Importance of the traceability of animals and animal products in epidemiology

V. Caporale, A. Giovannini, C. Di Francesco & P. Calistri
Istituto Zooprofilattico Sperimentale dell’Abruzzo e del Molise ‘G. Caporale’, Via Campo Boario, 64100 Teramo, Italy

Summary
Traceability of animals and animal products has become a priority for governments of the developed countries, due to consumer demand for comprehensive and integrated food safety policies. In addition to analysing the differences between traceback and traceability systems, the authors describe some applications of animal traceback systems and the principal characteristics of an animal identification and registration system. The importance of a traceability system for food-borne risk assessment and management, and the most recent approaches towards a comprehensive and integrated animal health and food safety policy are reported.

Keywords

Introduction
Consumer confidence in food safety has decreased considerably since the recent episodes of food-borne Escherichia coli O:157 infection in the United States of America (USA) and Europe, and the bovine spongiform encephalopathy (BSE) and dioxin crises in Europe. Globalisation of trade and industrialisation of food processing have exposed consumers to a greater number of hazards. The elimination of trade barriers and the complexity of the food processing chain may cause problems due both to the range and quantity of food products available and to the speed of dissemination of infection or contamination linked to food consumption.

Consumers increasingly insist on a comprehensive and integrated food safety policy (the so-called ‘farm to table’ policy), which has consequences both for producers and for control authorities (2). For the producer, this implies the following:

a) that full responsibility is assumed by animal feed manufacturers, farmers, the food industry and retailers for the quality of the products marketed, in relation to the safety of the final products
b) that animal feed, food products and all ingredients are fully traceable.

For the control authority, the tasks are as follows:
a) undertake proper risk analysis to describe and quantify risks along the food chain, including animal feed quality and animal health, to either eliminate or mitigate these risks by the application of proper safeguards
b) provide sound scientific advice to consumers regarding the risks of particular food products or food types.

Traceability is widely recognised to be the basis of any modern food safety control system integrating both animal health and food hygiene components. However, the exact meanings of ‘traceability’ and ‘traceability system’ have never been clearly defined and, in particular, the differences between a traceback system and a traceability system have never been analysed in depth.

The verb ‘trace’ refers to the following:
a) to follow the footprints, track, or trail of
b) to follow or study in detail or step by step
c) to discover by going backwards over the evidence step by step
d) to discover signs, evidence, or remains of.

It derives from the Vulgar Latin tractiare to drag, from Latin tractus, past participle of trahere (to pull) (10). The word
'traceability' is a neologism employed in very specific contexts. For example, the United States Environmental Protection Agency defines 'traceability' as 'the ability to trace the history, application, or location of an entity by means of recorded identifications' (12).

Traceback systems have been implemented for the purposes of animal health, as part of surveillance, to provide the information required to implement control measures against disease. Similar systems have been implemented for the food production industry to provide the information needed to recall and to remove any contaminated product from the market.

Traceability systems have a broader scope and aim to document the history of a product along the entire production chain from primary raw materials to the final consumable product. The scope of these systems is not limited to the ability to detect and trace batches of high risk animals or products, but to support quality assurance processes for animals or products. Quality is defined as 'the totality of characteristics of an entity that bears its ability to satisfy stated and implied needs' (9).

Therefore, in the fields of animal health and food safety, traceability can be defined as the ability to document all relevant elements – movements, processes, controls – needed to define an animal/animal product life history. In this sense, traceability becomes the principal tool to both ensure the effective responsibility of feed manufacturers, farmers and food operators in relation to the final product quality and to assess and manage risks effectively.

**Traceability of animals**

The primary goal of an animal traceback system is to provide information on the source of infection or prohibited additives so that preventive and control measures can be applied to avoid the introduction of the contaminant.

For the purposes of veterinary medicine, the need to trace the origin of animals arises as soon as control programmes for infectious disease are implemented in a population. In many cases, the success of a control programme is linked to the ability to trace the origin of an infected animal. An early example of traceback is the Market Cattle Identification (MCI) programme first applied in the 1950s in the USA (11). The MCI programme was based on the identification and registration of marketed cattle, which allowed traceback of infection to the herd of origin from animals which gave positive test results at slaughter.

Epidemiological surveillance is a system for information collection and analysis, aimed at continuous monitoring of the health status of a population, to plan and implement actions for prevention and control of disease. The existence of an identification and registration system for animals and animal holdings is often crucial for proper action planning. An example of an epidemiological surveillance system based on identification and registration of bovine animals is the Israel Computerised Animal Health Monitoring System (ICAHMS) (13). The ICAHMS was implemented in 1961, to provide relevant information on epidemic emergencies, to facilitate epidemiological investigations and to provide information to plan appropriate strategies for animal disease control.

Modern technologies (e.g. the Internet, software for the management of geographical information, etc.) can be applied to build on-line systems to increase the efficacy and the efficiency of the management of epidemic emergencies (1). Such systems supply information on the origin and movements of animals very rapidly, when speed in tracing infection sources and disease spread analysis is crucial to plan and implement proper action.

Animal identification and registration is the foundation of any traceability system for animals and animal products.

Animals can be identified either individually or as homogeneous groups, depending on the objectives of the system. A range of identification tools can be used in the implementation of a traceability system based on identification of the single animal (e.g. brands, tattoos, ear tags and electronic transponders). However, the identification must be permanent, tamper-proof and cause no harm to the animal. Identifiers should not be reused, and must be easy to apply and read.

An animal identification and registration system must identify and archive both animals and holdings or herds. The concept of a holding can be defined differently according to local conditions. For example, in the European Union (EU), holding means 'any establishment, construction or, in the case of an open-air farm, any place in which animals are held, kept or handled' (5). In other farming conditions, pastures, villages, etc., can fit the concept of a holding.

The concept of a herd or flock can be used to identify different groups of animals kept inside a holding and having the same epidemiological or health characteristics. In the EU, herd means 'an animal or group of animals kept on a holding as an epidemiological unit; if more than one herd is kept on a holding, each of these herds shall form a distinct unit and shall have the same health status' (4).

To allow complete traceability of animals, an ideal animal registration system should be able to supply at least the following information:

- a) the list of all animals (or groups of animals depending on the chosen identification unit) present in a holding (or herd/flock)
- b) the dates and the list of all movements – changes of holding (or herd/flock) – of each animal (or group of animals) from birth to death/slaughter.
Animal registration systems must also record the interactions between entities. The laying down of rules and procedures to be followed to report and to record interactions between entities and to update, verify, validate, process and store all information, is crucial. The implementation of a database, where all information regarding the origin, movements and death of animals is recorded, is a considerable organisational challenge. Therefore, an efficient animal registration system must be based on clear rules and procedures that all stakeholders (animal keepers, veterinary services, associations of farmers, slaughterhouses, etc.) must follow, to assure the integrity of the entire system. If procedures are not followed strictly, even by single participants or within limited geographical areas, the system could rapidly become invalid. In other words, an animal registration system, like a puzzle, requires that all the ‘pieces’ be present and in the right sequence, in order to show the complete final image.

**Traceability of animal products**

An integrated production chain control system should be able to identify and document the following with accuracy:

- **a)** all materials and ingredients used
- **b)** production processes
- **c)** personnel involved
- **d)** final products.

This identification and documentation has the following aims:

- **a)** to increase confidence in product safety
- **b)** to control public health risks derived from product use/consumption
- **c)** to facilitate disease control procedures, including sampling
- **d)** to identify the source of possible contamination
- **e)** to facilitate the product recall procedure.

The globalisation of trade complicates the identification of the origin of materials used for either feed or food preparation. Furthermore, the lack of harmonisation of labelling requirements, in particular at the international level, often precludes traceback of an ingredient or raw material to the source. However, to imagine that acceptable food safety systems precludes traceback of an ingredient or raw material to the requirements, in particular at the international level, often

Furthermore, the lack of harmonisation of labelling requirements, in particular at the international level, often precludes traceback of an ingredient or raw material to the source. However, to imagine that acceptable food safety systems precludes traceback of an ingredient or raw material to the requirements, in particular at the international level, often

**Importance of traceability for assessment and management of food risks**

The existence of an adequate and integrated traceability system, covering both animals and animal products, is essential to perform effective risk assessment along the production chain. This is true both for animal health and food safety relating to foods of animal origin.

In particular, an effective food safety policy must recognise the inter-linked nature of food production, and thus, the need for an accurate system to assess and monitor the risks associated with raw materials, farming practices and food processing. A sound food safety policy requires effective regulatory action to manage risks and the implementation of an effective control system to monitor and enforce regulations. Each element is a part of a chain; thus, changes in farming practice, feed and food production and processing often require amendments to existing regulations, while feedback from the control systems help to identify and manage both existing and emerging risks. Each part of the cycle is critical to ensure that the highest safety standards are enforced (2).

The identification of high-risk components in food production (e.g. feed production, animal rearing, transportation, pre-slaughter processing, slaughter, further processing, retailing or consumption practice) requires knowledge of the flow of trade from raw materials, semi-manufactured and final product lots, to the final product sold to the consumer.

In the absence of an effective traceability system, this knowledge can only be achieved through exhaustive monitoring of the entire production system. In contrast, an effective traceability system would allow the collection of all necessary information at critical points of the production chain, resulting in a clear improvement in the efficiency of the data collection process. The simplification of monitoring becomes particularly relevant in the case of very rare events, by avoiding the risks from overly complicated systems based upon hypothetical problems. Collection of data for risk assessment could be performed retrospectively, following the same principles used for case-control studies.

**Comprehensive and integrated animal health and food safety policies**

Consumers in many areas of the world are increasingly voicing wide-ranging demands relating to the health of animals and the safety of animal products. These include animal welfare,
traceability, good environmental management practices and genetic makeup of animal feed components. In summary, consumers want to be provided with more information about the source of food and details of the ways and means of production (3).

Traceability of animals and animal products along the entire production chain is an important issue for consumers, and this consumer demand has forced governments to make traceability of products a priority issue.

In food safety policies based on ‘hazard analysis and critical control point’ (HACCP), such as those applied in the industrialised countries, producers are asked to guarantee the quality of animal products by documenting that all steps of the food chain, from feed safety and animal health status, to final product wholesomeness, are clearly known and under control so that appropriate corrective actions can be taken if required. However, responsibility for inspection and auditing procedures and tests, including random sampling and analysis, to assess and certify that the system is working properly falls upon the competent control authority (e.g. veterinary service or food safety agency).

Nevertheless, the application of HACCP systems does not imply the existence of a traceability system as a direct consequence of the documentation procedures. Although one of the HACCP principles (principle number 7) states the need to establish documentation and record-keeping procedures, and although these procedures can provide useful information for a traceability system, the aims and scope of documentation in HACCP are different. In the latter, the aim is to document that the system is under control, that corrective actions are always taken when pre-defined critical limits are exceeded, and that recall of unsafe products is undertaken when required.

Some industrialised countries are attempting to implement effective traceability systems. However, most of these attempts are based on a voluntary application of specific programmes by food producers. In the case of the Program for Certifying Non-Hormone Treated Beef to the European Union of the Food Safety and Inspection Service (FSIS) in the USA (8), specific standards are defined to guarantee the traceability of beef to be shipped to the EU.

The first comprehensive answer to the traceability challenge was provided by the EU in the beef and veal sector, as a

Fig. 1
Example of a bovine meat traceability system using electronic transponders
consequence of the BSE crisis. In particular, the European Commission implemented a system for the identification and registration of bovine animals at the production stage and created a beef labelling system specific to the EU (6).

The EU legislation requires that bovine meat be labelled in such a way as to provide information concerning the identification of the animal (or batch), the slaughterhouse and the cutting facility, if any. As of 1 January 2002, labels will also have to provide information on the country of birth of the animal and on all those countries in which the animal lived.

Such a system requires a consistent connection between multiple identification and registration systems which is almost impossible to achieve in the absence of an integrated automatic information system.

New technologies can facilitate the exchange of data. A large-scale electronic identification project (IDEA project: identification électronique des animaux) has been promoted by the European Commission. The aim of this ongoing project is to evaluate both the on-farm performances of electronic identification (EID) devices in cattle, sheep and goats, and the feasibility of EID in a realistic scenario involving animals and animal products in the EU. The three-year project involves nearly one million animals in six member countries and, if the results are satisfactory, EID may be recognised as an official system for animal identification under EU policies. Thus, EID will be applied to a potential livestock population of approximately 300 million animals in Europe.

This new experience provides the opportunity to envisage efficient traceability systems based on electronic identification of animals and telematic networks (e.g. the Internet) which will lead to the implementation of automated registration systems. An example is the beef traceability system hypothesised in Figure 1, the components of which are as follows:

a) a database containing identification and all relevant animal data

b) electronic identification of each animal using transponders encapsulated either in ear tags or in an endoruminal bolus

c) automatic registration of animal identification data at slaughterhouses and transfer of identity and relevant information on the animal to the carcass and meat cuts using electronic labels (‘Tag-it’)

d) reading and printing of tag data by the retailer (butcher) who makes this information available to consumers.

Deoxyribonucleic acid (DNA) profiling is under study as a possible means to audit the entire production system from the identity of animals, to carcasses and meat cuts.

Importance épidémiologique de la traçabilité des animaux et des produits d’origine animale

V. Caporale, A. Giovannini, C. Di Francesco & P. Calisti

Résumé
La traçabilité des animaux et des produits d’origine animale est devenue une priorité pour les gouvernements des pays industrialisés, les consommateurs exigeant la mise en place de politiques de sécurité alimentaire globales et intégrées. Après avoir analysé les différences existant entre les systèmes de traçage ascendant et de traçabilité, les auteurs décrivent quelques exemples relevant du premier système ainsi que les principales caractéristiques d’un système d’identification et d’enregistrement des animaux. L’importance d’un système de traçabilité pour l’évaluation et la gestion du risque de toxine-infection alimentaire, ainsi que la tendance récente visant à mener une politique intégrée et globale de sécurité alimentaire et de santé animale font également l’objet de la discussion.

Mots-clés
Importancia de la rastreabilidad de animales y productos de origen animal en epidemiología

V. Caporale, A. Giovannini, C. Di Francesco & P. Calisti

Resumen
La demanda de políticas globales e integradas de protección alimentaria por parte de los consumidores de los países industrializados ha hecho de la rastreabilidad de los animales y sus derivados un tema prioritario para los gobiernos de esos países. Además de analizar las diferencias entre los sistemas de rastreabilidad y los de determinación del origen, los autores describen algunas aplicaciones de estos últimos y las características principales de un sistema de identificación y registro. También aluden a la importancia que reviste un sistema de rastreabilidad para evaluar y gestionar los riesgos de toxi-infecciones alimentarias, y describen los planteamientos más recientes para elaborar políticas de protección alimentaria de carácter global e integrado.

Palabras clave

References
