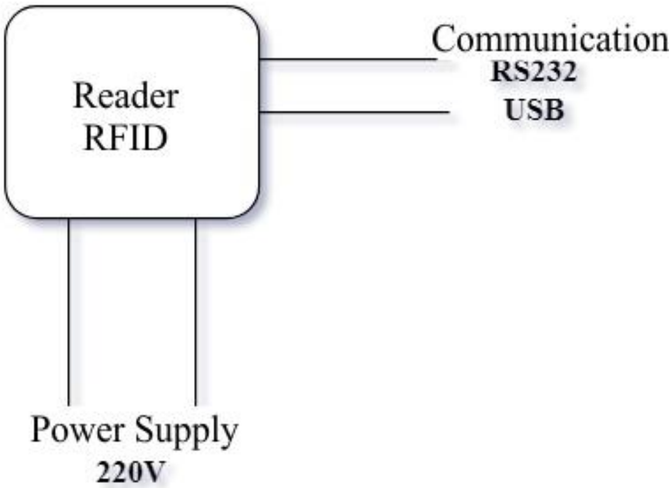

Figure 6 - RFID Reader Diagram

In previous figure, is possible to see the power supply, which feeds an integrated source of 12 Vcc and this is powered by a voltage of 220 Volts, communication with the controller is performed via USB RS232 port.

4.3 System Testing

For the development of the system it was necessary to perform tests for the validation of the various functionalities of the software. These tests were formalized into well-defined activities.

Initially one were described the particular conditions to be tested, these composed of inputs, constraints and an expected result or behavior. In the following is described the test procedure, which details the steps required to perform it. Finally, the test criteria were defined, whose purpose was to select and evaluate in order to increase the chances of causing failures or, in other hand, to establish a high level of confidence in the correctness of the product [16].

To correctly use the system, some steps must be taken to standardize the iteration between the user and the

system and thus prevent errors. Initially, the RFID tags are pre-registered in the database by the system administrator. These tags at the beginning do not have any associated animals, only the number of the earring and the identifier of the same. Then the system is prepared for the data entries of the animals to be registered. After registration in the system, is already possible to carry out the checks of the animals.
For the implementation of RFID verification tests, were used of a batch of 30 animals. These were selected in order to make it difficult to read the reader, either by the side of the earring or by the height of the animal, the position of the reader was also changed in 3 levels, as 150 cm, 90 cm and 60 cm.

4.3.1 Pre-registration of Animals

In this stage the database was fed with 30 tags, initially without any associated animals. Afterwards the animals were selected to participate in the tests, where the criterion for the selection was to choose animals with varied heights (calves and adult cows) and to vary the earring side in the animal's ear.
With the 30 animals selected, the system was fed with the animal data. Some animals were filtered by age, number and altered with the purpose of simulating changes in the software.

4.3.2 Reading

To verify the system's verification features, the RFID reader was positioned in 3 different positions to evaluate the quality of the readings and then to select the optimal configuration to maximize the identification of the animals. All the proposed configurations were applied in brete of the corral. This brete is a compartment to hold / pass cattle, horses or other types of cattle safely while they are examined, marked or given veterinary treatment.
Initially the reader was positioned at a distance from the ground of 150 cm, the reader was angled at 45 degrees from the ground. The proposed inclination was set against the flow direction of the animals. Figure 7 shows the proposed configuration.

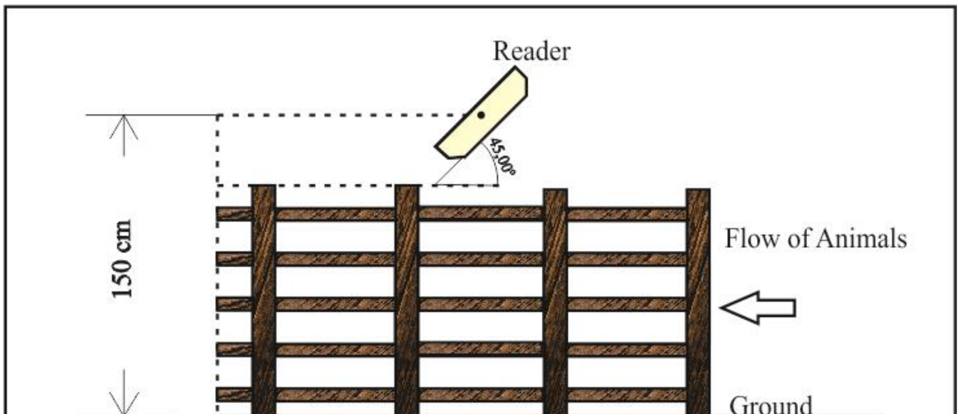

Figure 7 - First configuration of the reader at 150 cm of the ground

The second configuration proposed for the reader was located at a distance of 90cm from the ground, where the reader was positioned on the side of the brete with a slope in relation to the ground of 90∘ degrees. Figure 8 shows the proposed configuration.

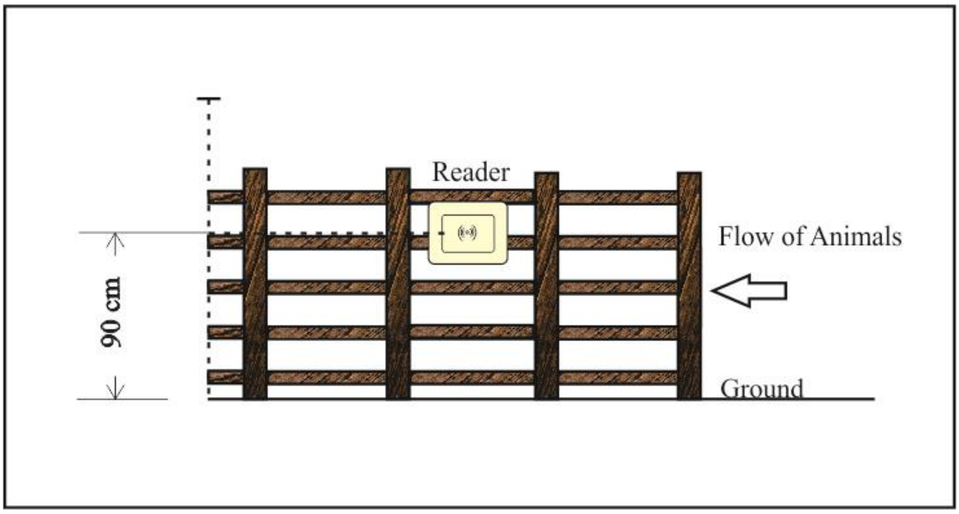

Figure 8 – Second configuration of the reader at 90 cm of the ground

The last configuration proposed for the reader was located at a distance of 60cm from the ground, where the reader was positioned on the side of the brete with a slope in relation to the ground of 90∘ degrees. Figure 9 shows the proposed configuration.

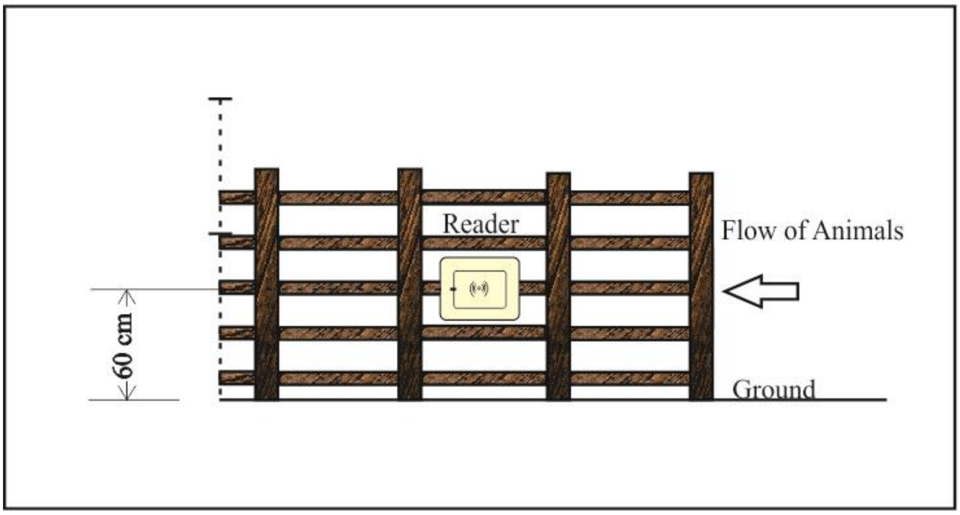

Figure 9 - Third configuration of the reader at 60 cm of the ground

For each configuration, 3 animal check cycles were performed and the amount identified for each test was recorded. These quantities served to infer the best configuration.

4.3.3 Results

The results of the operational tests of the use of the software initially presented no problems. A proposed improvement was to increase the speed when starting the software. The slowness occurred during the tests because the software was running many connections to the bank. To work around this problem the queries were clustered.

For the verification tests in each proposed configuration, the 30 animals were evaluated 3 times and the results for the tests are presented in Table 3.

Table 3 - Number of animals captured by the system

Tests	1^{st} Configuration 150 cm	2^{st} Configuration 90 cm	3^{st} Configuration 60 cm
1	15	12	11
2	16	10	12
3	14	9	13

It is evident that in none of the tests was the expected result of all animals verified. However, the best 150 cm configuration of the soil was identified, angled at 45 °. The problem with the other two configurations is that she could not always identify when the earring was on the opposite side of the RFID reader. When studying the tags used it can be verified that they did not have a circuit (antenna) prepared to long reach. When comparing with a long-range tag, can identify the size difference of the resonance antennas of the tags. Figure 10 shows the two tags, in yellow the tags used and colorless to long range tags.

Also, to improve the readability of the tags, an RFID reader with a longer reading range could be used. The reader used has 5 meters of reading range, there will be a considerable improvement if you use a reader with a range of 12 meters or more.

A great difference in the geometry of the circuit of the two tags is observed. This difference is justified by the performance range of each one, where the tag indicated in Figure 10 (b) can be used in a range up to 3 meters, in Figure 10 (a) can be used in a range up to 6 meters.

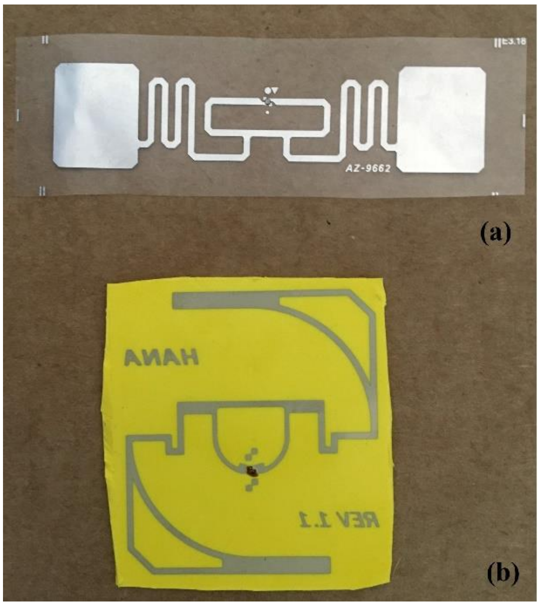

Figure 10 - Comparison between the used tag (b) and long-range tag (a)

6. Conclusions

Analyzing the values found in the different identification systems, it is concluded that the economic viability of the system is evident, since its total cost was around $ 261.64, being $ 157.00 from the reader and $ 78.00 from the RFID tags.

The value of the conventional earring ranged from $ 0.41 to $ 0.47 against $ 0.50 and $ 1.31 of the earring with UHF TAG. Applicator and the cost of labor in the application is identical to that of the conventional earring, having only as an extra expense the reading system.

The extra cost is also later compensated in the operation, since the electronic system requires less manpower for the conference of the animals, consequently reducing the expenses of the producer.

The system initially proved to be economically viable. However, it was not effective with the selected assemblage. More tests will be performed, and new costs will be incorporated using other readers and tags. It also presents indisputable practicality, readily identifying the absence of any of the animals and reducing the probability of human errors during the conventional conference. The system can still be associated to a system that facilitates the selection of animals previously selected in some criterion. Such as example, add an alert so that the producer identifies the matrices that did not breed in the last 12 months, thus facilitating the disposal of unproductive animals.

6. Acknowledgement

The authors thank the graduate program in organizational management of the Federal University of Goiás, Regional Catalão, and the owners of the farm where the tests were carried out for this research.

7. References

[1] Pereira, A. C.; Oliveira, A. B. S.; Barbalho, V. F. A utilização da informação contábil na gestão da pecuária bovina de corte: uma pesquisa empírica. BBR-Brazilian Business Review, FUCAPE Business School, v. 4, n. 1, 2007. pp 1.

[2] Usda, F. United States Department of Agriculture, Foreign Agricultural Service. 2015. pp 1.

[3] Abiec. Associação Brasileira das Indústrias exportadoras de Carne. ABIEC, 1979. Disponível em: <http://www.abiec.com.br/3 rebanho.asp>. 1.

[4] Zen, S. d. et al. Perspectivas de consumo de carne bovina no brasil. In: SOCIEDADE BRASILEIRA DE ECONOMIA, ADMINISTRACAO E SOCIOLOGIA RURAL (SOBER). 46th Congress, July 20-23, 2008, Rio Branco, Acre, Brasil. [S.l.], 2008. 1.

[5] Lopes, M. Informática aplicada à bovinocultura. [S.l.]: FUNEP, 1997. 4.

[6] Artmann, R. Requirements for control systems in automated dairy farm. In: Proceedings of the XXV CIOSTA-CIGR V Congress. Wageningen. [S.l.: s.n.], 1993. p. 10–13. 4.

[7] Austin, R. Fine for beasts but what about staff. Farmers weekly, v. 45, 1995. 4.

[8] Daniel, D. et al. The rf in rfid: Passive uhf rfid in practice. Elsevier, 2008. 4-5.

[9] Historico. Radio-Frequency Identification (RFID). HISTORICO, 2009. Available in:<https://www.gta.ufrj.br/grad/09 1/versao-final/rfid/historico.html>. 4.

[10] Sousa, M. Rfid e suas aplicações-um estudo de caso com prateleiras inteligentes. Livros Gratis, 2010. 5-6.

[11] Narciso, M. G. Aplicação da tecnologia de identificação por rádiofreqüência (rfid) para controle de bens patrimoniais pela web. Global Science and Technology, v. 1, n. 1, 2008.

[12] Prediger, D.; Silveira, S. R.; Freitas, E. P. de. Modelo de aplicabilidade de sistema rfid para rastreabilidade na indústria alimentícia. Revista de Sistemas e Computação-RSC, v. 6, n. 1, 2016. pp 5-6.

[13] Lahiri, S. RFID sourcebook. [S.l.]: IBM press, 2005. pp 5.

[14] Bertoletti, R.; Santos, F. d. Sistema RFID para controle de patrimônio. Dissertação (B.S. thesis) — Universidade Tecnológica Federal do Paraná, 2014. 5.

[15] Keskilammi, M.; Sydänheimo, L.; Kivikoski, M. Radio frequency technology for automated manufacturing and logistics control. part 1: Passive rfid systems and the effects of antenna parameters on operational distance. The International Journal of Advanced Manufacturing Technology, Springer, v. 21, n. 10-11, p. 769–774, 2003. 6.

[16] Craig, R. D.; Jaskiel, S. P. Systematic software testing. [S.l.]: Artech house, 2002. 12.