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Taenia solium in Europe: Still endemic?

Brecht Devleesschauwer[a,*], Alberto Allepuz[b,c], Veronique Dermauw[d], Maria V. Johansen[e], Minerva Laranjo-González[b], G Suzanne A. Smit[a,f], Smaragda Sotiraki[g], Chiara Trevisan[e], Nicola A. Wardrop[h], Pierre Dorny[a,d], Sarah Gabriël[d]

[a] Department of Virology, Parasitology and Immunology, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium
[b] Centre de Recerca en Sanitat Animal (CReSA), UAB-IRTA, Campus de la Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain
[c] Departament de Sanitat i Anatomia Animals, Universitat Autònoma de Barcelona, Bellaterra, Barcelona, Spain
[d] Department of Biomedical Sciences, Institute of Tropical Medicine, Antwerp, Belgium
[e] Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark
[f] Institute of Health and Society (IRSS), Université catholique de Louvain, Brussels, Belgium
[g] Veterinary Research Institute, Hellenic Agricultural Organisation-Demeter, Thessaloniki, Greece
[h] Geography and Environment, University of Southampton, Southampton, UK

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ABSTRACT

The pork tapeworm, *Taenia solium*, causes an important economic and health burden, mainly in rural or marginalized communities of sub-Saharan Africa, Asia, and Latin-America. Although improved pig rearing conditions seem to have eliminated the parasite in most Western European countries, little is known about the true endemicity status of *T. solium* throughout Europe. Three recent reviews indicate that autochthonous human *T. solium* taeniasis/cysticercosis may be possible in Europe, but that current peer-reviewed literature is biased towards Western Europe. Officially reported data on porcine cysticercosis are highly insufficient. Favourable conditions for local *T. solium* transmission still exist in eastern parts of Europe, although the ongoing integration of the European Union is speeding up modernisation and intensification of the pig sector. Further evidence is urgently needed to fill the gaps on the European *T. solium* endemicity map. We urge to make human cysticercosis notifiable and to improve the reporting of porcine cysticercosis.

1. Introduction

Taenia solium, the pork tapeworm, is a neglected zoonotic parasite causing cysticercosis in pigs and taeniasis and cysticercosis in humans. In a recent ranking of parasitic diseases by the Food and Agriculture Organisation of the United Nations (FAO), *T. solium* cysticercosis was ranked first, motivated by the economic impact of porcine cysticercosis and the health impact of human neurocysticercosis-related epilepsy (FAO/WHO, 2014).

To maintain its lifecycle, *T. solium* requires non-industrialized pig rearing conditions, consumption of undercooked pork, and low sanitation standards. As a result, *T. solium* taeniasis/cysticercosis is mainly a problem in rural or marginalized communities of sub-Saharan Africa, Asia, and Latin America. Nevertheless, three recent reviews concluded that the prevalence of neurocysticercosis is also on the rise in Europe (Del Brutto, 2012; Fabiani and Bruschi, 2013; Zammarchi et al., 2013). Although this is mainly due to increased migration and travel, the authors also mention several autochthonous cases of neurocysticercosis. Such cases may be the result of an imported *T. solium* tapeworm carrier, but also of local transmission, raising questions about the true endemicity status of *T. solium* in Europe. Although human and porcine cysticercosis were highly prevalent in Western Europe by the end of the nineteenth century, improved pig rearing conditions following the end of World War I reduced the incidence of cysticercosis considerably (Del Brutto, 2012). In Eastern Europe, on the other hand, cysticercosis supposedly remained endemic throughout the twentieth century (Del Brutto, 2012). However, there appears to be large uncertainties about these statements. Indeed, the latest *T. solium* endemicity map of the World Health Organization shows that no data are available for most Eastern European countries; most Western European countries show imported cases, but with possible human cysticercosis transmission; and Spain, Portugal, and Russia are suspected endemic (WHO, 2015; Fig. 1).

* Correspondence to: University of Florida, Shealy Drive 2055, Gainesville 32611-0910, USA. Tel.: +1 3523921981.
E-mail address: brechtdv@gmail.com (B. Devleesschauwer).

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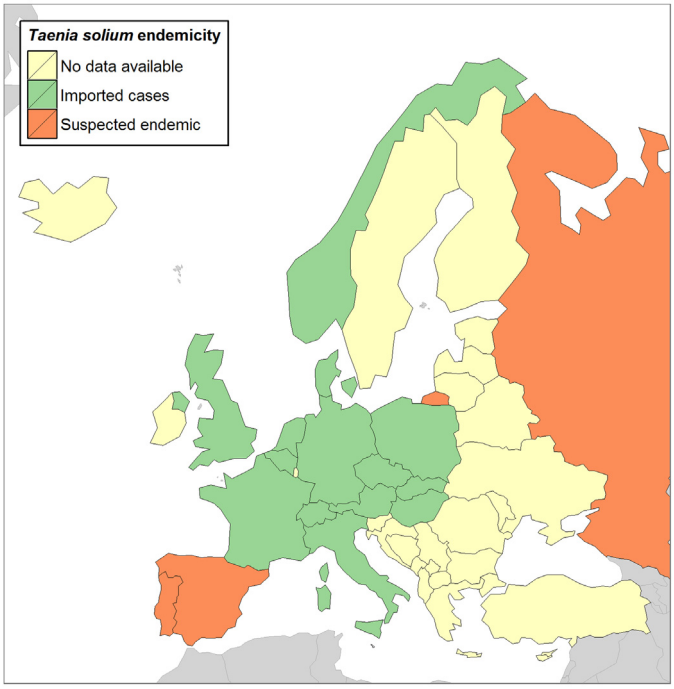

Fig. 1. World Health Organization definition of European countries and areas at risk of cysticercosis, 2012 (WHO, 2015).

In this short communication, we aim to summarize what is known on the endemicity status of *T. solium* in Europe, by reviewing information on autochthonous human *T. solium* taeniasis/cysticercosis, porcine cysticercosis, and pig rearing conditions.

2. Autochthonous human *T. solium* infection in Europe

Three recent reviews summarized available literature on human *T. solium* taeniasis/cysticercosis in Europe. Del Brutto (2012) performed a review of patients diagnosed with neurocysticercosis in Western Europe between 1970 and 2011, and identified a total of 779 patients. Of the 371 cases with available citizenship status information, European non-travellers accounted for 39% (143/371). Compared to immigrants and travellers, these putative autochthonous cases were more often diagnosed before 2000, older, and more likely to present with calcified cysts. Fabiani and Bruschi (2013) reviewed European literature from 1970 onwards, and found 176 human cysticercosis cases reported in 17 European countries. Of these cases, 20 were described as autochthonous (including 14 in Italy, 5 in Germany, and 1 in the United Kingdom). Eight other cases originated from the former Yugoslavia, Turkey, Greece, Portugal, and Spain, but were diagnosed in other European countries. Seven of these 28 cases were published in 2000 or later (including 3 patients from Italy, and 1 each from Germany, Greece, the former Yugoslavia, and the United Kingdom). Zammarchi et al. (2013) provided the most detailed assessment of possible autochthonous human *T. solium* infection in Europe to date. In a review of papers published between 1990 and 2011, they found 846 cysticercosis cases, of which 522 were described as autochthonous. More than 90% of these cases originated from three countries: Portugal (70%), Serbia (15%), and Spain (7%). The Portuguese cases were diagnosed in the 1980s and 1990s, but information was lacking on the history of the Serbian and Spanish cases. In general, autochthonous cases tended to be older and more likely to have calcified lesions, indicating that infection might have been acquired in the past. Zammarchi et al. (2013) also identified 68 putative autochthonous *T. solium* taeniasis cases, reported in Poland (49), Albania (18), and Italy (1). However, as these cases were not molecularly confirmed, at least some of these, could be misdiagnosed cases of *Taenia saginata*, the beef tapeworm.

3. Porcine cysticercosis in Europe

Despite the import of live pigs from endemic countries or the chance of importing *T. solium* taeniasis (Zammarchi et al., 2013; Gabriël et al., 2015), porcine cysticercosis would be a near conclusive sign of *T. solium* endemicity and local transmission in Europe. We reviewed information on porcine cysticercosis in Europe provided by the World Organisation for Animal Health (OIE) and the European Food Safety Authority (EFSA), and searched PubMed for additional peer-reviewed literature.

Table 1 shows the number of "porcine cysticercosis" cases reported to OIE from 2005 onwards (www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail). Several hundreds of cases were reported from Bulgaria in 2005 and 2006, dropping to 3 in 2009. Sporadic outbreaks were reported from Romania, Serbia (and Montenegro), Slovakia, Slovenia, and Spain. Other countries reported no cases, or did not report data.

EFSA, in collaboration with the European Centre for Disease Prevention and Control, publishes annual reports on trends and sources of zoonoses in the European Union (EU). Available volumes span reporting years 2004–2013. In this period, only Belgium, Estonia, and Sweden provided any information on (bovine/porcine) cysticercosis, despite the fact that data should be available from meat inspection at slaughter due to prescribed EU legislation (BIOHAZ/AHAW, 2007). Only Estonia reported putative porcine cysticercosis cases: in 2006, 8 slaughtered pigs were reported to have "*Taenia saginata* cysticerci" (sic) or "*Cysticercus tenuicollis*", i.e., *Taenia hydatigena* cysticerci (EFSA, 2008), while in 2010, 38 slaughtered pigs were reported to have "cysticerci", in addition to 41 with "*C. tenuicollis*" (EFSA, 2012). In 2010, EFSA assessed the current disease situation of bovine and porcine cysticercosis in the then 25 EU member states based on a survey of relevant national institutes (Dorny et al., 2010). Porcine cysticercosis cases were reported from Austria (34 in 2007), Estonia (10 in 2006), Lithuania (113;

Table 1
Porcine cysticercosis cases reported to the World Organisation for Animal Health from 2005 onwards (sorted by period).

Country	Region	Period	Number of cases
Slovakia	Banska Bystrica	Jun 2014	1
Slovakia	Banska Bystrica	Nov 2013	1
Romania	Ialomita	Dec 2013	3
Spain	Catalonia	Jan–Jun 2013	5
Romania	Satu Mare	Mar 2011	1
Romania	Satu Mare	Feb 2011	1
Serbia	Whole country	Jul–Dec 2009	65
Bulgaria	Whole country	Jan–Jun 2009	3
Spain	Andalusia	Jan–Jun 2009	7
Spain	Andalusia	Jul–Dec 2008	1
Bulgaria	Whole country	Jan–Jun 2008	12
Spain	Catalonia	Jan–Jun 2008	1
Spain	Madrid	Jan–Jun 2008	47
Bulgaria	Whole country	Jul–Dec 2007	3
Spain	Catalonia	Jul–Dec 2007	233
Slovenia	Maribor	Nov 2007	1
Bulgaria	Whole country	Jan–Jun 2007	30
Bulgaria	Whole country	Jul–Dec 2006	152
Serbia and Montenegro	Whole country	Jul–Dec 2006	4
Spain	Catalonia	Jan–Jun 2006	37
Bulgaria	Whole country	Jan–Jun 2006	316
Slovenia	Maribor	Jan 2006	1
Bulgaria	Whole country	Jul–Dec 2005	205
Bulgaria	Whole country	Jan–Jun 2005	136

year unspecified), Poland (547,941; year unspecified), and Romania (around 50 in 2007). The remaining countries either reported no cases or did not respond at all.

A PubMed search only yielded two publications published after 2000. In Lublin Province, Poland, porcine cysticercosis was reported in 93 out of 1,577,370 pigs examined between 2005 and 2008 (Kozłowska-Łój, 2011), and in 150 out of 3,367,444 pigs examined between 2009 and 2012 (Kozłowska-Łój and Łój-Maczulska, 2014). Own ongoing research further identified 1 suspected *T. solium* cyst in 1217 pigs slaughtered in Estonia between February and April 2014 (Åhlberg et al., 2015).

4. Pig rearing conditions in Europe

Given the continued presence of *T. saginata* in most European countries (Dorny et al., 2009), we argue that current meat inspection practices and sanitary levels in Europe are not sufficient to interrupt the lifecycle of *Taenia* species. Pig rearing conditions are therefore believed to be the main risk factor for *T. solium* transmission.

Eurostat provides information on the pig rearing sector in the EU (Marquer et al., 2014). In 2013, the total number of pigs in the 28 EU member states was estimated at 146 million. Pig production however shows a strong geographical concentration, with more than half of the breeding pigs being reared in eleven regions of Denmark, Germany, Spain, France, the Netherlands, and Poland. Pig rearing in the EU also shows considerable variations with respect to the herd size, which may be seen as an indication of industrialisation and biosecurity. Although only 1.7% of all pig farms have at least 400 fattening pigs, these units rear 77.9% of all fattening pigs and 48.6% of all sows. On the other hand, small units of less than 10 fattening pigs account for 73.3% of all pig farms, while rearing only 3.8% of all fattening pigs. The proportion of pigs reared in these smallholder farms varies strongly between member states, amounting to 22% of all pigs reared in the 13 newest EU member states, and 63% of pigs reared in Romania (Fig. 2). However, the proportion of smallholder pig farms in these new member states is decreasing, as industrialisation of the pig rearing sector is actively encouraged (Wellbrock et al., 2010). Further information from FAO shows that the proportion of pigs kept in low biosecurity farms in Belarus, the Russian Federation, Ukraine, and the Republic of Moldova, ranged from 25% to 83% in 2000–2011 (Khomenko et al., 2013; Fig. 2). Information from other non-EU member states could not be retrieved, although an important contribution of smallholder pig farms is also likely in Balkan countries. As most of these countries are formal or potential candidates for EU membership, it is expected that they are also in the process of speeding up modernisation and intensification of their pig sector.

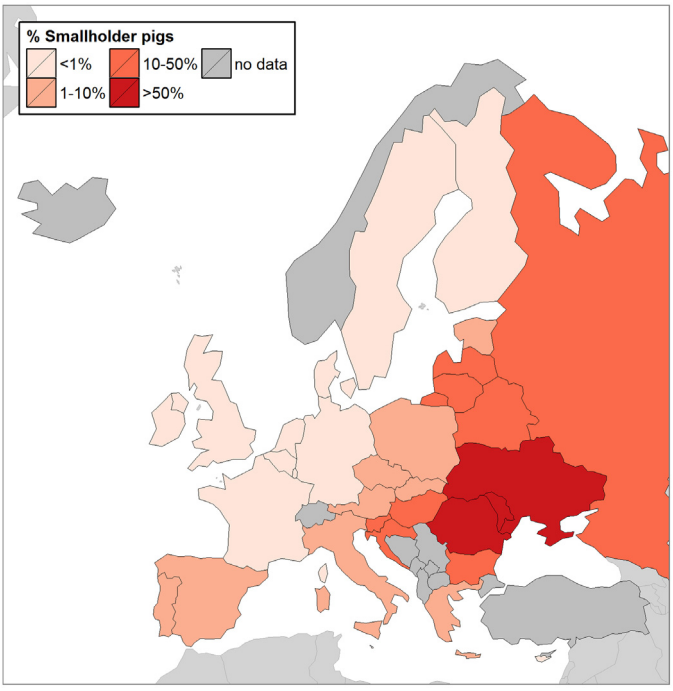

Fig. 2. Percentage of pigs kept in smallholder farms (after Khomenko et al., 2013 and Marquer et al., 2014).

Certified organic pig farming still holds a very minor share in the EU pig market, amounting to 0.9 million heads in 2011 (EC, 2013). It is mainly practiced in the old EU member states, with Germany, Denmark, and France being the largest producers, although there is also an increasing scope in other countries (Papatsiros et al., 2012). To our knowledge, the risk of introducing *T. solium* in such farms is currently unknown, though probably less than in traditional backyard systems, as certified organic farms usually have properly controlled outside access with proper feeding. However, with growing consumer demand for organic pork, uncertified small-scale production units are on the rise.

5. Discussion

The occurrence of *T. solium* in Europe is known since antiquity, demonstrated by the writings of Aristotle, who compared the appearance of "pork measles" to hailstones (Schantz, 2002). In the nineteenth century, European clinicians unravelled the parasite's lifecycle. Since then, improved pig rearing conditions seem to have eliminated the parasite in most Western European countries. However, little is known about the current true endemicity status of *T. solium* throughout Europe.

Three recent and independent reviews indicated that, although autochthonous *T. solium* taeniasis/cysticercosis may be possible in Europe, peer-reviewed literature does not provide sufficient information on the current endemicity status of *T. solium* in Europe. Indeed, only few case reports were available from Eastern European countries. Nevertheless, recent serological studies in Croatia (Meštrović et al., 2012) and Slovenia (Šoba et al., 2014) show that neurocysticercosis does deserve further attention in this region. The available literature, biased towards Western European countries, also showed remarkably high numbers of cases from the Iberian peninsula. Most case reports further did not mention any investigation towards a possible tapeworm carrier, the source of cysticercosis. From an epidemiological and public health point of view, this is however crucial. Even though clinical disease can occur many years after infection, cysticercosis cases are warning signs for the possible presence of a *T. solium* tapeworm carrier. By screening patients and their contacts for taeniasis, clinicians may therefore play an important role in the early detection of such tapeworm carriers. Furthermore, as all tapeworms found could be *T. solium*, proglottids should systematically be examined by molecular methods for species identification.

Officially reported data on porcine cysticercosis are highly insufficient. Indeed, not all countries report their findings, and reported cases are typically diagnosed based on morphology, without molecular confirmation. We therefore urge all member states to report their findings on cysticercosis to the concerned European agencies. Cases of so-called "porcine cysticercosis" should be better defined, e.g., differentiating *T. solium*, *T. hydatigena* and *Echinococcus granulosus*. To this end, better training of meat inspectors is crucial. The high numbers reported in certain Eastern European countries require further investigation, including molecular confirmation of suspected *T. solium* cysticerci. In Spain, molecular methods have

already shown that suspect lesions were in fact *T. hydatigena*, and not *T. solium* (González et al., 2006).

Although the ongoing integration of the EU is speeding up industrialisation in the pig sector, favourable conditions for local *T. solium* transmission still exist in eastern parts of Europe. The situation in the new EU member states, the candidate Balkan member states, and the Eastern European non-member states therefore deserves special attention. Veterinary public health authorities should remain conscious about the problem, and epidemiological studies are needed to assess the current situation. Evidence is needed to assess the potential risk of importation of unsafe pork from one European country to another.

6. Conclusion

Further evidence is urgently needed to fill the gaps on the European *T. solium* endemicity map, and it is clear that this should be a shared responsibility of both the medical and veterinary sector. We urge to make human cysticercosis a notifiable disease and to develop a register of human cysticercosis cases. Further efforts are needed to make sleeping data, or "lost science" (Del Brutto, 2012), available, especially from Eastern European countries. Active epidemiological research is needed to generate new information. Recently, several European groups joined forces in a European network on taeniasis/cysticercosis, CYSTINET (COST Action TD1302). We hope that CYSTINET can play an important role in accomplishing these challenging tasks.

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