TRICHINELLA IN ARCTIC, SUBARCTIC AND TEMPERATE REGIONS: GREENLAND, THE SCANDINAVIAN COUNTRIES AND THE BALTIC STATES

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Abstract. The transmission and occurrence of *Trichinella* spp according to the zoogeography of different climatic conditions, socioeconomy and human activity are discussed. Comparing arctic, subarctic and temperate regions, it appears that the species of *Trichinella* present, the composition of the fauna and the human activity are all very important interacting factors affecting epidemiology. In Greenland, where only sylvatic trichinellosis is present, the high prevalence in wildlife appears closely connected with polar bear hunting. In the Scandinavian countries, the prevalence of both sylvatic and domestic trichinellosis differ widely. Denmark is regarded as *Trichinella*-free in the case of domestic trichinellosis and sylvatic trichinellosis is very rare. In Sweden and Norway, *Trichinella* is found in wildlife but domestic trichinellosis is rare. In Finland, both domestic and sylvatic trichinellosis have increased dramatically during the last decade. Among the Scandinavian countries, Finland also has the largest populations of carnivorous mammals. In the Baltic states, *Trichinella* is frequently found in wildlife and domestic trichinellosis is increasingly diagnosed. The high prevalence in the widespread wildlife populations may have epidemiological importance in relation to the recent changes in production and infrastructure in these former Soviet states.

INTRODUCTION

The main reservoir hosts of *Trichinella* spp. are primarily wildlife, especially large carnivorous mammals. Prevalence in both domestic and sylvatic life cycles appears closely related to the diversity and size of the carnivore populations. Additionally, the spread of *Trichinella* appears strongly influenced by factors such as hunting and veterinary hygiene (*ie* rat control). In Western Europe sylvatic trichinellosis is primarily found in mountain areas, national parks and other areas with undisturbed populations of wild carnivorous hosts. In many Eastern European countries increasing prevalence of *Trichinella* has been observed in wildlife, domestic animals and man. These apparent changes in prevalence may be assigned to the political and socioeconomic changes that have affected the veterinary control and hunting regulations. Additionally, the vast forests with large populations of wildlife create an optimal biotop for the transmission of *Trichinella.*

Both sylvatic and domestic *Trichinella* can infect man, wildlife and domestic animals, but, since infectivity and pathogenicity differs widely according to the species of host and species of *Trichinella,* parasite identification is very central for our knowledge of the epidemiology and the control of the disease.

TRICHINELLA IN GREENLAND

In Greenland, *Trichinella nativa* is the only *Trichinella* species present (La Rosa *et al,* 1990; Kapel *et al,* in prep). Freezing tolerance of the *T. nativa* muscle larvae allows transmission even at temperatures below -20 °C. The main wildlife reservoirs are polar bears (32%)(Born and Henriksen, 1990), arctic foxes (6%) (Kapel *et al,* 1996), and walruses (2%)(Born *et al,* 1982), but prevalence among sled dogs is even higher (>75%)(Madsen, 1961). All diagnosed cases of human trichinellosis in Greenland have occurred from consumption of raw or insufficiently cooked walrus and polar bear meat (Thornborg *et al,* 1948; Thing *et al,* 1976). In the period 1960-1980, 61 human cases were registered (Bohm, 1984), but if subclinical cases are included the actual number may be tenfold higher. From a survey on human sera, 22% of the native population in an endemic area had antibodies against *Trichinella.* but only in 13% of the positive cases were clinical symptoms recorded, apparently due to immunity at the intestinal level (Bohm and van Knapen, 1989).

The prevalence in wildlife in Greenland is highly variable geographically, with the highest prevalence found in the north. These differences appear connected to two factors: polar bear hunting and the use of sled dogs. In areas where polar bears are hunted, the prevalence in wildlife is very high. When polar bear carcasses from the hunt are left on the ice, they attract other polar bears, arctic foxes or sled dogs. If dumped into the sea, walruses will eventually have access to the carcass. Since sled dogs are fed all remains of the hunt, they will very often become infected with *Trichinella.* The sled dogs are used intensively and after a few years of hard labor they are killed. Tradition is to leave them on the ice or dump them into the ocean, and, as with the polar bear carcasses, the surrounding carnivore fauna will have access to them.

TRICHINELLA IN SCANDINAVIA

In Scandinavia, marked differences exist between countries, and the prevalence of the three species found (*T. spiralis, T. britovi,* and *T. nativa*) appears closely related to the presence of carnivorous species (foxes, racoon dogs and lynx).

In Denmark, only very low prevalence in wildlife is found. In foxes the prevalence is less than 0.1% (Clausen and Henriksen, 1976), and in other carnivorous species *Trichinella* has not been found. In a few cases, *Trichinella* has been reported from imported wild boars held in game parks (Henriksen and Clausen, 1977). In domestic pigs the parasite has not been found since the 1930's, although 18 million pigs are routinely examined annually. Human trichinellosis is very rare and the few cases recorded have all been assigned to consumption of infected meat during holidays in endemic areas.

Both Sweden and Norway have larger and more diverse populations of mammalian carnivores, which appear to favor the life cycle of *Trichinella.*

In Sweden, *Trichinella* infections in wildlife are more common than in Denmark with a prevalence of 7-20% found in the fox population (Roneus and Christensson, 1979; Nordqvist *et al,* 1992), whereas *Trichinella* is found rarely in domestic pigs (Christensson, 1994). Only *T. spiralis* is demonstrated in domestic pigs, whereas *T. nativa* and *T. britovi* are also present in the sylvatic reservoirs (Pozio, 1995).

In Norway, infections both in wildlife and domestic pigs seem more frequent than in Sweden. Thus, prevalence among foxes is 25% and 5% or less among other carnivores (Stuve and Holt, 1992), while in domestic pigs only 13 cases have been detected since 1970 (Skjerve, 1987). Human cases, which have not been registered since the 1940's, were all assigned to consumption of uncontrolled pork meat products, imported or from outdoor-reared domestic pigs (Skjerve, 1987). On the Norwegian arctic islands, Svalbard, a prevalence of 33% has been found among polar bears (Larsen and Kjos-Hanssen, 1983) and 9% among arctic foxes (Prestrud *et al,* 1993), but human cases have never been reported. Interestingly, only the sylvatic strain *T. nativa* has been found in Norway (Pozio, 1995).

Finland has the highest prevalence in wildlife: Foxes 58%, lynx 41%, badgers 33%, raccoon dogs 25%, minks 3%, ermines 12%, bears 2%, and wild boars 1% (also cats 55%, rats 13%)(Hirvelä-Koski *et al,* 1985; Nikander and Oivanen, 1992). Although *Trichinella* was first recorded in domestic pigs in the 1950's, recent outbreaks seem to suggest that the problem is rising and that infections may be connected to increasing prevalence in wildlife and especially among rats and cats. Thus, *Trichinella* has been detected in more than 100 pig farms and prevalence among brown rats (*Rattus norvegicus*) and cats (*Felis catus domesticus*) in the surroundings of these positive farms, were 20 and 48%, respectively (Oivanen and Oksanen, 1994). Similarly, trichinellosis among racoon dogs has increased and a recent investigation has shown a prevalence of 50% (Mikkonen *et al,* 1995). Both *T. nativa* and *T. spiralis* are found in Finland, but whereas *T. nativa* appears confined to sylvatic animals, both species are found in synanthropic animals (Pozio, 1995). Although, the situation in Finland may pose a serious threat to human health, no cases have been reported, possibly due to intensive meat inspection employing digestive technics.

TRICHINELLA IN THE BALTIC COUNTRIES

In the three Baltic states (Estonia, Latvia, and Lithuania) human trichinellosis is an increasing problem. The large forests in the Baltic countries permit an extraordinary diverse and numerous wildlife fauna to exist. In the Baltic areas, three *Trichinella* species are found *T. spiralis, T. britovi* and *T. nativa,* and the main reservoirs are wild boars, racoon dogs, foxes, wolves, lynx, and badgers. In the northernmost of the Baltic countries, Estonia, all three species are present, whereas in Latvia and Lithuania only *T. britovi* and *T. spiralis* have been found. Thus, *T. nativa* seems restricted to areas where its ability to tolerate freezing is advantageous for transmission.

According to the host species the different *Trichinella* species vary in their infectivity and pathogenicity. The occurrence of the different *Trichinella* species in the various host species and the possibility of multiple infections in the same host individual (Pozio *et al*, 1995) may influence epidemiology. Of the three species found, *T. nativa* appears confined to sylvatic animals, *T. britovi* to both sylvatic and domestic animals and *T. spiralis* to synanthropic and domestic animals (Pozio *et al*, 1995).

Although differences exist regarding prevalence in wildlife between the countries, human infection arises primarily from the consumption of insufficiently cooked wild boar meat, but domestic pigs also appear to be a source of infection. Infections among domestic pigs are rare, but the few findings could possibly be a result of using non-digestive diagnostic methods for routine control. Socioeconomic changes in the Baltic countries have also led to more frequent poaching on wild boars and home slaughtering of outdoor reared pigs from both of which uncontrolled meat has been sold.

In Estonia, the prevalence has been rising in sylvatic and domestic animals during the last two decades (Peebsen, 1967; Miller and Järvis, 1995). The prevalence is high especially among raccoon dogs (71%), rats (11%), and cats (4%). Also among farmed carnivorous animals, in the rat populations and among domestic cats the prevalence has increased dramatically recently (Miller and Järvis, 1995). Human trichinellosis occurs more frequently than earlier and, although the size of the problem is not known, consumption of meat from wild boars as well as from domestic pigs appears to be the source of infection (Miller, 1994). As in Finland, the high prevalence of *Trichinella* in wildlife may pose a serious threat to meat production, although trichinellosis among domestic pigs is as yet rarely detected in Estonia.

In Lithuania, the threat of trichinellosis to human health has been underlined by an increasing number of severe and also fatal cases during the 1990's (Ročkené *et al*,1995). Meat from wild boars and domestic pigs are both frequent sources of infection (Rockiene, 1994). Prevalence in wildlife and synanthropic animals is high (lynx 24%, fox 18%, raccoon dog 18%, wild boar 1%, rat 9%, cat 6%, dog 9%) (Stankevicius, 1975; Rockiene, 1994), and among domestic pigs it has increased from 0.0015% in the 1930's to 0.03% in 1993 (Paulikas and Sarkunas, 1995).

In Latvia, epidemiological data on trichinellosis have not been published since 1980. The latest data on prevalence in wildlife (Viksne, 1969; Beloshapkina *et al*, 1980) is comparable to those found in the other Baltic countries, and it is likely that trichinellosis is a growing problem both among human and domestic animals in Latvia as well.

DISCUSSION

Trichinellosis in domestic pigs and humans appears closely associated with prevalence in wildlife, veterinary hygiene, hunting traditions and diagnostic methods employed in meat inspection. A summary of information on the occurrence of *Trichinella* in Greenland, Svalbard, Scandinavia, and the Baltic countries is presented in Table 1.

Trichinellosis in wildlife is, as mentioned above, found where carnivorous populations are large and

Table 1

Trichinella status in wildlife, domestic animals and humans in Greenland, Svalbard, Scandinavia and the Baltic countries 1980-1995.

Country	Wildlife	Dom. pig	Routine control	Man	*Trichinella* species present
Greenland (DK)	+++	-	-	+	*T. nativa*
Svalbard (N)	+++	-	-	(?)	*T. nativa*
Finland	+++	+++	Digestion	0	*T. nativa, T. spiralis*
Norway	++	+	Digestion	0	*T. nativa*
Sweden	++	+	Digestion	0	*T. nativa, T. britovi, T. spiralis*
Denmark	+	0	Digestion	0	*T. spiralis*
Estonia	+++	(++)	Compressorium	+	*T. nativa, T. britovi, T. spiralis*
Latvia	+++	(++)	Compressorium	(+)	(*T. britovi, T. spiralis*)
Lithuania	+++	+++	Compressorium	+++	*T. britovi, T. spiralis*

Brackets indicate that no recent information is available.

diverse. To reduce the prevalence in wildlife, one must prevent transmission due to human. Thus, preventing hunters from discarding carcass remnants which could be scavenged by wild and synanthropic animals has been shown to decimate trichinellosis in wildlife populations (Worley *et al*, 1994).

Basically, trichinellosis in domestic pigs is found where carnivorous wildlife, especially populations of carnivores with cannibalistic and scavenger behavior, are numerous. Where efficient barriers preventing transmission by synanthropic animals (cats and rats) are lacking, trichinellosis in production animals may evolve. Therefore, reduction of this transmission by rat control, etc, appears very important for controlling the disease. Another central issue in reducing transmission is the need for veterinary regulations prohibiting feeding of improperly heated food to production animals especially waste meat from slaughtering and hunting.

In arctic areas, human trichinellosis arises from consumption of wildlife, but, where climatic conditions allow animal production, the domestic pig is also a potential source of infection. In Europe, usually often smoked meat, sausages or other fresh meat products from wild boars, as well as domestic pigs raised under poor sanitary conditions, are sources of infection. Since trichinellosis is relatively rare in most parts of Europe, infection in human will often be primary infections with expressed clinical symptoms. In the hunting cultures in the arctic areas, gradual immunization of the local population may be obtained, through tradition bound ingestion of small pieces of raw meat from newly-shot animals. Visitors, tourists, expedition members, etc from non-endemic areas participating in these hunting rituals may show severe clinical symptoms if infected.

When estimating the prevalence of trichinellosis, it is very important to take into account the diagnostic method. Clearly, the digestive techniques are much more sensitive than the compressorium technique, with 0.1 larvae per gram detected compared with 3 larvae/g. In most West European slaughter houses, digestive techniques are used for routine examination of domestic pigs, but in the Baltic countries compressorium is still the approved method. Thus, light infections may not be detected and the prevalence among domestic pigs in the Baltic region is most likely underestimated.

All species of *Trichinella* can infect humans, domestic animals, and wildlife but infectivity and pathogenicity varies. For humans, *T. spiralis* and *T. nativa* have high pathogenicities while *T. britovi* produces fewer severe symptoms. The same three *Trichinella* species all show a high infectivity in carnivores, but appear to have no influence on the health and fitness of the infected animals. Only *T. spiralis* has high infectivity in domestic pigs. As the composition of the *Trichinella* population differs geographically, parasite identification appears to be central importance in epidemiological studies and thereby in controlling trichinellosis.

In summary, the threat to human health by the different *Trichinella* species is basically influenced by:

1) The local hunting tradition, including processing of the meat.

2) The prevalence and species composition of *Trichinella* populations.

3) The veterinary hygiene at pig farms (heating of food, rat and cat control).

4) Diagnostic techniques used for meat inspection at slaughter houses.

ACKNOWLEDGEMENTS

I am grateful to Dr I Miller for translating relevant information on *Trichinella* epidemiology in the Baltic countries from Russian and to Prof P Nansen and the Danish National Research Foundation for financial support.

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