

## **Cysticercosis and meat safety in the EU – status and perspectives**

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### Introduction

While porcine cysticercosis has been eliminated from most EU countries, bovine cysticercosis continues to be a concern for public health and the cattle industry, despite systematic meat inspection and good hygienic standards. It has been suggested that the persistence of bovine cysticercosis is due to the low sensitivity of meat inspection, cattle husbandry systems that allow grazing and consequently exposure to *Taenia* eggs, and the common practice of eating raw or undercooked beef in many EU countries. However, accurate data on taeniasis and cysticercosis are mostly lacking in most member states. In addition, the ways by which *Taenia* eggs find their way to pastures or feed are not well understood.

### Current situation in the EU

*Taenia saginata*, *T. solium* and *T. asiatica* are zoonotic helminths that have humans as the only definitive host. Their life cycles depend on the close link between humans and cattle (*T. saginata*) or pigs (*T. solium* and *T. asiatica*). Interruption of these links could result in the elimination of the parasites, which appears to be straightforward and easy. Indeed, infection by *T. solium* was eradicated in Western Europe mainly due to general socioeconomic development and intensification of pig husbandry systems that prohibits access of pigs to human stools. In contrast, *T. saginata* persists, despite general development and systematic meat inspection (EU Directive 854/2004). In European countries, the prevalence of bovine cysticercosis, mostly estimated from meat inspection results, varies between 0.007-6.8% (Dorny and Praet, 2007). However, many member states do not report the status of cysticercosis and the large differences in prevalence that exist between countries cannot be explained by differences in farm management systems and culinary habits only.

### Epidemiology

Humans are the definitive host of *T. saginata*, and are responsible for the dissemination of eggs in the environment through the elimination of proglottids via the stools. One proglottid can contain up to 50,000 eggs. Transmission to cattle can occur through the contamination of pasture, fodder or water with eggs. Direct transmission of eggs, resulting from hand-raising of suckling calves by tapeworm carriers has been reported, but appears to be rare. Eggs may remain viable for several weeks or months. When eggs are ingested by cattle, the oncospheres hatch, penetrate the intestinal mucosa and migrate via the general circulation to skeletal and cardiac muscles where they develop into cysticerci that become infective to man in about ten weeks. They begin to degenerate within a few months after infection, and by nine months, a substantial proportion of them are dead and calcified. Humans acquire infection by ingesting raw or undercooked infected beef. The tapeworm develops in the small intestine and becomes sexually mature in about three months, producing gravid proglottids, which are mobile and either migrate from the host's anus spontaneously or are shed in the stools. The tapeworm can survive in the definitive host for several years.

Cysticerci do not resist high temperatures and dietary habits and culinary practices affect transmission. Taeniosis is more common in populations/age groups that consume raw or undercooked beef.

Heavy infections in cattle are rather uncommon and are mostly associated with illegal application of sludge from septic tanks on pasture or crops, by indiscriminate defecation associated with camping and tourism, or by grazing on pastures in close proximity to sewage treatment plants. Light infections are much more common. They are the result of accidental ingestion of eggs that are disseminated in the environment. How these eggs are spread from tapeworm carriers, who often live in urban areas, to the rural areas is not well known, but it is clear that sewage treatment plants and water streams are pivotal.

The processing of sewage sludge and the delay between its application onto a pasture will affect the possibility of transmission. The standard application of sludge on pastures does not seem to be an important risk factor (Cabaret et al., 2002). In contrast, infection of cattle appears to be more often associated with the flooding of pastures, free access of cattle to surface water and the proximity of wastewater effluent. In the same study, demographic pressure has also been suggested to be a risk factor. Higher population density can increase the risk of bovine cysticercosis (Boone et al., 2007).

#### Current control measures and evaluation of their performances

Meat inspection is the cornerstone for control of *T. saginata*. Other measures include regulations for the treatment and use of sludge from sewage water treatment plants. According to the EU Directive n° 854/2004, all bovines of over six weeks of age have to be individually inspected for cysticercosis by visual observation and by cuts in masseter muscles, tongue, diaphragm and heart. If an animal has a generalised infection, the carcass and offal are declared unfit for human consumption. If the infection is localised, the carcass has to be stored at a temperature not exceeding -10°C for > 14 days before release for human consumption.

Many studies report on the low sensitivity of meat inspection. Less than 15% of infected animals are detected by this method. This is due to the fact that most animals are lightly infected and that only a proportion of the cysts (25%) are located in the so-called predilection sites that are inspected. In addition, the success of the method is highly dependent on the skills and the motivation of the meat inspector and on the stage of degeneration of the cysticerci. On the other hand, the specificity of meat inspection is moderate to high.

#### Alternative control measures

A recent Swiss study shows a considerably improved sensitivity of meat inspection by increasing the number of incisions (6 additional cuts) in the heart muscle: from a total of 1088 carcasses, 20 (1.8%) were found positive by the classical meat inspection (n° 854/2004), while the improved method with extra cuts detected 49 (4.5%) cases (Eichenberger et al., 2011).

Different serological tests have been described that demonstrate the presence of specific antibodies or circulating parasite antigens. Until now, these tests have not been routinely applied, but rather have been used for research purposes or for sero-prevalence studies. Antibody detection cannot differentiate between past and current infection and is therefore not an appropriate alternative for meat inspection. Circulating antigen can only be detected when viable cysticerci are present in the carcass. Only viable cysticerci are of public health importance, although the EU directives recommend seizure/condemnation of all cysticercosis cases, including those with viable, degenerated and calcified cysticerci. Validation of serological tests for bovine cysticercosis is problematic. Only full carcass dissection can unequivocally confirm the presence or absence of cysticerci. Preliminary results from our own laboratory show that a monoclonal antibody-based antigen capturing ELISA shows a sensitivity of 91% and a specificity of 96%; in contrast, the sensitivity and specificity of classical meat inspection were 8% and 88%, respectively (results apply for the detection of viable cysticerci only).

#### Conclusions

As a result of the low sensitivity of meat inspection, cysticercosis prevalence is likely to be seriously underestimated. In a Belgian study, 10 times more animals had circulating antigens than a positive result on meat inspection (3.09% versus 0.26%) (Dorny et al., 2000). In a recent study conducted in 10 slaughterhouses in NE Spain, this difference was even greater, 1.11% positives by Ag-ELISA versus 0.02% by meat inspection (Allepuz et al., 2012).

A variety of risk factors or practices maintain the cycle of *T. saginata*. Due to its low sensitivity, meat inspection cannot totally prevent the consumer from being infected through ingestion of raw or undercooked beef. Few data are available on the incidence of taeniasis in man because this parasitic infection is not notifiable; however, the incidence in Belgium was estimated at 0.01%, based on the sales of cestodicidal drugs. Current wastewater management not only fails to halt, but rather contributes to the

dissemination of *Taenia* eggs in the environment. It is assumed that water streams and surface water are potentially polluted with *T. saginata* eggs. In most cases, light infection of cattle is beyond the control of the cattle owner. Risk factors appear to vary between regions and studies are necessary on a regional level to identify the most important factors that will serve as a basis for selecting the most appropriate control measures. An effective control programme has to include actions intervening at various points of the life cycle of *T. saginata*. It requires an integrated approach among all stakeholders: consumers, medical doctors and pharmacists, meat inspectors, veterinary practitioners and farmers (Kyvsgaard and Murrell, 2005), and efficient coordination at national and European levels.

In conclusion, detection methods for bovine cysticercosis should be improved. Serological methods, such as the detection of circulating antigens (Ag-ELISA) are 10 to 50 times more sensitive than meat inspection. Their use will inevitably lead to an increased number of seized/condemned carcasses. The impact of this zoonosis on public health and the meat production sector should be thoroughly evaluated. Serological methods should be validated on a large scale before commercialisation. Other formats for serological diagnosis, both for rapid individual detection and for high throughput diagnosis should be developed and tested for ante-mortem and post-mortem detection. Finally, the efficacy on cysticerci of antihelminthic treatment should be assessed in cattle. In Latin American countries, the use of benzimidazoles for treatment of bovine cysticercosis is advocated by drug companies. Highly efficacious vaccines for bovine cysticercosis have been developed but these have to date not been commercialised yet, probably because of a lack of interest by the pharmaceutical industry.

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