



Trichinella spp. imported with live animals and meat



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ARTICLE INFO

Keywords:

Trichinella

Horse

Pig

Wild boar

Bear

Meat trade, animal trade

ABSTRACT

Nematodes of the genus *Trichinella* are widely distributed throughout the world in omnivorous and carnivorous animals (mammals, birds, and reptiles) and in incidental hosts. To prevent the transmission of these zoonotic parasites to humans, meat samples from *Trichinella* spp. susceptible animals are tested at the slaughterhouse or in game processing plants. The aim of the present review was to collect documented cases on *Trichinella* infected animals, meat, or meat derived products which reached the international trade or were illegally introduced from one to another country in personal baggage. In the course of the last 60 years in the international literature, there have been 43 reports of importation of *Trichinella* spp. infected animals or meat, most of which (60%, 26/43) related to live horses or their meat. Meat or meat derived products from pigs, wild boar and bears, account only for 18.6% (8/43), 4.7% (3/43), and 14.3% (6/43), respectively. However, only live horses or their meat intended for human consumption, meat from a single wild boar, and live polar bears caught in the wild for zoos, were imported through the international market; whereas, meat from pigs, wild boars and bears were illegally introduced in a country in personal baggage. *Trichinella* infected animals or meat which were officially or illegally introduced in a country were the source of 3443 *Trichinella* infections in humans in a 40-year period (1975–2014). Most of these infections (96.8%) have been linked to horsemeat consumption, whereas meat from pigs, wild boars and bears accounted only for 2.2%, 0.7% and 0.3% of cases, respectively. This review shows the *Trichinella* spp. risk in the international animal and meat trade has been linked mainly to horses and only one time to wild boar, if they carcasses are not adequately tested, whereas pigs and other wild animals or their derived products infected with *Trichinella* spp. are unlikely to reach the international market by the official animal and meat trade.

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1. Introduction

Nematodes of the genus *Trichinella* are parasites of mammals, birds and reptiles, which circulate in all continents but Antarctica (Gottstein et al., 2009). These parasites are transmitted to humans by the consumption of raw or undercooked meat and meat derived products of domestic and sylvatic swine, carnivores (e.g., bears, dogs, badgers,

walruses), and horses. The term zoonotic agent was first coined by Rudolph Virchow for *Trichinella spiralis* in 1859 (Virchow, 1859; Schultz, 2008).

Since the XIX century, these nematodes have been considered a problem for the pig and pork international trade. In the period 1879–1888, several countries banned the importation of pork from the United States because there was no mandatory pig inspection for *Trichinella* sp. larvae in this country, despite a high prevalence of the parasite in the pig population. However, it was also considered an excuse for blocking importation because it could be justified on medical grounds (Campbell, 1983). In 1890,

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mandatory trichinostomy examination of exported pork was introduced in USA, but the commercial war with the European market has continued in a more or less veiled manner up to the present days (Cassedy, 1971; Campbell, 1983).

Since the Second World War, there have been improvements in animal husbandry, preventive medicine and disease control programs with increased growth rates of the animals as well as increased production and herd sizes. This has led to a significant rise in the number of animals slaughtered at a younger age in relatively uniform groups with a reduction in age related diseases. The changes in pig rearing practices have strongly reduced the transmission of *Trichinella* sp. which is today confined to poor and disadvantaged areas where backyard and free-ranging pig production prevails in both developed and under developed countries (Pozio, 2014).

Parallel to the improvement in pig rearing practices, there has been an increasing attention to the circulation of *Trichinella* spp. in wildlife and an increasing number of human cases due to the consumption of game meat (Ancelle et al., 2005; Murrell and Pozio, 2011; Holzbauer et al., 2014; Fichi et al., 2015).

Unexpectedly in 1975, horsemeat has been identified as source of trichinellosis in humans in France and Italy, the two countries with the highest consumption of raw horsemeat in the world (Boireau et al., 2000). Outbreaks occurred for 31 years (1975–2005), involving more than 3000 people and were then stopped by strict veterinary controls in the last 9 years (Boireau et al., 2000; Liciardi et al., 2009).

The aim of the present review was to collect documented cases on *Trichinella* infected animals, meat, or meat derived products which reached the international trade or were illegally introduced from one to another country in personal baggage. In this work, we do not take into consideration persons who acquired trichinellosis abroad and developed the disease when they came back home. Furthermore, the natural migration of animal populations which are potential carriers of *Trichinella* spp. and the passive or active introduction of allopatric *Trichinella* spp. susceptible host species in a country have been also considered.

2. *Trichinella* spp. in imported domestic animals or their meat

2.1. Horses

From 1975 to 2005, 15 outbreaks of trichinellosis have been documented in France (eight outbreaks) and Italy (seven outbreaks) resulting from the consumption of horsemeat imported from Eastern European countries (Former Yugoslavia, Poland, Serbia, Romania) or from North America (Canada, Mexico, USA). Out of 3334 human infections, 2296 were documented in France and 1038 in Italy, and five patients died in France in 1985 (Table 1). In 1998, a horse imported from Poland was slaughtered in Italy (Brescia) and identified as *Trichinella* sp. positive by artificial digestion. The carcass without the head, and the head of a *Trichinella* sp. negative horse were destroyed; by mistake, the head of the *Trichinella* sp. infected horse

was placed on the market and was the source of a human outbreak which occurred in Piacenza (Italy) 1 month later (Tamburrini et al., 2001). In the same year, two horses imported from Serbia to France were not correctly tested by artificial digestion at the slaughterhouse, and their meat was the source of two large outbreaks in France (Ancelle, 1998). In 2000, a veterinarian of a slaughterhouse failed to detect *T. spiralis* larvae by artificial digestion in an infected horse imported from Eastern Europe to Italy, which was the source of a further human outbreak. In 2005, a *Trichinella britovi* infected horse imported from Eastern Europe was not identified as positive at a slaughterhouse in Belgium, and the infected meat reached the Italian market where it was consumed raw causing the last documented outbreak of trichinellosis (Table 1).

Between 1975 and 1990, testing for *Trichinella* larvae in local and imported horses was not mandatory in the EU. However, mandatory control of horse carcasses was imposed in France since 1986 due to two very large outbreaks, which occurred in that year (Table 1). The mandatory testing of fresh horsemeat produced in or imported to the EU was established by Directive 91/497/EEC of the European Council (1991). Specifically, this directive specified the testing of 1 g of muscle tissue by artificial digestion, i.e., the same procedure used to detect *Trichinella* in pigs (European Council, 1976). In 1994, the minimum weight of the meat to be tested was increased to 5 g (European Council, 1994). In 1996, *Trichinella* larvae were detected at the slaughterhouse of Bordeaux (France) in two horses imported from Poland (Table 2). After the two human outbreaks of trichinellosis due to horsemeat consumption in France in 1998, the veterinary authority requested the testing of all horses slaughtered in France by artificial digestion in two different laboratories. This strict regulation allowed the identification of two *T. spiralis* infected horses imported from Poland and Serbia to France in 1999 and 2001, respectively. From 1988 to 2008, eight horses imported from Former Yugoslavia, Poland, Romania and Serbia to Italy tested positive for *Trichinella* spp. at the slaughterhouses (Table 2). Since 2006 in the European Union, it is mandatory to test fresh horsemeat produced in or imported to the EU according to the Commission Regulation 2075/2005 (European Commission, 2005).

2.2. Domestic pigs

The pig international trade represents one of the largest livestock market in the world (Pozio, 2014), and pig meat is the main source of human trichinellosis (Murrell and Pozio, 2011). However, in the last 20 years, there are only eight documented reports of pig meat illegally imported in personal baggage into another country where it was the source of infection for humans or it was, by chance, tested for *Trichinella* sp. larvae (Table 3). *Trichinella* sp. infected pigs originated from four countries where its prevalence was quite high in the pig population not reared under controlled management conditions at that time (1995–2003) (Pozio et al., 1996; Marinculić et al., 2001; Olteanu, 2001; Cuperlovic et al., 2005; Sofronic-Milosavljevic et al., 2013). There is no report on the detection of *Trichinella* sp. infected pigs originating from the international trade.

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