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Trichinella nativa in Iceland: an example of *Trichinella* dispersion in a frigid zone

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Abstract

In most Arctic and subarctic regions, *Trichinella nativa* is a common zoonotic pathogen circulating among wild carnivores. The polar bear (*Ursus maritimus*) is one of the most important reservoirs for *T. nativa* in frigid zones. In Iceland, *Trichinella* infection has never been detected in the local wildlife, despite the presence of one of the host species, the arctic fox (*Alopex lagopus*). In 2008, one of two polar bears that had swum to Iceland's coast was found to have been infected with *Trichinella* sp. (8.5 larvae/g in the tongue, 6.8 larvae/g in the masseter and 4.4 larvae/g in the diaphragm); the larvae were identified as *T. nativa*. This is the second report of *Trichinella* infection in polar bears that reached the Icelandic coast. In the present work, we describe this case of infection and discuss the epidemiological features that have allowed *T. nativa* to spread in Arctic regions.

Introduction

In Arctic and subarctic areas of the Holarctic region, most carnivores at the top of the food chain act as a reservoir for *Trichinella nativa* (Rausch, 1970; Kumar *et al.*, 1990; Forbes, 2000; Rah *et al.*, 2005; Pozio & Murrell, 2006; www.iss.it/site/Trichinella/index.asp). An important biological characteristic of this *Trichinella* species is that muscle larvae survive in frozen carnivore muscles for up to 5 years, favouring the transmission from one carnivore host to another under extreme conditions, such as those existing in these areas (Pozio & Murrell, 2006).

In Iceland, *Trichinella* infection has never been documented in humans or in domestic or wild animals living on the island (Skírnisson *et al.*, 2003). However, in 1963, a polar bear (*Ursus maritimus*), shot in the area of Hornvík (66°23′17″N, 22°40′58″W) but transported immediately on a boat to the town of Ísafjörður, was found to have *Trichinella* sp. larval infection (Pálsson, 1964). Given that the meat from this infected bear had been distributed for human consumption, the health authorities warned the local population not to eat polar bear meat, although it became clear that most of them had already done so. However, no cases of human infection were reported or suspected, probably because the meat had been thoroughly cooked (Pálsson, 1964).

Polar bears are one of the most important reservoirs of *T. nativa* in Alaska, Canada, Greenland, the Barents and Norwegian Seas and the Chukotsk peninsula, with a prevalence of infection of up to 61% (Weyermann *et al.*, 1993). In Iceland, most polar bears arrive when pack ice is stranded ashore or comes into close proximity of the northern or north-western coasts. Documentation of their presence dates back to the 'Icelandic Saga', written in the 13th and 14th centuries, and over the centuries more than 500 polar bears have been recorded, 50 of them in the past 100 years (Haraldsson & Hersteinsson, 2004). Over the past centuries, many of the bears were killed, although in some cases they returned to the ice and disappeared (Haraldsson & Hersteinsson, 2004). In 2008, a polar bear that had swum to Iceland was found to have been infected with *T. nativa*. The objective of the present study was to describe this second case of a *Trichinella*-infected polar bear and to evaluate the epidemiological features that allowed *T. nativa* to spread in Arctic regions.

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We also provide epidemiological information that could explain the reason why *T. nativa* seems not to have been transmitted in terrestrial ecosystems of Iceland, at least in the past two centuries.

Materials and methods

In June 2008, when the nearest edge of the pack ice was 100 nautical miles (185 km) off the northern coast of Iceland, two polar bears, a male and a female, swam to Skagi (66°06′53″N, 20°08′51″W). Soon after their arrival, the bears were shot for security reasons by a team led by police officers: the male was shot on 3 June and the female on 16 June.

The bear carcasses were transported to the Institute for Experimental Pathology at Keldur, University of Iceland, and various biological samples were collected. To estimate the age of the bears, growth layer groups were counted in the cementum region of I1 in both animals (Skírnisson, 2009). To detect *Trichinella* sp. larvae, muscle samples (50 g each) were collected from the masseter, diaphragm and tongue, and were digested using the standard method (Nöckler & Kapel, 2007). After digestion, the larvae were collected, stored in 95% ethyl alcohol and sent to the International Trichinella Reference Centre (ITRC, www.iss.it/site/Trichinella/index.asp) for species identification. At the ITRC, 20 single larvae were analysed by a validated multiplex polymerase chain reaction (PCR) analysis, following a previously described method (Pozio & La Rosa, 2003).

Results and discussion

Both of the polar bears were unusually small and lean: the male weighed 220 kg and had a body length of 209 cm; the female weighed 142 kg, with a body length of 194 cm. The female was estimated to be 14.5 years old and the male at least 22.5 years old. *Trichinella* sp. larvae were only detected in the male (8.5 larvae/g in the tongue, 6.8 larvae/g in the masseter and 4.4 larvae/g in the diaphragm). The larvae were identified as *T. nativa* (isolate code 2229; www.iss.it/site/Trichinella/index.asp) and this is the first report of *T. nativa* infection in Iceland.

Polar bears have a circumpolar distribution. They range throughout the Arctic region surrounding the North Pole. The limits of their range are determined by the ice pack of the Arctic Ocean and the landfast ice of surrounding coastal areas (DeMaster & Stirling, 1981; Nowak, 1999). The prevalence of *T. nativa* infection in polar bears varies by geographic area and increases with age (Henriksen *et al.*, 1994), although it is generally quite high: 10–60.9% in Alaska (Fay, 1960; Rausch, 1970; Weyermann *et al.*, 1993); 59% in the Barent's and Norwegian Seas (Thorshaug & Rosted, 1956); 23–32% in Greenland (Madsen, 1961; Born & Henriksen, 1990; Henriksen *et al.*, 1994); and 31.4% on the Svalbard Islands (Larsen & Kjos-Hanssen, 1983). In polar bears from the Beaufort and Chukchi Seas, anti-*Trichinella* antibodies were detected serologically in 55.6% (278/500) of the animals (Rah *et al.*, 2005). This very high serological prevalence is due to the fact that the polar bear is at the top of the food chain and that its life span is longer than that of other carnivores, reaching up to 30 years in the wild and 45 years in captivity (Hemstock, 1999).

Iceland first began to be populated by Norse settlers in AD 874. These settlers brought with them livestock (sheep, horses, cattle, pigs and poultry), pets (dogs and cats) and probably both the house mouse (*Mus musculus*) and the field mouse (*Apodemus sylvaticus*) (Skírnisson *et al.*, 2003). When the settlers arrived, the only terrestrial mammal present was the arctic fox (*Alopex lagopus*) (Haraldsson & Hersteinsson, 2004), which is still common in Iceland. Its population has increased markedly in recent decades, with an estimated autumn population of approximately 6000 (Hersteinsson, 2004a). Although *Trichinella* sp. has never been detected in arctic foxes in Iceland, this species does act as a reservoir of *T. native* in the Arctic, with a prevalence of infection of 12% (16/136) in Greenland, 8.5% (59/697) on the Svalbard Islands, 7% (16/222) in Alaska, 11.5% (23/200) in the Chukotsk peninsula, and 13% (35/270) in the Iamal peninsula (Madsen, 1961; Rausch, 1970; Prestrud *et al.*, 1993; Kapel *et al.*, 1996).

As mentioned, *Trichinella* nematodes have never been documented in humans or domestic or wild animals living on Iceland (Skírnisson *et al.*, 2003; Hersteinsson, 2004b). In the 1950s and 1960s, no infection was detected among domestic pigs that had been fed imported food remains which had originated from the American military base in Keflavík (Thorsteinsson, 1992). In the period from 1998 to 2008, diaphragm samples from more than 1600 horses that were raised in Iceland were also free of infection (Anonymous, 1998–2008). In the 1990s, none of the dozens of arctic foxes and feral minks (*Mustela vison*) captured in different parts of Iceland were found to have been infected, as determined by the digestion of diaphragm samples (Karl Skírnisson, unpublished data). One of the factors that could be responsible for the absence of *T. nativa* in Iceland's terrestrial ecosystem is the island's geographical isolation and its small size (103,000 km^2). This is probably also one of the reasons why *Trichinella spiralis* has never been detected, in addition to the limited importation of animals potentially infected with *T. spiralis*, including the brown rat (*Rattus norvegicus*) (Skírnisson, 2004a). Potentially, migratory seals could introduce *T. nativa* to the island. In fact, four seal species (*Phoca groenlandica*, *Phoca hispida*, *Cystophora cristata* and *Erignathus barbatus*) have regularly been observed off and on Iceland's coast, and *T. nativa* has been detected in two of these species: *E. barbatus*, with a prevalence of infection of 0.8% (2/245) in Greenland and 0.7% (1/148) in Alaska, and *P. hispida*, with a prevalence of infection of 0.05% (1/1775) in Greenland and 0.7% (2/300) in Alaska (Forbes, 2000). Moreover, two seal species breed in coastal areas of Iceland: the harbour seal (*Phoca vitulina*), with a present population of 10,000 – 15,000 (Hauksson *et al.*, 2004), and the grey seal (*Halichoerus grypus*), with a population of approximately 5000 animals (Hauksson & Ólafsdóttir, 2004), although *T. nativa* has never been detected in either of these species. Seals infected with *T. nativa* could act as a source of infection for terrestrial mammals; in particular, seal carcasses on the beach could be consumed by the arctic fox. Nonetheless, the very low prevalence of infection and the low worm burden in seals suggest that these animals do not act as a reservoir.

Another potential source of infection is the walrus (*Odobenus rosmarus*), which is known to host *T. nativa*, with a prevalence of infection ranging from 1.0 to 9.4%. Walruses also represent an important source of infection for humans (Forbes, 2000). However, only on very rare occasions have they been spotted along Iceland's coasts (Thórdarson & Hauksson, 2004).

If *T. nativa* were to be introduced into Iceland's ecosystem, it is believed that both the arctic fox and the mink could maintain a sylvatic cycle. Minks were first imported for fur farming in 1931, and they soon escaped and established feral populations on all parts of the island (Skírnisson, 2004b). Furthermore, in the past 50 years there has been an approximately threefold increase in the arctic fox population (Hersteinsson, 2004a), increasing the likelihood of the survival of *T. nativa*, if it were to be introduced. Although the possibility of the future introduction of *T. nativa* in Iceland's wildlife cannot be excluded, careful surveillance can contribute to preventing this occurrence, as was the case in 2008, when the polar bears were discovered and killed and the carcasses were destroyed to prevent them from being consumed by domestic or wild animals.

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