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Overview of Ultra-High Frequency technology in livestock farming and stakeholder opinions

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Abstract

In many countries across the world, administrations are discussing traceability in order to be able to protect public and animal health. In addition, there is an increasing use of electronic Identification (EID) as a farm management tool. The overall aim of this study was to look at the suitability of UHF technology for electronic Identification of livestock and the possibility to replace paper copies of cattle passports with an electronic system. Focus groups with stakeholders were run to get feedback from the farming community, markets, abattoirs and hauliers. During these focus groups, the use of UHF technology as a management tool moved more in the centre of discussions. First of all, the study demonstrated that UHF technology is so far advanced that all the important components can be purchased, either within the agricultural industry or, more often from other industrial branches and can be amended for agricultural use. A number of UHF ear tags for cattle and other species are now commercially available. The main benefits are the reading speed, the ability to read several transponders simultaneously and the reading distance of up to 5 m for UHF ear tags. The capacity to write data, such as management or cattle passport information (including the movement history) onto the UHF tags is suitable. There is a fast development of memory size currently ongoing and it will be improved substantially in the near future.

The use of UHF technology across many different industries can have substantial cost benefits to farmers compared to the LF technology which is almost solely used in the livestock industry. The technological characteristics support the hypothesis that UHF technology can substantially automate livestock management inside farm gates and outside, at markets and abattoirs.

The stakeholder focus groups showed a positive picture with a scope for many advantages for farmers and the supply chain but it also identified issues which need to be addressed in future. Positive aspects of the potential to reduce the amount of labour needed for documentation and traceability came out very strongly in the discussions. An example for labour savings on farm tasks are compiling lists of animal IDs before they go onto a truck without having to take cattle through handling facilities. Further advantages are stress reduction for animals due to longer reading and writing distances, improved health and safety for farm workers, improved communication and reduced paper work. Even new applications, such as simple early warning systems for disease, could become an easy and economical option. Representatives from the abattoir were particularly interested in the aspect to reduce time and

error in matching up ear tags with cattle passports and the health and safety aspect of being able to read ear tags automatically from a distance.

The synthesis of this paper is that it is feasible to use UHF-RFID technology for cattle. The possibilities to use the technology on and off farm are manifold and could cost effective.

Keywords: cattle passport, labour savings, RFID, traceability

1 Introduction

Electronic Identification (EID) ear tag application has been a requirement in the sheep sector within the European Union since January 2010 under EC 21-2004. The standards adopted by EC 21-2004 are ISO 11784 and ISO 11785. These specify both the technical concept for radio frequency (RF) identification (ISO 11785) and also the structure of the radio-frequency identification code for sheep (ISO11784). These are Low Frequency (LF) inductively coupled devices operating at 134.2 KHz. All passive EID devices use RF energy to excite the transponder. This can limit the range at which they may be read, especially inductively coupled devices.

A number of application areas utilise LF-RFID (Low Frequency-Radio Frequency Identification) effectively in cattle farming, such as automatic weighing, shedding, milking and automated recording of individual feed intake and other close range systems. Apart from the benefits which can be gained from EID for cattle on-farm management there is also a considerable interest across the world on the question of compulsory EID tagging for the cattle sector. For example, New Zealand introduced the mandatory electronic Identification using LF-RFID in cattle on the 1st of July 2012 (Nason, 2011). Other countries already operating a mandatory system are e.g. Australia (Nason, 2011), Canada (Sundermann and Pugh, 2008), Uruguay (Swedberg, 2008) and Denmark (Swedberg, 2012).

However, newer alternative ultra-high frequency (UHF) transponder technologies are showing significant promise. They are used in other industries, and commercial implementations for bovines are starting to appear on the market. In this study we looked at the literature to investigate the developments in the livestock sector around the world and we organised focus groups to find out more about the stakeholder interests and possible drivers for decision making.

2 Materials and methods

The study reported on in this paper was split into a literature review to identify the state of the art and, on the other hand, to run focus groups in order to investigate stakeholder opinions and drivers for uptake. We concentrated mainly on cattle due to the current state of UHF technology. Yet, the UHF technology develops so fast that it is foreseeable that the described technology could also be used for smaller livestock species. Especially, as the first UHF ear tag for deer is already on the market. As it is a button tag it could also be used for larger sheep.

Regarding the literature review, there is currently not a lot of scientifically published literature on the use of UHF ear tags. Therefore, a large amount of information had to be collated through the internet.

To collect information on stakeholder opinions, three focus groups were conducted, two after the literature review and one at the end of the project. Stakeholders involved were mainly beef farmers, members of a levy body, abattoir, haulier, consultancy and national farmers union.

3 Results

3.1 Brief history of RFID in livestock management

In order to be able to place the UHF technology within the development of EID in the livestock sector, we will give a brief overview over the historic development. In 1948 Stockman published "Communication by Means of Reflected Power" where he reported that radio waves could power a remote transmitter. This discovery was the foundation for the passive transmitters of today (Stockman, 1948). RFID (Radio Frequency Identification) are now widely adopted within a range of industries in order to optimise the process of asset tracking and stock management. The agricultural industry has been one such sector that has benefitted from the use of these technologies (Ruiz-Garcia & Lunadei, 2011). In 1978 an RFID transponder was successfully incorporated under the skin of a dairy cow (Banks et al., 2007, p. 28) and today, the application of implants into animals is widespread ranging from wildlife to domestic pet identification. One of the largest demonstrations of the use of RFID within animal monitoring took place in the Columbia River basin where transponders were injected into salmon (*Oncorhynchus*) and steelhead (*Oncorhynchus mykiss*) to follow their life cycle (Banks et al., 2007, p. 461). Since 1987 over 15 million fish have been tagged and monitored using RFID (ptagis, s.a.)⁰. However, in general the application of this technology within livestock monitoring relates predominantly to the use of ear tags to facilitate activities such as automatic segregation or regulate feed intake. In some parts of the world boluses are also commonly deployed.

3.2 UHF technology

UHF technology has improved significantly within the last 10 years, becoming a useful technology, and adopted broadly for tracking and tracing goods in the supply chain (Pugh, 2004). It also became an interesting technology to be considered for livestock purposes. New Zealand, although opting for the LF option for their cattle, conducted trials to investigate the early application of UHF-RFID technology for animal tagging looking at three different species, including cattle (Sundermann & Pugh, 2008).

UHF ear tags potentially have a number of advantages. The read-range is much higher (in the order of metres compared to decimetres in LF-RFID) depending on the type of UHF transponder chosen. Usually a medium read-range of about 5 m is chosen for cattle ear tags. This makes UHF more adaptable to reading off the identifications at commercial locations such as auction markets, abattoirs, animal transport vehicles etc. The UHF transponders themselves are capable of storing information as opposed to just containing a unique identification code, and data transfer rates are orders of magnitude faster.

UHF technology implements anti-collision as standard which means that multiple tags can be read simultaneously, for instance a batch of animals passing through an opening would not require singulation to be read effectively.

The antenna reader devices can also write information to these devices when an animal passes within range. So in future, management information could be applied and stored on individual animal tags, and subsequently retrieved directly from the transponder. Data such as recorded weight, medications applied, movement history, breed, sex and date of birth etc., could all be potentially stored on the tag, and conveniently retrieved where appropriate.

There are also appropriate UHF handheld readers available on the market which can be very useful for on-farm management purposes to read the UHF ear tags and also to write to them.

However, these handheld readers are not specifically made for the agricultural market but for other industrial supply chains.

EID technology is moving fast, and new opportunities will arise due to increasing performance and reduced cost for UHF transponders and reading devices. The advantage of this technology is that it is used so broadly across different industries that fast developments and implementations may be anticipated.

In Scotland, ScotEID (<http://www.scoteid.com>) ran an extensive field study of electronic tagging and an evaluative field testing study of UHF tags alongside LF equipment in cattle is currently underway (Moxey, 2011). Moxey stated that inclusion of UHF technology in the pilot project was because UHF systems are capable of accurately reading multiple tags at a much faster rate and greater range.

There are already two USDA approved UHF cattle tags commercially available on the market (Eriginate's eTattoo tag and Hana Innosys tag; Figure 1 a and b). Figure 1 b shows the eTattoo tags, which have the same size and shape as a conventional Size 5 cattle tag. The Hana tag has a slightly different shape.

Some results on performance can already be found in literature. The eTattoo ear tag was tested over a period of 6 months (s.n., 2010) and the findings showed that the tags with a Sirit reader system can achieve greater than 99% tag capture in a 19 foot alleyway with 4 antennas placed 12 feet overhead. However, the report states that body masses may have more easily blocked a successful read of a tag and these findings are important and indicate that cattle behaviour can also affect the ability to successfully capture the tag ID and not simply size of the reading zone. Brazil were also trialling UHF technology for the use on cattle and water buffalos (Swedberg, 2010) using Eriginate's eTattoo dangle tags. The water buffalos were specifically chosen to test the tag's durability and they performed well, as reported by Swedberg (2010).



Figure 1 a and b: Dairy cows tagged in the right ear with Hana Innosys UHF tag (left) and Eriginate's eTattoo ear tag (right).

3.3 Focus Group Results

3.3.1 Positive voices

The stakeholders largely welcomed the technology and potential benefits that bovine EID may bring to their herd management. In particular, the greater read range of the UHF ear tags (compared to visual inspection and LF), the ability to store more data on the transponder, to read and write data to the transponder, to read multiple animals at once, and the ability

for handheld readers to be adjusted to narrow the beam to identify single animals in a group were all seen as positives for the technology. The main discussion points are listed in Table 1.

Table 1: Overview over the main pros and cons collected during three focus group sessions.

PROs	CONS
Reading batches of animals.	Haulier mentioned to expect difficulties due to water and salt ingress from spray water for all technical equipment if mounted onto the trucks > too high maintenance costs.
Reduced handling due to long reading distances.	Some farmers see less advantages for primary producers but for supply chain further down. However, costs will be landed on primary producers if it became compulsory.
Abattoirs and markets see great benefits in labour reduction (verifying IDs), reduced stress for animals, improved health and safety for stock workers (less close contact while reading ear tags).	If a new electronic passport system is introduced it needs to be compatible with the existing paper based system.
New management approaches, such as affordable alert systems e.g. if calves spent less time at creep feeder.	A central database is needed if paper passports will be replaced by an electronic system.
Management information can be stored on tags, e.g. barcodes from medical batches.	
Traceability can be improved and time saved when BVD testing is done.	

3.3.2 Concerns

Some concerns were also raised. The longevity of the ear tags is not yet fully tested as it is a new technology for the livestock sector. For LF-RFID ear tags, ScotEID reported that an indication was found that read rates decrease with time by about 3% over 600 days (ScotEID, 2011). Knowledge about longevity can only be gathered when the UHF ear tags will be applied for long periods of time and in larger numbers under commercial circumstances. Farmers at the focus groups reported that a durability of around 12 years would be required for cattle.

Another question is the read rate of the ear tags, as tissue masking effects might be found, especially for young calves at foot. This needs to be addressed in relation to the reader set-up.

3.3.3 Cattle paper passport replacement

The option to replace cattle paper passports was also discussed with the participants. This triggered in some farmers a certain negativity as a compulsory top down approach was feared. Especially, a compulsory introduction was seen negative if read rates were not 100% as this could cause problems with cross-compliance and a degree of flexibility would be needed.

If passport information was to be put on, timing could also become an issue. The favoured solution was to tag the calves with ear tags containing ID number and holding information

and at later stage sex, breed, date of birth etc. could be added when the calves come into contact with a reader/writer for the first time.

In contrast to farmers, the levy body, the livestock markets and abattoir representatives all felt that containing the passport data on the transponder would be beneficial to their business and the wider supply chain. However, a farmer keeping finishers pointed out that his business can only benefit from the technology if all suppliers have adopted the same technology. In that light, the mandatory approach looked more favorable to him. The last point but not the least was the issue of data security and integrity. Could other people read the information written onto the tag and could they even alter the passport information, was a question raised by many participants.

4 Discussions

Overall, when reviewing literature on bovine EID, useful applications of electronic tagging can be found and are more and more used on farms. A number of countries have already made electronic tagging compulsory. Those countries usually opted for the LF technology. The already high number of LF ear tags and boluses in the livestock sector might be seen as a stumbling block for the introduction of UHF. However, both technologies can easily be operated alongside each other because there are no electromagnetic issues running them in parallel. In addition, it is also feasible to use so-called dual or hybrid tags which integrate both systems, LF and UHF technology, within one ear tag (ScotEID, 2014) if farm management deems such an approach necessary.

The UHF technology is developing fast on a global scale across various industries which give the technology an innovative momentum. The advantages of UHF ear tags make them certainly interesting for the bovine sector and the few reports which are already published shine a very favourable light on the technology so far.

The focus groups have shown that, overall, stakeholders are welcoming the technology if it stays voluntary. Especially farmers with an early adopter attitude developed new ideas how to integrate UHF technology into their management. They also saw the benefits of labour reduction and time savings on their farms. Markets, abattoirs and representatives of the levy body saw the benefits primarily in reduction of health and safety issues as well as in potential labour savings. However, there is an amount of nervousness among the farming community that the European Union will be opting for a mandatory approach. Therefore, a few farmers adopted a negative attitude as a precaution which resulted in a very closed attitude towards UHF technology. The representative of the haulier company had also concerns if equipment needed to be mounted onto the trucks as water and salt ingress from spray water causes severe problems for all technical equipment. This would result in high maintenance costs.

5 Conclusions

In conclusion, the literature review has shown that there is a strong interest in EID across the world, as a farm management tool as well as a tool to ensure traceability. Although, the majority of administrations chose LF-RFID as compulsory technology, there is a growing amount of interest in UHF technology. UHF systems can be considerably cheaper than the alternative LF systems. Importantly, UHF transponders also have advantages over LF systems in that UHF transponders can contain significantly more information, including essential information (such as an animal's unique identifier) in a permanent, non-modifiable format, and additional information that can be 'written' during their lifetime. An additional advantage is that UHF tags have a collision avoidance capability that enables many to be read simultaneously in real time.

On the basis of the focus groups, the stakeholders welcomed the technology due to the interesting management possibilities which it provides but did not welcome mandatory adoption, as had been the case with sheep EID. Notably, the potential to reduce labour was seen as a major benefit. In addition, other benefits such as new management approaches, health and safety for workers and stress reduction for animals were the main points raised. Overall, a UHF transponder tagging and database system has many positives and some risks for different elements of the cattle production chain. In terms of quick identification and reading of identity such a system provides potential for increased throughput, more reliable reading of IDs and more rapid updates of movements. This has time saving benefits for farmers, hauliers, auction markets and abattoirs. Risks of this element of the system are reading failures, corruption of data and breakdown of technology. In general, many farmers voiced that practical demonstrations can aid the uptake of this new technology. A demonstration at the last focus group meeting showed the ease of use and the technical team was able to address many of the concerns.

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