

SCIENTIFIC REPORT submitted to EFSA

Development of harmonised schemes for the monitoring and reporting of *Cysticercus* in animals and foodstuffs in the European Union ¹

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ABSTRACT

Harmonised schemes are proposed for the monitoring and the reporting of *Cysticercus* in animals and foodstuffs in the European Union. The current disease situation and national monitoring in Member States is reviewed in order to identify public health needs in Member States and to create a basis for formulating the sampling plans. The proposal focuses primarily on the species most relevant to public health, namely *Taenia saginata* and *Taenia solium*; in addition *Taenia multiceps* is to be considered in certain areas of the European Union. The animal species to be monitored are cattle for *T. saginata* and pigs for *T. solium*. Current monitoring should continue to be based on visual meat inspection according to current European legislation, because more sensitive methods are not yet commercially available or fully validated for a routine diagnosis. However, central recording and reporting of results should be improved, including data on type of infection (light or heavy) and type of animal (adult cattle or calves, and pigs). Moreover the development and validation of a serodiagnostic test for bovine cysticercosis for use as a routine surveillance tool is recommended.

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KEY WORDS

Cysticercosis, *Cysticercus*, monitoring, *Taenia*, tapeworm, *T. saginata*, *T. solium*

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SUMMARY

Among circulating *Taenia* spp. within Europe, two species have been identified as zoonotic: *Taenia saginata* and *Taenia solium* originating from cattle and pigs, respectively. Human taeniosis is caused by the adult stage (tapeworm) of *T. solium* or *T. saginata* whereas human cysticercosis (bladderworm) is due to the larval (metacestode) stages of *T. solium* only. Human taeniosis does not necessarily cause symptoms but is considered as unacceptable in most part of the European Union since about 98% of patients have an unpleasant sensation caused by active discharge of proglottids from the anus. Taeniosis can be easily treated by the use of antihelmintics. In the case of human cysticercosis, cysticerci of *T. solium* can establish in muscles, subcutaneous tissue, the central nervous system (neurocysticercosis, NCC) and the eyes. NCC can be subclinical but is often accompanied by mild to very severe neurological symptoms of which epilepsy is the most common. Treatment of cysticercosis is cumbersome and needs hospitalisation of patients.

The current epidemiological situation in EU Member States is based on the detection of cysticerci in the carcasses of bovine animals over six weeks old and swine during meat inspection at slaughterhouse. The inspection is performed by visual inspection (macroscopic examination) of predilection sites according to Regulation (EC) No 854/2004, or by specific serological tests. Among Member States, only 13 reported to have a national collection of data on animal cysticercosis, and for more than one third of the Member States this data are lacking, complicating the evaluation of the epidemiological situation. Indeed, incomplete information is available on bovine cysticercosis with a disparity regarding number of cases in the different countries. Only three countries report prevalence data of this parasite in their bovine population. Regarding pig cysticercosis, the disease still occurs in Member States mainly in the eastern part of Europe (Austria, Estonia, Hungary, Lithuania, Poland and Romania).

The visual inspection currently performed at slaughterhouse is not sensitive enough to detect all the positive cases. The real prevalence of disease is thus underestimated. For bovine cysticercosis, there is at present no alternative to visual inspection because serological methods are not fully validated. In the case of porcine cysticercosis, serological tests identifying circulating antigens have been validated but are available only in research laboratories.

This report recommends the monitoring of bovine and porcine cysticercosis by visual inspection of carcasses and the development and validation of a serodiagnostic test for bovine cysticercosis.

TABLE OF CONTENTS

Abstract	1
Summary	2
Table of Contents	3
Background	5
Terms of reference.....	5
Acknowledgements	6
Introduction and Objectives	7
Objectives.....	9
Objective 1. Identify current disease situation in Member States and current national level of monitoring and reporting information	9
1.1 Rationale	9
1.2 Approach.....	9
1.3 Results.....	9
Objective 2. Identify animal species and/or foodstuffs which could be affected and specify which should be monitored	11
2.1 Identify parasite species to be monitored.....	11
2.1.1 Rationale.....	11
2.1.2 Approach	11
2.1.3 Results	12
2.2 Identify relevant animal species and/or foodstuffs to be monitored	14
2.2.1 Rationale.....	14
2.2.2 Approach	14
2.2.3 Results	14
Objective 3. Identify most suitable diagnostic and analytical methods to be used	15
3.1 Rationale	15
3.2 Approach.....	15
3.3 Results.....	15
Objective 4. Define sample size, collection procedure, specimen types and sampling techniques.....	17
Objective 5. Propose harmonised monitoring and reporting schemes	18
5.1 Monitoring schemes.....	18
5.2 Derogations from meat inspection	18
5.2.1 Data to be reported both at national and EU level.....	18
5.2.2 Population data	19

Objective 6. Propose information to be analysed by the Commission and EFSA for detecting trends.....	20
6.1 Analysis of data	20
6.2 Descriptive analyses.....	20
6.3 Monitoring trends over time	20
6.4 Spatial analysis	20
6.5 Other analyses.....	20
References	21
Appendices.....	24
A. Suggested proposal for reduced sampling of <i>Cysticercus bovis</i> in areas with low prevalence.....	24
B. Summary of country responses.....	25
C. Zoonotic species risk assessment – <i>Taenia</i> species (metacestodes <i>Cysticercus/Coenurus</i>) – Non-European species.....	27
D. Relevant animal species and/or foodstuffs to be monitored – <i>Cysticercus</i>	28
E. Summary of analytical methods.....	29
Abbreviations	30

BACKGROUND

In the EFSA (European Food Safety Authority) Community Summary Report (CSR) (2009) on zoonoses, the information received from the Member States (MSs) is analysed and summarised specifically to identify trends in the occurrence of the zoonotic agents and the sources of human infections. As there are currently no harmonised rules or recommendations for the reporting and monitoring of *Echinococcus* spp., *Trichinella* spp., *Cysticercus* spp. and *Sarcocystis* spp. in the European Union (EU), the data obtained is often difficult to analyse and interpret.

EFSA's Scientific Panels on Biological Hazards (BIOHAZ) and on Animal Health and Welfare (AHAW) issued an opinion on the Review of the CSR on Zoonoses, Zoonotic Agents and Antimicrobial Resistance in the European Union in 2004. In this opinion the panels concluded among other things: parasites (*Toxoplasma gondii*, *Echinococcus* spp., *Trichinella* spp. and *Taenia* spp./*Cysticercus* spp.) have been reported less frequently in humans, and have caused fewer outbreaks than bacteria and viruses in the EU in 2004. However, in many instances the impact of these zoonotic agents (severe illness, disability, death, and costs related to diagnostic procedures, hospitalisation and treatment) on vulnerable groups of the population, and often in immunocompromised persons, has probably been considerable.

The panels also stated that there is a need for a common strategy on data collection, monitoring and reporting as well as an improvement of harmonisation of definitions, in order to improve the usefulness of the data presented in the CSR.

TERMS OF REFERENCE

The objective of the call is to obtain proposals for projects, which will develop harmonised monitoring and reporting schemes for *Cysticercus* spp., respectively, in animals and, when appropriate, in foodstuffs under the Directive 2003/99/EC (EC, 2003). The schemes shall be applicable in all EU MSs.

These schemes shall, in particular, specify:

- the animal species and/or foodstuffs, which should be monitored and the study populations (subgroups of the population) to be targeted. The animal species may cover farm animals, pet animals, zoo animals and wildlife;
- the stage when the sampling should take place (e.g. at farm, at slaughterhouse);
- sample size (the number of samples to be collected) and the procedure setting out how samples should be selected;
- the type of specimen to be taken and sampling techniques;
- the diagnostic and analytical methods to be used;
- the information to be collected at national level; and
- the information to be reported to the Commission and EFSA.

The rationale for the specifications chosen in the monitoring and reporting schemes must be given. When developing the schemes, it is advisable to take into account public health needs, the feasibility and cost effectiveness of the schemes as well as different situations in the MSs.

The schemes shall also include suggestions for the analyses of the data at national and Community levels, and, in particular, indicate where the following of trends over the reporting years would be useful.

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- Rijksinstituut voor Volksgezondheid en Milieu (RIVM), The Netherlands; and
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- Agricultural University of Athens (AUA), Greece;
- Prince Leopold Institute of Tropical Medicine Antwerp (ITG), Belgium;
- Danish Agricultural & Food Council (DAFC), which has been created on 3 June 2009 by the merger of the Danish Meat Association (DMA) with four other organisations, Denmark;
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INTRODUCTION AND OBJECTIVES

INTRODUCTION

Cysticercosis, caused by the larval metacestode stages of *Taenia* spp., is monitored in the EU under Regulation (EC) No 854/2004 (EC, 2004), with requirements for post-mortem slaughterhouse inspection. In addition, specific serological tests may be used in meat inspection. In the case of bovines over six weeks of age the incision of masseter muscles is not compulsory if a specific serological test is used or when these animals derive from holdings officially certified as free of cysticercosis. Species with zoonotic potential occurring in the EU include *Taenia saginata*, the beef tapeworm and *Taenia solium*, the pork tapeworm. *Taenia saginata asiatica* can also infect humans in the adult stage but has until now not been reported outside Asia. Other *Taenia* species that circulate in domestic and wild animals in the EU do not normally infect humans although reports on human cases of coenurosis caused by *Taenia multiceps* have been reported (Scala and Varcasia, 2006).

The beef tapeworm, *T. saginata* is cosmopolitan in its distribution (Dorny and Praet, 2007). Humans acquire the infection by consumption of raw or undercooked beef containing live cysticerci. Upon ingestion of these cysticerci, an adult tapeworm will develop in the host's small intestine that will reach maturity within two to three months. An adult tapeworm can measure up to 3 to 12 metres and will release gravid proglottids that contain between 30,000-50,000 eggs (oncospheres) (Murrell et al., 2005). These proglottids leave the host by active migration through the anus or in the stools. The eggs contain a larva and are infective for the intermediate host (cattle), immediately after release from the human host. Cattle acquire the infection by accidental ingestion of the eggs while grazing or through contaminated feed. Following migration in the animal's body, the larvae will establish in the muscles and develop into cysticerci after 8 to 10 weeks. These cysticerci, which remain viable for several months/years, will finally degenerate and calcify. While it is known that the beef tapeworm persists in the EU despite slaughterhouse inspections, little is known about the prevalence in humans and cattle in the EU MSs. In some MSs a re-emergence in the number of cases in cattle was recorded in the last decade (Dorny and Praet, 2007). Some studies indicate wastewater effluent and sludge from water treatment plants, flooding of grazing land, drinking from effluent streams and tourism as risk factors for infection in humans (Ilsøe et al., 1990; Kyvsgaard et al., 1991; Cabaret et al., 2002; Boone et al., 2007; Flüttsch et al., 2008). The public health significance of the beef tapeworm is less important than the economic importance due to condemnation of carcasses (heavy infection) or freezing treatment to inactivate cysticerci (light infection). The parasite generally causes light clinical signs in the human host and is easy to treat. Control of the parasite is hampered by the low sensitivity of meat inspection (Dorny and Praet, 2007).

The pork tapeworm, *T. solium* has a very similar lifecycle compared to *T. saginata* but uses the pig (and the wild boar) as the intermediate host. However, humans can be infected with the adult tapeworm upon ingestion of cysticerci from infected pork, but also with the larval metacestode stage upon accidental ingestion of eggs excreted by a human tapeworm carrier or by self- or autoinfection². In humans, these cysticerci have a neurotropism and cause neurocysticercosis (NCC), the most important cause of acquired epilepsy in endemic countries (Garcia et al., 2003). *T. solium* is eradicated in most MSs but isolated foci still seem to occur (Overbosch et al., 2002). Eradication in EU MSs is the result of meat inspection, improved sanitation and modern pig production systems. Occasionally, import cases of NCC are seen in immigrants and in individuals who stayed in endemic countries. The parasite is still highly prevalent in most developing countries where pigs are raised and pork is consumed (Garcia et al., 2003; Phiri et al., 2003).

² Self-infection: accidental ingestion of eggs shed with the stools by the same person; Autoinfection: infection with the larval stage of *T. solium* in a tapeworm carrier by intestinal retro-peristaltic movements (this way of transmission is contested).

Cysticercosis is listed in point B.3 of the Annex I of the Directive 2003/99/EC as an infection to be monitored according to the epidemiological situation. Monitoring is done by meat inspection at the slaughterhouse. Bovine, porcine and other animal cysticercosis is notifiable to the World Organisation for Animal Health (OIE, 2008).

Cysticercosis is included in the CSR on Trends and Sources of Zoonoses of EFSA but only a few countries report data. This problem has also been addressed in the opinion of the EFSA Biological Hazard panel (EFSA, 2004) where the panel suspected cysticercosis to be present in MSs but to be under-reported (both in animals and humans). Also the low sensitivity of slaughterhouse inspection was acknowledged as well as the need for development of more sensitive tests.

OBJECTIVES

The objective of this report is to develop a harmonised scheme for the monitoring and reporting of *Cysticercus* in defined animal populations in the EU. The results from the application of such a harmonised scheme should create data that would enable comparison of disease levels and status between MSs and identification of trends on a national and Community level.

The overall objective was broken down into several milestones. The first milestone was to review the current disease situation and national monitoring in MSs. The rationale behind this was to identify public health needs in MSs and to create a basis for formulating the sampling plans. Other milestones assessed the agent and its species to identify which ones are relevant to public health, their impact on human health and their epidemiology. A list of animals and foodstuffs was created for the relevant agents and their suitability within monitoring schemes was assessed. Analytical methods are one of the limiting factors in surveillance. Existing analytical methods were summarised and assessed regarding their feasibility in sampling schemes that are designed to be carried out throughout the EU.

Objective 1. Identify current disease situation in Member States and current national level of monitoring and reporting information

1.1 Rationale

In the call for proposals it is specified that harmonised schemes should consider different situations in MSs and the schemes should be designed to be applicable to all MSs. Consideration should also be paid to testing schemes currently carried out in MSs. The table was designed to gather data needed to assess public health needs, the current testing situation and to define epidemiological parameters.

1.2 Approach

A spreadsheet for data and information collection was designed and circulated to MSs using personal contacts, established contacts of National Competent Authorities or networks within the project team. The spreadsheet asked for information on confirmed human cases and the current disease situation in relevant animal populations, as well as for supporting information on sampling and testing carried out in MSs. Where answers were not received, a literature search was carried out in order to fill the gaps. A summary table was compiled to give a brief overview of the current disease and a testing situation in the different MSs (Appendix A).

1.3 Results

Twenty-two out of the 27 Competent Authorities in MSs received the spreadsheet and 22 replied. Monitoring is done by visual inspection (macroscopic examination) of carcasses at slaughterhouse by the meat inspection. Only 13 MSs report that there is national coordination of cysticercosis, i.e. that the results of meat inspection from all slaughterhouses in the country are entered in a database.

Bovine cysticercosis

Very incomplete information was collected on bovine cysticercosis by MSs. Only three countries: Belgium, Germany and Italy, reported national prevalences of bovine cysticercosis based on meat inspection results (0.22, 0.02 and 0.01%, respectively). Other countries report the number of cases/year: Austria, Czech Republic, Denmark, Estonia, France, Hungary, Germany, Lithuania, Luxembourg, the Netherlands, Poland, Portugal and the United Kingdom UK (range 0-557 cases). Finland, Greece, Ireland, Latvia, Sweden, and Romania could not provide information on bovine

cysticercosis. Bulgaria, Cyprus, Malta, Slovakia, Slovenia and Spain could not be contacted since no official contacts have been identified. There is obviously a disparity in the number of cases detected in each MS.

Porcine cysticercosis

Five countries reported cases of porcine cysticercosis: Austria, Estonia, Lithuania (prevalence 0.01% in carcasses), Poland and Romania. In nine countries no cases were found at slaughter: Belgium, the Czech Republic, Denmark, Germany, Italy, Luxembourg, the Netherlands, Portugal and the United Kingdom. The other countries reported to have no information (N=5) or did not report (N=6). This means that data on porcine cysticercosis are lacking from more than one third of MSs. However, these incomplete results show that *T. solium* is persisting in some East European MSs and that the parasite has virtually been eradicated in North, West and South Europe.

Objective 2. Identify animal species and/or foodstuffs which could be affected and specify which should be monitored

2.1 Identify parasite species to be monitored

2.1.1 Rationale

In the Call for Proposals (CFP/EFSA/Zoonoses/2007/01), in the Manual for Reporting on Zoonoses, Zoonotic Agents, Antimicrobial Resistance and Food-borne Outbreaks in the framework of Directive 2003/99/EC (EFSA, 2007), and in the Reports on Trends and Sources of Zoonoses, Zoonotic Agents and Antimicrobial Resistance in the European Union in 2004 and 2005 (EFSA, 2005b, EFSA, 2006), *Cysticercus* is either referred to as *Cysticercus* spp. or it is not further specified. It was considered important to clarify which species are relevant in the context of public health, i.e. which are the zoonotic species and what is their impact on human health. The effect on human health needs to be considered when addressing the feasibility of sampling schemes especially in the light of the economic impact that these sampling schemes could have on individual MSs. A clear definition of the species in question was also required for addressing analytical methods, as methods may differ from species to species and different analytical techniques may be required for species differentiation.

2.1.2 Approach

Literature: scientific publications, textbooks, official websites (World Organisation for Animal Health (OIE); World Health Organisation (WHO); European Center for Disease Prevention and Control (ECDC)) on *Cysticercus* were reviewed and the information/existing knowledge on zoonotic species summarised (Appendix B). The identified species were run through a number of criteria, listed below, and their zoonotic potential assessed. A summary of the results can be found in the spreadsheet '*Cysticercus* Zoonotic species RA' in Appendix C.

The species were run through the following criteria:

Criterion 1: Zoonotic (Y/N)?

Species which have not been reported in literature as zoonotic were not taken further through the qualitative risk assessment, as they were considered irrelevant to this project.

Criterion 2: Pathogenicity

This qualitative assessment was based on clinical symptoms reported in humans. Distinction was made between taeniosis and cysticercosis. Taeniosis is caused by infection with the adult stage of *Taenia* spp, the tapeworm that lodges in the small intestine and generally causes mild abdominal discomfort, anal pruritis and weight loss, and occasionally diarrhoea and vomiting. Cysticercosis is caused by the larval metacestode stage of the parasite, the *Cysticercus* or *Coenurus*. Clinical symptoms are dependent on the organ in which the cyst develops and the severity of infection. They are inexistent or mild in the case of light muscular or subcutaneous infection, but can be very severe in the case of establishment in the central nervous system or in the eye, requiring medical treatment, possibly hospitalisation, long term effects and can be fatal.

Criterion 3: Geographical distribution

Geographical distribution signifies the presence in the EU or likelihood of introduction into EU MSs and likelihood of establishment if agent were to be introduced.

Zoonotic species, currently not considered autochthonous to the MSs, were assessed as to how likely it is for them to be introduced into EU MSs and, consequentially, the likelihood of establishment. This all depends on the epidemiology of the agent and the role of humans as intermediate or final/dead end hosts or 'carriers'.

Criterion 4: Economic impact of human disease

For a qualitative assessment of the economic impact of human clinical disease, treatment costs and/or number of sick days, and long term effects were considered. Again, this was carried out on a qualitative scale, to give a rough guideline and justification of monitoring schemes.

2.1.3 Results

Cysticercosis is caused by infection with the larval stage of *Taenia* spp. This infection occurs mostly in animals but humans may also be infected with the cysticerci (*Cysticercus cellulosae*) of *T. solium*, the pork tapeworm. Human infection occurs via ingestion of eggs of *T. solium* that are passed with the faeces from a human tapeworm carrier or by self- or autoinfection. *C. cellulosae* can cause neurocysticercosis, a severe condition affecting the nervous system and causing seizures. Human susceptibility is high and the effects severe, long term and the treatment expensive (Garcia et al., 2003).

Taeniosis

Taeniosis is the infection with the adult tapeworm. Humans are the final host of *T. solium*, *T. saginata* and *T. saginata asiatica* that are zoonotic species because they are transmitted to man by eating raw or undercooked meat from pig, cattle and pig, respectively (intermediate hosts). *T. s. asiatica* or the Asian tapeworm has not been reported in Europe and is considered more relevant to Asia. Tapeworm infections do not necessarily cause symptoms. However, taeniosis causes emotional distress in the carrier and is considered unacceptable in most parts of Europe. When present, clinical signs include mild abdominal discomfort, anal pruritis and weight loss. Anal pruritis is caused by the active migration of gravid proglottids through the anus. Gravid proglottids of *T. saginata* are more active than those of *T. solium*, which are mostly expelled during defecation. Between three and seven proglottids are released every day. Occasionally, taeniosis may be accompanied by more severe symptoms, such as diarrhoea, nausea, and very rarely intestinal perforation and peritonitis. Taeniosis in humans is not notifiable in the EU. As a result, there is a lack of data on the prevalence of human taeniosis. Estimates are derived from sales of cestodicidal drugs, mainly niclosamide (Niclosamide®, Bayer), which is the drug of choice for the treatment of taeniosis in the EU.

Cysticercosis

Cysticercosis is caused by infection with the metacestode (*Cysticercus*) stage of *Taenia* spp. Cysticercosis is caused by larvae of *T. saginata* (*Cysticercus bovis*), *T. solium* (*Cysticercus cellulosae*) and *T. s. asiatica* (*Cysticercus viscerotropica*). Larvae develop in the intermediate host, but for *T. solium* they may also develop in humans. *T. solium* causes taeniosis and cysticercosis in humans. Human cysticercosis is acquired by the accidental ingestion of eggs through environmental contamination of soil, water, raw vegetables, through direct contact with a tapeworm carrier (faecal–

oral infection) or through self- or autoinfection. In humans cysticerci of *T. solium* can establish in the muscles, subcutaneous tissue, the central nervous system and the eyes. Infection of the central nervous system can be associated with mild to severe neurological symptoms, but is asymptomatic in some cases. Symptoms usually occur several months/years after infection, when the cysticerci start to degenerate, which is accompanied by tissue reaction. Symptoms include severe headache, seizures, epilepsy, increased intracranial pressure, hydrocephalus, blindness and death. Diagnosis is based on anamnesis, clinical symptoms and neuroimaging techniques such as CT-scan and MRI, supported by serological methods. Treatment of human cysticercosis is complicated and patients have to be hospitalised during and after the treatment course because they can develop seizures (Murrell et al., 2005).

T. saginata/Cysticercus bovis

The public health risk of *T. saginata* in humans is limited because symptoms are mild in most cases and infection is easily treated. Bovine cysticercosis is usually not accompanied by clinical symptoms. However, monitoring of *T. saginata* in the EU is advised, mainly because of the emotional stress involved in having a tapeworm, and also because of the occasional heavier symptoms it can cause. The prevalence of taeniosis is unknown. According to data from sales of anti-parasitic drugs, prevalence estimates vary from 0.01% to 10%. The symptoms are – as described above – mild, abdominal discomfort to which effective drug treatment exists.

The currently used post mortem meat inspection is not sensitive for detection of the parasite. It has been shown that meat inspection underestimates the real prevalence of bovine cysticercosis by a factor of 3 to 10 (Dorny et al., 2000; Kyvsgaard et al., 1990; Walther and Koske, 1980). Currently, there is no alternative to visual post mortem meat inspection. Detection of circulating parasite antigen or specific antibodies is promising (Harrison et al., 1989; Dorny et al., 2000; Abuseir et al., 2007), but these techniques can show a lower sensitivity in animals that harbour a low number of cysticerci, which is the case in most infected cattle in Europe. According to preliminary validation results, the sensitivity of Ag-ELISA is close to 100% when 50 or more viable cysts are detected in the carcass, and around 65% when between 1-49 cysts are found (P. Dorny, personal communication). Accurate measurement of sensitivity and specificity of sero-diagnostic techniques for bovine cysticercosis is only possible through complete dissection of bovine carcasses.

T. solium/Cysticercus cellulosae

Human cysticercosis is one of the main causes of acquired epilepsy and the most important parasitic infection causing neurological disorders. Consequently, the monitoring of *T. solium* is strongly advised. Infection with *Cysticercus cellulosae* in pigs has become scarce in most MSs because of improved hygiene and modern pig production systems, preventing the pigs from having access to human faeces. However, the results of our study indicate that there is still active transmission, probably in Eastern European countries. Monitoring is done by visual post mortem meat inspection, which is sensitive in massive parasite infections. The sensitivity is, however, greatly reduced in light infections, which occur along the heavy infections in endemic regions. Detection of the circulating antigen is an interesting alternative for meat inspection because it is much more sensitive. It will only detect viable infections (Dorny et al., 2004). A major drawback of antigen detection is that infections with cysticerci of *Taenia hydatigena*, a tapeworm that has dogs as a final host and ruminants and occasionally pigs as an intermediate host, may cross-react in the antigen-detecting test (Dorny et al., 2004). No information on the occurrence of *T. hydatigena* in pigs is available in MSs.

2.2 Identify relevant animal species and/or foodstuffs to be monitored

2.2.1 Rationale

Parasite species are often reported in a wide variety of hosts, not all of which necessarily play a role in the transmission of the disease, have an impact on the human food chain or are suitable for surveillance in a public health context. The aim was to identify which species would be suitable for surveillance in all MSs and consideration was given to existing surveillance carried out in MSs.

2.2.2 Approach

A table was compiled with animal species in which the zoonotic agent has been reported (Appendix C). The animal species were then assessed for their role in the epidemiological chain and the human food chain.

2.2.3 Results

Of all *Taenia* spp. occurring in humans, domestic animals and wildlife in the EU, only *T. saginata* and *T. solium* are likely to be monitored, the other species having no or very limited zoonotic potential or not being reported in MSs. A few human cases of *T. multiceps* with brain or eye involvement have been reported in the EU and with the emergence of this parasite in some regions of the EU (e.g. Sardinia) (Scala and Varcasia, 2006) monitoring of this parasite in certain areas of the EU might be considered.

The animal species to be monitored are cattle for *T. saginata* and pigs, for *T. solium*. For the monitoring of *T. multiceps*, small ruminants may also be considered, as these are the most common intermediate hosts. In addition, where meat inspection is routinely carried out on wild boars hunted or slaughtered for human consumption, these should also be monitored for *T. solium*. There are currently no recommendations for cysticercosis control in game meat in Regulation (EC) No 854/2004.

No other foodstuffs than carcasses are relevant for the monitoring.

Objective 3. Identify most suitable diagnostic and analytical methods to be used

3.1 Rationale

For most agents more than one detection method exists, applicable to different sample materials and producing results that often vary from method to method. These methods were compiled to identify the limitations of what can be achieved diagnostically, compare the cost benefits of various methods and to assess practical aspects. Not every test can be used for every sample type. However, if two different methods produce the same result, e.g. measuring of national prevalence to a certain level, the result of both methods could be directly compared. A cost estimate was also included as this is an important criterion when recommending analytical methods.

3.2 Approach

Existing analytical methods, as cited in publications or official methods (Murrell et al, 2005; OIE, 2008) were compiled and test specifics (sensitivity, specificity), listed as far as available. The summary can be found in Appendix E. Also considered were the expenditure and complexity of the test methods. The costs were roughly estimated, where possible, bearing in mind that they vary from country to country and depend on the daily throughput in a diagnostic facility.

3.3 Results

Bovine cysticercosis

The presence of *T. saginata* cysts in cattle is determined during visual inspection of carcasses and enforced through Regulation (EC) No 854/2004. Inspection includes incisions into the internal and external masseter muscles (not applicable to animals under six weeks of age) and a lengthwise incision of the heart in cattle of all ages (plus visual inspection). The sensitivity of visual inspection of carcasses is believed to be low (<30%), which has been demonstrated in Danish and Belgian studies. Dorny et al. (2000) reported that the cysticercosis sero-prevalence found in slaughtered cattle (1,164) was 10 times higher than the annual prevalence (0.26%) reported by the Institute of Veterinary Inspection.

The available research thus suggests that the prevalence of bovine cysticercosis in the EU as determined through meat inspection is underestimated (Dorny and Praet, 2007).

Other methods based on molecular biology (Geysen et al., 2007), serology or histopathology, are not available for a routine diagnosis at the slaughterhouse although in surveillance programmes they might be more reliable and suitable for a quality assurance system than direct visual meat inspection. Currently the only affordable and feasible test available is routine visual meat inspection but this is not sufficient and cannot really be recommended for a harmonised approach. However, it is believed that visual meat inspection is able to identify the heavily infected carcasses, which also constitutes the largest risk for humans and so still prevents heavily infected animals from entering the food chain.

Therefore, current monitoring should continue to be based on visual meat inspection according to current EC legislation, however, central recording and reporting of results should be improved. Regulation (EC) No 854/2004, Chapter IX, currently allows the use of serological tests on cattle, and it is recommended that such tests be further developed for use as a routine surveillance tool as soon as possible.

The main problem with current serological tests is the lack of adequate sensitivity for lighter infections, common in Europe, though infections are still being picked up. In preliminary validation study, the Ag-ELISA was positive in two out of three animals with 21-50 cysticerci, four out of six animals with 11-20 cysticerci and one out of four with 1-10 cysticerci (P. Dorny, personal communication). This however is not considered sufficient for using this test as replacement for meat inspection because we cannot guarantee that the meat is 100% safe. According to expert opinion it is expected that developing a more sensitive ELISA will be extremely difficult and the development of other monoclonal antibodies with higher affinity, is likely to take years. Only once this problem has been overcome, the validation of serological tests and availability on a commercial basis is considered a priority for the surveillance of cysticercosis. Validation could be carried out through collection of animals identified as negative or positive at visual meat inspection. This would involve dissection of the predilection organs (masseter, heart, oesophagus, tongue and diaphragm) on a large number of animals that were found negative and positive during routine visual meat inspection.

Porcine cysticercosis

The presence of *T. solium* cysts in pigs is determined during visual inspection of carcasses and enforced through Regulation (EC) No 854/2004. Inspection includes a lengthwise incision of the heart. The sensitivity of visual inspection of carcasses is low (<25%), which has been demonstrated in African studies (Dorny et al., 2004), where besides massive infections that are easily diagnosed by meat inspection, light infections occur that are easily overlooked.

Other methods based on molecular biology (Geysen et al., 2007), serology or histopathology, are not available for a routine diagnosis at slaughterhouse although in surveillance programmes they might be more reliable and suitable for a quality assurance system than direct visual meat inspection. Currently the only affordable and feasible test available is routine visual meat inspection but this is not sufficient and cannot really be recommended for a harmonised approach. However, it is believed that visual meat inspection is able to identify the heavily infected carcasses, which also constitutes the largest risk for humans and so still prevents heavily infected animals from entering the food chain.

Therefore, current monitoring should continue to be based on visual meat inspection according to current EC legislation, however, central recording and reporting of results should be improved.

A number of serological tests for the diagnosis of porcine cysticercosis were developed that showed good performances. Tsang et al. (1991) adapted an immunoblot test for antibody detection in pigs and described a sensitivity and specificity of both 100%. A monoclonal antibody based ELISA for detecting circulating antigen was fully validated in African village pigs (Dorny et al., 2004). It showed a sensitivity of 86.7% and a specificity of 94.7%. Cross-reactions with this test were observed in pigs infected with cysticerci of *Taenia hydatigena*. Several other tests are described in the literature. However, none of these tests are commercially available. These tests should be validated in MSs where *T. solium* still circulates.

Objective 4. Define sample size, collection procedure, specimen types and sampling techniques

For visual meat inspection all animals should be sampled at slaughterhouse or game handling establishment according to Regulation (EC) No 854/2004.

Sample size

Sample sizes are not applicable for visual meat inspection where all slaughtered animals are tested. If serological tests become widely available, options for reduced testing of some animal categories may be considered. In this case a suitable sample size to detect prevalence at the recommended level will need to be determined.

Objective 5. Propose harmonised monitoring and reporting schemes

5.1 Monitoring schemes

As discussed above, until serological tests are available for surveillance and monitoring uses, all animals should be examined at slaughter via routine visual meat inspection. MSs should be encouraged to register and report all cases of cysticercosis detected in the slaughterhouse and include data on type of infection (light or heavy) and type of animal (adult cattle or calves, and pigs).

Because routine visual meat inspection is very likely to underestimate the true prevalence of cysticercosis, the possibility of using serological methods for surveillance of cysticercosis should be further explored. Attempts should be made to validate serological tests and to explore the ways and at what cost these tests can be implemented.

Furthermore, consideration should be given in the future to the option of reduced testing for cysticercosis. This is of particular relevance to porcine cysticercosis in regions where it had been eradicated (e.g. North and West Europe). This would rely on a sensitive test to ensure freedom from the disease. An example of reduced testing for bovine *Cysticercus*, should sensitive serological tests become available is given in Appendix E.

Where positive animals are identified at the slaughterhouse it is recommended that the farm of origin be traced and epidemiological investigations be carried out on the farm. For pigs, cases of cysticercosis are usually clustered around a human tapeworm carrier (Garcia et al., 2003). This is in contrast to the situation in cattle, where environmental contamination occurs. In cattle, when several animals are found infected on the same farm, it is recommended that the people working on the farm be subject to a stool examination (Murrell et al., 2005).

5.2 Derogations from meat inspection

At present Regulation (EC) No 854/2004, Chapter IX, only permits an exemption for incisions of masseter muscles (in bovines over six weeks old) at post-mortem inspection when a specific serological test is used or when bovine animal have been raised on a holding officially certified to be free of cysticercosis. Currently no serological tests exist and the importance of validating tests has been outlined elsewhere in this report.

The official certification of farms as free from *Cysticercus* could be carried out by classifying herds according to their risk of *Cysticercus* and allow a simplified post-mortem examinations for calves from integrated productions systems from farms officially classified as having a low risk e.g. calves for white meat that are kept in zero grazing conditions. This has been suggested by the opinion from the Scientific Panel on Biological Hazards within EFSA (EFSA, 2004).

5.2.1 Data to be reported both at national and EU level

- MS name
- Date of start and end of surveillance
- Analysis method used or reference to visual post mortem meat inspection

- Number of animals tested by species and production type/husbandry system (e.g. controlled housing, breeding for pigs or veal, dairy, beef for cattle) as given in Food Chain Information (FCI)
 - pigs
 - cattle
 - other

- Overall results
 - number of positive animals in each species/production type category
 - prevalence of *Cysticercus* in each category
 - number of carcasses infected heavily/lightly (when data available)

5.2.2 Population data

MSs should also submit population data on all species monitored for cysticercosis if this has not already been done. It is essential that population data also contain information on the production and husbandry types of the national livestock populations.

Objective 6. Propose information to be analysed by the Commission and EFSA for detecting trends

The information to be reported by MSs is described below and consists of a description of a surveillance programme and data on the animals tested. MSs are encouraged to utilise FCI described in Regulation (EC) No 853/2004 (EC, 2004a) and in Regulation (EC) No 854/2004 (EC, 2004b) where possible, as collection of information on origin of bovine carcasses is mandatory under the new food hygiene legislation introduced on 1 January 2009.

6.1 Analysis of data

Please note, the suggestions below are dependent on the quality and quantity of monitoring and population data. EFSA's working group on statistical analysis of temporal and spatial trends in zoonotic agents in animals and food are due to publish recommendations on the analysis of monitoring data and these recommendations should also be taken into consideration. Additional suggestions are set out below.

6.2 Descriptive analyses

As is currently reported in the EFSA CSR, tables showing the number of animals tested, numbers positive, intensity of infection (light or heavy infections) and prevalence for each animal category monitored and for each MS. An estimate of the prevalence of *Cysticercus* at Community level should also be reported.

Reporting of prevalence according to animal production type or husbandry can also be carried out and presented at the community level.

6.3 Monitoring trends over time

The prevalence of *Cysticercus* in previous years can be presented at Community level in a bar chart or similar to illustrate changes in prevalence in previous years. Individual MS charts can also be presented if informative.

Because all animals are monitored and the numbers are large, the detection of trends in disease can be carried out over consecutive years. Suggested approaches might include multilevel models (e.g. GEE, random effects) to account for differences in trends between MSs, or other non-parametric tests as recommended by the above mentioned working group.

6.4 Spatial analysis

Choropleth maps can be used to illustrate the proportion of the different species or different production/husbandry types. Where account of the underlying populations is required a cartogram could be used to highlight regions with the largest pig or cattle populations.

6.5 Other analyses

Where adequate data exists, an estimate of the relative risks of *Cysticercus* in each husbandry/production system can be made. This may inform later recommendations regarding the option of reduced sampling in low prevalence areas (see Appendix A). However, based on current data it is not possible to make any recommendation about the possibility of 'risk based' monitoring or surveillance. Once data have become available, it will deserve further study.

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APPENDICES

A. SUGGESTED PROPOSAL FOR REDUCED SAMPLING OF *CYSTICERCUS BOVIS* IN AREAS WITH LOW PREVALENCE

In many areas the prevalence of *Cysticercus bovis* is very low, e.g. Denmark (see Figure 1). It is recommended that in areas where the prevalence of *C. bovis* is below 0.1% (as demonstrated by meat inspection) the veterinary authorities in a country may decide in which regions the risk can be considered low. That might be based on statistics from slaughterhouses as well as on how sewage water is disposed of – because exposure of cattle to human faeces is required for the parasite to be spread to cattle. In regions with low (<0.1%) prevalence, a surveillance programme involving a stratified (by slaughterhouse) sample of all cattle slaughtered can be suggested.

Sample sizes should be estimated depending on the prevalence level required for demonstrating absence of disease, for example testing 300 negative corresponds to a prevalence of less than 1%, testing 600 negative corresponds to a prevalence of less than 0.5% and testing 3,000 negative corresponds to a prevalence of less than 0.1%.

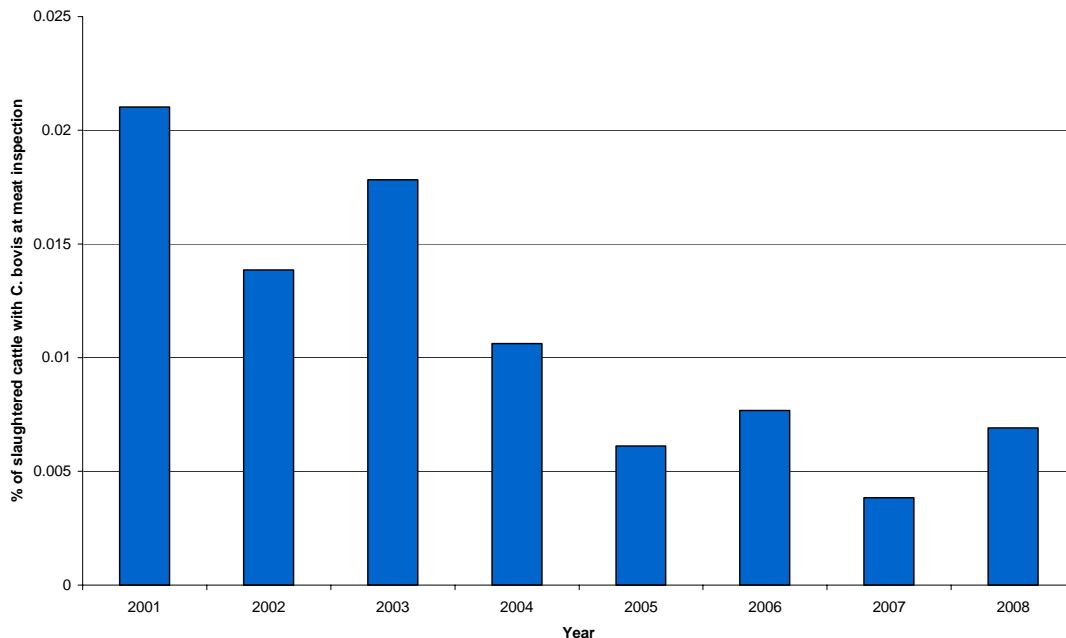


Figure A1. Prevalence of *C. bovis* in cattle at slaughter in Denmark

B. SUMMARY OF COUNTRY RESPONSES

Member States	Institute contacted	Contacted	Response	Method	Information Summary		National Coordination
					Positive Animals		
					Cattle	Pig	
Austria	AGES Österreichische Agentur für Gesundheit und Ernährungssicherheit GmbH	Y	Y	Macroscopic examination	204 cases (2007)	34 cases (2007)	Y
Belgium	Institute of Tropical Medicine	Y	Y	Macroscopic examination	Prevalence 0.22% (2006)	Not autochthonous	Y
Bulgaria							
Cyprus	Department of Veterinary Services, Ministry of Agriculture, Natural Resources and Environment, Republic of Cyprus	Y	Y	Carcasses are examined at slaughterhouses. All cases reported concern <i>Cysticercus taenuicollis</i> or <i>Cysticercus pisiformis</i> . No data on human cysticercosis is available (official or literature).	No data provided	No data provided	
Czech Republic	Department of Veterinary Hygiene, Public Health and Ecology	Y	Y	Macroscopic examination	152 in 2007	None in 2007	Y
Denmark	Food Department Danish Meat Association	Y	Y	Macroscopic examination	50 cases (2007)	No (2007)	Y
Estonia	Food and Veterinary Service, Latvia	Y	Y	Macroscopic examination	No	10 (2006)	Y
Finland	Finnish Food Safety Authority (to be confirmed)	Y	Y		No information		
France	Ministry of Agriculture	Y	Y	Macroscopic examination	18 cases (2006)	No information	N
Germany	BfR - Bundesinstitut für Risikobewertung	Y	Y	Macroscopic examination	682 cases (2007) Prevalence 0.02	0 (2007)	Y
Greece	Agricultural University of Athens	Y	Y		No information		
Hungary		Y	Y	From the 1960s, only few cases (<10) were recorded in swine, and the prevalence of cysticercosis was 0.05-0.28% in cattle (Kassai, 1989, 2003). In the past decade, no autochthonous <i>Taenia solium</i> infection was recorded in man, and the incidence of human <i>Taenia saginata</i> infection is negligible (0.00-0.06 case per population of 100,000) in Hungary (Epinfo; Kassai, 2003).			

B (contd.). Summary of country responses

Member States	Institute contacted	Contacted	Response	Method	Information Summary		National coordination
					Positive Animals		
					Cattle	Pig	
Ireland	Central Meat Control Laboratory Ireland	Y	Y			No information	
Italy	Istituto Superiore di Sanità	Y	Y	Macroscopic examination	Prevalence 0.01 (2007)	0 (2007)	Y
Latvia	Food and Veterinary Service, Latvia	Y	Y			No information	
Lithuania	Food and Veterinary Service, Latvia	Y	Y		None in 2007 10 cases in 2005	113 cases Prevalence 0,01	Y
Luxembourg		Y	Y	Macroscopic examination	125 cases/year	/	Y
Malta		Y	N				
Netherlands	RIVM - Laboratory for Zoonoses and Environmental Microbiology	Y	Y	Macroscopic examination	557 cases in 2008	No cases in 2006	Y
Poland	National Public Health Institute	Y	Y	Macroscopic examination	69 cases (2007)	547,941 cases*	Y
Portugal		Y	Y	Macroscopic examination	1 case (2005)	None in 2005	Y
Romania	Faculty of Veterinary Medicine of Cluj Napoca	Y	Y	Macroscopic examination	No data	Around 50 cases in 2007	Y
Slovakia							
Slovenia							
Spain		Y	N				
Sweden	National Veterinary Institute (to be confirmed)	Y	Y			No information	
United Kingdom	UK Food Standards Agency	Y	Y	Macroscopic examination	No cases in 2006	No cases in 2006	Y
Total		24/27	22				

* Note from authors: figure considered too high and awaiting confirmation. We suspect an error occurred in the communication line.

C. ZOONOTIC SPECIES RISK ASSESSMENT – *TAENIA* SPECIES (METACESTODES *CYSTICERCUS/COENURUS*) – NON-EUROPEAN SPECIES

Taenid Species	Metacestode	Final Host	Intermediate Host	Zoonotic (Cysticercosis) (Y/N)	Geographical distribution	Likelihood of introduction (H/M/L)	Likelihood of establishment in Europe (H/M/L) Intermediate/final hosts present/ life cycle sustainable?	Human Susceptibility (H/M/L)	Pathogenicity (humans)* e.g. severity of symptoms/ morbidity	Mortality Rate (%)	Long-term effects ?	Economic impact of disease	Risk groups?	Monitoring in the EU recommended? (Y/N)	Comments	Reference
<i>Taenia solium</i>	<i>Cysticercus cellulosae</i>	Human	Pig (human)	Y	Worldwide. Endemic Latin America, Africa, Asia. Foci in Spain, Germany, Poland and Eastern Europe	N/A Endemic	N/A Endemic	N/A Endemic	Neurological symptoms (e.g. seizures and epilepsy) are severe.	N/A. Racemose form >20%	Y	Economic impact of <i>T. solium</i> in endemic countries high, in Europe most likely medium.	Poor sanitation, pig herd practices, eating habits	Y	Main cause of acquired epilepsy in developing countries. Becoming a problem in industrialised countries because of immigration of tapeworm carriers from areas of endemic disease.	WHO/FAO/OIE Guidelines (2005) Burneo J.G. (2006). Neurocysticercosis @ http://www.emedicine.com/neuro/topic629.htm
<i>Taenia saginata</i>	<i>Cysticercus bovis</i>	Human	Cattle	Y	Worldwide. Particularly important in Africa and South America.	N/A Endemic	N/A Endemic	N/A Endemic	Infection usually asymptomatic, possibly mild symptoms such as abdominal discomfort, digestive upset and diarrhoea.	0	None	L	Poor sanitation, cattle herd practices, eating habits	Y	Infection usually mild in humans.	Dorny P, Praet N. 2007. <i>Taenia saginata</i> in Europe. <i>Vet Parasitol.</i> 149, 22-24.
<i>Taenia saginata (asciatica)</i>	<i>Cysticercus bovis</i>	Human	Pig	Y	Taiwan, Korea, Vietnam, Thailand, Indonesia, China.	L	L	H	As for <i>T. saginata</i>	0	None	None		NO, because risk of introduction into Europe at this point low.	As for <i>T. saginata</i>	Ito A, Nakao M, Wandra T, Suroso T, Okamoto M, Yamasaki H, Sako Y, Nakaya K. 2005. Taeniasis and cysticercosis in Asia and the Pacific: present state of knowledge and perspectives. <i>Southeast Asian J Trop Med Public Health.</i> 36 Suppl 4:123-30.
<i>Taenia hydatigena</i>	<i>Cysticercus tenuicollis</i>	Dog, fox	Cattle, sheep, goat, pig, deer, horse	N	Worldwide	N/A Endemic	H Endemic	L	N/A	N/A	N/A	M	Sheep, cattle	N	Severe infections can produce liver/carcass condemnation and death	Rehbein S, Kollmannsberger M, Visser M, Winter R. 1996. [Helminth burden of slaughter sheep in Upper Bavaria. 1: Species spectrum, infestation extent and infestation intensity]. <i>Berl Munch Tierarztl Wochenschr</i> 109, 161-167.
<i>Taenia ovis</i>	<i>Cysticercus ovis</i>	Dog, fox	Sheep, goat	N	Worldwide	N/A Endemic	H Endemic	L	N/A	N/A	N/A	M	Sheep, goat	N	Infections can lead to carcass condemnation	Borgsteede FH, Dijkstra J, Dijkstra RG, Sol J, Vellema P. 1985. [Various cases of cysticercosis in sheep in the Netherlands]. <i>Tijdschr Diergeneesk.</i> 110, 898-900.
<i>Taenia multiceps</i>	<i>Coenurus cerebralis</i>	Dog, fox	Sheep, goat, cattle, deer, pig, horse, man	Y	Worldwide	N/A Endemic	H Endemic	L	N/A	N/A	N/A	L	Sheep, goat	To be considered, only in endemic regions of the EU	The prevalence is generally low and only a few human cases reported.	Pozio E. 2008. Epidemiology and control prospects of foodborne parasitic zoonoses in the European Union. <i>Parasitologia</i> 50, 17-24.
<i>Taenia taeniaeformis</i>	<i>Cysticercus fasciolaris</i>	Cat, fox	Small rodents	N											Non-zoonotic, therefore not further assessed.	
<i>Taenia crassiceps</i>	<i>Cysticercus longicollis</i>	Dog, fox	Small rodents	N*	Worldwide	N/A Endemic	H Endemic	L	N/A	N/A	N/A	None	None	N	Not usually considered zoonotic, but has been reported sporadically in humans in conjunction with immunodeficient conditions. Hence routine monitoring not recommended.	Heldwein et al., 2006.
<i>Taenia pisiformis</i>	<i>Cysticercus pisiformis</i>	Dog, fox	Rabbit	N											Non-zoonotic, therefore not further assessed.	
<i>Taenia cervi (krabbei)</i>	<i>Cysticercus cervi (tarandi)</i>	Wolf, fox	Deer (reindeer)	N											Non-zoonotic, therefore not further assessed.	
<i>Taenia hyaenae</i>	<i>Cysticercus dromedarii</i>	Hyena	Camel (dromedary)	N											Non-zoonotic, therefore not further assessed.	

* depending on amount of intake

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D. RELEVANT ANIMAL SPECIES AND/OR FOODSTUFFS TO BE MONITORED – *CYSTICERCUS**Cysticercus cellulosae (Taenia solium)*

Animal species or foodstuff	Role in infection chain (DH/PH/SH/IH/DEH/RH)*	Part of human food chain/ diet (Y/N)	Known as source of human infection/ linked to outbreaks (Y/N)	Suspected source of infection / outbreaks (Y/N)	Relevant to be monitored (Y/N)	Rationale for monitoring / application of result	References
Pigs	IH	Y	Y	N/A	Y	Direct protection of human health	FAO/WHO/OIE Guidelines for the surveillance, management, prevention and control of taeniosis / cysticercosis. K.D. Murrell, 2005. Office International des Epizooties (OIE), France. ISBN 92-9044-656-0
Wild Boar	IH	Y	N	N	N	Even in endemic countries low prevalence in wild boar. No infection of WB in Europe known.	P. Dorny, personal communication
Dogs	IH	N	N	N	N	Not part of human diet in Europe.	P. Dorny, personal communication
Bears	IH	Yes, in some European MSs.	?	?	N	Not considered suitable species for monitoring on EU level. Species does not occur throughout Europe and is under special protection (Bern convention).	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Sixth Edition, 2008. Office International des Epizooties (OIE), France. ISBN 978-92-9044-718-4. Convention on the Conservation of European Wildlife and Natural Habitats. Bern 1979.

Cysticercus bovis (Taenia saginata)

Animal species or foodstuff	Role in infection chain (DH/PH/SH/IH/DEH/RH)*	Part of human food chain/ diet (Y/N)	Known as source of human infection/ linked to outbreaks (Y/N)	Suspected source of infection / outbreaks (Y/N)	Relevant to be monitored (Y/N)	Rationale for monitoring / application of result	References
Cattle	IH	Y	Y	N/A	Y	Direct protection of human health.	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Sixth Edition, 2008. Office International des Epizooties (OIE), France. ISBN 978-92-9044-718-4. Regulation 854/2004/EC.
Buffalo	IH		?		N	No relevant food source in Europe (?)	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Sixth Edition, 2008. Office International des Epizooties (OIE), France. ISBN 978-92-9044-718-4.
Reindeer	IH	Y	?	N/A	?	Insufficient evidence	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Sixth Edition, 2008. Office International des Epizooties (OIE), France. ISBN 978-92-9044-718-4.

*DH = definitive or final host in which an organism undergoes its sexual phase of reproduction.

*PH = Primary host. Animal that maintains an infection in its endemic area.

*SH = Secondary Host. Species that is additionally involved in the life-cycle of an agent, especially outside typical endemic areas.

*IH = Intermediate Host. Animal in which the infectious agent undergoes some development, frequently with asexual reproduction.

*DEH = Dead-end host or incidental host. Host that usually does not transmit an infectious agent to other animals.

*RH = Reservoir Host. Host in which an infectious agent normally lives and multiplies, therefore a common source of infection (frequently a primary host).

E. SUMMARY OF ANALYTICAL METHODS

Analytical method/technique	Sensitivity	Specificity	Application (sample materials)	Application result	Throughput	Estimated costs*	Technical requirements (instruments, etc)	Suitable for QA?	Comments	References
				Individuals/ herd level/ national prevalence etc.	E.g. no of animals tested per person and day.			QA = Quality Assessment		
Meat inspection	Estimated below 30%	N/A	Carcass	Individual	50	€ 5.00	Meat inspector expertise	No	Gross examination part of routine meat inspection for cattle > 6 months of age by cuts into the external and internal masseter muscles. The pericardial surface of the heart also inspected, and cuts through the heart muscle. When one or more cysts are found	Regulation EC 854/2004
Parasite taxonomic identification	N/A	100%	Muscle sample	Individual	10-20	€ 25.00	Specialist parasitology facilities	Yes		Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Sixth Edition, 2008. Office International des Epizooties (OIE), France. ISBN 978-92-9044-718-4.
Histopathology	N/A	N/A	Muscle sample	Individual	10-20	€ 25.00	Specialist histology facilities	Yes	Labour intensive, costly and requires specialist facilities.	Ogunremi O., MacDonald G., Geerts S., Brandt J. 2004. Diagnosis of <i>Taenia saginata</i> cysticercosis by immunohistochemical test on formalin-fixed and paraffin-embedded bovine lesions. J. Vet. Diagn. Invest. 16, 438-441.
Serology (ELISA)	Reported to be 100% in cattle	Reported to be 98% in cattle	Serum, meat juice	Batch	160	€ 5.00	Specialist laboratory	Yes	Not commercially available	Abuseir S, Kühne M, Schnieder T, Klein G, Epe C. 2007. Evaluation of a serological method for the detection of <i>Taenia saginata</i> cysticercosis using serum and meat juice samples. Parasitol Res. 10, 131-137.
Serology (ELISA)	Reported to be 86.7% in pigs N/A cattle	Reported to be 94.7% in pigs; N/A cattle	Serum	Batch	80	€ 5.00	Specialist laboratory	Yes	Not commercially available	Dorny P, Vercammen F, Brandt J, Vansteenkiste W, Berkvens D, Geerts S. 2000. Sero-epidemiological study of <i>Taenia saginata</i> cysticercosis in Belgian cattle. Vet Parasitol. 88, 43-49.
Molecular methods (DNA)	N/A	N/A	Muscle sample	Batch	?	€ 25.00	Specialist laboratory	Yes	Not commercially available	Geysen et al 2007 JFP 70, 236-240; Abuseir S, Epe C, Schnieder T, Klein G, Kühne M. 2006. Visual diagnosis of <i>Taenia saginata</i> cysticercosis during meat inspection: is it unequivocal? Parasitol Res. 99, 405-409.

*Will vary from country to country and depend on the throughput. In this context it is meant to give a rough indication to allow comparison between methods, if possible.

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ABBREVIATIONS

Ag-ELISA	antigen detection enzyme-linked immunosorbent assay
AHAW	Animal Health and Welfare
CT-scan	computed tomography scan
EC	European Commission
ECDC	European Centre for Disease Control
EFSA	European Food Safety Authority
ELISA	enzyme-linked immunosorbent assay
EU	European Union
FCI	food chain information
GEE	generalised estimating equations
MRI	magnetic resonance imaging
MS	Member State
NCC	neurocysticercosis
NUTS	European country classification system
OIE	World Organisation for Animal Health
QA	quality assurance
RA	risk assessment
WHO	World Health Organisation
ZCC	Zoonoses Collaboration Centre