Meat sources of infection for outbreaks of human trichinellosis

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Abstract

Trichinellosis is one of the most important foodborne zoonotic diseases, with worldwide distribution. While human risk for trichinellosis has historically been linked to pork, modern pork production systems and slaughter inspection programs have reduced or eliminated pork as a source for trichinellosis in many countries. While pork may no longer pose a significant risk for trichinellosis, many other animal species may be hosts for *Trichinella* species nematodes and when human consume meat from these animal species, there may be risk for acquiring trichinellosis. This review article describes the various non-pork meat sources of human trichinellosis outbreaks, where these outbreaks have occurred and some of the factors that contribute to human risk. The literature reviewed here provides evidence of the persistence of *Trichinella* as a human health risk for people who eat meat from feral and wild carnivores and scavengers, as well as some herbivores that have been shown to harbor *Trichinella* larvae. It points to the importance of education of hunters and consumers of these meats and meat products.

Keywords: Human Trichinellosis, *Trichinella* SPP., Meat sources,

1. Introduction

Trichinellosis, a serious and sometimes fatal human disease, is a foodborne zoonotic disease with worldwide distribution. It is caused by the larval stage of tissue-dwelling nematodes of the genus *Trichinella*. Transmission to and survival of *Trichinella* spp. in various hosts occurs through the ingestion of infected meat, mainly through predation or scavenging of meat from an infected animal (Foreyt & Abbott, 2013). Human infection results from consumption of raw or improperly cooked meat containing infective larvae (Pozio, 2015) and human infection has historically been associated with pork. The course of human infection can be divided into two phases including an intestinal phase and a muscular phase. The main clinical symptoms are diarrhea and abdominal pain in the first stage (intestinal phase) and fever, myalgia, myocarditis, skin allergenic reactions and encephalitis in the second stage (muscular phase) (Faber, et al., 2015; Gottstein, Pozio, & Nöckler, 2009).

Trichinellosis outbreaks have been reported in 55 countries with an annual global average of 5751 cases and five deaths (Devleesschauwer, et al., 2015; K. D. Murrell & Pozio, 2011; Pozio, 2007). It is estimated that the global number of disability-adjusted life years (DALYs) due to trichinellosis be 76 per billion persons per year (95% credible interval: 38–129) (Devleesschauwer, et al., 2015).

Significant costs are incurred in the prevention of human infection resulting from pork and pork products. It is estimated that the annual cost linked to post-mortem inspection of pigs is approximately US$ 570 million in Europe (K. Murrell & Pozio, 2000). Additional costs are incurred through processing methods (freezing, cooking, curing) used to inactivate *Trichinella*. Assurances of the safety of pork and pork products relative to *Trichinella* are a major issue in many international trade agreements.

Heretofore, nine species and three genotypes have been documented in the genus *Trichinella* (Bruschi & Dupouy-Camet, 2014; Mitreva & Jasmer, 2006). These *Trichinella* species and genotypes and their epidemiological and biological features are shown in Table 1. Detailed reviews on the history, life cycle, genome, immunology, treatment and the worldwide status of *Trichinella* spp. are available in various publications (Bruschi & Dupouy-Camet, 2014; Bruschi, Dupouy-Camet, Kociecka, Pozio, & Bolas-Fernandez, 2002; Foreyt & Abbott, 2013; Gottstein, et al., 2009; Mitreva & Jasmer, 2006; Pozio, 2001, 2007).

While *Trichinella* has historically been associated with pork (responsible for 64% of reported outbreaks), in many countries human infection more commonly results from exposure to infected meat of other animals, notably wild boar and bear. These animals pose a high risk for exposure to *Trichinella* based on their eating habits. Human *Trichinella* infection has also been associated with meat from animals which would not typically be considered at risk for harboring *Trichinella* spp. These include horses, and other some other herbivores. While *Trichinella* can develop in many herbivorous, carnivorous and omnivorous animals, routes of natural exposure in herbivores, for example, are not obvious.

The risk of human exposure to *Trichinella* is also influenced by eating habits. People in different cultures and religions consume various type of meat from non-traditional food animals. Meats from many of these animals could be sources of infection in humans.

While improved pig production systems and meat inspection make it possible to reduce or eliminate trichinellosis resulting from ingestion of pork, risk remains for consumers of wild game meats and other meat animals species which may harbor *Trichinella* and for which proper processing or preparation methods are not followed. In this paper, we review non-pork meat sources of outbreaks of human trichinellosis in different areas of the world.

2. Wild boar meat as a source of human trichinellosis

Wild boar are indigenous in many countries and have broad geographic distribution that includes mountainous regions, semi deserts, forest areas and wetlands (Sales & Kotrba, 2013). During the mid-20th century, a dramatically increase was observed in the overlap of the range of wild boars with humans and domestic animals due to changes in human habitation and agricultural practices and rapid growth of world populations (Meng, Lindsay, & Sriranganathan, 2009). Wild boars meat harbors many important pathogens that are transmissible to humans, including *Trichinella*. Recreational hunting of wild boars and consumption of wild boar meat in different parts of the world have increased the risk for human exposure to *Trichinella* from wild boar meat (Meng, et al., 2009).

Wild boar meat is currently the second most important source of human trichinellosis and has been responsible for many human outbreaks reported in recent years in Europe, Asia, and North and South America (Table 2). Hunters, their families and friends are at high risk of acquiring trichinellosis after consumption of wild boar meat, especially when meat is prepared without proper cooking (Pozio, 2015). Sausages made with meat from domestic pigs mixed with contaminated meat from infected wild boar have also been a source of human infection (Pozio, 2015). *T. spiralis, T. britovi* and *T. papuae* are the main species responsible for human outbreaks of trichinellosis related to wild boar meat consumption (Table2). Franssen et al. (2016), using a Quantitative Microbial Risk Assessment (QMRA) have demonstrated that consumption of wild boar meat is responsible for 55% of modeled cases of human trichinellosis. According to their assessment,
Trichinella prevalence in wild boar is 4,100 times higer than in pigs from non-controlled hou sing.

3. Horse meat as a source of human trichinellosis

Horsemeat is considered as a good dietetic alternative for red meat; however, global consumption is very low (Lorenzo, et al., 2014). Based on the information provided by the Food and Agriculture Organization of the United Nations (FAO), horsemeat production represents 0.25% of the total worldwide meat production (FAO, 2015).

Horsemeat has been responsible for 16% of human trichinellosis outbreaks reported in the literature (Bruschi & Dupouy-Camet, 2014). Between 1975 and 2005, 15 horsemeat-related outbreaks of trichinellosis involving at least 3200 people occurred in France and Italy, two countries with the largest per capita consumption of horse meat. These outbreaks occurred despite veterinary controls implemented in 1985 (Boireau, et al., 2000; Pozio, 2001, 2015) (Table 3). Of these human outbreaks, eight occurred in France involving 2296 people and seven occurred in Italy involving 1038 people; five patients died in France in 1985 (Pozio, 2015). The countries of origin of the infected horsemeat causing the outbreaks were reported to be Eastern European countries including Yugoslavia, Poland, Serbia and Romania and from North America including Canada, Mexico and USA (Table 3) (Boireau, et al., 2000; Pozio, 2015).

Globally, the prevalence of *Trichinella* in slaughtered horses appears to be very low, however a single infected horse carcass can infect hundreds of consumers if it is not well cooked before consumption. The muscles from the head of the horse including the *Musculus buccinator*, *Lingua*, *Musculus levator labii maxillaris*, and *Musculus masseter* are preferred sites for settlement of *Trichinella* spp. larvae, even more than diaphragm muscle (Pozio, 2001). The head of a *Trichinella* infected horse was the source of a human outbreak in Italy in 1998.(Tamburrini, Sacchini, & Pozio, 2001).

122 *T. spiralis,* which is the predominant species involved in the domestic cycle of transmission,
123 is the major species responsible for human outbreaks of trichinellosis associated with
124 horsemeat consumption. Horsemeat-related outbreaks of trichinellosis due to *T. britovi* and
125 *T. murrelli*, species found in the sylvatic cycle, have also been reported (Dick, deVos, &
126 Dupouy-Camet, 1990; Gill, 2005; Pozio, Cappelli, Marchesi, Valeri, & Rossi, 1987).

127 Transmission of *Trichinella* spp. to horses could occur accidentally by grazing in pastures
128 contaminated with infected small animal and rodent carcasses or through hay containing
129 pieces of rodents (Bruschi & Dupouy-Camet, 2014; Pozio, 2001).

130 Since 2006 in the European Union, it has been mandatory to test fresh horsemeat produced in
131 or imported to the EU according to Commission Regulation 2075/2005 (Commission, 2005).
132 Human outbreaks of trichinellosis associated with horsemeat consumption have been reduced
133 or eliminated by strict veterinary controls over the past eleven years (Pozio, 2015).

134

135 **4. Dog meat as a source of human trichinellosis**

136 It is well documented that dogs are commonly infected with *Trichinella* spp. in many
137 countries of the world due to their scavenger behavior (Borji, Sadeghi, Razmi, Pozio, & La
138 Rosa, 2012; Dubey, Hill, & Zarlenga, 2006; Fu, et al., 2009; Gómez-Morales, et al., 2016;
139 Mikhail, Mansour, & Awadalla, 1994). Based on the literature since 1975, approximately
140 37,000 dogs were tested for *Trichinella* spp. by digestion or by serological tests in different
141 geographical areas of the world; almost 21% were positive, most of which were from China
142 (Gómez-Morales, et al., 2016).

143 The consumption of dog meat is common in Korean communities in some parts of China and
144 Korea and. Between 1974 and 2003, nine outbreaks of human trichinellosis related to
145 consumption of dog meat occurred in northeastern China (Cui & Wang, 2001; Cui, et al.,

2011; Z. Wang, Cui, & Xu, 2006). In 2007, *Trichinella* spp. larvae were detected in two of seven (28.5%) dog carcasses imported from Korea to China (Wu, 2008). In addition, dog meat was the source of one outbreak in Thailand in 1981 (Khamboonruang, 1991). In Switzerland, the consumption of raw dog meat, accounted for 30 infections and one death in humans between 1938 and 1955 (Hörning, 1965). Smoked sausages containing dog meat were identified as a source of human infection in Slovakia (Dubinský, et al., 2001) (Table 4).

5. Bear meat as a source of human trichinellosis

Annually, hundreds of black bears (*Ursus americanus*), grizzly bears (*Ursus arctos ssp.*) and polar bears (*Ursus maritimus*) are hunted in North America and Alaska, with most meat used for human consumption. Bear meat was responsible for approximately 5% of human trichinellosis outbreaks reported in the literature (Table 5) (Bruschi & Dupouy-Camet, 2014).

During the period 1997-2012, bear meat was implicated in 12 of 20 outbreaks of human trichinellosis reported in U.S., involving 91 individuals (Control, 2009; Roy, Lopez, & Schantz, 2003; Wilson, Hall, Montgomery, & Jones, 2015). As an example, one outbreak in 2014 involved four hunters in Alaska who consumed bear meat cooked over an open fire (Donna Fearey, 2015).

In addition to cases recorded in North America, over the past 20 years, 31 cases of trichinellosis have been reported in French travellers to the Arctic (North Quebec, Nunavut and Greenland) who consumed undercooked meat from black, brown, or polar bears (Jean Dupouy-Camet, Yera, Dahane, Bouthry, & Kapel, 2016). In one of the larger outbreaks, 9 people acquired trichinellosis in France in 2005 due to bear meat imported from Canada (Thierry Ancelle, De Bruyne, Poisson, & Dupouy-Camet, 2005).

169 Due to the frequency of trichinellosis resulting from ingestion of bear meat, proper methods
170 for preparation should be communicated to hunters and consumers of hunted bear meat.
171 According to the U.S. Centers for Disease Control and Prevention (CDC), wild game meat
172 like bear should reach an internal temperature of 160 degrees and rest at that temperature for
173 three minutes. Curing, drying, smoking processes and slow cooking in open fire are not
174 recommended by the CDC or the International Commission on Trichinellosis (ICT) to
175 inconsistency in the inactivation of *Trichinella* larvae.

176

177 **6. Other meat sources of human trichinellosis**

178 Among domestic animals, interestingly, it has been reported that mutton, the meat of adult
179 sheep, is the second most common food that causes trichinellosis in China, responsible for at
180 least 23 outbreaks (Takahashi, Mingyuan, & Waikagul, 2000). Moreover, consumption of
181 beef meat has been reported as source of human infection in China (K. D. Murrell, 1994).
182 While the source of a natural route of infection of sheep or beef cattle is unclear,
183 experimental studies have shown that sheep, goats and cattle could be infected with
184 *Trichinella* spp. (Kořínková, Pavlíčková, Kovarčík, & Koudela, 2006; Reina, Munoz-Ojeda,
185 Serrano, Molina, & Navarrete, 1996; Smith, Snowdon, Finley, & Laflamme, 1990;
186 Theodoropoulos, et al., 2000). During the period of 2000-2012, beef meat was reported to be
187 the cause of infection in four patients in the U.S. (Control, 2009; Wilson, et al., 2015). Beef
188 or other herbivorous animal meat may be mixed with infected meat from other sources and
189 sold in restaurants and stores. For example, *Trichinella* infected pork meat mixed with beef
190 was the source of a large outbreak of trichinellosis in Turkey affecting 1098 people (Akkoc,
191 et al., 2009).

192 Among wild animals, badger meat has been implicated as the cause of infection in
193 approximately 1% of outbreaks worldwide (Bruschi & Dupouy-Camet, 2014). Deer, cougar,

194 seal meat and walrus have also been reported as sources of human infection (Control, 2009;
195 Roy, et al., 2003; Wilson, et al., 2015).

196 In addition to above mentioned animals, reptiles could be also a source of human
197 trichinellosis. Terrapins, snakes, lizards, crocodiles and iguanas are now farmed and the
198 consumption and trade of their meat and other edible products has recently increased in some
199 areas of the world (Magnino, et al., 2009). In 1995, *Trichinella* was detected for the first time
200 in farmed Nile crocodiles (C. niloticus) in Zimbabwe (Foggin, Vassilev, & Widdowson,
201 1997). Subsequently, several field and experimental studies implicated that reptiles including
202 lizard (*Varanus niloticus*), Nile crocodile (*C. niloticus*), caimans (*C. sclerops*), varans
203 (*Varanus exanthemicus*), turtles (*Pelomedusa subrufa*) and pythons (P. *molurus bivittatus*)
204 are susceptible to *Trichinella* infection. *T. zimbabwensis* and *T. papuae* were the main
205 *Trichinella* spp. detected in reptiles (Magnino, et al., 2009; Pozio, et al., 2004; Pozio, Owen,
206 Marucci, & La Rosa, 2005). There have been four reported human trichinellosis outbreaks
207 due to the consumption of reptile meat from a monitor lizard (*Varanus nebulosus*) and a turtle
208 (not determined species) in Thailand and Korea (Jeong, Seo, Hong, & Kim, 2015;
209 Khamboonruang, 1991; Lee, Yoo, Kim, Lee, & Seo, 2013). Some of these unusual sources
210 of human trichinellosis are presented in Table 6.

211

212 **7. Prevention of risk for human trichinellosis in non-pork meat products**

213 According to legislation of the European Union (Commission Implementing Regulation (EU)
214 2015/1375, it is mandatory for all animals (pig, horse and wild animals) which are potential
215 carriers of *Trichinella* spp. larvae and are intended for human consumption to be examined
216 for *Trichinella* larvae with one of several approved methods. The artificial digestion
217 technique is the standard method used to detect *Trichinella* larvae in meat. Artificial digestion

is a sensitive, efficient, reliable and cost effective method that can be used to test a pool of muscle samples from up to 100 carcasses per assay (Nöckler, Pozio, Voigt, & Heidrich, 2000). In 2015, the FAO-WHO Codex Alimentarius Committee on Food Hygiene, prepared guidelines for food safety on a global level and developed a guideline for a risk based control of *Trichinella* in meat of suidae (CAC, 2015). These guidelines should be followed for all meat that is intended for human consumption and poses a risk for harboring *Trichinella* spp. Additional measures that can be used to reduce the risk of infection in human are available in various publications (European Union, 2005, 2015; CAC, 2015; (Gajadhar, et al., 2009; Marucci, et al., 2016).

Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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492 **Table 1.** *Trichinella* species, distribution, biological characteristics, and hosts

Species (genotype)	Distribution	Cycle	Larval form	Resistance to freezing	Pathogenicity to humans	Major hosts
***T. spiralis* (T1)**	worldwide	Domestic, Sylvatic	Encapsulated	No	High	Pig, wild boar, rat, carnivores
***T. nativa* (T2)**	Arctic and subarctic areas of Asia, Europe, and America	Sylvatic	Encapsulated	Yes (high)	High	Wild carnivores, dogs. Rare in pigs
***T. britovi* (T3)**	Europe, Asia and middle east countries	Sylvatic	Encapsulated	Yes (low)	High	Wild boar, dog, jackal
***T. pseudospiralis* (T4)**	Nearctic and palearctic regions, Australia, New Zealand, Thailand	Sylvatic	Nonencapsulated	No	High	Mammals and birds
***T. murrelli* (T5)**	USA and Canada	Sylvatic	Encapsulated	No	Moderate	Carnivores
***T. T6* (T6)**	Arctic or subarctic regions of Canada and USA	Sylvatic	Encapsulated	Yes (high)	unknown	Terrestrial or marine carnivores
***T. nelsoni* (T7)**	Eastern-Southern Africa	Sylvatic	Encapsulated	No	Low	Carnivores
***T. T8* (T8)**	South Africa	Sylvatic	Encapsulated	No	unknown	Carnivores
***T. T9* (T9)**	Japan	Sylvatic	Encapsulated	No	unknown	Carnivores
***T. papuae* (T10)**	Papua New Guinea, Thailand	Domestic, Sylvatic	Nonencapsulated	No	Moderate	Mammals and reptiles
***T. zimbabwensis* (T11)**	Zimbabwe, Mozambique, Ethiopia, South Africa	Sylvatic	Nonencapsulated	No	unknown	Mammals and reptiles
***T. patagoniensis* (T12)**	Argentina	Sylvatic	Encapsulated	Unknown	unknown	Carnivores

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505 **Table 2: Outbreaks of trichinellosis associated with consumption of wild boar meat,**
506 **2005–2015.**

Country	Date	No. of cases	Preparation of meat	Trichinella species	References
China	2006	22	Raw wild boar	Not determined	(L. Wang, et al., 2009)
Thailand	2006	28	Raw wild boar meat	*T. papuae*	(Khumjui, et al., 2008)
Thailand	2007	22	Raw wild boar meat	*T. papuae*	(Kusolsuk, et al., 2010)
Iran	2007	6	Raw wild boar meat	*T. britovi*	(Kia, Meamar, Zahabiun, & Mirhendi, 2009)
Spain	2007-2009	27 (1 fatal)	Raw wild boar meat	Not determined	(Berger, 2016)
China	2008	26	Raw wild boar	Not determined	(Cui, Wang, & Xu, 2011)
India	2008-2011	42 (11 fatal)	Raw wild boar meat	Not determined	(Sethi, Butola, Kumar, & Mishra, 2013)
Lithuania	2009	104	sausage	Not determined	(Bartuliene, Liausediene, & Motiejuniene, 2009)
Poland	2011	23	sausage	Not determined	(Sadkowska-Todys & Gołab, 2012)
Korea	2010	20	Raw wild boar meat	Not determined	(Kim, et al., 2011)
USA	2011	2	Sausage	*T. spiralis*	(Holzbauer, et al., 2014)
Vietnam	2012	36	Raw wild boar meat	Not determined	(Van De, et al., 2015)
Italy	2012	38	Vacuum-packed sausages	*T. britovi*	(Fichi, et al., 2015)
USA	2013	9	Sausage	*T. spiralis*	(Greene, et al., 2014)
Germany	2013	21	Raw sausage	*T. spiralis*	(Faber, et al., 2015)

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Table 3: Outbreaks of trichinellosis in Europe associated with consumption of horse meat, 1975–2005.

Country	Date	Origin of the infected horse	No. of human cases	Trichinella species	References
France	1975	Eastern Europe	125	Not determined	(Bouree, Bouvier, Passeron, Galanaud, & Dormont, 1979)
Italy	1975	Former Yugoslavia	89	*T. britovi*	(Mantovani, Filippini, & Bergomi, 1980)
Italy	1984	Former Yugoslavia	13	Not determined	(Parravicini, et al., 1986)
France	1985	USA	431	*T. murrelli*	(THIERRY ANCELLE, et al., 1988)
France	1985	Poland	624	*T. spiralis*	(THIERRY ANCELLE, et al., 1988)
Italy	1986	Former Yugoslavia	300	*T. britovi*	(Pozio, et al., 1987)
Italy	1990	East Europe	500	*T. spiralis*	(Pozio, 1991)
France	1991	USA	21	Not determined	(Beytout, Mora, Laurichesse, Cambon, & Rey, 1991)
France	1993	Canada	538	*T. spiralis*	(T Ancelle, et al., 1993; THIERRY Ancelle, et al., 1998; Jean Dupouy-Camet, Soulé, & Ancelle, 1994)
France	1994	Mexico	7	*T. spiralis*	(Maillot, Desenclos, Dupouy-Camet, & Aubert, 1997)
France	1998	Serbia	128	*T. spiralis*	(Haeghebaert, et al., 1998)
France	1998	Serbia	404	*T. spiralis*	(Touratier, Boireau, Dupouy-Camet, & Pages, 1999)
Italy	1998	Poland	93	*T. spiralis*	(Pozio, et al., 1998)
Italy	2000	Romania or Poland	36	*T. spiralis*	(Liciardi, et al., 2009)
Italy	2005	Eastern Europe	7	*T. britovi*	(Liciardi, et al., 2009)

526 **Table 4: Outbreaks of trichinellosis associated with dog meat**

Date	No. cases	Country-province	Preparation of dog meat
1938-55	30 (one death)	Switzerland	Raw
1974	9	China-Jilin	Raw
1979	8	China-Liaoning	Semi-cooked
1980	9	China-Jilin	Semi-cooked
1981	33	China-Jilin	Roasted
1981	-	Thailand-Phetchabun	Raw
1987	9	China-Jilin	Raw and semi-cooked
1987	8	China-Jilin	Scalded
1987	6	China-Beijing	Scalded
1989	5	China-Liaoning	Raw
1998	2	China-Henan	Semi-cooked
1997-2001	373	Slovakia-Valaska	Smoked sausage
2000	3	China- Liaoning	Raw
1998–2002	103	Russia	-
2002	7	China- Heilongjiang	Raw frozen dog
2005	4	Russia-Tulsakaya	Raw
2009	9	Russia-Zabaykalsky	Stray dog meat

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528 Data from Khamboonruang (1991), Cui & Wang (2001), Ozeretskovskaya et al. (2005) and stephensen berger
529 (2016).

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Table 5: Outbreaks of trichinellosis associated with consumption of beer meat, 2000–2016.

Country- state	Date	No. of cases	Preparation of bear meat	Trichinella species	References
Canada-Alaska	2000	4	Bear steaks	*T. nativa*	(Roy, et al., 2003)
Canada- Northern Saskatchewan	2000	31	Uncooked bear meat	*T. nativa*	(Schellenberg, et al., 2003)
USA-California	2001	2	Barbequed Bear meat	Not determined	(Roy, et al., 2003)
USA-California	2001	2	Uncooked bear meat	Not determined	(Roy, et al., 2003)
Russia	1998-2002	341	Uncooked bear meat-steak	Not determined	(Ozeretskovskaya, Mikhailova, Sabgaida, & Dovgalev, 2005)
Canada-Alaska	2002	5	Uncooked bear meat	Not determined	(Control, 2009)
USA- Tennesee	2003	2	steaks	*T. nativa*	(Control & Prevention, 2004)
USA- New York	2003	1	raw bear meat	*T. nativa*	(Control & Prevention, 2004)
Canada-Alaska	2005	3	raw bear meat	Not determined	(Control, 2009)
France (imported from Canada)	2005	9	Uncooked bear meat-steak	*T. nativa*	(Thierry Ancelle, et al., 2005)
USA-California	2006	2	steaks	Not determined	(Control, 2009)
USA-California	2008	28	Steaks- raw bear meat	*T. murelli*	(Hall, et al., 2012)
USA-California	2008	5	Uncooked bear meat	Not determined	(Wilson, et al., 2015)
France (imported from Canada)	2009	5	Uncooked bear meat-steak	Not determined	(Houzé, et al., 2008)
Russia	2002-2010	200	Bear meat	Not determined	(Berger, 2016)
USA- Minnesota	2012	1	Uncooked bear meat	Not determined	(Wilson, et al., 2015)
USA- Illinois	2012	1	Uncooked bear meat	Not determined	(Wilson, et al., 2015)
East Greenland	2016	3	Polar bear meat	Not determined	(Jean Dupouy-Camet, et al., 2016)

549 **Table 6: Outbreaks of trichinellosis with consumption unusual sources meat, 1995–**
550 **2015.**

Country	Date	Source of infection	No. of cases	Trichinella species	References
Korea	1997	Badger	2	*T. spiralis*	(Sohn, Kim, Chung, & Yee, 2000)
Russia	1997-2002	Badger	92	Not determined	(Ozeretskovskaya, et al., 2005)
Canada	1999	Walrus	1	*T. nativa*	(Serhir, MacLean, Healey, Segal, & Forbes, 2001)
Algeria	2004	grilled leg of jackal	1	*T. britovi*	(Nezri, et al., 2006)
USA	1997-2007	Cougar	2	*T. nativa* OR *Trichinella T6*	(Control, 2009; Roy, et al., 2003)
USA	2002-2007	Walrus	1	Not determined	(Control, 2009)
Russia	2008	Walrus	8 (2 fatal)	Not determined	(Berger, 2016)
Russia	2005-2009	badger	33	Not determined	(Berger, 2016)
Taiwan	2009	Soft-shelled turtle	8	*T. papuae*	(Lo, et al., 2009)
Senegal	2009	Warthog	3	*T. britovi*	(J Dupouy-Camet, Lecam, Talabani, & Ancelle, 2009)
Korea	2012	Soft-shelled turtle	2	Not determined	(Lee, et al., 2013)
Korea	2014	Soft-shelled turtle (*Trionyx sinensis*)	6	Not determined	(Jeong, et al., 2015)

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