

REVIEWS

REVIEW: Identification and Traceability of Cattle in Selected Countries Outside of North America

M. B. Bowling,* D. L. Pendell,†¹ D. L. Morris,‡ Y. Yoon,* K. Katoh,* K. E. Belk,* and G. C. Smith*

*Center for Meat Safety and Quality, Department of Animal Sciences; and †Department of Agricultural and Resource Economics, Colorado State University, Fort Collins 80523; and ‡USDA/APHIS/VS/NCAHP/SIP/NAIS, Fort Collins, CO 80526-8117

ABSTRACT

Animal identification by means of marking animals' bodies was first recorded 3,800 yr ago in the Code of Hammurabi, and throughout history, valuable animals such as horses have been identified to prevent thievery all over the world. Today, the reasons for identification of livestock include production management, control of disease outbreaks, establishment of ownership, requirements for export, and consumer demands. Additionally, there are many methods of animal identification and traceability available today including ear tags, tattooing, branding, electronic methods that implement radio frequency identification technologies (such as rumen boluses, ear tags, and injectable transponders), and biometric methods (such as retinal scanning, nose prints, and DNA). The objective of this review is to demonstrate the implementation of bovine animal identification and traceability systems in selected countries outside of North

America (i.e., United States, Canada, and Mexico) for the purpose of creating a knowledge base whereby an effective North American bovine animal identification and traceability system may be created and implemented. This review will discuss regulatory requirements of animal identification and traceability in selected countries.

Key words: animal identification, radio frequency identification device, traceability

INTRODUCTION

Animal identification by means of markings on an animal's body has been recorded as early as 3,800 yr ago (King, 1910). According to Blancou (2001): 1) In many ancient civilizations, hot-iron branding was employed as a means of individual animal identification but only on valuable animals, such as horses of the Greek armies, the Chinese postal service, and the Teutonic Knights; 2) Outbreaks of diseases such as rinderpest, contagious bovine pleuropneumonia, glanders, and rabies

made animal identification for disease control a necessity, and as early as the 17th century, animals were identified and monitored for disease using indelible ink tattoos; and 3) During the human plague epidemics of the 14th century, animal products were monitored, and many products could not be traded internationally without certificates guaranteeing the origin and safety of the product.

Modern animal identification utilizes some of the same practices that were used in ancient times to identify animals (i.e., tattooing and branding). Additionally, the reasons for animal identification (i.e., public health, animal health, animal management, trade, and consumer demand) remain the same (Marchant, 2002). However, technologies exist today that allow for more precise identification of individual animals and for the tracing of those animals throughout their lives from birth until purchase by a consumer. The World Organization for Animal Health (OIE) defines animal identification as “the combination and linking of the identification and registra-

¹ Corresponding author: Dustin.Pendell@ColoState.EDU

tion of an animal individually, with a unique identifier, or collectively by its epidemiological unit or group, with a unique group identifier" (OIE, 2006). The OIE defines animal traceability as "the ability to follow an animal or group of animals during all stages of life" (OIE, 2006); the OIE defines an animal identification system as "the inclusion and linking of components such as identification of establishments/owners, the person(s) responsible for the animals, movements and other records with animal identification" (OIE, 2006). Currently, many different types of animal identification technologies exist that may implement mechanical (e.g., tagging, branding, and tattooing), electronic (e.g., ear tags, ruminal boluses, and injectable transponders), and biometric (e.g., nose prints, DNA profiling, iris scanning, and retinal scanning) methods to identify and trace animals throughout their lives (Marchant, 2002). The objective of this review is to demonstrate the implementation of bovine animal identification and traceability systems in selected countries outside the United States, Canada, and Mexico for the purpose of creating a knowledge base whereby an effective North American bovine animal identification and traceability system may be created and implemented. Three companion articles describe 1) animal identification in North America (Murphy et al., 2008); 2) swine identification in selected countries outside North America (Meisinger et al., 2008) and; 3) identification of sheep in selected countries outside North America (Bass et al., 2008). When taken as group, these reviews offer comprehensive insight into animal identification and traceability in selected countries throughout the world.

REVIEW AND DISCUSSION

Cattle Identification and Traceability Systems

European Union. On April 21, 1997, the European Union (EU)

implemented an individual animal identification and traceability system (EU, 1997). This European Union Regulation EC 82/97 mandated that, by January 1, 2000, all bovine animals must be identified with 1) ear tags that individually identify animals, 2) electronic databases, 3) animal passports, and 4) individual animal registries kept at each premises (EU, 1997; Table 1). On July 17, 2000, subsequent regulation EU 1760/2000 was passed, fully implementing and making mandatory the bovine identification and traceability system now in place in the EU (EU, 2000). The framework for EU animal identification and traceability is laid out in article 17 of EU regulation 1760/2000, which states that "In order to permit movements of bovine animals to be traced, animals should be identified by an ear tag applied in each ear and, in principle, accompanied by a passport throughout any movement. The characteristics of the ear tag and of the passport should be determined on a Community basis. In principle, a passport should be issued for each animal to which an ear tag has been allocated (EU, 2000)". Pursuant to EU regulation 1760/2000, each animal must be individually identified with 2 ear tags that have a country code, a bar code (used to enter information by scanning the bar-code number into a database), and a 12-digit number; the first 2 digits of the number identify the region of the country, followed by a 5-digit herd identification number (the EU method of premises identification), and finally, by a 5-digit individual animal identification number (DAF, 2000). Ear tags must be applied within 20 d of birth or before the first transportation of any bovine animal (EU, 2000). In addition to individual bovine animal identification by ear tags, a passport is generated for each animal to track movements and is issued by the competent authority of each EU member state within 14 d of notification of birth (EU, 2000). Passports carry information including the animal's individual identification number,

date of birth, breed, sex, and mother's individual identification information (DEFRA, 2007). Passports accompany bovine animals during transportation and are updated by each new owner of cattle until the passports are surrendered to the EU member state competent authority by abattoirs after animals are harvested (EU, 2000). Thus, animal termination records are kept for each individual animal.

Member states within the EU are allowed to develop animal movement databases that preclude the use of passports to track cattle movements; however, when animals are moved between member states, a passport must accompany each animal (EU, 2000). Ireland has implemented the Computerized Cattle Movement Monitoring System, which collects calf birth registration records and cattle movements between properties (DAF, 2003). In addition to tracking animals from birth through harvest, the EU regulations stipulate the labeling of meat products in the following way: 1) a reference number that links the meat product to the animal or animals of origin; 2) identification of the member state where the meat was harvested and processed; and 3) the harvesting or fabrication facility's approval number(s) (EU, 2000).

Australia. All of the information in this paragraph was derived from DAFF (2006). Australia has had some form of bovine animal traceability since the 1960s, when the government implemented the Brucellosis and Tuberculosis Eradication Campaign. Prior to the use of electronic means of animal identification and tracking, Australia used plastic or vinyl tail tags to identify and track bovine animals. In 1999, the National Livestock Identification System (NLIS) was introduced. All cattle are now identified based on their property of birth, and their movements are tracked in the NLIS database (Table 1). Since the 1960s, farms and agricultural parcels of land in Australia have been required to have a property identification code (PIC), an 8-digit number

Table 1. Comparison of cattle population and identification and traceability systems

Country	Cattle population (1,000 hd) ¹	Premises identification ²	Individual cattle identification ²	Group or lot cattle identification ²	Electronic cattle identification ²	Recorded animal movement ²	Retire animal number ²
Australia	28,560	M	M	V	M	M	M
Botswana	3,100	V	M	Not allowed	M	M	V
Brazil ³	207,157	M	M	V	V	M	M
Canada	14,830	V	M	Not allowed	M	V	M
European Union	90,355	M	M	V	V	M	M
Japan	4,391	M	M	V	V	M	M
Mexico	28,648	V	V	V	V	V	V
Namibia	2,384	M	M	V	V	M	M
New Zealand ³	9,652	V	V	V	V	V	V
South Korea ³	2,484	M	M	V	V	M	M
Uruguay	11,956	M	M	V	M	M	M
United States ³	96,702	V	V	V	V	V	V
World	1,383,157	—	—	—	—	—	—

¹All numbers are for cattle populations in 2006 as reported by the Food and Agriculture Organization of the United Nations (FAOSTAT, 2008).

²M = mandatory, V = voluntary.

³Indicates a voluntary program. The requirements listed are for those who choose to participate.

that identifies its state, region, and specific location. The PIC system, which was originally introduced to assist the Brucellosis and Tuberculosis Eradication Campaign, is still in place today, and as of November 2006, the NLIS database tracks nearly 160,000 premises. Producers in Australia have the option of using the NLIS database as a management tool. In specific cases (55,000 total carcasses as of November 2006), a producer may use their PIC to access individual animal carcass information entered into the NLIS database by the abattoir (DAFF, 2006). The implementation and enforcement of the NLIS is governed by each individual state or territory.

According to DAFF (2006), individual animal identification became mandatory on July 1, 2005, in all Australian provinces. Prior to that date, states and territories implemented bovine animal traceability systems compliant with the NLIS on a voluntary basis. Individual animal identification is accomplished

by placing an NLIS-approved device either in an animal's ear or by administering a rumen bolus. The NLIS-approved devices consist of a radio-frequency identification device (RFID) that contains an encoded microchip with the PIC of the property of birth. An approved NLIS device also has 2 identifying numbers: the first identifying number is the RFID number within the microchip that includes a manufacturer code and a unique number for that device. The second number begins with 8 characters that code for the PIC, followed by a manufacturer's code, device type code, year of device manufacture code, and 5 ending digits that provide an individual bovine animal serial number. Use of RFID devices allows for "whole-of-life" tracking, whereby bovine animals can be tracked from the time they leave their property of birth through each property to which they are transported until their harvest. Due to national regulatory requirements, animals in Australia are identified individually and are

not traced through the production and harvesting system as groups.

The NLIS system requires that animal transportation be tracked from the property of birth to any property thereafter (DAFF, 2006). The PIC and the National Vendor Declaration (NVD) are used to link livestock to the most recent location and to track the history of each individual bovine animal's movements. The NVD must accompany any livestock being transported and serves as an assurance that livestock are being moved with the owner's permission (SAFEMEAT, 2007). Upon arrival at a new property, each animal's RFID tag is scanned, and the information is recorded and linked to the RFID device. Animal movement information is stored in the central NLIS database (DAFF, 2006).

The primary responsibility of processors in Australia is reading and recording bovine animal transactions in the NLIS database (MLA, 2007). When cattle are harvested in Australia, each individual animal

is assigned a unique identification number that is attached to a bar code (SAFEMEAT, 2007). The animals' NVD numbers, individual animal identification numbers, and kill date and time are linked to live animal information and to carcasses, hides, and byproducts of each animal (SAFEMEAT, 2007). Unless specific agreements are reached between producers and harvesting facilities, animals are grouped into lots by harvest date and time, and individual animal information (carcass data) is not available.

It is also stated in DAFF (2006) that: 1) The Australian NLIS is a comprehensive "whole-of-life" animal traceability system that implements RFID technology to allow for user-friendly premises identification, animal movement tracking throughout every production sector, and animal termination records. 2) In 2004, DAFF conducted the National Livestock Tracing Audit, and all of the animals identified using NLIS were traced to their property of origin within 24 h. 3) It is also possible for producers who so choose to apply animal identification technologies to their management decisions to access carcass information provided by abattoirs (if prior arrangements are made with the abattoir). 4) The cost of animal identification in Australia is absorbed mainly by producers who spend approximately \$3.50/RFID tag. 5) Governmental RFID tag grant programs are available should producers wish to seek assistance.

New Zealand. According to MAF (2006), 1) In August 2004, the Animal Identification and Traceability Working Group (AITWG) was established in New Zealand to evaluate current procedures of animal traceability and to make recommendations for the future. The AITWG, in cooperation with industry representatives, agreed to take steps toward an eventual whole-of-life animal identification and traceability system, beginning with cattle and deer. Specifically, the AITWG proposed "a greater harmonization of information and electronic recording of key data

in a centralized repository" in order "to use animal identification and traceability for market access, biosecurity, food safety and other related purposes." 2) Two systems of bovine animal identification in New Zealand were implemented under the Biosecurity Act of 1993 (Table 1). According to MAF (2005), the first system, operated by Livestock Improvement Board, is the Management Information System for Dairy Administration (MINDA), which is a livestock and herd management system that, although voluntary, is used by 97% of dairy farmers in New Zealand. The MINDA system was not designed for animal traceability and, consequently, has notable flaws when used for this purpose. The second system, the National Bovine Tuberculosis Identification Program (NBTIP), administered by the Animal Health Board, is a mandatory, herd-based system that requires the identification of cattle and deer 30 d old and older before movement from the property of origin. Cattle and deer are identified using a 2-ear tag system, and animal movement records are recorded using an Animal Status Declaration form. Under NBTIP, no animal death records are collected. 3) In addition to these 2 animal identification programs, many private and governmental traceability databases are available for producers' use. 4) Under these current animal identification and traceability systems, New Zealand is unable to consistently and accurately trace animals from their place of birth through the production system.

In conclusion, the AITWG (MAF, 2005) has proposed that the following data be collected and stored in a central database when New Zealand implements a mandatory animal identification and traceability program: 1) farm or premises information, 2) livestock information, 3) animal health information, 4) animal movement records, and 5) missing or dead animal information. New Zealand intended to conclude the "planning-phase" of a new animal

identification and traceability system by the end of 2006 (MAF, 2006).

Namibia. Unless otherwise indicated, all of the information in this section was derived from the Meat Board of Namibia (2002). Meat exports are an important business for the African countries of Namibia and Botswana. Due to strict importing requirements of the EU, Namibia and Botswana have implemented bovine animal identification and traceability programs to maintain access to their main export markets (Table 1). 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. 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. 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. Upon arrival at a new property, an arrival 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.

Botswana. All of the information in this section was derived from DAHP (2005). To comply with EU Regulation 1760/2000 (EU, 2000), which requires individual animal identification and a central database

for all animals destined for export to the EU, Botswana implemented the Livestock Identification and Trace-back System (**LITS**) in 2001. The LITS system identifies animals using rumen boluses with embedded RFID microchips to trace animals throughout the production chain (Table 1). Rumen boluses are used instead of ear tags to aid producers in the prevention of livestock rustling. Each rumen bolus is coded with the owner's name, a personal identification number, the brand on the animal, the position of the brand, the sex of the animal, the hide color of the animal, the location of the animal, and a date. Information about each bovine animal is uploaded to an extension officer's computer and stored on the central database in Gaborone. Group identification of animals is not allowed in Botswana. Movement of animals within Botswana and to abattoirs outside the country is allowed only after a digital movement permit is issued by the extension officer in the district where the cattle are currently located. In 2005, the Department of Animal Health and Production reported that over 1.8 million of the 3.0 million cattle in Botswana could be individually identified. There was no mention of animal termination records or premises identification in any of the information reviewed on the Botswana LITS system.

Japan. As reported by MAFF (2003), Japan mandated on December 1, 2003, that bovine animals be individually identified from birth through the production chain until purchase by consumers. At birth, each bovine animal is assigned an individual identification number, and the date of birth, gender, parents' individual identification numbers, and the breed of the animal are recorded. Cattle are identified on the farm by 2 ear tags that are imprinted with a 10-digit number and a bar code. Animal movement records are required both for outgoing and incoming cattle, and the individual animal identification number, date of the transfer, and both parties involved

in the transfer are required to be recorded in the database. Abattoirs are required to record individual animal identification numbers, the date of slaughter, and the party from which the cattle arrived at their facility (Table 1).

According to MAFF (2003) and Clemens (2003), Japan implemented in July 2002 a set of bovine animal traceability and identification laws specifically designed as countermeasures to the spread of bovine spongiform encephalopathy. This law requires animal traceability from the feedlot to the abattoir. In 2003, Japan implemented the Beef Traceability Law that requires animal identification and traceability from "distribution to consumption." This law mandates that consumers be able to obtain specific information (name and address of the producer, breed, sex, unique identification number, shipping date, ear tag number, slaughter date, and abattoir at which the animal was processed) about the beef products they purchase.

South Korea. The South Korean Beef Traceability System (**BTS**) was initiated in 2004 and will become mandatory in 2009 (BTS, 2006; MAFRoK, 2006; Table 1). Under the BTS, producer information, including farm owner's name, telephone number, address, identification number, and geographical location of the premises, are stored in a central database known as the Beef Traceability database (Click Online Agricultural News, 2004; MAFRoK, 2006). Although the BTS is voluntary through 2008, individual animal identification is required to participate (BTS, 2006; MAFRoK, 2006). Each calf must be identified within 2 wk of birth with 2 ear tags that contain a 12-digit number and a bar code (BTS, 2006; MAFRoK, 2006). For each bovine animal, individual animal identification number, date of birth, sex, breed, mother's individual identification number, feed consumed, and all medication administration data are collected and recorded in the Beef Traceability

database (Korea Plus, 2005; BTS, 2006; MAFRoK, 2006). Records are required for movements both to and from premises, and individual animal identification number, date, and reason for movement (sale, death) are required to be entered into the Beef Traceability database within one week (Click Online Agricultural News, 2004; MAFRoK, 2006). At abattoirs, inspectors from local governments enter into the Beef Traceability database the individual animal identification number, the results of post-mortem inspection, the date of slaughter, and the quality and yield grades (MAFRoK, 2006). Consumers can access breed, sex, quality grade, location of birth and subsequent premises, brand name of the product, owner's personal information, feed administered, medications given, location of slaughter, date of slaughter, date of inspection, and location of processing (Korea Plus, 2005; MAFRoK, 2006). The Korean BTS is in the preliminary trial stages, during which options such as RFID and other technologies can be implemented and evaluated (MAFRoK, 2006). South Korea intends to conclude the trial phase of the BTS in 2008 and plans to implement a mandatory whole-of-life BTS in 2009 (BTS, 2006; MAFRoK, 2006).

Brazil. The Brazilian System of Identification and Certification of Origin for Bovine and Buffalo (**SISBOV**) is the official system of animal identification in Brazil. Created in 2001 as a farm-level identification system, SISBOV was originally designed for mandatory participation to increase food safety and to meet international market demands. However, SISBOV was not warmly received by producers and hence was not implemented. In September 2006, the system was changed to include the entire beef chain rather than just the producer. Today participation is voluntary except for those producers who export. Beginning in 2008, participation in SISBOV will be mandatory (J. Stroade, Kansas State University, Manhattan, personal communication).

The SISBOV program is designed to identify animals born in Brazil, as well as animals imported into the country. The system, which is based on eartags, matches the eartags with individual animal certificates (Table 1). The certificates, which are required if an animal moves to another premises, is a certification registered with the state government. The identification and certification procedures are done by private companies that have been contracted through the government. As of November 2006, there were 69 of these private companies in Brazil. Responsibilities of the agencies include confirming the identification of the animal, checking production practices, monitoring the movement of the animals, and sanitary control. Currently it takes a producer about 30 d to get into the program; for animals already in the program, about 15 d are needed for recording of vaccination and antibiotic documentation in the system (J. Stroade, Kansas State University, Manhattan, personal communication).

Although the original intent for SISBOV was for animals to be individually identified, animal classification is by group lot. Although the national program is still identified by group lot, animals destined for export need to be individually identified as required by EU export programs. The next step in implementation of the SISBOV system is for individual animal identification and the computerization of these certificates. As of November 2006, there were approximately 35 million animals in the database. In order for an animal to be harvested, the animal must be in the database 90 d before harvest (J. Stroade, Kansas State University, Manhattan, personal communication).

Uruguay. All of the information in this section was derived from NLIS (2007). In Uruguay, every farm is registered with a 9-digit number, known as a "Dirección de Controlar de Semovientes" (DICOSE) number. The first 2 digits of the DICOSE number correspond to the

geographical location within Uruguay where the farm is located, and the following 2 digits identify the police district within that area. The final 5 DICOSE numbers identify the individual producer that owns each parcel of land. On September 1, 2006, the Ministry of Livestock, Agriculture and Fisheries implemented the National Livestock Information System (SNIG), which requires individual animal identification of all animals before they reach 6 mo of age or are transported from the property of birth (NLIS, 2007; Table 1). The SNIG system mandates that each animal be identified with one ear tag that includes a 12-digit number: the first 3 numbers identify the country of origin of the animal, in accordance with ISO 3166 or equivalent international standards, and the remaining 9 digits identify the animal individually with a unique number. All cattle must also be identified with a RFID device, either in the opposite ear of the ear tag described previously or in a rumen bolus. The RFID tag codes only for the individual animal identification number. All other required information, including DICOSE number, breed, sex, season and year of birth, and movement records are stored on the SNIG database. Producers not only must register animals with individual identification in the SNIG, but also they have the responsibility of notifying all changes of property, including movement of animals from or onto their property. For movement notification, producers must rely on the services of an operator or an authorized individual (or company) that is registered within SNIG and has equipment, software, training, and security clearance to access the SNIG database. Operators electronically notify the SNIG database of cattle movements. Termination records are recorded into the SNIG database in Uruguay by technicians of the Animal Industry Division of the Ministry of Livestock, Agriculture and Fisheries. These technicians read the RFID tags (using a hand-held device) and, subsequently, supervise the

destruction of the tags. The SNIG database stores the date and location of harvest for each animal. Meat identification from animal harvest to human consumption is not currently mandatory; however, the government of Uruguay is currently considering implementing such a system (NLIS, 2007).

In addition to countries described herein that have mandated and implemented systems of animal identification and traceability, it is also important to mention the many other countries around the world that do not have animal identification and traceability systems in place. Notwithstanding the economic burden of implementation and management of animal identification systems, religious preferences, preferences toward less governmental control of production, large land masses consisting of mainly agrarian populations that are not technologically advanced, and lack of a distribution chain for animal products are all potential reasons that countries do not implement animal identification and traceability systems, despite the animal disease control and monitoring opportunities and export markets lost. Most importantly, in many countries around the world, consumers are not willing to pay any premium for food that is identified and traceable, and therefore, animal identification and traceability systems have been market driven in many countries around the world. Meatnews.com (2007) reported that China is developing an animal traceability system that will implement RFID technology; and that system will be a part of animal husbandry laws. A search of Chinese governmental documents yielded only a mention that China would eventually like to create an animal identification and traceability system, meaning that there is no current mandate in place. In addition to China, there are many countries around the world with large numbers of cattle and no animal identification system, including but not limited to Indonesia, Myanmar, India, Bangla-

desh, Pakistan, Russia, Ukraine, and Poland. In the coming future, individual countries (or conglomerates of countries such as the EU) could possibly implement and maintain animal identification and traceability laws based on their own economic and animal health assessments, or perhaps at the urging of third-party non-governmental organizations such as the OIE.

IMPLICATIONS

Different methods of animal identification and traceability exist among countries. Technologically advanced systems that utilize RFID tags in the ear or the rumen of animals and allow for traceability throughout the production chain are in place in countries such as Australia, Uruguay, and Botswana. However, more conventional methods are used with great success in countries such as those in the EU, Japan, South Korea, Namibia, and Brazil. Key features of the systems described herein (either currently in place or soon to be in place) include 1) individual animal identification from birth until harvest (and, in some cases, until purchase by end-users), 2) animal movement records that trace animals as they are transported and identify both the location of origin and destination, 3) animal termination records that document the location of each animal's death and the cause, and 4) a central database that is able to quickly trace animals, identify cohorts in the case of disease, and, possibly, provide valuable management tools for producers. Animal identification and traceability systems are becoming important tools that can assist in assuring credible attributes with consumers. Additional benefits of animal identification and traceability include tracing of diseased animals, opening or maintaining current international markets, providing valuable management tools for producers, and improving supply chain management. This review has demonstrated that, regardless of the methods used and the motivation

behind implementation, individual animal identification is possible on a large scale.

ACKNOWLEDGMENTS

The authors gratefully acknowledge funding provided by the Colorado Department of Agriculture (CDA)-Interagency Agreement 07BAA00140 and the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). The views expressed here are those of the authors alone and should not be attributed to the CDA or USDA/APHIS.

LITERATURE CITED

- Bass, P. D., D. L. Pendell, D. L. Morris, J. A. Scanga, K. E. Belk, T. G. Field, J. N. Sofos, J. D. Tatum, and G. C. Smith. 2008. Review: Sheep traceability systems in selected countries outside of North America. *Prof. Anim. Sci.* 24:302.
- Blancou, J. 2001. A history of traceability of animals and animal products. *Rev. Sci. Tech.* Office des International Epizooties. 20:420.
- BTS. 2006. Traceability from farm to table provides a foundation stone for Hanwoo 1. Beef Traceability System. <http://www.mtrace.net> Accessed February 23, 2007.
- Clemens, R. 2003. Meat traceability and consumer assurance in Japan. Midwest Agribusiness Trade Research and Information Center Briefing Paper 03-MBP 5. Iowa State University, Ames, Iowa.
- Click Online Agricultural News. 2004. Concepts and necessity of beef traceability system. http://enews.maf.go.kr/main/php/search_view.php?idx=1073 Accessed February 23, 2007.
- DAF. 2000. Ireland competent authority, model of passport, eartags and holding register. Department of Agriculture and Food, Maynooth, Ireland. <http://www.agriculture.gov.ie/bovineld/ireland.pdf> Accessed February 23, 2007.
- DAF. 2003. Irish bovine animal identification tracing system and computerized database (CMMS). Department of Agriculture and Food, Maynooth, Ireland. http://www.agriculture.gov.ie/foi_2002/sect16_manual/nbas.pdf Accessed February 23, 2007.
- DAFF. 2006. Report of findings from a review of the operation of the National Livestock Identification System. Department of Agriculture, Fisheries, and Forestry, Canberra, Australia. http://www.daff.gov.au/_data/assets/pdf_file/0019/117325/nlis-report.pdf Accessed February 22, 2007.
- DAHP. 2005. Department of Animal Health and Production. Gaborone, Botswana. http://www.witfor.org.bw/themes/documents/Livestock_Identification_and_Trace-back_System.pdf Accessed February 18, 2007.
- DEFRA. 2007. Livestock movements, livestock identification: Cattle - general information on identification and traceability. Department of Environment, Food and Rural Affairs, London, England. http://www.defra.gov.uk/animalh/id-move/cattle/id_info.htm Accessed February 23, 2007.
- EU. 2000. Establishing a system for the identification and registration of bovine animals and regarding the labeling of beef and beef products and repealing Council Regulation no. 82/97. No. 1760/2000. http://www.fsai.ie/legislation/food/eu_docs/Meat_Fresh/Reg1760_2000.pdf Accessed November 26, 2007.
- EU. 1997. Establishing a system for the identification and registration of bovine animals and regarding the labeling of beef and beef products. No. 82/97. http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31997R0820&model=guichett Accessed February 23, 2007.
- FAOSTAT. 2008. Livestock: Primary and processed. <http://faostat.fao.org/site/573/DesktopDefault.aspx?PageID=573> Accessed February 7, 2008.
- King, L. W. 1910. The Code of Hammurabi (translation). <http://www.wsu.edu/~dee/MESO/CODE.HTM> Accessed February 23, 2007.
- Korea Plus. 2005. Beef "genealogy" at a glance: The end of concerns at the table. http://koreaplus.korea.kr/koreaplus/jsp/koreaplus1_branch.jsp?action=news_view&property=f_sec_3&id=80061024 Accessed February 23, 2007.
- MAF. 2005. A proposal for an enhanced national animal identification and traceability system. Ministry of Agriculture and Forestry, Wellington, New Zealand. http://www.deernz.org.nz/upload/notion/sectionimages/2221_Animalid.PDF Accessed February 22, 2007.
- MAF. 2006. Animal identification and traceability. Ministry of Agriculture and Forestry, Wellington, New Zealand. <http://www.maf.govt.nz/mafnet/animal-identification-and-tracing.htm> Accessed February 22, 2007.
- MAFF. 2003. Beef traceability law. Ministry of Agriculture, Forestry and Fisheries, Tokyo, Japan. http://www.maff.go.jp/trace/beef_trace18.pdf Accessed February 26, 2007.
- MAFRoK. 2006. Instruction manual for a model beef traceability system. Ministry of Agriculture and Forestry, Gwacheon, Republic of Korea.

- Marchant, J. 2002. Secure animal identification and source verification. http://www.optibrand.com/uploadedfiles/Animal_ID.pdf Accessed February 25, 2007.
- Meat Board of Namibia. 2002. Farm assured Namibian meat scheme manual. <http://www.nammic.com.na/pdf/fan.pdf> Accessed February 21, 2007.
- Meatnews.com. 2007. China develops traceability system on beef. <http://www.cattle.guelph.on.ca/weekly-updates/Updates-2007/2007-03-09-wu.pdf> Accessed March 7, 2007.
- Meisinger, J. L., D. L. Pendell, D. L. Morris, K. E. Belk, and G. C. Smith. 2008. Review: Swine traceability systems in selected countries outside of North America. *Prof. Anim. Sci.* 24:295.
- MLA. 2007. National livestock identification system. Meat and Livestock Australia. <http://www.mla.com.au/TopicHierarchy/IndustryPrograms/NationalLivestockIdentificationSystem/Producers+and+Feedlots.htm> Accessed November 26, 2007.
- Murphy, R. G. L., D. L. Pendell, D. L. Morris, J. A. Scanga, K. E. Belk, and G. C. Smith. 2008. Review: Animal identification systems in North America. *Prof. Anim. Sci.* 24:277.
- NLIS. 2007. Identification and Register Animal System. National Livestock Information System. Ministry of Livestock, Agriculture and Fisheries, Oriental Republic of Uruguay.
- OIE. 2006. General Definitions. Terrestrial Animal Health Code. Article 1.1.1.1. World Organization for Animal Health. http://www.oie.int/eng/normes/Mcode/en_chapitre_1.1.1.1.htm Accessed January 23, 2007.
- SAFEMEAT. 2007. Traceability. <http://www.safemeat.com.au/English/Traceability/> Accessed February 15, 2007.