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Construction of standardized surveillance indicators for bovine cysticercosis

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ABSTRACT

Bovine cysticercosis is a zoonotic parasitic disease due to *Cysticercus bovis*. This study aimed to identify factors that could have an impact on the prevalence of cysticercosis and to use them to build standardized indicators of prevalence.

Multivariate logistic regression analyses were performed on data from 4,564,065 cattle (91.3% of the cattle population slaughtered in France in 2010) among which 6491 cattle (0.14%) were found to harbor at least one lesion of cysticercosis (including 611 cattle harboring viable cysts, 0.01%). Two multivariate logistic models were fit to the data using as outcome variables either the presence or absence of viable cysts and the presence or absence of cysts whatever their level of development.

Age and sex were identified as the main factors influencing bovine cysticercosis prevalence and were used for the construction of standardized prevalence and standardized cysticercosis rate. To illustrate the use of such indicators, they were calculated for the first and second semester of 2010 and for two different areas in France. The differences between raw prevalence and standardized prevalence highlight the use of standardized indicators for comparisons of prevalence between different areas and time periods as the structure of the slaughtered populations differ considerably from one to another.

1. Introduction

Bovine cysticercosis is a zoonotic parasitic disease due to *Cysticercus bovis* that induces the development of *Taenia saginata* (adult tapeworm) in the human small intestine. Humans, the definitive host, are infected by the consumption of raw or under-cooked meat from infected cattle (Scientific Committee on Veterinary Measures to Public Health, 2000). Cattle, the intermediate host, are infected by grazing on pasture infected by human feces that contain tapeworm eggs (Cabaret et al., 2002). Although this disease rarely produces symptoms in humans, it can have a negative impact on consumer confidence in the food industry. It also induces direct financial losses for farmers due to condemnation or treatment by freezing of infected carcasses (Cabaret et al., 2002).

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The prevalence of bovine cysticercosis, defined as the number of animals harboring cysts divided by the number of animals submitted to meat inspection, is useful for monitoring the disease. Nevertheless, this prevalence could vary according to different factors such as sex, age and production type of the slaughtered animals. So the raw prevalence of cysticercosis at the slaughterhouse depends on the type of animals slaughtered. Several parameters are known to influence the type of animal slaughtered, such as meat price, cattle feed price, milk production level or fertility, because they influence the decision of farmers to cull their animals (Beaudeau et al., 1996; Rajala-Schultz and Gröhn, 1999; Barbin et al., 2011). These proportions also vary from one country to another, making it difficult to compare the prevalence of bovine cysticercosis between countries. For instance, taking into account data from France, Italy, Iceland, Germany and Ireland (European Food Safety Authority, 2012), the annual proportion of bulls, cows, heifers, steers and calves annually slaughtered ranged, according to the country, from 3 to 42%, 12 to 38%, 0 to 15%, 1 to 62% and 0 to 28% respectively.

The objective of this study was to identify factors associated with the prevalence of cysticercosis in the slaughtered cattle population and to use this information to build standardized indicators of prevalence so as to be able to compare prevalence estimates even if the nature of the slaughtered cattle population changes over time or differs between areas.

2. Materials and methods

2.1. Data collection

A survey was conducted in France in 2010 by the French Ministry of Agriculture in all cattle slaughterhouses. Each slaughterhouse was asked to report all animals that presented at least one lesion of cysticercosis during post-mortem inspection, performed according to current European legislation by veterinary services staff (European Parliament, 2004). Visual inspection of the heart, tongue, masseter muscles, esophagus and diaphragm was performed on every carcass, together with one lengthways incision of the heart. Three additional incisions in the masseter muscles are performed for cattle older than 6 weeks. The stage of cysticercosis (viable or degenerated cysts) was specified. Viable cysts were defined as fully transparent cysts with a visible scolex and degenerated cysts as cysts with cheesy (yellowish and smooth) or calcified (solid and perceptible when cysts were sliced) contents (Kyvsgaard et al., 1990; Minozzo et al., 2002).

All animals slaughtered in one of the slaughterhouses that answered the survey were included. The French National Cattle Register (BDNI) was used to identify animals slaughtered in these slaughterhouses and that did not harbor cysticercosis lesions and to extract, for each animal, the animal ID, sex, age, breed and the *région* (French administrative area) where the animal was being raised two months before slaughter. According to zootechnical standards (Barbin et al., 2011) and European regulation (European Parliament, 2007), the ages of cattle were classified into six categories: less than 8 months old, 8 to less than 24 months old, 2 to less than 3.5 years old, 3.5 to less than 5 years old, 5 to less than 10 years old, ≥10 years old. Breeds were grouped according to production type, as defined by FranceAgriMer (the French national organization of agriculture products), into “dairy”, “beef” and “mixed” cattle (FranceAgriMer, 2011).

2.2. Data analysis

2.2.1. Identification of adjustment variables

Multivariate logistic regression analyses were performed to identify which variables were significantly associated with the presence of cysticercosis lesions. Two models were fit to the data: the first using as outcome variable the presence or absence of viable cysts (recent infection of less than 9 months) and the second using the presence or absence of cysts, whatever their level of development (viable or degenerated). Sex, age and production type were examined for their association with the outcome variables. Month of slaughter was included in the model for viable cysts only (not relevant for chronic lesions). Missing data were considered as missing at random regarding the outcome variable and cattle with missing data were excluded (Donders et al., 2006). If any pair of variables was found to be strongly correlated using the Cramer’s V measure of association (correlation coefficient > 0.7), the two correlated variables were replaced by a combined variable.

The modeling selection strategy of Hosmer and Lemeshow was used (Hosmer and Lemeshow, 2000). In a first step, each variable was evaluated separately for statistical significance. Each variable with a p-value lower than 0.20 at this univariate step was included in a multivariate model. A backward step-wise selection was performed and non-significant covariates were removed from the model (p-value higher than 0.05). To assess confounding effects we checked if the removal of non-significant variables produced important changes in the coefficient of the other variables in the model. Moreover, we investigated the hypothesis that animals slaughtered in the same slaughterhouse were more similar than animals from different slaughterhouses regarding cysticercosis lesions. The need to control for the effect of slaughterhouse was investigated by the inclusion of a random effect for the slaughterhouse ID through a mixed logistic model. The objective was to evaluate the impact of slaughterhouse on the other statistically significant effects knowing that a slaughterhouse effect could not be taken into account to build a standardized indicator. The extent of the random effect was evaluated by comparing the odds ratio of fixed effects in the model with and without random effect (overlapping or not of confidence intervals).

For the comparisons of nested models, likelihood ratio tests or Akaïke information criterion (AIC) were used. We used area under the ROC curve (AUC) for fit assessment. This provides a measure of the model’s ability to discriminate between cattle with or without cysticercosis