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Research Article

Electronic Identification of Cattle: Traceability for Food Safety in Madagascar

Razafinarivo Tsirinirina Donnah[1]*, Rakotomanana Olga Rachel[1], MICHELLE Reine Lucie[1], Rasoanomenjanahary Auldine[2], Janelle Jérôme[3], Salgado Paulo[3], XavierJuanès[3] and Tillard Emmanuel[3]

[1]*National Center for Research Applied to Rural Development (FOFIFA-DRZVP)*

[2]*The National Institute of Vaccines (IMVAVET)*

[3]*Centre for International Cooperation in Agricultural Research for Development (CIRAD)*

***Corresponding Author:** Razafinarivo Tsirinirina Donnah, National Center for Research Applied to Rural Development (FOFIFA-DRZVP).

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Abstract

The cattle are one of the riches that make the Malagasy people famous, it intervenes in their daily life whether cultural, social or economic. However, due to a lack of traceability, several shortfalls are to be deplored in this sector, including the export of meat to European markets. This document presents the development of an electronic cattle identification system in order to control the sanitary traceability of products from cattle breeding for food safety. This system uses an electronic chip in the form of a ruminal bolus that works by low-frequency radio waves. To do this, about 600 cattle from the FOFIFA station in Kianjasoa, Madagascar, were identified using the electronic boluses and then monitored monthly to determine the retention rate of the identification system. At the same time, all information about each identified animal was collected, over time, to be transcribed and centralized in the LASER database. This makes it possible, on the one hand, to trace the product back to its original rearing in the event of a dispute and, on the other hand, to determine certain zootechnical parameters indicative of the breeding. For example, thanks to this tool, the annual growth rate of the identified herds was calculated at about 30%. This data seems essential to us in order to be able to estimate the demographic evolution of the workforce as well as the quantity of cattle meat to be exported while preserving the current number of livestock. During the first three years of cattle monitoring, the application of boluses showed no particular incident. This identification system could obtain approval from the International Committee on Animal Identification, as an annual retention rate of 100% was recorded during the study. In addition, this device impossible to falsify will make it possible to considerably reduce the theft of cattle in Madagascar. Thus, traceability, beyond the bond of trust established with consumers, is an important factor in enhancing the value chain and economic recovery of the beef sector in Madagascar.

Keywords: Bolus; Demography; LASER; Legislation; Puce; RFID

Introduction

Cattle breeding is an activity that plays an important role in poor society, whether culturally, socially or economically. Apart from being an important means of savings for farmers, it also provides a significant income supplement that can meet the needs of livestock farmers. However, it is currently strictive activity, even risky, because of the insecurity that reigns in the country. In addition, the economic benefits of the sector are considerably reduced despite the high exploitable potential. At the national level, cattle farming provides a large part of the population's animal protein needs, which amount to 1 500 heads/day [19]. At the international level, promising markets such as those of the European Union (EU) could contribute significantly to the development of the Malagasy national economy. Before 1997, Madagascar still exported meat to EU markets. However, due to a lack of traceability and non-compliance with slaughter rules, the veterinary services of the European Commission have imposed an embargo on products of animal origin from Madagascar [15]. Indeed, the traceability of animal products to the breeding of origin is a new constraint of world production systems which aims to meet public health and food safety requirements [2]. Thus, in order to be able to export cattle meat again, it is essential to develop a reliable identification system. Little research and innovation work has been undertaken in Madagascar on this subject. With this in mind, a study was carried out by the Department of Veterinary and Fish Zootechnical Research of FOFIFA at the Kianjasoa station (Middle West of Madagascar), on the possibility of replacing or supplementing the classic animal identification loop with an electronic identification bolus. This system is coupled with a centralised database providing detailed and instantaneous information on identified animals.

Materials and Methods

Generality

In the etymological sense, the word «traceability» is related to the «trace» which, in the figurative sense, is a «mark left by an event». «Traceability» is therefore an approach that consists in giving the possibility of tracing the different stages and places of life of a product, from its creation to its destruction. Thus, in view of the various health crises that the world has experienced in recent years (bovine spongiform encephalopathy, foot-and-mouth disease, avian influenza, melamine in milk powder), the traceability of food is essential in order to prevent the circulation of foodstuffs that may harm the health of the consumer. Thus, legislators and standardisation bodies have put in place a series of regulatory and normative texts that encourage the adoption of traceability as an indispensable element for food safety [22]. In Madagascar, pursuant to Inter ministerial Order No. 12.880/2007 of 3 August 2007 [25], a codified system for the identification of cattle is established throughout the country, based on the attachment of a previously numbered loop on the left ear of each animal. This system is accompanied by the issuance of an Individual Card of Cattle (FIB) which according to Decree No. 2005-503 of 26 July 2005, must include the code number of the earring and all the information concerning each bovine [25]. The FIB must accompany the animal throughout its movements and bear the mention of the successive owners until slaughter. These devices have been installed in particular to ensure the traceability of livestock products so that the product can be traced back to its origin. However, this system has several disadvantages such as the possibility of falsification and the detachment of the loop which, according to the recommendations of the ICAR (International Committee for Animal Recording) in 2005 [9], the annual retention rate of animal identification devices must be greater than 98% to obtain approval. In addition, the current system does not meet the specifications of the EU (European Decree No. 2005-1557) despite the implementation of Protocol 7 on bovine me at to the «Lomé Convention» [13]. Indeed, as a member of the ACP, Madagascar would benefit from this protocol which gives privileged access to the European market for an export quota of about 7 500 tonnes of meat per calendar year. In addition, since 1997, the veterinary services of the European Commission have imposed an embargo on products of animal origin from Madagascar and therefore on the approval of export to the EU. The lack of identification of cattle and therefore their non-certification(traceability) is the main reason for this embargo. In addition, an improvement in the reliability of the system of individual identification, considered as a critical point of the animal traceability chain [3,16], must be carried out in order to be able to export meat from Madagascar again.

Implementation of an electronic identification system

The first basic element of the traceability scheme for live animals and their products (meat, milk, skin, etc.) is the permanent identification device. To test this new system, the identification loop will be complemented by an electronic chip(e-ID). To do this, as part of the ECLIPSE project (2017), about 600 cattle from the Kianjasoa station were identified individually using an ear loop coupled with an electronic chip in the form of a ruminal bolus. These two devices have the same identification number including, the loop for visual identification and the chip for electronic identification. This electronic identification system uses a passive RFID (Radio Frequency Identification) transponder which operates by radio waves of low frequency (134.2 kHz). Electronic identification would significantly improve traceability systems (NmISO11784 and ISO 11785), eliminating errors related to manual data transcription. In order to ensure the retention of this device in the rumen of the bovine, the system is wrapped in a material of high density in the form of bolus, not obstructing electromagnetic emissions and resistant to the digestive conditions of the rumen. These boluses are presented in the form of a tube 6.5 cm long, 2.0 cm in diameter and weighing 72 grams. They were provided by the International Atomic Energy Agency (IAEA) as part of the MAG 5024 project. The physical characteristics of standard fab boluses made of ceramic composed of alumina and used for the identification of bovine animals [23] have been the subject of a patent filed by the EU [26]. Its oral application is simple and safe for animals. The bolus will first lodge in the rumen until the moment when rumination becomes effective, then it migrates and is preferentially found in the network. Due to the immaturity of the digestive system of young ruminants, and the presence of the esophageal gutter that makes the mouth communicate directly to the abomasum, retention tests will be carried out to determine the age and ideal weight for the introduction of the electronic bolus. A portable reader (DATA MARS) was used to read the unique numbers contained in the transponders. For example, cattle with electronic puce were tested monthly during the five years of the project, using this reader to determine the bolus retention rate and other criteria related to the operation of the electronic system. Durings laughter, the bolus is easily recovered in the reticulum. After recovery, the boluses must be destroyed to avoid any further reuse of this device [25].

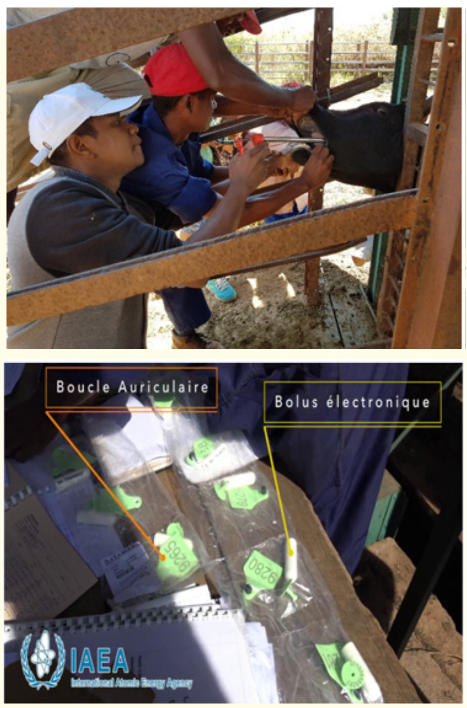

Figure 1: Introduction of the electronic bolus into the rumen of cattle.

Use of herd management software

The second and third basic element of the traceability scheme are: (i) a register of the activities and movements of the animals and (ii) a centralized database on these same animals. These two critical points can be ensured by the LASER database (Software to Help Monitor the Breeding of Ruminants). LASER [10] is a tool that allows the management and computerized analysis of data for the monitoring of herds in which zootechnical data are collected at the animal level. It therefore allows automated management of animal registries and their products [3,6]. LASER is the result of a series of conceptual works, the first of which were carried out north of the Ivory Coast in the1970s [18]. The current version «LASER2», used in this study, was written in Visual Basics© and uses a relational database in the format Access©. The tool can therefore manage a large volume of data of different kinds: demography (reproduction, mortality, exploitation, etc.), meat and milk production, pathologies (symptoms, serologies, etc.), artificial insemination, and all kinds of zootechnical interventions on animals. This tool has been designed so that it can be used by livestock technicians without any special computer knowledge.

For the first entry, the information entered on each FIB of bovine animals, relating to Article Five on the identification of bovine animals in Madagascar [25], is transcribed in the LASER database. These data concern: (i) the identification number, (ii) the sex, (iii) the breed, (iv) the date of birth, (v) the color of the dress, (vi) the distinctive signs, (vii) the owner with name and address, (viii) the date of entry, (ix) the breeder code, (x) the district and municipality, (xi) the dates of vaccination, (xii) the type of vaccines and the batch of vaccines, and (xiii) the name and quality of the vaccinator. For the future, this database is fed regularly following the arrival of different events such as the change of ownership, changes in particular distinctive signs, diseases and sanitary treatments, calving, dietary changes (grazing and supplementation), mortalities. Thus, each time an animal's identification number is entered into the LASER database, the latter displays all the information collected about the animal. Following the Laser-Decomp methodology [14] for the calculation of herd demographic parameters from the database, LASER makes it possible to carry out analyses and/or queries if necessary [12].

Results and Discussion

To the retention of electronic boluses

During the five years of experimentation, the application of boluses did not show adverse effects on the ingestion or digestion of food as cited by Caja [3] and Ghirardi [8]. This device also has no negative effect on the development and histology of the rumen-network wall [3], and on the zootechnical performance and health of young and adult [3,8]. So far, everything seems to show that boluses are effectively retained, when they have the required characteristics [4]. En effect, the annual retention rate of the bolus is 100% (600/600) against 92% (553/600) for the loop. According to Fallon [6], to have good retention, the density of the bolus must be greater than $3g/cm^3$. Since the volume of our bolus is 20.4 cm^3, it corresponds well to the law of response according to the weight and volume of the bolus described by Fallon (Figure 2). However, to avoid possible obstruction that could be caused by the size of the bolus and to ensure the emotional maturity of the digestive tract of calves (4 to 8 months) before its introduction, it was considered advisable to introduce the bolus only if the animal reaches a minimum weight of 100 kg.

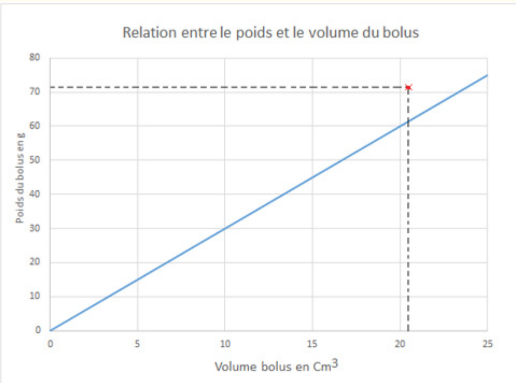

Figure 2: Relationship between weight and bolus volume [22].

Mechanism

The development of RFID electronic tags in the world of industry has favored the miniaturization of electronics and it is now the world of animal husbandry that benefits from these advances. The transponder consists of a passive transceiver, i.e., without its own source of power supply. The receiver transforms the magnetic field emitted by the reader into electric current and supplies the transmitter, which in turn transmits the contents of its memory which is the identification number of the animal. In addition, this device does not require a battery and has an almost infinite lifespan (except breakage). Thus, it will be able to ensure effective traceability of cattle in Madagascar that have a lifespan of up to 16 years. However, passive RFID has the disadvantage of limiting the reading distance between the transponder and the reader which is about 20 cm. In this system, it is also necessary to ensure that there are no metal parts or other RFID chips in the reader environment, as this disrupts or inhibits the reading of the transponder. The use of low-frequency transponder's (134.2 kHz) is also essential for better penetration into the various tissues that makeup the animal's body. Once the animal identification number is transcribed into the LASER database, all information about the animal will be displayed and can be used as needed. This recorded information provides immediate or subsequent detailed knowledge, to ensure analysis, decision-making, control, etc. With this information, it will be possible, for example, to treat an entity or a batch of entities in case of danger, in a preventive or curative way.

For its application, the legislation in force on the identification of bovine animals in Madagascar based on the use of earrings must be slightly adapted, as for Article eleven [25]: herd conveyors are required to present accompanying documents such as the control book or the logbook relating to the movement of oxen at any requisition of elements of the forces of order who can exercise controls throughout the official routes. From now on, this activity can be replaced by a simple reading of the information contained in the animal identification chip. Similarly for Article Nine [25]: the persons responsible for the health inspection of the slaughterhouse or the killing are responsible for the recovery of the individual records of the slaughtered animals and their storage for a minimum period of five calendar years. This would be replaced by the recovery and destruction of the electronic bolus, and then by an update of the database. However, it should be noted that from this point on, a new traceability system must be put in place to be able to label meat [11]. Therefore, the labelling must keep the same identification number of the animal and must be drawn up according to the information in the database with the indication: (i) of the place of birth, rearing and slaughter, (ii) of the category of the animal, and (iii) of the approval number of the slaughterhouse and the place of cutting [1].

Other applications

Electronic identification is a key that allows us to glimpse a multitude of applications, each with a different purpose and user. It is therefore desirable that all users can use the same transponder on board an animal. Conversely, RFID readers can be compatible with different types of electronarcotic chip. In this study, the reader used made it possible to read the bolus from the Data Mars industry (Europe), the microchips of Texas instrument (USA) and nanochips of Fijan technology (Asia). In addition, these compatibilities and standardizations open up several horizons on the use of this new technology.

On the one hand, this identification system (e-ID) could contribute significantly to the fight against the insecurity caused by the theft of goods in Madagascar. Indeed, the identification system plays an important role in the process, as it is the main object of laundering of stolen cattle that will be returned to the circuit by any other identity. At the same time, there will be a considerable reduction in fraud in this sector through the total dematerialisation of the various transactions. In addition, the various documents necessary (control book, FIB, passport, etc.) for the sale of cattle in Madagascar estimated at about 60,000 Ar (about 15 euros) can be replaced by the electronic bolus (2 euros). Moreover, apart from the first investment costs for its application, this identification system is economically profitable and presents the possibility of being unfalsifiable [6].

On the other hand, before beef from Madagascar can be exported, prerequisites must be put in place locally to be able to preserve the current efficiency of the livestock. This preservation ensures national needs, but also stabilizes at the price on the local market. With the Laser-Decomp methodology, based on a systematic feeding of the database, it was possible to calculate certain indicators of the criptives of the breeding such as the age of the cow at the first calving, the rate of calving, the mortality rate etc. (Figure 3).

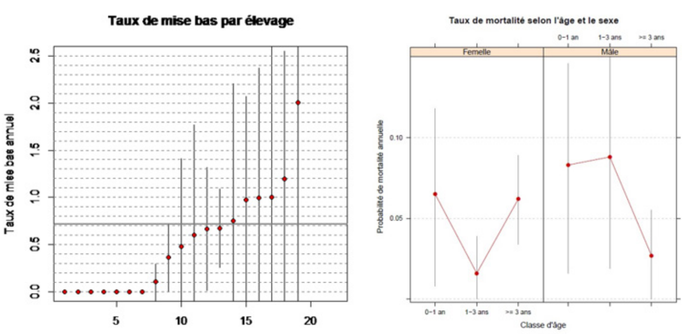

Figure 3: Calving and Mortality Rates of Cattle in the Study Area.

The determination of the mortality and calving rate leads to a projection on the evolution of the number of livestock. The first graph of Figure 3 indicates that the annual calving rate is 0.71 or about two calves every three years with a peak at 3.56 years of the age of the female at first calving. The second graph in Figure 3 shows an annual mortality probability of 0.06, with a high peak mortality (0.09) in males aged between 1 and 3 years. Subsequently, if there are as many females as males in the herd, the annual growth rate in our study area is estimated at about 2.7%. In addition, with a systematic reporting protocol (Laser-Decomp) of veterinarians and/or officers of police judiciaries in the different breeding areas in Madagascar (SLC-MINEL, 2012), the same scenario may be carried out at national level. This information may be used to determine the number of cattle (meat) that can be exported, without jeopardising the total number of cattle.

Conclusion

The traceability of cattle to the rearing of origin is of considerable importance to consumers and producers. In the agri-food sector, it has now become a component of food safety assurance. Thus, the lack of this traceability is the main reason for the embargo on the export of meat from Madagascar by the European Union. To remedy this, it was considered essential to improve the animal identification system which is the basis of traceability. This study suggests the establishment of an electronic cattle identification system through the use of ruminal bolus. This individual identification system (e-ID) makes it possible, on the one hand, to envisage new technical applications that are the elements of a true precision breeding, and on the other hand to significantly improve traceability systems, by eliminating errors related to the manual transcription of data. This technology should find a favorable echo among breeders in Madagascar by its contribution to the reduction of the insecurity that reigns in this sector, but also to the reduction of the taxes essential to the transaction of animals. However, this study is far from exhaustive, so several perspectives are to be considered such as bringing national slaughterhouses up to standard for the continuity of traceability to meat labelling. The implementation of a well-defined health management protocol consisting of a surveillance and vigilance system against the various animal diseases is also possible. Finally, it is essential to set up a system of control of the whole, for an external audit, which constitutes the fourth and last basic element of the traceability scheme for products of animal origin.

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