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Can routinely recorded reproductive events be used as indicators of disease emergence in dairy cattle? An evaluation of 5 indicators during the emergence of bluetongue virus in France in 2007 and 2008

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ABSTRACT

In response to increasing risks of emerging infectious diseases, syndromic surveillance can be a suitable approach to detect outbreaks of such diseases across a large territory in an early phase. To implement a syndromic surveillance system, the primary challenge is to find appropriate health-related data. The objective of this study was to evaluate whether routinely collected dates of reproductive events in dairy cattle could be used to build indicators of health anomalies for syndromic surveillance. The evaluation was performed on data collected in France between 2003 and 2009. First, a set of 5 indicators was proposed to assess several types of reproductive disorders. For each indicator, the demographic coverage over the total number of cattle at risk was analyzed in time and space. Second, the ability to detect an emerging disease in an early phase was retrospectively evaluated during epidemics of bluetongue serotypes 1 and 8 (BTV-1, BTV-8) in France in 2007 and 2008. Reproductive indicators were analyzed weekly during these epidemics for each indicator in each infected French district (16 in 2007 and 50 in 2008 out of 94 districts). The indicators were able to detect the BTV epidemics despite their low demographic coverage on a weekly basis relatively to total number of cattle (median = 1.21%; range = 0–11.7%). Four indicators related to abortions, late embryonic death, and short gestations were abnormally elevated during both BTV epidemics. Median times to abnormal elevations in these indicators were 20 to 71 d after the first notification of clinical signs of BTV by veterinarians. These results demonstrate that reproduction data can be used as indicators of disease emergences, whereas in the specific case of these BTV epidemics, detection via these indicators was later than clinical detection by veterinarians. The emergence of bluetongue in 2007 in France was associated with gestations that were a few days shorter than expected. A short gestation indicator underwent high elevations relative to prior random fluctuations and was the earliest (out of the 4 indicators) to show abnormal elevations, making it possible to detect this emergence.
Key words: syndromic surveillance, reproductive indicators, bluetongue epidemic, disease emergence

INTRODUCTION

The global increase in emerging infectious diseases requires that public and animal health institutes develop surveillance programs that are capable of detecting emergence of a disease as fast as possible (Jones et al., 2008). For cattle, several recent disease emergences have been described in Europe. Six exotic bluetongue virus (**BTV**) serotypes have been detected since 1998. One serotype, BTV-8, caused a major epidemic from 2006 to 2008 in Northern Europe, with important health and economic losses (Hateley, 2009; Wilson and Mellor, 2009). During fall 2011, an unknown virus named Schmallenberg emerged in Northern Europe (Hoffmann et al., 2012). Although the exact routes of introduction of these emerging diseases are difficult to trace, global warming and increasing international trade and travel increase the incidence of such epidemics (Mintiens et al., 2008; Purse et al., 2008). In this context, commonly implemented diagnostic-based active surveillance is not sufficient because it is limited to known diseases that could emerge or re-emerge (e.g., brucellosis and tuberculosis). Therefore, parallel nonspecific surveillance systems have to be developed for unexpected disease

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outbreaks such as the recent BTV and Schmallenberg virus emergences in Europe.

This syndromic surveillance approach is designed to early detect exceptional variations in nonspecific clinical signs or disorders caused by a disease in a large population. To implement such a system, the primary challenge is to find routinely collected data that can be used to indicate nonspecific signs (Shmueli and Burkom, 2010). The relevance of the data depends on their close association with clinical signs, the nonspecificity of signs, the demographic coverage, and the continuity of monitoring (Mandl et al., 2004; Buckeridge, 2007). For cattle, 4 data sources have already been evaluated for syndromic surveillance: mortality, notification of abortions, laboratory submissions, and milk production (Carpenter et al., 2007; Perrin et al., 2010; Brouwer et al., 2012; Madouasse et al., 2014). These were successfully used to retrospectively detect infectious diseases (BTV-8, brucellosis, or bovine viral diarrhea). However, timeliness of detection was not estimated and, for mortality in particular, it could be that "high mortality" is observed much later after the start of the epidemic, as was observed for humans during influenza epidemics (Choi and Thacker, 1981; Costagliola et al., 1991; Basu, 2009). Generally, to increase the range of diseases that can be detected, syndromic surveillance would benefit from using different data sources simultaneously to obtain complementary signs of health disorders.

Reproductive events such as AI and calving are routinely recorded for herd management purposes as well as for the genetic evaluation of sires. They have been successfully used in several studies to evaluate the effects of various diseases on reproductive performance in dairy cattle known to have been infected. For example, a lower rate of nonreturn to service was observed in dairy cattle infected with *Mycobacterium avium* ssp. *paratuberculosis* (Marcé et al., 2009), and lower rates of 56-d return to service were observed in dairy cattle infected with BTV-8 (Santman-Berends et al., 2010; Nusinovici et al., 2012b). However, these data have never been used for syndromic surveillance; that is, when the infection status is not known, but can be of interest because many diseases can have an effect on reproductive performance and gestation. The emergence in Europe of BTV-8, a virus that causes reproductive disorders (e.g., abortion and stillbirth; Elbers et al., 2008), provided the opportunity to assess the value of these indicators for syndromic surveillance.

The objective of this study was to evaluate the use of routinely collected reproduction data in dairy cattle to build indicators suitable for syndromic surveillance. First, the definition of 5 indicators of reproductive disorders was provided. Their demographic coverage in the French dairy cattle population was analyzed weekly and at the district level to assess their representativeness. Then, the ability of these indicators to detect reproductive disorders during the emergence of BTV in 2007 and 2008 in France was evaluated.

MATERIALS AND METHODS

Description and Selection of Reproduction Data

In French dairy cattle enrolled in the official milk recording scheme, AI and calving are extensively reported to the breeding organization by the farmers or inseminators for herd management purposes and genetic evaluation of sires. Farmers are required to report each calving (dead or alive) within 7 d with the date of the event, the identification number of the dam, the herd of birth, and the breed. In dairy cattle, most AI are performed by inseminators (95.8% in 2012; Institut de l'élevage, 2012), who are required to report, within 2 wk, the date of the event as well as the identification of the animal and its herd. In addition, farmers must report dates of death or culling within 7 d to the national bovine identification database.

These data are centralized in a unique national database managed by Institut National de la Recherche Agronomique (INRA). The following variables were extracted from this database: dates of AI, dates of calving, dates of death/culling, identification numbers (**ID**) of animals, herd ID, and breeds. Only inseminated animals in herds enrolled in the official milk recording scheme were selected. To have a historic period before the 2007 BTV-8 epidemic and at least one full year after the end of the epidemic, data recorded from January 1, 2002, until December 31, 2009, were extracted. Breeds with several recorded calvings >1,000 calvings per year in at least one district were selected to AI on about 10 million animals located in about 100,000 herds over 8 yr.

Description and Selection of BTV Notification Data

The notification of a BTV infection in bovine herds (dairy and beef herds) was mandatory in France in 2007 and 2008. The recorded notifications consisted of those herds that had at least one animal diagnosed with BTV-1 or BTV-8. In total, 8,603 and 18,259 bovine herds were notified in 2007 and 2008 respectively. Most of these notifications (93%) corresponded to the BTV-8 epidemic, which began in July 2007 in northeastern France and reached most districts by the end of 2008 (79 out of 94 districts). The remainder of the notifications (7%) corresponded to the BTV-1 epidemic, which spread only in southwestern France in 2008 (19 out of 94 districts). The following variables were available for each notified