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The use of geographic information systems for foot and mouth disease surveillance in Argentina

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Summary

A model developed as a complementary tool in the surveillance of foot and mouth disease (FMD) was based on two main components: data and basic cartography. The data was obtained from the veterinary services of Argentina. It included different animal species, movement records and data on vaccination campaigns. The basic cartography was produced from cadastral maps of four departments of Buenos Aires province that were scanned, incorporated to a geographic information system and then overlapped to satellite images to adjust the borders of farms to the correct coordinates. Digital maps of the four departments were obtained, with all premises represented as polygons. Then, each premise was identified with its unique code, provided by the veterinary services. The data was processed and then linked to the maps. The output of the model are maps of different types, in which it is possible to characterise animal population at farm level, to analyse the evolution of the systematic vaccination campaigns against FMD, to determine patterns of animal movements and others.

Keywords

Argentina, Epidemiology, Foot and mouth disease, Geographic information system, Surveillance.

Utilizzo di sistemi d'informazione geografica per la sorveglianza dell'afta epizootica in Argentina

Riassunto

E' stato sviluppato un modello come strumento complementare nella sorveglianza dell'afta epizootica basato su due componenti principali: i dati e la cartografia di base. I dati sono stati ottenuti dai servizi veterinari argentini: essi includono le diverse specie animali, le registrazioni dei movimenti e i dati sulle campagne di vaccinazione. La cartografia di base è stata prodotta seguendo le mappe catastali di quattro dipartimenti della provincia di Buenos Aires che sono state scannerizzate, incorporate in un sistema d'informazione geografica e, in seguito, sovrapposte a delle immagini satellitari per adeguare i confini degli allevamenti alle coordinate corrette. Sono state ottenute delle mappe digitali dei quattro dipartimenti, con tutti i fabbricati rappresentati come poligoni; e in seguito ogni fabbricato è stato identificato con un codice unico, fornito dai servizi veterinari. I dati sono stati trattati e collegati alle mappe. I risultati del modello sono mappe di tipi differenti, nelle quali è possibile descrivere la popolazione animale a livello di allevamento, analizzare l'evoluzione delle campagne sistematiche di vaccinazione contro l'afta epizootica e

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determinare il quadro dei movimenti degli animali e altro.

Parole chiave

Afta epizootica, Argentina, Epidemiologia, Sistema informativo geografico, Sorveglianza.

Introduction

Prior to the 1990s, foot and mouth disease (FMD) had been endemic in Argentina for many decades. Between 1990 and 1992 a new control strategy was implemented, based on the compulsory vaccination of all cattle with an oil-adjuvanted vaccine, active participation of producers and effective epidemiological surveillance.

As a consequence of this new strategy, cases of FMD progressively decreased. Vaccination was stopped by the veterinary services in April 1999, after several years without clinical or serological evidence of the circulation of FMD virus. In May 2000, Argentina was recognised as being 'FMD-free without vaccination' by the World Organisation for Animal Health (OIE: Office International des Épizooties).

In August 2000 an epidemic affected almost all provinces located to the north of the Colorado River. It extended until January 2002. During this period, 2 563 outbreaks (farms with one or more diseased animal) were detected. The peak of the epidemic curve was in May-June 2001. Movement restrictions and a ring vaccination strategy were implemented to reduce the spread of the virus. In March 2001, the systematic and compulsory vaccination strategy was re-implemented.

Since that epidemic, two new occurrences of FMD virus were detected (in 2003 and 2006); both were situated close to the northern border of Argentina and affected one premises in the first case and two premises in the second.

Currently, the principal strategy to prevent and control FMD in Argentina is the systematic vaccination of all cattle located north of the Colorado River. However, many other activities, most of them conducted in the field of epidemiological surveillance, are also performed. All these actions are implemented by the *Servicio Nacional de Sanidad y Calidad Agroalimentaria* (SENASA), the Argentine animal health service, with the participation of other public institutions, producers and the private sector.

We present a model that includes data obtained from different SENASA databases that were incorporated into a geographic information system (GIS). The objective of the work was to develop a model that could be used as a complementary tool for surveillance of FMD and other diseases.

Materials and methods

The model had two principal components, namely: data and basic cartography.

The input data for the model was mainly obtained from the *Sistema de Gestión Sanitaria* (SGS), a database developed and administrated by SENASA. In the SGS, all producers are identified by a unique code called a *registro nacional de productores agropecuarios* (RENSPA) or national register for agricultural producers. The data of interest were as follows:

- location and description of premises
- stock of different FMD-susceptible livestock species
- records of FMD vaccination
- records of animal movements.

The location of premises consisted in the definition of province, department and closest locality. Argentina has a land area of 2 800 000 km^2 divided into 23 provinces and over 500 departments (Fig. 1). Other data of interest included area (in hectares), predominant species, production system, among others.

Data on different FMD susceptible species were obtained from two sources. For cattle, the most up-to-date data were obtained from the SGS, from records of FMD vaccination campaigns which are performed twice a year on all cattle. For pigs, sheep and goats, population distribution data were obtained from the national agricultural census conducted in 2002 by the *Instituto Nacional de Estadística y Censos* (INDEC), the national statistics and census institute. At the time the census was conducted, the national sheep and

pig populations totalled approximately 12 million and 2 million, respectively. Approximately 56 million cattle were vaccinated during the first vaccination campaign in 2006.

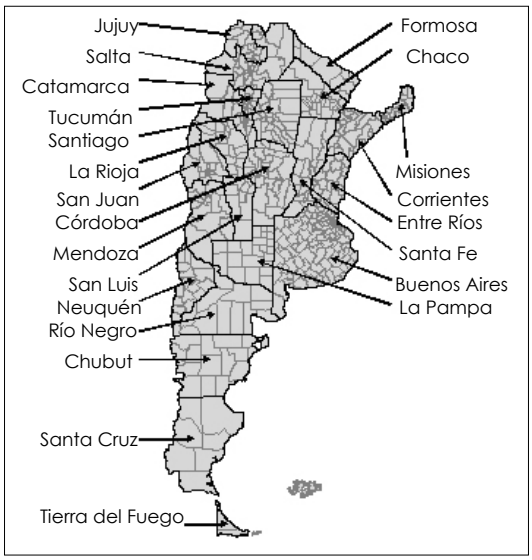

Figure 1
Provinces and departments of Argentina

FMD vaccination is conducted twice a year in Argentina. In each campaign, the aim is to vaccinate all cattle within a period of two months. Campaigns are coordinated and performed by private producer organisations (called 'ENTEs') that are evaluated by SENASA. There are over 300 ENTEs, each in charge of an area that has a varying number of premises. Vaccination of premises may be implemented in a single session (total vaccination) or in more than one session (partial vaccinations). After vaccination has been performed, a certificate is given to the producer, indicating the date of vaccination, the type of vaccination (partial or total), the number of vaccinated animals per age category, the brand of vaccine used and the name of the vaccinator. The data are stored in local databases and regularly transferred to SENASA.

In regard to movements of FMD-susceptible animals, not all species are treated in the same way. Sheep, goats and pigs are mostly moved only once, from premises of origin to markets or slaughterhouses. Very little movement occurs between premises. For cattle, the situation is different: calves are born mostly during the late winter and early spring (July to September) in breeding units located in areas where the quality of soil is relatively poor and pastures are unimproved. After weaning (March to April), calves are moved to finishing units in areas with better soil and improved pastures. Once steers and heifers have reached market weight they are sent to slaughter; either directly from finishing farms or via animal markets (5).

To transport live animals, livestock producers must first declare to local health authorities all details related to the intended movement, including the RENSPA initiating the movement, the date on which the movement will occur, the species of animals involved, the number of animals per age category, the reason for movement and the destination premises (the RENSPA of the recipient farm, market or slaughterhouse). Records of all movements are stored at the local level and backups are sent to the central headquarters of SENASA on a regular basis.

The data was obtained from the SGS databases in dbf format and then were imported to MS Access© where the data was categorised according to needs and then was recorded, sorted and manipulated in different ways so as to perform searches in the appropriate format to be exported to the GIS programme. For instance, data concerning vaccination were grouped in periods of 15 days (for each vaccination campaign). The proportion of vaccinated animals on premises was classified into five categories: 0%, <33%, 33-66%, 66.01-99.99% and 100%. Cattle movements were classified according to their purpose (finishing, market, reproduction or others), their movement to or from farms, access to destination premises (direct farm to farm, or indirect through markets). Movements were grouped by different times of the year.

The second component of the model was the basic cartography. Maps of four departments of Buenos Aires province were used showing premises in the form of polygons. The basic information was obtained from cadastral maps, which were scanned and processed in

ArcView 3.2™. Satellite images of the departments were superimposed onto the scanned cadastral maps to adjust the borders of farms to the correct coordinates. The Gauss Krüger projection method was used for the maps. Once the maps were completed, each polygon was identified with its corresponding RENSPA.

Access© queries were joined to the ArcView™ tables. Different maps were then drawn (characterisation of animal population for each department, progress status of vaccination campaigns, movement patterns and others).

Results and discussion

Figure 2 presents an example of the basic cartography (department of Coronel Brandsen, in Buenos Aires province, where 541 premises were represented as polygons). The total cattle population of the department totalled 160 000 head.

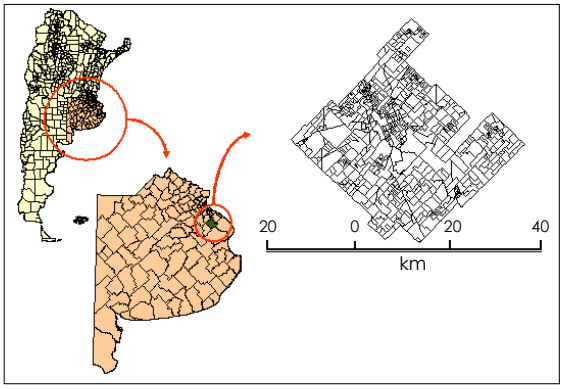

Figure 2
Department of Coronel Brandsen, province of Buenos Aires: 541 premises represented as polygons, containing about 160 000 cattle

In regard to the distribution of the FMD-susceptible population, Figures 3, 4 and 5 show the distribution of cattle, sheep and pigs by department, respectively. Over 90% of the national cattle population are located in the central-eastern areas of the country. Two thirds of the national sheep population is located in Patagonia. For the rest of the country, there are two main areas of livestock concentration: the provinces of Corrientes and Buenos Aires. Many cattle producers have small flocks for domestic consumption and

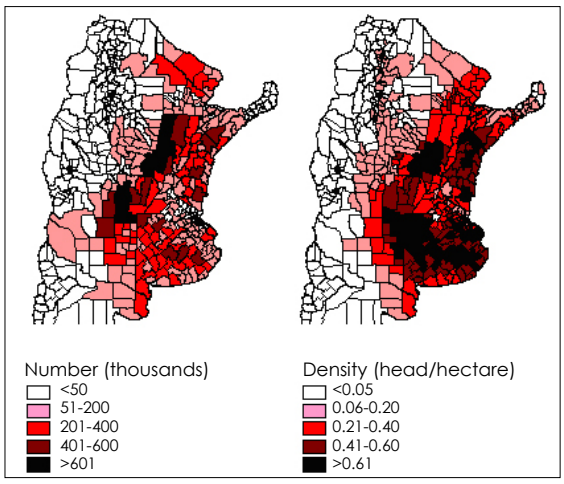

Figure 3
Cattle distribution by department, Argentina (excluding Patagonia)

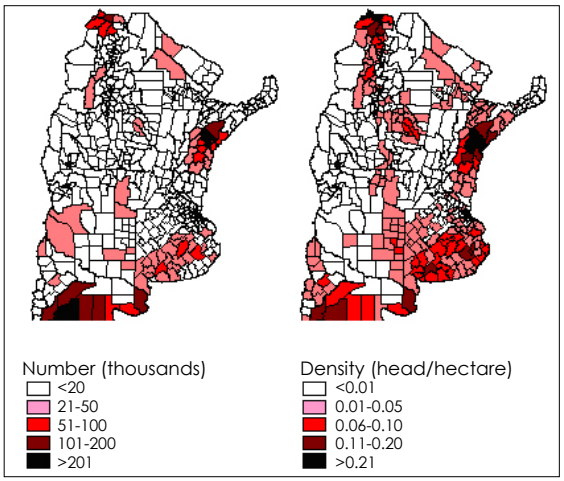

Figure 4
Sheep distribution by department, Argentina (excluding Patagonia)

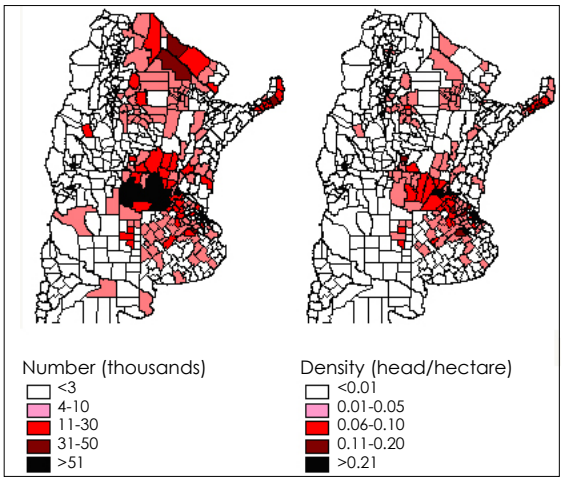

Figure 5
Pig distribution by department, Argentina (excluding Patagonia)

both species may be in relatively close contact. Pigs are concentrated in the central area of the country, the heart of cereal production.

The characterisation of population distribution is important to identify risk areas. Ward and Perez (6) found that the variable that most strongly correlated with the density of outbreaks in Buenos Aires province was herd distribution. Figure 6 shows three population distribution indicators for the department of Daireaux. In this department, 360 000 cattle were distributed in about 600 premises. High animal density areas were identified after establishing the number of animals per premises. The density of animals is in direct relation with the risk of spread of FMD virus. Breeding and finishing premises were identified using the ratio of young bulls/cows, which were generally values <0.8 and >1.2, respectively). Finishing units receive animals, therefore the risk of introduction of FMD virus may be greater than in other establishments. Breeding units export animals and for that reason they may be the origin of virus spread to other premises.

In regard to vaccination, an example of the procedure followed is given in Figure 7, where the evolution of the first FMD vaccination campaign in 2004 in the department of Coronel Brandsen is presented. In this case, 160 000 cattle located in 541 premises should have been vaccinated in two months, starting on 16 February. The objective was not accomplished, since coverage reached 100% on all premises three months after the campaign was launched. ENTEs follow different vaccination strategies. In some cases, they start with premises with the highest number of

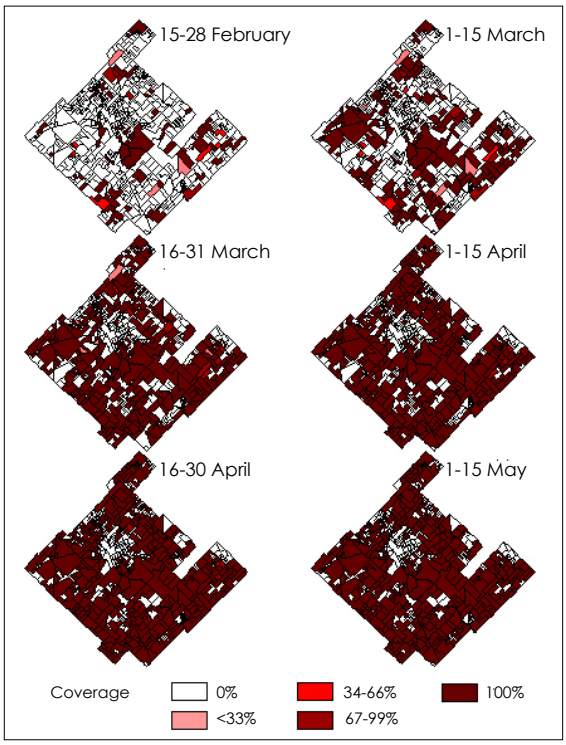

Figure 7
First foot and mouth disease vaccination campaign in 2004, Department of Coronel Brandsen, province of Buenos Aires
Evolution of coverage by premises every fortnight

Figure 6
Department of Daireaux, province of Buenos Aires: number of cattle, density (animals/hectare) and ratio of young bulls/cows per premises

cattle, reaching a high proportion of vaccinated animals within a short time. Others follow a geographic order, starting for instance from the premises placed in the north of their area and moving southwards. Finally, others vaccinate according to availability of producers. This last procedure appears to be the one followed by the Coronel Brandsen ENTE.

Figure 8 presents cattle movements into and out of the department of Monte, Buenos Aires province, in April, May and June 2004, by department of origin and destination, respectively. These movements are only for finishing purposes and are direct, from farm to farm. The second quarter of the year is normally when the bulk of finishing movements take place in Argentina. In the case of Monte, some of the introductions of animals came from the north of the country. Given that exotic disease incursions into Argentina are likely to enter from the north (4), particular attention should be given to those animals. This example is part of a study that has been published recently by Leon *et al*. (3).

Movements of individuals or groups of animals from one farm location to another involve an interaction of all three vertices of the triad of animal, space and time. Where diseased individuals are being moved or if these animals carry infection at the time of movement, direct and indirect contact that arises from mixing increases the risk of introducing disease into populations previously free of disease (1). A working knowledge of source and destination areas is important in the early phase of an exotic disease incursion (should one occur) by providing a better focus for tracing activities (2).

Conclusion

To conduct surveillance of FMD, the following basic data are necessary:

- distribution of the susceptible population
- immunity level of the population
- movements of susceptible individuals
- frequency and distribution of cases of the disease
- frequency and distribution of risk factors
- others.

The epidemiological analysis of these data generates the information required for making decisions and implementing actions.

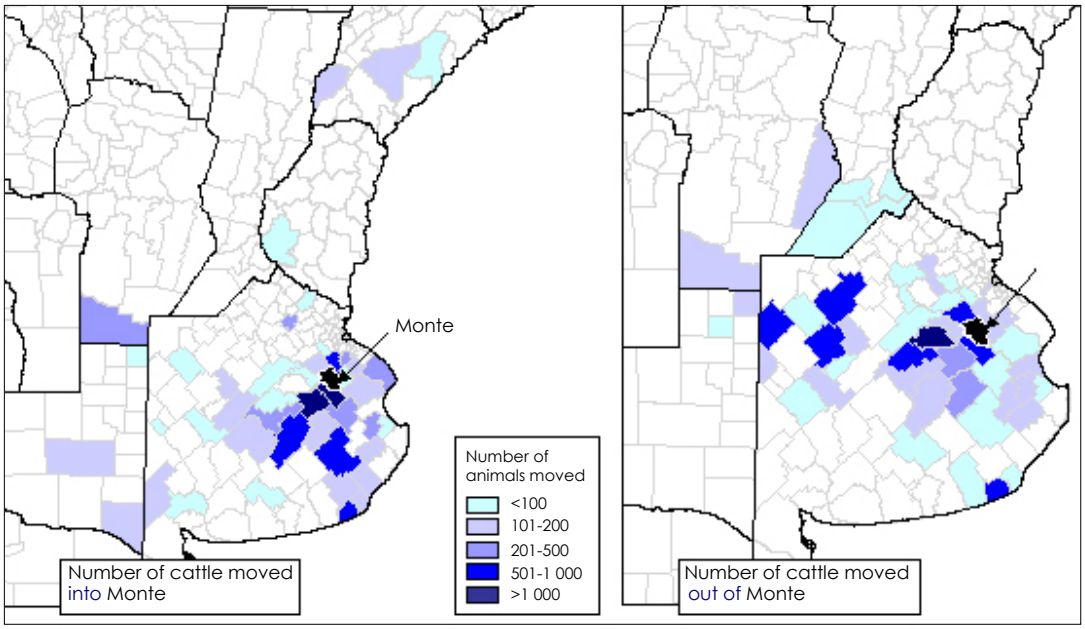

Figure 8
Department of Monte, province of Buenos Aires: movements of cattle for finishing purposes into and out of the department (by department of origin or destination respectively), April, May and June 2004

The use of GIS provides a complement for the analysis and presentation of results and is a helpful tool for epidemiological surveillance of FMD and other diseases.

Acknowledgement

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