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The Use of Radio Frequency Identification as a Security Measure to Control Cattle Rustling in Nigeria

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ABSTRACT

The goal of this paper is to propose an avenue to minimise cattle rustling in Nigeria. The proposed solutions, which involve the use of Radio Frequency Identification (RFID) transponders, readers and software have been tested both in the laboratory and in barns as documented by various authors. Electronic identification of animal could be exploited by farmers as an interesting opportunity to increase traceability of stolen or missing animals. However, RFID system is faced with some challenges. Financially, a system as vast as RFID could be extremely costly. In countries were RFID is made mandatory for all farmers, there is concern that the costs of complying with the program will drive small farmers out of business, due to the cost associated with registering each animal. Small farmers and families that sell off parts of their herds or flocks periodically, would have to register and pay a registration fee for every head of livestock or poultry, while corporate farms with large herds or flocks that move through the production chain as a group, will only have to pay the fee equivalent of owning one animal. Another major challenge is that, the system is mostly suitable for larger animal. Using RFID in poultry management might not be profitable. Therefore, the most appropriate and affordable traceability could be achieved through the use of Global Position System (GPS).

Keywords: *Animal tracking, animal surveillance, electronic identification, herd management, traceability.*

INTRODUCTION

Identification of animal by means of marking animal's body was first recorded 3800 years ago in the Code of Hammurabi to prevent thievery (Bowling *et al.*, 2008). According to Bowling *et al.* (2008) and Vallat (2009), identification was initially applied to particularly valuable animals such as horses which were used by the Chinese postal system or by Roman charioteers. Since then, animal identification and traceability have become widely recognized as essential tools for ensuring the safety of livestock products and facilitating surveillance and control (Blancou, 2001). Recently, requirements for export and consumer demands had led to the use of Radio Frequency Identification (RFID) (Bowling *et al.*, 2008). Livestock identification and trace back system (LITS) in Africa is mainly adopted in Bostwana and Namibiya. LITS was introduced for instance in Botswana over 11 years ago, though it has largely failed to meet the expectations of both the Government of Botswana (GoB) and the beef sector at the initial stage (FAO, 2010). In Nigeria, Livestock identification and trace back system (LITS) is experiencing policy and implementation challenges. Therefore, this paper investigates the advantages and disadvantages of animal identification and traceability using electronic methods of livestock identification, as well as, challenges to Livestock identification and trace back system (LITS) implementation.

RADIO FREQUENCY IDENTIFICATION (RFID)

Radio frequency identification (RFID) is a technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal or person. RFID is coming into increasing use in industry as an alternative to the bar code. The advantage of RFID is that it does not require direct contact or line-of-sight scanning (Hessel*et al.*,2008). RFID system consists of three components: an antenna and transceiver (often combined into one reader) and a transponder (the tag). The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna. The data is used to notify a programmable logic controller that an action should occur. The action could be as simple as raising an access gate or as complicated as interfacing with a database to carry out a monetary transaction. RFID is of either low or high frequency. Low-frequency RFID systems (30 KHz to 500 KHz) have short transmission ranges (generally less than six feet). High-frequency RFID systems (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) offer longer transmission ranges (more than 90 feet). In general,the higher the frequency, the more expensive the RFID system. (Hessel*et al.*,2008)

The Usage of RFID

When an RFID system has to be integrated into traceability system for animal identification, animal shape has to be related to the reading area of the antenna and probability of collision among tags has to be considered. Caja*et al.* (2005) observed that, the safe detection area (SDA) of the adopted tag–antenna combination should be determined precisely before planning the layout of an RFID gate to be installed in the barns, so as to determine the dimensions and shape of the animal passage where the antenna should be mounted. However, when dealing with small animals like piglets, the overall detection area, that is, the area obtained considering all the possible orientations, should be taken into account. In this case, many identifiers could, in fact, be present temporarily in the detection area, leading to tag-to-tag collisions that can cause wrong or missed detection and/or faults in establishing the right queue (Caja*et al.*,2005).

The information about the reading areas and dynamic reading performances (Hessel*et al.*,2008) are fundamental to integrate RFID systems in real traceability applications. The collision among tags, result in a strong decrease of the reading rate when more than one tag were present in the detection area. From the results obtained by Hessel*et al.* (2008), the worst case was that of the presence of multiple tags of the same model and brand, especially for the half duplex (HDX) tag considered. Similar to the system proposed by Voulodimo s*et al.* (2010) for farm management and Mutenje*et al.* (2012) for cattle handling, the ICT framework allows increased efficiency of the collection and management of traceability data, increasing reliability and reduced costs. This framework, improving, via real-time data exchange, safety and traceability (Dabbene and Gay, 2011) and allowing a deep optimization of the supply chain (Schwägele2005; Dabbene*et al.*, 2008a, b), will enhance the competitiveness of the producers on the global market, favouring new forms of business-to-business electronic transactions (Liu and Shao 2012; Mingxiu*et al.*,2012).

Animal Identification And Traceability

Animal identification is defined as “the combination and linking of the identification and registration of an animal individually, with a unique identifier, or collectively by its epidemiological unit or group, with a unique group identifier” (Sehularo, 2010). According to Greene (2010), animal identification refers to keeping records on individual farm animal or groups of farm animals so that they can be easily tracked from their birth through the marketing chain. Historically, animal identification was used to indicate ownership and prevent theft, but the reasons for identifying and tracking animals have evolved to include rapid response to animal health and/or food safety concerns. Hoffmann *et al.* (2009) and Besbes and Hoffmann (2011) stated that animal identification is an important tool for many purposes including farm management, genetic improvement, biodiversity management, prevention and control of zoonosis and other animal diseases, trade opportunities, proof of ownership and theft control.

Traceability of meat to the farm of origin is becoming increasingly important to consumers and producers. Within EU, traceability is driven mainly by food safety concerns while in the United States of America it is perceived as important with regards to both bioterrorism and food safety (Donelly and Thakur, 2009). Traceability systems would be greatly facilitated by electronic animal identification (e-ID) which, for example, would eliminate errors associated with the manual transcription of data (Fallon, 2001). Greene (2010) argued that traceability is limited specifically to movements from the animal’s point of birth to its slaughter and processing location. For Carné*et al.* (2009), permanent and reliable animal ID is a primary goal for the implementation of animal traceability systems. Electronic identification (e-ID) by using radio frequency (RFID) passive transponders improves traceability due to faster monitoring of livestock and easier management of databases for inventory and movements between premises. According to Smith *et al.*

(2005), traceability, for livestock, poultry and meat, in its broadest context could or will eventually be used (1) to determine origin and ownership, and to deter theft and misrepresentation of animals and meat; (2) for surveillance, control and eradication of exotic animal diseases; (3) for bio-security protection of the national livestock population; (4) for compliance with the requirements of international customers; (5) for compliance with country-of-origin labeling requirements; (6) for improvement of supply-side management, distribution/delivery systems and inventory controls; (7) to facilitate value-based marketing; (8) to facilitate value-added marketing; (9) to isolate the source and extent of quality-control and food-safety problems; and (10) to minimize product recalls and make crisis management protocols more effective.

Electronic Poultry Identification and Traceability

As technology advances at light speed, it seems like everything is getting smaller, including GPS trackers. One of the smallest GPS trackers available today is no more than the size of two grains of brown rice. With the benefit of size, GPS tracking is no longer only being used to track cars, fleet vehicles, our pets, or people. Researchers are now using GPS tracking on birds: not only to understand their migration habits, but to help prevent certain bird species from becoming extinct, to control diseases, monitor their breeding and track poultry (Caja*et al.*, 2004).

Nick on a quest to learn where the bald eagles in his nearby Terrebonne Parish area go. It seems the bald eagles disappear each year in June, July, and August. Over two summers, Nick attached a GPS tracker device to 10 birds to find out where these Louisiana eagles are going. Because these species of birds were placed on the federal endangered-species list, the tracking was aimed to study their nesting success, population, breeding and migrating behaviors (Caja*et al.*, 2004).

Bird watchers and featured-creature enthusiasts have studied the behaviors and migratory patterns of various bird groups for years because birds have always been of interest to man (Hessel*et al.*,2008). Researchers and scientists have learned intriguing information from their studies. Yet, these observations have always had a drawback: how to keep taps on a particular bird. With the advent of smaller GPS tracking devices, scientists then started using tag on individual birds and monitor their flight patterns in way that is more precise than before. This lead to the utilization of GPS tracking devices on poultry generally (Hessel*et al.*,2008).

The use of GPS tracking devices on poultry generally (Hessel*et al.*,2008) involves creating bird watching documenting procedures such as common name, genus and species, etc. Each event is marked along the GPS track(s) with a numbered pin on google maps allowing instant access to the media you captured at each site. When an event is created, it automatically documents the longitude, latitude, altitude, time and date with instant access to the smart phone camera, audio recorder, notes, and a theodolite tool (for calculating distances to or elevation of objects) to further document the event. Each event comes with formatted fields to record a description of the event, detailed notes, size and gender of the bird, genus/species, number of birds, temperature and pressure. Specific fields can be hidden and an unlimited number of additional fields can be added (Bowling *et al.*, 2008) and (Vallat, 2009).

The mode of Work of Global Positioning System (GPS) in Poultry

The Global Positioning System (GPS) is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.

The US began the GPS project in 1973 to overcome the limitations of previous navigation systems, integrating ideas from several predecessors, including a number of classified engineering design studies from the 1960s. The U.S. Department of Defense (DoD) developed the system, which originally used 24 satellites. It became fully operational in 1995. Roger L. Easton, Ivan A. Getting and Bradford Parkinson are credited with inventing it (Bowling *et al.*, 2008). Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS and implement the next generation of GPS Block IIIA satellites and Next Generation Operational Control System. In addition to GPS, other systems are in use or under development. The Russian Global Navigation Satellite System (GLONASS) was developed contemporaneously with GPS, but suffered from incomplete coverage of the globe until the mid-2000s. There are also the planned European Union Galileo positioning system, India's Indian Regional Navigation Satellite System, China's BeiDou Navigation Satellite System, and the Japanese Quasi-Zenith Satellite System (Bowling *et al.*, 2008).

Electronic Animal Identification and Traceability in Africa

Africa, particularly Sub-Saharan African countries have adopted a declaration on animal identification and recording, a move that is expected to improve food security, livestock genetics and better flock management as well as manage animal health and disease control but these have not been implemented. In Nigeria, livestock expert has advocated that, the establishment of a livestock identification programme will help the government to track livestock in cases of disease outbreaks and/or theft. Tracking of cows should be a concern as identification will make investigations faster and easier in case of any theft and/or rustling. However, apart from Botswana and Namibia who has started implementing RFID system, no available literature on usage of RFID system in Africa (Economic Commission for Africa, 2012).

Electronic Identification and Traceability of Animal in Botswana

Botswana is more biased towards cattle production with cattle accounting for 73% of the total livestock population, followed by goats (22%) and sheep (5%) (Economic Commission for Africa, 2012). Beef is primarily produced for export with 70-75% going to the EU countries and 15% and 10% going to South Africa and Norway, respectively. As a result, changes in the requirements for the global market and consumer demands affect Botswana beef exports (Fanikiso, 2009). In 1997, the EU introduced Council Directive EC820/97 which made it mandatory for beef going to the EU to be identifiable and traceable through a computerized system (Fanikiso, 2009; Marumo and Monkhei, 2009). The EU Council Directive totally changed the landscape for animal identification and trace-back in Botswana as the country could not fulfill the requirement of the directive using the traditional branding system (Fanikiso, 2009). As a result, Botswana introduced the uses rumen bolus in 1999 to fulfill the EU export requirements and to maintain the much needed EU market access (Marumo and Monkhei, 2009). The bolus system is a complete departure from the traditional 'hot iron' branding and ear tagging that have little or no deterrence to cattle thieves (Peace Bulletin, 2004). The Livestock Identification and Traceability System (LITS) identify animals using rumen boluses with embedded RFID microchips to trace animals throughout the production chain (Bowling *et al.*, 2008). Furthermore, each rumen bolus is coded with the owner's name, a personal identification numbers, the brand on the animal, the position of the brand, the sex of the animal, the hide/coat colour of the animal, the location of the animal is uploaded to an extension officer' computer and stored on the central database in Gaborone. In an attempt to comply with EU Regulation 1760/2000 (EU, 2000), Government of Botswana (GoB) implemented LITS in 2001 (Bowling *et al.*, 2008). The key requirements of Regulation (EC) No 1760/00 are: every bovine animal must be registered and individually identified using one ear tag in each ear, individual paper passports are required for all bovine animals and passports must accompany the animals when they move, the governments of the Member States must be informed of each animal movement, Member States must maintain a computerized cattle tracing database and animal keepers must maintain up-to-date registers of on-farm bovine animals (Botswana Ministry of Agriculture and Forestry, 2009). On the other hand, the objectives of LITS were to establish a computerized system for cattle identification and trace-back in order to ensure export market access for Botswana beef, to computerize separate cattle, animal disease and brand databases into a single computerized database system that can be used to achieve cattle identification and beef traceability in fulfillment of EU requirements and rapid disease trace-back and trace-forward (security and cross-border movements) and to bring about efficiency in livestock and disease information management system (Fanikiso, 2009).

The LITS implementation in Botswana has experienced a number of challenges which resulted in Government of Botswana (GoB) resolving to replace the rumen bolus with electronic ear tags as of 1st January 2013. Besbes*et al.* (2010) in Spain attributed failures to animal identification and traceability to lack of political will, capacity limitations (human, financial), system costs are often underestimated, lack infrastructure and support services, lack of information on available technologies and guidelines, lack of coordination among different players, farmer's perceived intrusion and non-confidentiality of information and illiteracy of farmers. In Botswana, electronic ear tags are only sold by the Government Livestock Advisory Centers (LACs) at a unit price ranging from P15 to P20 (Paskin, 2004)).Livestock Advisory Centers across the country are known to be inefficient as epitomized by the irregular supply of veterinary requisites and livestock feeds due to bureaucratic red tape. Similarly, the supply of ear tags by LACs is likely to be irregular if LACs are the only entities selling this technology, thus affecting cattle identification and traceability. This in turn lead to a few cattle being ear tagged resulting in the decline in cattle slaughters at the export abattoirs. It is therefore apparent that the use of ear tags which unlike bolus will be at the farmer' expense is likely to lead to a decline in beef exports. It is also unlikely that the use of ear tags will reduce delays in livestock data processing as it is not going to be easy for farmers to be forthcoming with information to be assimilated into the national livestock database (Marumo and Monkhei, 2009)).

The use of Electronic Devices for Animals Identification and Traceability

Meat exports are an important business for the African countries of Namibia as in the case of Botswana. Due to strict importing requirements of the EU, Namibia has implemented bovine animal identification and traceability programs to maintain access to their main export markets. In 1999, the Government of Namibia implemented the Farm Assured Namibian Meat Scheme (FANMS). The FANMS database is administered by the Meat Board of Namibia and contains livestock brands, FANMS member information, livestock traceability information, and meat import and export information (Meat Board of Namibia, 2002). Individually owned parcels of land are not specifically identified under the FANMS; rather, the brand that identifies the livestock owner is the only means of identifying where individual animals were born. This brand is retained in the FANMS database and serves to identify the property of origin of each animal (Meat Board of Namibia, 2002). Because the goal of the FANMS is to produce meat for export to the EU and other export markets, individual cattle are identified using ear tags that have a registered bar code and an individual animal serial number. All animals must be identified with a FANMS-approved device before they leave their property of birth, and an exit register must be completed by the producer before departure of any animal from their premises (Meat Board of Namibia, 2002). Upon arrival at a new property, arrivals register also must be completed, and ear tag numbers must match the exit register accompanying the cattle. Abattoirs are also required to complete animal arrival registers, which serve as records of animal termination.

Traceability System and Tracking System

This is a combination of Global Positioning System (GPS) and RFID technology. This will help to enhance farm management capabilities. It is proposed that GPS technology be included in RFID tags in to tracing cattle movements, and locate individual cows with a single program (Karnjanatwe, 2005). Obviously, with a small herd size, this is not a particularly prominent issue (as farmers will be able to know cow locations from their own knowledge of the herd and cow movements), however as herd size increases, GPS location ability becomes increasingly valuable. This ability is further enhanced as the farmer may be able to use a PDA or other mobile device to display a map of their farm and pinpoint the cow's location within the farm layout. Utilizing this approach, farmers can be guided to the exact location of any cow they desire. It is in farmer's best interest to minimize the risk of such incidents, with a GPS system utilizing plotted boundaries can facilitate. Similarly, the combination of GPS with RFID will aid to prevent and detect any theft of animal. Additionally, proof of identification and ownership of each cow can be provided via the RFID capability of such devices. Furthermore, software could be designed to detect individual cow movement. This may include if a cow does not move as much as it is expected (based upon the historical location chronicle of the cow), or likewise, if it is moving significantly more than expected or unusual. If a cow is moving significantly less than usual, this could be a strong sign of illness, and certainly something worthy of a farmer's investigation. Additionally, this tracking may also be used as a mechanism for detecting when cows are in heat. When a cow is in heat their activity (movement) will increase by up to eight times the normal rate. Thus, if a cow's movement is detected to be abnormally high, this may be a strong sign that she is in heat, and thus notification of this should be provided to the farmer. This system can be used for tracing movements and locate wild animals.

Animal Identification and Traceability Implementation and Challenges

The radio frequency identification (RFID) of each single head of animals especially cattle is already mandatory in many countries for some species (Smith *et al.*, 2008). For example, to meet European Union requirement for meat import, Australia, in 1999, introduced a system for RFID identification and traceability of livestock called National Livestock Identification System (NLIS), which became compulsory in July 2005 for cattle; in the United State, electronic identification is a voluntary program such as National Animal Identification System (NAIS), which has been active since 2002, and some states, e.g., Michigan, officially started electronic animal-tracking in March 2007. In Canada, RFID identification for cattle has been mandatory since July 2010 (Smith *et al.*, 2008). Some researchers proposed RFID solutions at higher frequencies (HF, 13.56 MHz) for pig identification at the feed trough, which allow the simultaneous detection of multiple transponder and use anti-collision systems (Reiners*et al.*, 2009). Analogously, Leong *et al.* (2007) proposed the use of both HF and UHF (920–926 MHz) RFID tags for the identification of pigs in Australia.

The reliability of an RFID traceability system for livestock applications depends on two main factors, the persistence of the tag on the animal and the readability in different conditions in the stable. RFID system integration at the farm level should be carried out considering farm type, number and species of animals, as well as barn structure (Reiners*et al.*, 2009).

Conclusion

Electronic identification (e-ID) by using radio frequency (RFID) passive transponders improves traceability due to faster monitoring of livestock and easier management of databases for inventory and movements between premises. Traceability for cattle in its broadest context could or will eventually help to reduce cattle rustling, to determine origin and ownership, to deter theft and misrepresentation of animals a challenge Nigerian farmers had suffered over the years.

Recommendation

Electronic identification (e-ID) by using radio frequency (RFID) passive transponders for animal identification and traceability is recommended for cattle farmers in Nigeria. This provide avenue for recovery and traceability systems.

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