Current tools and technologies for the identification and traceability

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Summary

Radio frequency identification (RFID) systems were introduced in the 1970ies mainly for farm management purposes. They were followed in the 1990ies by the use of injectable transponders for companion animals. Since the beginning of this age, many countries have introduced animal identification schemes based upon RFID. The technology, its use and the testing of the equipment are defined in ISO standards. The International Committee for Animal Recording (ICAR) is the international registration authority for animal RFID and publishes approved products on its Website (www.icar.org). The low frequency signal is not influenced by body tissue, so the transponder technology can be used as eartag, injectable, bolus and leg tag.

The RFID transponder itself does not give information about the animal or the owner of the animal, but the identification code (ID-code) links the animal to related information (of the animal and the owner) in a database. The database can be hosted on the farm, by the manufacturer of the RFID transponder or by a national body. A central database on a national level is preferable over a database on farm level, because tracking and tracing is much quicker and more effective, and other systems (such as herd book, Health Service) can be easily linked to it.

The allocation of ID-codes being produced must be registered in a database to eliminate the risk of having identical ID-code for different animals. Depending on the coding of the transponder (country code or manufacturer code), the legal authority or the manufacturer of the transponders is responsible for maintaining such a database.

At this stage, low frequency RFID technology is generally considered as the most efficient technology for identifying animals.

Introduction

The development of the Radio Frequency Identification (RFID) systems started at the end of the 1960ies [1]. Results of institutes in the UK, Germany, the Netherlands and the USA were reported at the symposium 'Cow Identification Systems and their Applications', held in the Netherlands in April 1976 [2]. The first commercial (dairy) animal identification systems became available shortly after this symposium. At the end of the previous century, in several countries, there were already a high percentage of dairy cows equipped with a transponder on a collar around the neck.

There were several trials that used injectable transponders for identifying livestock [3,4], but the issue of slaughterhouse recovery has obstructed the broad use of this technique in livestock applications. Nevertheless, this technology fits very well for companion animals and horses, and since the 1990ies a large number of companion animals (especially dogs) and horses have been identified with injectable transponders. In companion animal identification, the main focus at that time was on treatment recording by the veterinarian and reunion of lost animals.

Nowadays in most EU countries it is compulsory to identify pets and horses with an injectable transponder, basically for animal health control reasons, including public health (i.e.: rabies).

Regulations have been introduced in many countries for the traceability of the origin and the movements of farm and also companion animals. They enable animals to be tracked during a disease outbreak and residual (e.g. dioxin) discovery at slaughter. In case of subsidizing schemes, individual animal identification can be an important tool for discovering fraud. Many of the identification schemes are based upon RFID [5].

There is a worldwide market for food animals and companion animals that pass borders frequently (e.g. during a vacation period for pets), and therefore the traceability of animals is an international concern, as well as the compatibility of electronic animal identification devices. The need of international standards was recognized already in the nineties, and the first meeting of the International Organization for Standardization (ISO) around animal identification was organized in 1991. In 1994, a resolution was approved by the ISO to start the standardization of electronic identification for all categories of animals (including fish).

Identification devices

RFID is based upon passive tags (without a battery), called transponders, with an (unique) identification number. Transponders do not have an own power source, so the tags always have to be powered externally by the electromagnetic field of a reader. The unique transponder number is a link to information of the product or animal e.g. inside a database.

Animal RFID devices are available as eartag, bolus and injectable transponder. Table I gives an overview of the advantages and disadvantages of the different devices [6]. Generally, eartags and boluses are used for identifying livestock and injectable transponder are used for identifying companion animals, horses, fish and endangered species. A leg tag transponder is an alternative method for identify livestock [7].

Table 1. Overview of the advantages and disadvantages of the different identification devices.

Type	Application	Fraud safety	User friendly	Animal friendly	Farm automation	Food safety
Ear tag	At birth	±	+	±	+	+
Bolus	~ 1 month	+	±	±	-	±
Injectable	At birth	+	±	±	-	-

[1] Is for pigs problematic, because the size of the hole sometimes increases with the size of the ear.

Standards

In close cooperation with the manufacturers of RFID technology (manufactures of Integrated Circuits; IC's, transponders and readers) and RFID user group organizations (all formally representing national standardization bodies, e.g. INN - Instituto Nacional de Normalización), ISO is developing standards for animal identification. The following standards related to animal identification have been developed and published:

The ISO 11784 [8] including amendment I [9] and amendment II [10] specifies the following fields:

- **Animal bit**: indicating if the transponder is intended for animal identification purposes.
- **Country code**: a 3 digit number referring to the unique ISO 3166 country number (000-899). The use of country coded transponders is restricted to countries that have a competent authority responsible for the registration and granting of ID-codes. It is the responsibility of the competent authority to maintain the uniqueness of the numbers. Countries without competent authority shall not use transponders with a country code. In these countries, the so called manufacturer coded transponders (900-998) shall be used. The manufacturer of the transponders is in this case responsible for maintaining unique ID-codes.
- **Identification code**: a 12 digit number that is, in combination with the country / manufacturer code, worldwide unique for all animals. The idea of the ISO 11784 standard is that the number itself should not carry any information (e.g. farm number, breeding organization or region code), because this leads to inefficient use of numbers. Information in relation to the animal shall be stored in databases.
- **Retag counter**: in some cases, an animal loses the tag or the tag does not function anymore. In this case, the owner of the animal has the possibility of retagging the animal with the same ID-code. The retagging with the same ID-code shall be registered in the database and also in the transponder. When issuing a new ID-code the retagging number shall be set to '0'. At every retagging the retag counter shall be incremented. The retag counter offers 7 retagging possibilities. In case of any further losses a new number shall be granted to the animal. The use of retagging is only allowed in combination with country coded transponders.
- **User information field**: The use of the user information field is only allowed in combination with country code. The 2 digit field shall be set to '00' in case of a manufacturer coded transponder. When used in combination with the country code, the code of the user information field should be coded to conform to the specifications of the competent authority (e.g. sheep and goats identification in European Union countries use the field as species identification and has defined that the value for this field shall be set to '04').
- **Trailer bit**: this bit shall be set in case information is written in the trailer of the transponder code else this bit shall be '0'.
- **RUDI-bit**: this bit shall be set if a transponder is of the advanced low frequency (LF) transponder (ISO 14223-1..3, [11, 12, 13] type, in case of a non advanced LF transponder the bit shall be '0'.
- **Reserved field**: This field is reserved for future use, all bits in this field should be set to zero.

The ISO 11785 [14] air interface allows the use of both transponder types: FDX and HDX. The air interface is standardized in such a way that reading possibilities (chance of being read by a reader) for HDX and FDX transponders are balanced with a so called dual adaptive protocol. Based upon the situation, the listening (reading of the ID-code) period for a certain technology (FDX or HDX) can be extended based upon what has been detected by the reader. In the ISO 11785 standard two synchronization methods are defined. One synchronization method for handheld readers and another method for wired synchronization of static readers. For identification systems, it is necessary to synchronize readers when two or more are used in physical proximity. HDX transponders convey data using two frequencies, one of which is the same frequency as the activation signal. When two readers operate independently, the activation signal of one reader can occur during the period when the other reader is attempting to receive HDX transponder signals. Consequently, the readers will mutually interfere with one another, unless ON and OFF periods of the activation signals are synchronized. Synchronized readers transmit activation signals and receive HDX transponder signals in unison and will not interfere with each other. ISO 24631-7 [15] presents more detailed information on wired synchronization of stationary reader equipment.

Test procedures for animal RFID (ISO 24631-1, 2, 3, 4 & 5 [16, 17, 18, 19, 20]):

- different RFID equipment is available on the market. For the users of the technology, it is difficult to understand what equipment suits their application; therefore standards have been developed for testing animal RFID equipment. Two different sets of test procedures are available:
- Testing the compliance to the ISO 11784 and ISO 11785 standards of transponders and readers. The granting of the manufacturer codes by a registration authority is described in the conformance test for transponders. The ID-codes of all transponders that have been conformance approved can be read with the reading equipment that has been conformance approved. So a small injectable glass transponder (used for identifying e.g. a cat) can be read with a big static reader that has been developed for reading cattle in a slaughterhouse.
- Testing the performance of ISO 11784 and ISO 11785 conforming products. The results of the performance procedures can be used to check if a RFID product meets the requirements of a certain application (e.g. a transponder used for identifying a bull should produce a stronger signal than a transponder that is used for identifying a cat).

ISO 24631-6 [21] data representation: RFID data can be displayed by using different formats. The use of different formats might lead to misinterpretation of the information. Therefore, the ISO 24631-6 standard is developed for the representation of the animal identification information. This standard mentions how the ISO 11784 information shall be displayed on a reader display (Figure 1) and how the ISO 11784 data shall be communicated over a data link (Figure 2). The displaying of country code (manufacturer code) and identification code is obligatory, and the

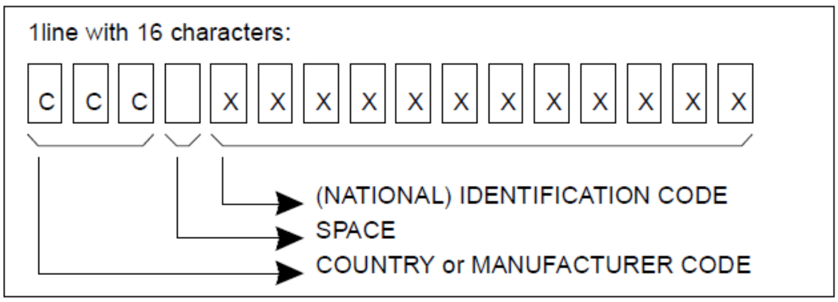

Figure 1. ISO 24631-6 representation of animal identification code.

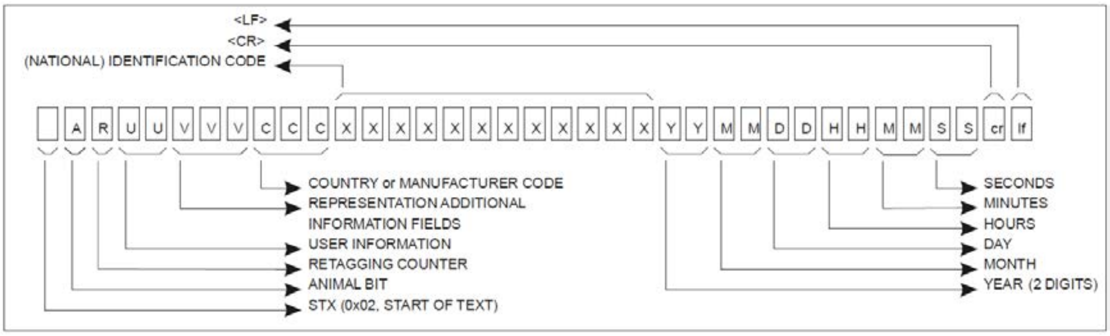

Figure 2. ISO 24631-6 communication of animal identification code.

displaying of the retagging counter value, user information (EU: species code) and the information of the additional information fields is optional. However, the format used for the optional parameters is obligatory. The obligatory format for the information communicated over a data link shall contain the following parameters: animal bit, retagging counter, user information (EU: species code), content additional information fields, country or manufacturer code, (national) identification code. Optionally a date and time stamp can be included (format is obligatory).

ISO develops International Standards, but does not conduct any conformance testing. Where required for ensuring the effective use of specific standards, ISO designates a competent body to serve as a maintenance agency or registration authority. In the case of the series of standards on radio frequency identification for animals, ISO has designated the Rome-based International Committee for Animal Recording (ICAR) as the registration authority (RA). The responsibilities of the RA will include the publishing of test reports on its Web site (www.icar.org). End of 1995, the first transponder products were ICAR conformance approved, and since that time more than 300 transponder products (eartag, injectable, bolus, tag attachment and leg tag) of more than a 100 different suppliers have been conformance approved and more than 70 transponders products of 30 manufacturers have been performance tested and 5 reader products of 5 different suppliers have been conformance approved.

Databases

Two types of databases are relevant for animal identification.

1. A database for animals

For tracking and tracing of animals, databases are used. In these databases, individual animal identification is linked to owner information and possibly other information. The owner of the database can be a government or private organization (it is even possible to maintain databases at owner (e.g. farmer) level). A country may use several databases, e.g. one for companion animals, one for pigs, one for sheep, one for goat, another for cattle, etc. Different organizations can be responsible for the different databases.

2. A database for RFID tags compliant with ISO 11784 and ISO 11785

The allocation of ID-codes being produced must be registered to eliminate the risk of having different animals with identical ID-code. When the manufacturer code is used, the manufacturer shall install and maintain such a database. When the country code is used, the legal authority shall ensure uniqueness of animal identification codes.

The above is why the ISO 11784 standard stipulates that nations should take the responsibility to ensure the uniqueness of the animal ID-code when a country code is used. When a country permits the use of the country code for any group of animals, several manufacturers may supply this market and therefore coordination of RFID numbers cannot be left to the manufacturers, and the country must assign the responsibility of the allocation of animal ID-codes to a government-controlled competent authority. If a country does not have such an authority, this country should only prescribe the use of manufacturer codes. In the case where the manufacturer code is used, each manufacturer is responsible to ensure the uniqueness of its codes. ICAR registers the manufacturers that are allowed to use a (shared) manufacturer code. Legal authorities shall, in case of using the country code, make sure that the national numbering system provides equal opportunities for unshared and shared manufacturer codes (e.g. shared manufacturer code manufacturers do not have the possibility to write their own 3 digit manufacturer code in the ID-code, because all shared manufacturer code manufacturers have to use '900'). The two databases have a different function and are independent from each other.

In a Dutch sheep and goat identification research project [22], a comparison (by using a simulation) was made between a central individual registration (CIR) of animals and animal flows and a system based on local (on farm) administration systems (LAS) (computerized or on paper) and reporting numbers of animals per transport to a central system. One advantage of CIR is that other systems (such as herd book, Health Service) can be linked to it, resulting in a decrease in paperwork. The report mentions that LAS can only work in an all-in-all-out system. In the sheep and goat sector in The Netherlands, herds never remain the same; individual animal data are yet of great importance. Enforcing institutions (Food and Consumer Product Safety Authority, General Inspectorate and Ministry of Agriculture, Nature and Food Quality) expect to get many benefits from implementing CIR as to efficiency gain and quality of data. Tracking and tracing is much quicker and more effective in CIR. Keepers particularly notice this advantage during time critical processes (tracing) in case of contagious disease and in dealing with its aftermath.

Other technologies

The RFID technology can be used at different frequencies. Each RFID frequency range (Low Frequency; LF: < 135kHz, High Frequency; HF: 13.56 MHz, Ultra High Frequency; UHF: 862 - 915 MHz, Microwave: 2.45 - 5.8 GHz) meets specific operational considerations of performance, tag form factors (the proportion of energy transmitted by that object which can be transferred to another object) and cost. Low frequencies can penetrate almost all materials while not being absorbed. In this range, however, the achievable operating distance is limited. On the other hand, microwave allows longer distances while penetration of objects is reduced.

For animal identification purposes, mostly LF technology is used because the penetration of the signal through living tissue is an important issue. This is important for bolus transponders and injectable transponders, but it is also relevant for eartag transponders, because there are situations were body parts of the animal are in between the reader and the tag to be read. The reading range should be sufficient so that if reader and transponder are close to each other information is exchanged, but on the other hand the reading distance should be limited so that the risk of reading a transponder of another animal is eliminated.

RF and UHF are mainly used for item management. Advantages of RF and UHF are the high reading distance, high data rate and the possibility of reading tag numbers when having several tags present in the field of the reader. Several studies on the use of UHF RFID technology for identifying animals are conducted around the world, e.g. the possibilities for deer, sheep and cattle farming were studied in New Zealand [23], and the possibilities for pigs were studied in Germany [24]. The ISO animal identification group is following the developments in this field and intents to initiate UHF animal identification standardization when convincing results showing that the UHF technology is meeting market requirements of specific (or general) applications are reported.

The animal RFID system developers (ATMEL Germany GmbH and Texas Instruments Germany GmbH) reported recently an interesting new development, were an ISO 11784, ISO 11785 (or ISO 14223) conforming tag is combined with an active (battery powered) UHF transmitter. Such a smart tag has a normal reading performance (reading distance up to 1m) for the passive ISO 11784, ISO 11785 (or ISO 14223) communication. However LF RF energy received by the tag within up to 5 m distance from an ISO 11784, ISO 11785 (or ISO 14223) reader can be used as LF RF wakeup commander for initiating UHF transmission. This active UHF signal can be received by an UHF receiver that has to be installed within a distance of a 100m maximum. There are no practical applications reported, but these transponders e.g. can be used to transmit information if an animal is passing a specific area in a stall.

Discussion and conclusion

Animal identification and recording of animal movements enable the worldwide trade of animals and make the exchange of animal identification related information possible. The use of standardized equipment and data formats ease this process.

LF RFID equipment is at this stage the most suitable technology for identifying animals. The technology can be used in combination with eartags, boluses, injectable transponders and leg tag transponders. The technology offers a reading performance that suits individual animal identification. ISO standards are available for testing the ISO 11784 and ISO 11785 conformance of transponders and readers and also procedures are available for characterising the performance of these RFID components.

Not only the technology itself is standardized, but also a system is developed for giving an unique identification number to every individual animal worldwide.

The RFID transponder itself does not give any information about the animal, but the transponder is just a link between the animal and the animal information inside a database. This database can be a database on a farm or can be central national database. The preferred option is a central database because this offers more flexibility, works quicker and is more efficient. A central database offers the possibility of discovering mistakes without having to go to every independent farm, and also when using a central database there is a possibility to fill in the numbers of animals that have not been read at a certain point (e.g. because the farmer has declared which animals have been put on transport).

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