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Estimation of the individual slaughterhouse surveillance sensitivity for bovine tuberculosis in Catalonia (North-Eastern Spain)

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ABSTRACT

The achievement of the Officially Tuberculosis Free (OTF) status in regions with low bovine Tuberculosis (bTB) herd prevalence, as is the case of North-Eastern Spain (Catalonia), might be a likely option in the medium term. In this context, risk-based approaches could be an alternative surveillance strategy to the costly current strategy. However, before any change in the system may be contemplated, a reliable estimate of the sensitivity of the different surveillance components is needed. In this study, we focused on the slaughterhouse component. The probability of detection of a bTB-infected cattle by the slaughterhouses in Catalonia was estimated as the product of three consecutive probabilities: (P1) the probability that a bTB-infected animal arrived at the slaughterhouse presenting Macroscopically Detectable Lesions (MDL); (P2) the probability that MDL were detected by the routine meat inspection process and (P3) the probability that the veterinary officer suspected bTB and sent the sample for laboratory confirmation.

The first probability was obtained from data collected through the bTB eradication program carried out in Catalonia between 2005 and 2008, while the last two were obtained through the expert opinion of the veterinary officers working at the slaughterhouses who fulfilled a questionnaire administered during 2014.

The bTB surveillance sensitivity of the different cattle slaughterhouses in Catalonia obtained in this study was 31.4% (CI 95%: 28.6–36.2), and there were important differences among them. The low bTB surveillance sensitivity was mainly related with the low probability that a bTB-infected animal arrived at the slaughterhouse presenting MDL (around 44.8%). The variability of the sensitivity among the different slaughterhouses could be explained by significant associations between some variables included in the survey and P2. For instance, factors like attendance to training courses, number of meat technicians and speed of the slaughter chain were significantly related with the probabilities that a MDL was detected by the meat inspection procedure carried out in the slaughterhouse. Technical and policy efforts should be focused on the improvement of these factors in order to maximize the slaughterhouse sensitivity.

1. Introduction

Bovine tuberculosis (bTB) is a chronic infectious disease of cattle caused by any of the mycobacterial species within the Mycobacterium tuberculosis-complex (Anon., 2013a) and it is one of the biggest challenges facing the cattle farming industry in some Member States of the European Union (EU) (EFSA, 2013a). In the EU, countries are classified as Officially Tuberculosis Free (OTF) if they maintained the herd prevalence below 0.1% for a minimum period of 6 consecutive years, and as non-OTF otherwise (Council Directive 98/46/EC). In non-OTF countries such as Spain, surveillance of bTB is based on (a) periodic testing of herds with tuberculin skin test and removal of reactor animals, (b) pre-movement testing and (c) meat inspection at the slaughterhouses (Council Directive 77/391/EEC).

When bTB eradication is achieved, the transition to a surveillance based only in meat inspection could be considered (EFSA, 2013b). However, OTF countries should continuously demonstrate their status, and therefore the sensitivity of the surveillance system should be high enough to substantiate that the bTB prevalence is below the required level. Besides, bTB infected herds should be detected early enough to prevent further dissemination to other herds. Therefore, the recognition of bTB during meat inspection is still a very important component for the surveillance and control of the disease, in either OTF or non-OTF countries. (Domingo et al., 2014).

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However, some negative experiences have been reported in OTF countries that relied exclusively on meat inspection for bTB surveillance. For example, Fischer et al., (2005) questioned the efficiency of meat inspection to detect infected cattle early enough to limit spread to other herds after they had an epidemic in the Netherlands which affected 10 herds.

On the other hand, in regions with low bTB herd prevalence, the achievement of the OTF status might be a likely option in the medium term and within this context, risk-based approaches could be an alternative surveillance strategy to the costly current strategy. However, before any change in the surveillance system may be contemplated, a reliable estimate of the sensitivity of the current surveillance components is needed. In this study, we focused on the slaughterhouse component, and the aim was to estimate the individual slaughterhouse surveillance sensitivity for bTB in Catalonia (North-Eastern Spain), where herd prevalence was 0.16% in 2014 (Anon., 2013b).

2. Materials and methods

In order to estimate the probability of a bTB-infected animal being detected at the slaughterhouse, we considered three consecutive steps each of them with an associated probability:

P1: probability that a bTB-infected animal arrived at the slaughterhouse presenting bTB Macroscopically Detectable Lesions (MDL).

This probability was estimated using data collected through the bTB eradication program carried out in Catalonia (North-eastern Spain) between 2005 and 2008. An animal was considered as infected by bTB if it resulted positive to either the single intradermal tuberculin skin test (SIT) or the single cervical comparative tuberculin skin test (SICCT), routinely applied by the control program. In order to take into account the existence of false positives (i.e. animals that tested positive to either SIT or SICCT but were not infected), we took into account the specificities of SIT and SICCT extracted from the metanalysis published by EFSA (2012). Therefore, P1 was calculated following the Eq. (1):

$$P1 = \frac{posMDL}{((possSIT - posSIT * (1 - Sp_{SIT})) + (posSICCT * (1 - Sp_{SICCT})))} \quad (1)$$

where posMDL represented the number of cattle positive to either SIT or SICCT which presented MDL; posSIT and posSICCT represented the number of cattle test-positive to those tests, and Sp_{SIT} and Sp_{SICCT} represented the specificities of SIT and SICCT, respectively. In order to incorporate the uncertainty associated with the skin test specificities, Pert distributions were assigned to SIT specificity (Sp_{SIT}) and SICCT specificity (Sp_{SICCT}), with the minimum, mode and maximum values extracted from the metanalysis published by EFSA (2012):

$Sp_{SIT} \sim$ Pert(0.7, 0.9, 1)

$Sp_{SICCT} \sim$ Pert(0.9, 1, 1)

Further steps were:

P2: probability that MDL, from cattle belonging to bTB negative farms, were detected by the routinely meat inspection procedure carried out in the slaughterhouse.

P3: probability that the veterinary officer suspected of bTB and sent the sample to the laboratory for confirmation, or notified directly to the authorities.

P2 and P3 were estimated by means of a questionnaire, administered during the first semester of 2014, to the slaughterhouse veterinary officers. The objective was to obtain these values based on their personal experience and expert opinion. In order to reduce bias, in those slaughterhouses where more than one veterinarian was working, the interview was performed with the two or three more experienced veterinarians working in the plant. Data was obtained by personal interview, except in some slaughterhouses, where the questionnaire was administered by phone interview due to logistical reasons. The questionnaire (available upon request) was structured in 5 different blocks: (i) general data about the slaughterhouse: location, number of veterinarians, meat technicians and number of inspection points; (ii) training received to detect MDL; (iii) condition of the facilities regarding lighting, space and speed of the slaughter chain; (iv) organs and lymph nodes examined by visual inspection, palpation and/or incision and (v) sampling protocol in case of identification of MDL.

At the end of the questionnaire, the veterinarians were asked to provide an estimate (in the scale of 0–10) for P2 and P3, taking into account all those factors that were mentioned during the interview. Additionally, their opinion regarding which aspects could be improved in order to increase the probability of detecting MDL was recorded.

Moreover, associations between the results from the questionnaires and the estimated probability of detecting MDL during meat inspection (P2) were evaluated using ANOVA test or Wilcoxon rank test, for categorical variables, and linear regression for continuous variables. A p-value of 0.05 was used as a significance level for associations.

According to the National bTB eradication program (Anon., 2014) when MDL are detected and samples are sent to the laboratory for confirmation, a preliminary evaluation is carried out through histopathological examination and Ziehl Neelsen staining. If the preliminary result is positive, a tuberculin skin test is carried out in the herd of origin without waiting for the mycobacterial culture result, which still remains the gold standard method for confirmation of infection (OIE, 2009). Due to the high sensitivity of histopathology in MDL (Courcoul et al., 2014) we did not included this probability into the model.

For each slaughterhouse, the sensitivity of the surveillance was calculated as the product of P1, P2 and P3. Monte Carlo simulations, with 10.000 iterations, were performed using the mc2d package (Pouillot and Delignette-Muller, 2010), implemented in R R Development Core Team (2013). Finally, the average sensitivity was calculated taking into account the sensitivities estimated from each slaughterhouse.

3. Results

3.1. Descriptive results

A total of 409 cattle were positive to the SIT and 231 to the SICCT. From those 640 positive animals, 282 presented MDL. In Table 1 the frequencies of the locations where MDL were detected during the meat inspection procedure, are shown. Approximately, 39% of the animals with MDL (112 out of 282) presented lesions in more than one cavity at the same time and 95% of the lesions where found in the thoracic cavity and in the head. Answers to the questions about training programs, human resources and sampling procedures are shown in Table 2. Remarkably, only 30% of the interviewed veterinarians considered that the current training program was adequate in order to fulfil all the requirements to recognize MDL during the slaughter process. Also, about 70% highlighted that sometimes the number of meat inspectors had not been enough in order to assure a reliable inspection during those periods of the year with high volumes of animals slaughtered. Finally, most of the veterinarians knew the protocol to collect and send the suspected samples to the laboratory and also knew about the existence of the Slaughterhouse Support Network called SESC (Vidal et al., 2015). On the other hand, the mean scorings for optimal slaughter chain speed