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Estimating the incidence of equine viral arteritis and the sensitivity of its surveillance in the French breeding stock

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ABSTRACT

Equine viral arteritis (EVA) may have serious economic impact on the equine industry. For this reason, it is monitored in many countries, especially in breeding stock, to avoid its spread during breeding activities. In France, surveillance is mainly based on serological tests, since mares are not vaccinated, but difficulties in interpreting certain series of results may impair the estimation of the number of outbreaks.

In this study, we propose specific rules for identifying seroconversion in order to estimate the number of outbreaks that were detected by the breeding stock surveillance component (BSSC) in France between 2006 and 2013. A consensus among multidisciplinary experts was reached to consider seroconversion as a change in antibody titer from negative to at least 32, or as an eight-fold or greater increase in antibody level. Using these rules, 239 cases and 177 outbreaks were identified. Subsequently, we calculated the BSSC's sensitivity as the ratio of the number of detected outbreaks to the total number of outbreaks that occurred in breeding stock (including unreported outbreaks) estimated using a capture-recapture model. The total number of outbreaks was estimated at 215 (95% credible interval 195–249) and the surveillance sensitivity at 82% ($CrI_{95\%}$ 71–91).

Our results confirm EVA circulation in French breeding stock, show that neutralizing antibodies can persist up to eight years in naturally infected mares and suggest that certain mares have been reinfected. This study shows that the sensitivity of the BSSC is relatively high and supports its relevance to prevent the disease spreading through mating.

1. Introduction

Equine viral arteritis (EVA) is an equine respiratory and reproductive disease, caused by equine arteritis virus (EAV), which can lead among other clinical signs to abortions and neonatal deaths (Pronost et al., 2010; Timoney, 2011). EAV belongs to the *Arteriviridae* family, order *Nidovirales* and infects equids only. EAV is an enveloped virus with a positive single stranded RNA genome and has been originally described in 1953, after an abortion outbreak in the city of Bucyrus, Ohio. EAV is usually transmitted horizontally by aerosols or venereal contact, including frozen semen. Vertical transmission through infection *in utero* and occasional indirect transmission by fomites may also occur. Following infection up to 70% of stallions will carry the virus in their reproductive tract and will shed the virus in their semen. Those stallions are the reservoirs of EAV and can transmit the virus to mares during breeding, even in absence of clinical signs (Balasuriya et al., 2013; Timoney and McCollum, 1993).

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Due to its economic impacts, EVA is one of the most frequently monitored equine diseases in many countries (Chirnside, 1992; Hans and Marcé, 2012; Newton et al., 1999). In France, the EVA surveillance system comprises several components, including the surveillance of breeding stock, i.e. brood mares and stallions (Amat et al., 2015). The aim of this surveillance component is to ensure that horses remain free of infection during breeding activities to avoid any spread of the disease either by airborne or venereal routes.

Over the last ten years, a few carrier stallions per year have been detected through assays based on virus detection in France (Hans and Marcé, 2012). More cases of infection, identified as seroconversions, have been identified by serological tests in mares, but their exact number remains unknown because there is no global data analysis. Moreover, some infected holdings remain undetected because the interpretation of some serological results may be difficult and because not all breeding horses are tested. Hence, the total number of EVA outbreaks—and thus EVA incidence—in the overall breeding stock population is not precisely known (Hans and Marcé, 2012).

Such incomplete detection of infected units is a recurrent issue in the field of disease surveillance. Capture-recapture methods are often advocated to address this matter because they give an estimation of the total number of infected units, whether or not they have been detected (Hook and Regal, 1995; Vergne et al., 2015). The sensitivity of the surveillance system or component, i.e. its ability to detect infected units, can then be estimated by the ratio of the number of infected units detected to the total number of infected units estimated.

Our first objective was to establish suitable rules for identifying seroconversion in order to estimate the number of EVA cases and outbreaks that were detected by the equine breeding stock surveillance component (BSSC) in France between 2006 and 2013. The second objective was to estimate the sensitivity of this surveillance component, by estimating the total number of outbreaks that occurred in breeding stock during this period (including those that were not reported) using a capture-recapture model.

2. Material and methods

2.1. Breeding stock surveillance

The BSSC is managed by both public authorities, i.e. the French institute for horse and riding (IFCE), and equine industry, i.e. the studbooks (Amat et al., 2015). Depending on their breed and sex, certain breeding horses must be tested annually before the stud season, according to the regulations and the studbooks' code of practice. Surveillance is only mandatory for mares producing racehorse foals, i.e. Thoroughbred (TB), French Chaser (FC) and a part of Arabian horse (AR), Anglo-Arabian (AA) and French Saddle Horse (FS) mares. Surveillance is mandatory for around 20 breeds for the stallions used for natural mating, and for all breeds for the stallions used for semen collection, regardless of breed (IFCE, 2015a). There are around 40,000 breeding stock holdings in France, totaling some 8000 stallions and 80,000 mares (IFCE, 2015b). Yet only around 7000 holdings are monitored for EVA each year, with around 3000 stallions and 10,000 mares actually tested. The 10,000 tested mares are located in around 6000 of these holdings, spread over 2000 communes. Between 2006 and 2013, the annual number of tested mares ranged from 9777 to 10,867, while the annual number of communes with at least one tested mare ranged from 1794 to 2343. More than 40% of these communes are located in the three northwest regions of the country (Basse-Normandie, Pays-de-la-Loire and Bretagne) which keep the greatest number of holdings (B. Ferry, X. Dornier and S. Vinatier, personal communication).

A serological test is used for surveillance purposes. This viral neutralization test (VNT), performed on a blood sample, is the current standard test for EVA prescribed by the OIE, the World Organization for Animal Health (OIE, 2013). The VNT, considered as the gold standard test for EVA diagnosis, detects the presence of neutralizing antibodies which persist for several years after natural infection (Timoney and McCollum, 1993). Stallions are often vaccinated in France with an inactivated EVA vaccine (Artervac®, Zoetis Animal Health Inc., Kalamazoo, Michigan, USA) but mares are not (B. Ferry, personal communication). We were very confident in the assumption that mares are not vaccinated, based on our knowledge as well as the answers given by the breeders, professionals from racehorse industry and people used to check passport of brood mares before mating activities. Given that VNT may detect antibodies produced after both infection and vaccination and that only stallions may carry the virus more than a few weeks after infection, the status of brood mares for EAV is only based on VNT results, while, in the event of a positive VNT result in stallions, tests based on virus detection by virus isolation or reverse transcriptase-polymerase chain reaction (RT-PCR) are performed on a semen sample in order to check for virus shedding and to confirm the case. All data related to breeding stock testing (including the test date, result, method, horse identification and location) are collected by the IFCE and held in 'SIRE', its national database.

2.2. Data

Data recorded in the SIRE database were used for analysis. We extracted data related to all breeding horses having at least one positive serological result using VNT between January 2006 and December 2013. These data included the horse identification number, location, dates and results of laboratory analyses (VNT) for EVA. We did not use data pertaining to stallions because the number of males with at least one positive result by VNT was very low (n = 32) compared to mares (n = 1645) and some had uninterpretable results. The low number of seropositive stallions recorded in the SIRE database during this period is probably partly due to stringent health protection measures applied regarding stallions, which prevent them from infection (especially through airborne viral transmission), as well as the low number of movements and low level of mixing with other horses. Moreover, vaccinated —and some unvaccinated- stallions are monitored using tests based on virus detection and not VNT. Last, cases detected through epidemiological investigations (and not routinely by the BSSC) were not considered in this study.

Only 28 out of 8934 VNT results recorded for mares were classified as uninterpretable by the laboratory and excluded from the analysis (0.3%). The location was recorded as the commune of the holding, which is registered at the beginning of each year.

2.3. Case definition

For each year, we were interested in the detection of (new) cases. A case was defined as a mare with seroconversion, detected by the interpretation of several VNT results for the same mare.

Due to the difficulties in the interpretation of certain series of titers, a panel of four experts was specially gathered for this study to establish suitable rules for identifying seroconversion. The chosen experts were specialists in the disease and its laboratory diagnosis, as well as epidemiologists.

2.4. Outbreak definition

An outbreak was defined as a commune where at least one EVA case occurred within one year. We chose the commune because it