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Evaluation of the risk of classical swine fever (CSF) spread from backyard pigs to other domestic pigs by using the spatial stochastic disease spread model Be-FAST: The example of Bulgaria

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ABSTRACT

The study presented here is one of the very first aimed at exploring the potential spread of classical swine fever (CSF) from backyard pigs to other domestic pigs. Specifically, we used a spatial stochastic spread model, called Be-FAST, to evaluate the potential spread of CSF virus (CSFV) in Bulgaria, which holds a large number of backyards (96% of the total number of pig farms) and is one of the very few countries for which backyard pigs and farm counts are available. The model revealed that, despite backyard pigs being very likely to become infected, infections from backyard pigs to other domestic pigs were rare. In general, the magnitude and duration of the CSF simulated epidemics were small, with a median [95% PI] number of infected farms per epidemic of 1 [1,4] and a median [95% PI] duration of the epidemic of 44 [17,101] days. CSFV transmission occurs primarily (81.16%) due to indirect contacts (i.e. vehicles, people and local spread) whereas detection of infected premises was mainly (69%) associated with the observation of clinical signs on farm rather than with implementation of tracing or zoning.

Methods and results of this study may support the implementation of risk-based strategies more cost-effectively to prevent, control and, ultimately, eradicate CSF from Bulgaria. The model may also be easily adapted to other countries in which the backyard system is predominant. It can also be used to simulate other similar diseases such as African swine fever.

1. Introduction

Classical swine fever (CSF) is a highly contagious viral disease of pigs and wild boars that causes severe economic impact due to the trade restrictions imposed on the affected countries. Considering that the pig sector in the European Union (EU) maintains a high level of production and exports, contributing more than €32 billion per year to

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the EU's economy (Food Chain Evaluation Consortium, 2011), the eradication of CSFV has become a chief priority in the EU.

Yearly, the EU invests a substantial amount of money in the co-financing of CSF monitoring and eradication programs in several Member States (MS). As an example, the EU funding for the eradication of CSF from 2005 to 2009 amounted to €17 million (Food Chain Evaluation Consortium, 2011). This financial effort has resulted in a significant reduction of the CSF outbreaks in most of the countries, with the practical eradication of the disease in domestic pig populations. Nevertheless, sporadic CSF outbreaks still occur in many European countries. For example, from January 2005 to July 2012 a total of 351 outbreaks were notified in Europe, affecting countries such as Hungary (142 outbreaks), Croatia (130), Russia (49), Bulgaria (11), Germany (8), Lithuania (6), Slovakia (3) and Serbia (2) (WAHID, 2012). Most of these CSF outbreaks have been associated either with low biosecurity premises (mainly backyard pigs) and/or with wild boar.

Certainly, backyard pigs have been recognized as key players for disease (not only CSF) occurrence (Food Chain Evaluation Consortium, 2011; Lupulovic et al., 2010; Pozio et al., 2010); however, there are no studies addressing and quantifying their epidemiological role in the CSFV endemicity and/or in the potential CSFV transmission to other domestic pigs. This lack of studies is, most likely, associated with the scarceness of complete and reliable information about backyard pig demographics and contact patterns, which are key factors to estimate disease transmission in countries/regions where backyard pig production is predominant. Certainly, a better understanding of the role that backyard pigs have in CSFV transmission will enhance the CSF eradication program, helping the implementation of better surveillance and control strategies. This will not only provide more cost-effective prevention and control of CSF but, ultimately, achieve CSF eradication in the EU and other territories.

In this study, we used detailed information of backyard pig population and contact patterns from Bulgaria, which is one of the EU countries in which backyard pig production predominates (96% of backyard farms), to evaluate the potential evolution of CSFV epidemics in Bulgaria. Our aim was, particularly, to assess CSFV spread from backyard pigs to other domestic pigs by using a stochastic and spatial disease spread model called Be-FAST (Martínez-López et al., 2010, 2012; Ivorra et al., 2013). Methods and results presented here may be useful to guide risk-based interventions not only in Bulgaria, but also in other similar countries where backyard pig production is predominant.

2. Materials and methods

2.1. Definitions and data

Bulgarian pig farms are categorized in five types based on (i) the level of biosecurity, (ii) the trade patterns permitted and (iii) the farm size (Alexandrov et al., 2011). The first type of farm is referred to as "Industrial", which is characterized by high levels of biosecurity, no restrictions on pig trade and large number of pigs on farm. "Family farm type A" is the second type, similar to industrial farms in permitted trading but, usually, with a smaller farm size and lower level of biosecurity (i.e. medium instead of high). "Family farm type B" is the third type characterized by poor or no biosecurity, smaller farm size and pig trade only allowed to other non-industrial pig farms. The fourth type is the "Backyard" pig farm, which has poor or no biosecurity, a very small farm size (up to 5 pigs and no sows) and in which pig trade is not allowed (pigs are only for self-consumption). Finally, the last type of farm is the "East-Balkan" pig herd, which is managed traditionally (i.e. free-range pigs fed in open grass areas), has poor or no biosecurity level, usually has medium to small farm sizes and in which trade is only allowed to other East-Balkan pig herds.

Data used in this study consisted of detailed pig demographics and trade for each type of pig farm, which was provided by the Bulgarian Food Safety Agency (http://babh.government.bg/en/). Specifically, the number of farms per municipality and per type of farm (i.e. industrial, family type A, family type B, backyard and East Balkan) and the number of pigs per farm during 2010 were available. Because the specific location of farms was not detailed, we used ArcGIS9.3 (ESRI®) to assign latitude and longitude coordinates for each farm within each municipality (Fig. 1). Pig movement records were also obtained and used to simulate CSFV spread by direct contacts. Specifically, the farm of origin, the farm of destination, the day of shipment and the number of pigs shipped from January to October 2010 were used (Fig. 2).

2.2. The model

The spread of CSFV in Bulgaria both by direct contacts (i.e. pig movements) and by indirect contacts (i.e. vehicles, people and local spread) was modeled by adjusting a previously described and validated spatial and stochastic model for CSF, referred to as Be-FAST (Martínez-López et al., 2010, 2012; Ivorra et al., 2013). Note that local spread was defined here as the indirect CSFV transmission by airborne spread or fomites from an infected farm to farms in close proximity (<2 km) (Martínez-López et al., 2010; Karsten et al., 2005a,b). Briefly, the Be-FAST model combines a discrete time stochastic 'Susceptible'-'Infected' model (SI) to simulate the daily CSFV spread within a particular farm with an Individual Based model (in which farms are considered as individuals and are assumed to be in either 'Susceptible', 'Infected', 'Infectious' or 'Clinical signs' state) to simulate the CSFV spread between farms. At the beginning of a simulation all farms are in the 'Susceptible' state except one randomly selected farm, which is assumed to have one infected pig and which is classified as an 'Infectious' farm. After this initial infection, the within- and between- farm transmission processes occur throughout the study region considering the parameterization of the model, the spatial location and demographics of farms and the contact patterns among them. Moreover, when the first farm is detected as CSFV-infected, a daily process for simulating the control measures (such as zoning, movement restriction, tracing