Epidemiological monitoring of **bovine cysticercosis** in France: situation in 2015

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Abstract

The French national meat inspection database (SI2A) was launched in all French cattle slaughterhouses on 1 January 2015. It has enabled the surveillance of annual bovine cysticercosis prevalence and incidence rates. In 2015, raw apparent prevalence was 0.123% [0.122-0.123] (95 CI) for both viable and degenerated cysts and 0.0096% [0.0095-0.0098] for viable cysts. True prevalence was estimated at 1.07% [0.72-1.67] and 0.08% [0.06-0.13] for both viable and degenerated cysts and for viable cysts respectively. The comparison of raw apparent prevalence in 2010 and adjusted prevalence for age-sex in 2015 showed a slight but statistically significant decrease during this period. This decrease could be attributed either to an improvement in the bovine cysticercosis situation or to lower meat inspection detection sensitivity in 2015 due to a difference in data collection methodologies. The implementation, in addition to the current surveillance system, of a method for identifying farms/areas at higher risk for infestation in France could enable the development of more appropriate prevention and control measures.

Keywords
Bovine cysticercosis, Surveillance, France

Résumé
Epidémiosurveillance de la cysticercose bovine en France : situation en 2015
Le déploiement, depuis le 1er janvier 2015, du Système d'information sur l'inspection en abattoir (SI2A) dans tous les abattoirs bovins français a permis la mise en place d'une surveillance annuelle de la prévalence et de l'incidence de la cysticercose bovine. En 2015, la prévalence apparente de la cysticercose bovine (tous types de cysticerques confondus, vivants et calcifiés) était de 0,123 % [0,122-0,123] (IC95) et de 0,0096 % [0,0095-0,0098] pour les cysticerques vivants. La prévalence réelle, prenant en compte la sensibilité estimée de la détection a été estimée à 1,07 % [0,72-1,67] pour les cysticerques quel que soit leur stade de développement et à 0,08 % [0,06-0,13] pour les cysticerques vivants. La comparaison de la prévalence apparente en 2010 et de la prévalence apparente ajustée sur l'âge et le sexe en 2015 a montré une diminution faible mais statistiquement significative sur cette période. Cette diminution pourrait être attribuée soit à une amélioration de la situation vis-à-vis de la cysticercose bovine, soit à une baisse de la sensibilité de détection liée à des modalités de collecte de données différentes. La mise en place, en complément de la surveillance actuelle, d'un dispositif d'identification des élevages dans les zones les plus à risque en France permettrait d'envisager des méthodes de prévention, de lutte et de détection plus adaptées.

Mots-clés
Cysticercose bovine, Surveillance, France

Cysticercosis (Box 1) has a considerable economic impact on the cattle rearing sector because of the associated condemnations and depreciation of carcasses following freezing treatment. The economic significance and zoonotic nature of this infestation warrant the implementation of an epidemiological surveillance system to contribute to better risk management (Box 2). To this end, it is necessary to use data collected at the slaughterhouse that were until recently very difficult to obtain. In 2010, a one-time survey was conducted to collect all necessary information regarding bovine cysticercosis in slaughterhouses in France *via* a questionnaire, but this process requires considerable energy and is not comparable to a permanent surveillance system.

On 1 January 2015, the Ministry of Agriculture launched the French national meat inspection database (SI2A) for use in all slaughterhouses in mainland France and overseas *départements* and territories. This tool is used to record and centralise the results of *ante-* and *post-mortem* inspections of animals that presented an anomaly (*ante-mortem* clinical signs/*post-mortem* lesions). The SI2A must be used in all cattle slaughterhouses. The database was designed to facilitate inspections by veterinary service officers at the slaughterhouse by enabling them to immediately issue registers, notifications (e.g. condemnation certificates) and letters. An application called Dedal (Decision-making system for food) was also developed to enable officers to access the results of pre-set queries. The direct use of recorded data to issue official documents on the one hand, and the

Box 1. Bovine cysticercosis

Cysticercus bovis-related cysticercosis is a parasitic zoonosis affecting cattle as the intermediate host and humans as the definitive host (Figure 1). Cattle are infected primarily by feeding on pastures infested with C. bovis eggs originating from excretion of the parasite by humans, particularly following landfarming with insufficiently treated water from water treatment plants (Cabaret *et al.*, 2002). C. bovis larvae then migrate from the gastrointestinal tract to the muscles where they become encysted into cysticerci. These cysticerci remain viable for a few months and then degenerate and calcify at the latest nine months after ingestion. Humans are then infected by ingesting living cysticerci when they eat parasitised meat that is raw or undercooked. An adult taenia (tapeworm) then develops in two or three months resulting in the release of proglottids in the faeces, which is a source of discomfort (Scientific Committee on Veterinary Measures relating to Public Health, 2000).

Since infestation is asymptomatic in animals, detection is only possible at the slaughterhouse on *post-mortem* inspection. All slaughtered cattle are inspected visually looking at the heart, tongue, masseters, oesophagus and diaphragm, as well as mandatory muscle incisions (European Parliament, 2004). Infested carcasses are seized integrally if there is massive infestation. In the event of local infestation, partial seizure or freezing treatments are applied. Infested meat may be placed on the market because of the low sensitivity of inspection at the slaughterhouse, leading to the sale of infested carcasses. Humans are then contaminated *via* consumption of undercooked beef.

possibility of accessing reports on aggregated data on the other, are important components that help to guarantee both the sustainability of information recording and data quality.

This review presents the epidemiological situation concerning bovine cysticercosis in 2015 based on SI2A data compared with data from the study carried out in 2010. It makes use of epidemiological indicators adjusted for age and sex, two important factors to consider when calculating the prevalence of this disorder so as to limit interpretation bias (Dupuy *et al.*, 2014b).

Material

The data on prevalence and distribution of the cattle population by age and sex in 2010 originate from the article by Dupuy *et al.*, (2014a). For 2015, data were extracted from the SI2A database for cattle subject to a *post-mortem* inspection decision for one of the following reasons: muscular cysticercosis, localised viable form; muscular cysticercosis, localised degenerated form; and muscular cysticercosis, generalised. Data from the national cattle identification database (BDNI) were used to obtain information on the date of birth, date of slaughter, and sex of all the cattle slaughtered over this period.

Method

Apparent prevalence, true prevalence and apparent prevalence adjusted for age and sex were calculated for 2015. Apparent prevalence is defined as the number of cattle detected at the slaughterhouse with at least one cysticercosis lesion divided by the total number of slaughtered cattle. True prevalence was calculated by dividing apparent prevalence by the probability of detection of cysticercosis, estimated by EFSA at 11.5% [7.4-17.1] (Dupuy *et al.*, 2012).

Age and sex were identified as the main individual factors associated with variability in terms of cysticercosis lesions at the slaughterhouse. Since there may be significant fluctuations over time in the proportions of cattle slaughtered regarding age and sex, prevalence data must be adjusted for these variables to enable comparisons of prevalence levels between years, without any bias related to changes in the typology of the slaughtered population.

Prevalence adjusted for a combined age-sex variable was therefore calculated by direct standardisation. The cattle population slaughtered in the year 2010 was defined as the reference population, and the data on the cattle population slaughtered in 2015 were adjusted by weighting of the distribution of cattle slaughtered in 2010 using the age-sex variable.

For this standardisation, the following age-sex classes were used: 0-8 months-female; 0-8 months-male; 8-24 months female; 8-24 months-male; 2-3.5 years-female; 2-3.5 years-male; 3.5-5 years-female; 3.5-5 years-male; 5-10 years-female; 5-10 years-male; >10 years-female; >10 years-male.

The standardised cysticercosis rate (SCR) can be used to quantify the difference observed between two adjusted prevalence levels. It is determined by indirect standardisation (Bouyer *et al.*, 2009; Breslow and Day, 1987). The cattle population slaughtered in 2010 was defined as the reference population and the distribution of the population in terms of age-sex in 2015 was used to determine the expected number of cattle presenting cysticercosis lesions in 2015, if the age-sex–adjusted prevalence was similar to that in 2010. This number was obtained by multiplying the number of cattle observed presenting cysticercosis lesions in 2010 by the ratio between the number of cattle slaughtered in 2015 and 2010, for each age-sex variable group. The SCR was then defined as the ratio between the observed number of cattle with a cysticercosis lesion in 2015 divided by the expected number of cattle presenting cysticercosis lesions in 2015.

Box 2.

Objectives
The objective of the epidemiological surveillance system for cysticercosis is firstly to monitor incidence and annual prevalence of this disorder in France. Subsequently, it aims to identify the holdings/zones that are most at risk in France.

Programming framework
Regulation (EC) No 854/2004 provides for systematic inspection of all cattle carcasses aimed at detecting bovine cysticercosis through incisions and palpations.

Protocol
Officers from the veterinary inspection services screen for the presence of viable or degenerated/calcified cysticercosis lesions at the slaughterhouse in all the cattle slaughtered in France. A decision is made for each carcass (partial seizure, full seizure, freezing treatment) and is recorded in the national SI2A database that must be used in all cattle slaughterhouses across the country.

A case of cysticercosis with a viable cysticercus is defined as any animal recorded in the SI2A with a *post-mortem* inspection including the reason "muscular cysticercosis, localised viable form".

A case of cysticercosis for all types of cysticerci is defined as any animal recorded in the SI2A with a *post-mortem* inspection of the second degree including one of the following reasons: "muscular cysticercosis, localised viable form"; "muscular cysticercosis, localised degenerated form"; "muscular cysticercosis, generalised".

Table 1. Apparent prevalence and prevalence adjusted for a combined age-sex variable and standardised cysticercosis rate for all types of cysticerci and for viable cysticerci, with a 95% confidence interval for cattle slaughtered in France in 2010 and 2015 (reference = cattle slaughtered in 2010)

	2010	2015
All types of cysticercosis		
Apparent prevalence (%)	0.142 [0.142-0.143]	0.123 [0.122-0.123]
Adjusted prevalence (%)		0.121 [0.121-0.121]
Standardised cysticercosis rate	1	0.84 [0.84-0.84]
Only viable cysticerci		
Apparent prevalence (%) = incidence	0.013 [0.013-0.014]	0.0096 [0.0095-0.0098]
Adjusted prevalence (%) = adjusted incidence		0.0095 [0.0095-0.0095]
Standardised cysticercosis rate	1	0.71 [0.71-0.71]

Results

The survey carried out in 2010 included 4,564,065 cattle (91.3% of cattle slaughtered in 2010) in the prevalence analysis, after exclusion of cattle without data on age and sex. The estimated apparent prevalence levels are presented in Table 1 (Dupuy *et al.,* 2014a, Dupuy *et al.,* 2014b).

In 2015, 4,692,454 cattle were slaughtered in the 209 cattle slaughterhouses in France. Of these 209 slaughterhouses, 202 used the SI2A to record slaughterhouse seizures. The available data for the analysis of prevalence in 2015 concerned 4,689,095 cattle slaughtered in these 202 slaughterhouses (99.9% of the cattle slaughtered in France over this period), including 5736 that were condemned integrally or partially due to cysticercosis lesions. After exclusion of cattle without data on age and sex (n=28,214, 0.6%), the study population contained 4,660,881 cattle. In this study population, *post-mortem* inspection enabled the detection of at least one cysticercosis lesion (irrespective of the development stage) for 5729 cattle, i.e. an apparent prevalence of 0.123% [0.122-0.123].

Among the infested animals, 450 (7.9%) presented lesions with viable cysticerci, i.e. an apparent prevalence of 0.0096% [0.0095-0.0098]. Also among the infested animals, 148 cattle presented a generalised form (2.6%).

The true prevalence, irrespective of the cysticercus development stage, was estimated to be 1.07% [0.72-1.67]. The true prevalence of bovine cysticercosis due to viable cysticerci was estimated to be 0.08% [0.06-0.13].

The adjusted prevalence values and SCRs are shown in Table 1. The difference between two prevalence values was considered statistically significant when their confidence intervals did not overlap.

Discussion

The prevalence of bovine cysticercosis due to viable cysticerci can be regarded as the incidence from an epidemiological perspective, as the presence of this type of lesion is indicative of recent infestation (at the most a few months before slaughter). Simultaneous monitoring of the prevalence of bovine cysticercosis due to viable cysticerci and the prevalence of bovine cysticercosis due to all types of cysticerci therefore provides complementary information.

The differences between the apparent prevalence values and the adjusted apparent prevalence values in 2015 were low, though statistically significant. This is related to small differences in the distribution of the slaughtered cattle population in terms of age and sex between 2010 and 2015 (variation ranging from 0.1 to 1.8% depending on the age-sex class). This does not, however, detract from the usefulness of comparing adjusted prevalence values rather than apparent prevalence values, because considerable differences may be observed in the future. The decision to slaughter an animal is a complex multi-factorial process (Dupuy, 2014c).

The comparison of the apparent prevalence in 2010 with the adjusted apparent prevalence in 2015 shows a statistically significant but small decrease between these two years. There were, in fact, 1.2 (1/0.84) and 1.4 (1/0.71) times fewer cases observed in 2015 compared to the values that should have been observed if the prevalence had been identical to 2010, respectively for all forms of cysticercosis and for cases of viable cysticerci only (Table 1). The decrease is statistically greater for incidence than for prevalence.

This could lead to the conclusion that there has been an improvement in the situation regarding bovine cysticercosis in France with a lower prevalence, but above all a lower incidence. However, caution should be exercised when comparing these results. The 2010 data originate from a survey specifically asking slaughterhouses through a guidance note to report information on cysticercosis lesions detected at the slaughterhouse *via* questionnaires. It is possible that this had an effect on the sensitivity of detection of cysticercosis lesions through increased awareness of this disorder among inspection services. Hadorn and Stärk *et al.* (2008) have demonstrated the substantial impact that increased awareness of inspection officers could have on detection sensitivity. For tuberculosis, sensitivity was shown to increase from 50.6% to 80.4%. This study is based on the hypothesis that sensitivity was identical in 2010 and 2015, even though the data collection process was different. In addition, the 2010 survey involved double recording of information: use of the local tool by officers to issue the condemnation certificate and, in parallel, recording in the survey questionnaire. There is a concern that this double recording may not have been systematic, leading to an under-reporting bias.

The information available *via* the SI2A is less precise than that from the 2010 survey. For generalised lesions, the development stage of cysticerci was not specified systematically because the distinction between generalised lesions with or without the presence of viable cysticerci was not provided for. In some cases, the officers recorded both generalised cysticercosis and localised cysticercosis due to viable cysticerci, enabling us to conclude that viable cysticerci were present, and similarly with localised cysticercosis due to degenerated cysticerci. The 143 cattle that presented generalised lesions without
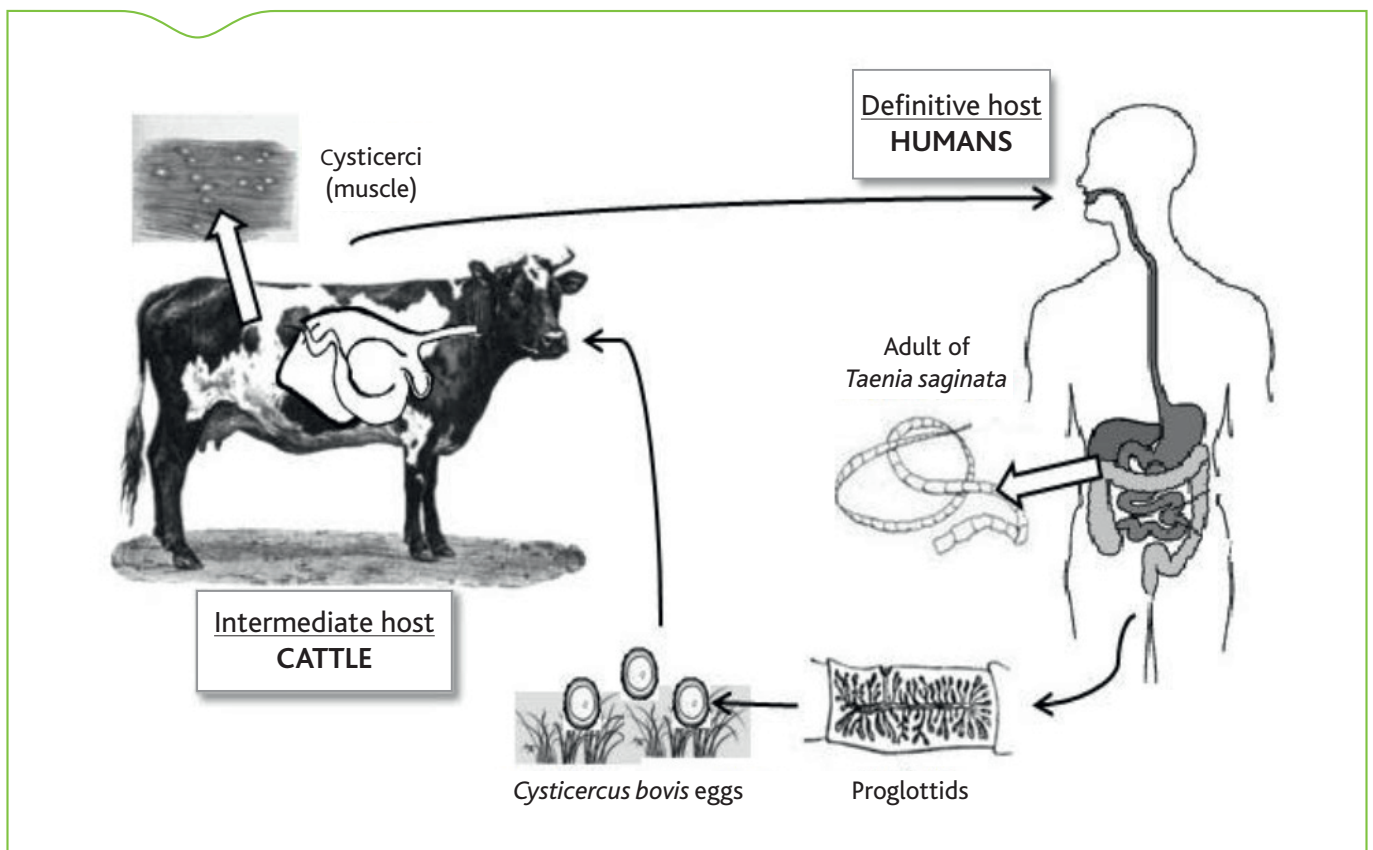

Figure 1. Cycle of *Taenia saginata* (Morlot, 2011)

other information were considered to have degenerated cysticerci lesions, which could have an effect on the incidence results if some of these animals had viable cysticerci lesions. It appears necessary to consider upgrading the lesion references in the SI2A to include this distinction for generalised lesions so as to increase the reliability of monitoring of bovine cysticercosis incidence and prevalence.

2015 was the first year of operation of the SI2A. Analysis of annual data on bovine cysticercosis from this system will be used to monitor changes in the incidence and prevalence of this disorder, on the basis of data collected in a similar way from one year to the next, thus limiting measurement bias.

Conclusion

The SI2A database has made it possible to set up an epidemiological surveillance system for bovine cysticercosis in France through routine collection of information regarding this disorder. We are now able to monitor the prevalence and incidence of bovine cysticercosis on an annual basis through practically exhaustive data for the whole country. This also facilitates feedback to farmers *via* standardised condemnation certificates and a possible move to digitise this information.

Inspections based on risk are already implemented using the Food Chain Information (FCI) forwarded by farmers. FCI covers all the relevant information that the breeder provides to the slaughterhouse on the animals intended for slaughter. A list of this information is defined by ministerial order, and includes information regarding bovine cysticercosis. However, FCI regarding bovine cysticercosis is based solely on cases recorded for the animal's most recent holding, which results in a considerable bias specifically for calcified cysticerci lesions (long interval between infestation and detection of the lesion at the slaughterhouse). This information could be improved by implementing a surveillance system that can identify farms or zones that are at the highest risk (high prevalence of cysticerci), taking into account the uncertainty about the place where the animal was infested (Dupuy *et al.,* 2015). Suitable prevention and control measures could also be implemented more easily. This would, however, require the use of data on cattle movements from birth to slaughter, and routine access to and analysis of these data are more complex.

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