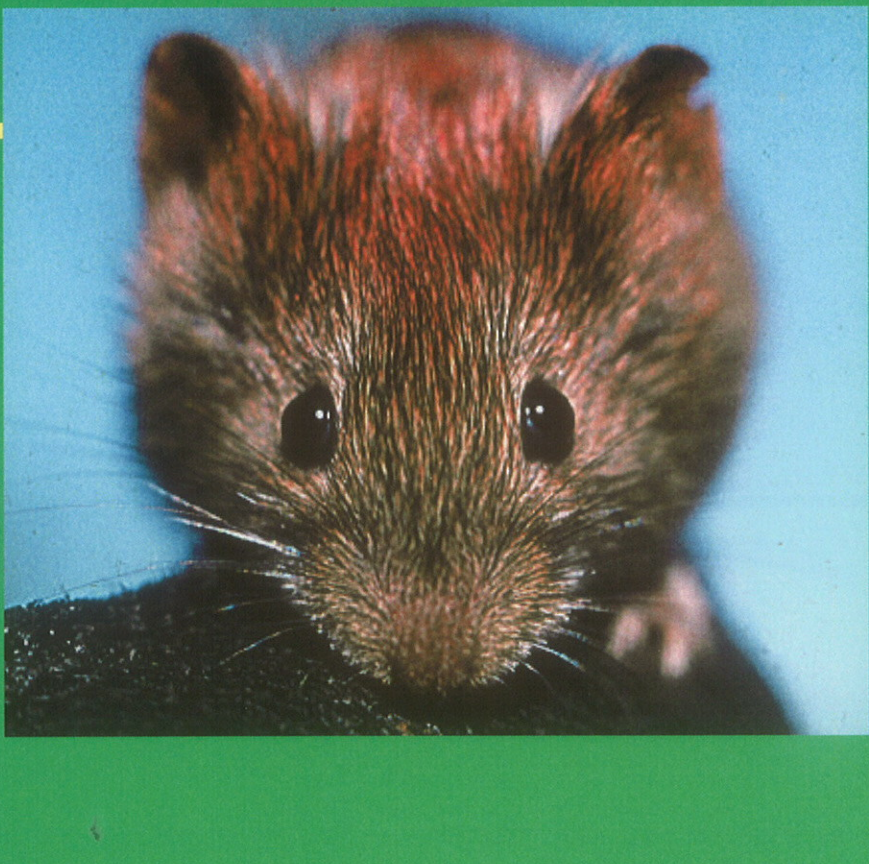
Risk assessment of the spread of *Echinococcus multilocularis* into and within Finland



EELA

Illustrations:

Front cover: red vole *(Clethrionomys rutilus)* / Heikki Henttonen

Back cover: A heavily infected liver of a sibling vole *(Microtus rossiaemeridionalis)* from Spitsbergen / Heikki Henttonen

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1. Introduction

The National Veterinary and Food Research Institute (EELA) invited a group of professionals in Finland, representing various disciplines, to review the latest research information on *Echinococcus multilocularis*, its present distribution in Europe, and assess the risk the parasite poses to Finland. The risk assessment calls for knowledge not only of the pathogen itself and its distribution, but also of any relevant factors concerning host populations and their ecology.

The Veterinary and Food Department of the Ministry of Agriculture and Forestry submitted a formal request to The National Veterinary and Food Research Institute (EELA), dated 13 October 2000, for a report on the risks of *Echinococcus multilocularis* spreading into Finland and on the optimum measures to be taken to stop its potential spread into Finland (1414/511/2000).

As a question of this nature needs to be answered from various view points, which were represented by the group, this qualitative risk assessment was produced in co-operation between all the group members following the import risk analysis principles of OIE (International Office of Epizootics). Limited resources were available for the assessment, and therefore only essential information available is presented and discussed.

The following professionals and institutes took part in the production of this risk assessment report:

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2. The risk of *Echinococcus multilocularis* spreading into Finland

2.1. Hazard identification

2.1.1 The parasite *Echinococcus multilocularis*

The life cycle of the fox tapeworm *Echinococcus multilocularis* includes an adult stage in a definitive (final) host and a larval stage in an intermediate host. The adult parasites live in the small intestine of carnivores, which remain as asymptomatic carriers. The eggs are expelled from the definitive host's intestines via its faeces. Intermediate hosts are infected via the oral route; in theory one egg is sufficient to infect an intermediate host. The larvae of the parasite develop asexually by forming fluid-filled cyst-like formations, hydatid cysts, in the intermediate host's internal organs. The hydatid cysts contain protoscoleces. Foxes (including arctic foxes) are the definitive hosts for the parasite, but dogs, cats, raccoon dogs and wolves can also act as definitive hosts, although in the cats the egg production is lower than in canids (Figure 1). Rodents act as intermediate hosts (particularly voles, lemmings and muskrats, and sometimes squirrels, rats and house mice).

An infected definitive host spreads the parasite efficiently into its surroundings via its faeces. The eggs can be spread by ants, flying insects etc. Some of the eggs will still be contained within the segments, and therefore the active movement of the segment can transport eggs several metres. The eggs are very resistant to environmental conditions and can survive over a year, particularly if they are not exposed to drought. The eggs remain infective at the temperature range from -30 °C to +60 °C. In order to destroy the infectivity off eggs, the samples must either be frozen at -80 °C for four days or heated at + 70 °C for 12 hours

Only a few anthelmintics are effective against the adult worms. The most effective agent is praziquantel (a single dose of 5 to 10 mg/kg). Nitroscanete must be administered into an empty stomach with a two-day interval between doses (daily dose of 200 mg/kg). However, these agents have no effect on the eggs in the gravid segments.

Human infection occurs via the faeces of a dog or fox, or via water or berries contaminated by the feces or via eggs adhering to dog hairs. Humans may act as an intermediate host for *E. multilocularis*, but are incapable of spreading the parasite further. In most cases the human immune response is capable of supressing the further development of the parasite, and the only outcome of the infection will be a rise in the antibody levels. Should the human immune response fail to eliminate the parasite, it will form a tumour-resembling cyst, usually in the liver. The parasite may then spread from the liver into the lungs, brain or elsewhere in the body particularly following a mechanical injury of some kind, e.g. during surgery (approximately 12 % of all cases). The development of the parasite in humans is slow and incubation period for visible symptoms to appear is from 5 to 15 years. In humans, this is a serious illness, which is treated with surgery and anthelmintics. Previously the patient would die within approximately five years, but the prognosis is much better today.

2.1.2. The geographic distribution of the parasite

Unlike *Echinococcus granulosus*, *E. multilocularis* is genetically uniform and parasites examined from various regions have all represented the same genotype. In the Old World, it has been identified particularly in Central Europe, large areas of the former Soviet Union, China, and the Arctic regions. In endemic regions, 15% to 70% of the fox population are carriers. Recently, the parasite has spread to new regions in Europe and the proportion of foxes carrying the disease has increased. This has been aided by the increase in fox numbers. Furthermore, parasite-carrying foxes have also been encountered near and within large towns. The annual incidence in the rural human population in endemic regions in Central Europe is 1-20 / 100,000 inhabitants.

Of the regions close to Finland, the parasite is known to occur in Poland, Germany and on the island of Sjelland in Denmark. According to the information available from the Baltic countries, Estonia and Lithuania are free from the parasite, but it was identified in 1959 in Latvia in one bank vole *Clethrionomys glareolus*. However, the parasite

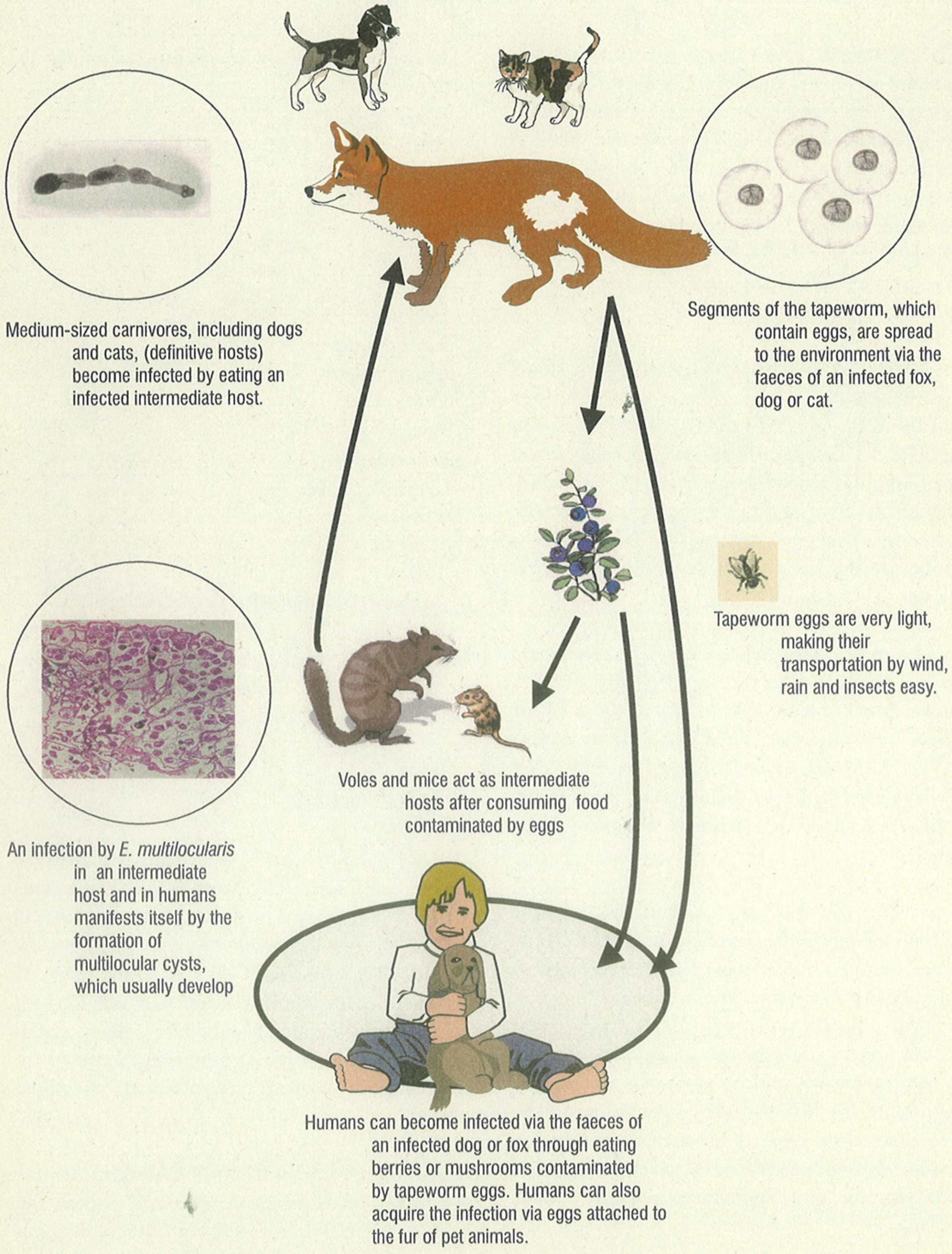

Figure 1. The life cycle of *Echinococcus multilocularis*

is found in Belarus, with whom both Latvia and Lithuania share a border. *E. granulosus* is found in the Murmansk area in Kola Peninsula, but not apparently *E. multilocularis*.. According to the Russian officials, the parasite is not found in the Republic of Karelia, east of the Finnish border. According to literature, it is common in the regions east of the White Sea.

The parasite has never been identified on the mainland of Fennoscandia (Finland, Sweden, Norway). This conclusion can be considered reliable, at least as far as Finland is concerned. Finnish vole researchers (METLA, the Finnish Forest Research Institute) annually examine thousands of voles and lemmings from study sites covering most of Finland (Figure 2). Had hydatid cysts occurred in the livers of wild rodents in Finland, they would have been found and reported on.

In 1998, the National Veterinary and Food Research Institute (EELA) examined 169 dogs from the Salla area, eastern Lapland, and in the year 2000, 10 foxes from Lapland. No echinococci were found during these examinations. The cause of death of 30 to 40 *E. multilocularis* potentially intermediate hosts is determined at EELA annually, and the parasite has never been identified in these animals.

If the population density of definitive hosts is below transmission threshold density for the parasite, it will not be able to survive in the host population. However, it is difficult to define the threshold density of fox and raccoon dog population required for the survival of the parasite, as the life cycle of the parasite is governed by many factors.

According to the Department of Bacteriology and Immunology at the Helsinki University's Haartman Institute no human has ever been reported to be infected by *E. multilocularis* in Finland.

Even though the collection of information has not been systematic and no particular surveillance programme for this parasite is yet in existence, all research data support the statement that the parasite has not been encountered in Finland for a considerable time and that at present it does not exist.

2.2 Release assessment

It is possible for *E. multilocularis* to spread into Finland via wild animals, dogs, cats and foodstuffs. An infected human does not spread the parasite any further. The probability that an animal, entering Finland, carries the parasite depends upon its country of origin.

The regions where *E. multilocularis* is known to occur include:

- Spitsbergen
- Areas of Russia east of the White Sea
- Belarus
- Poland
- Germany
- Denmark
- France
- Belgium
- Luxembourg
- Liechtenstein
- Holland
- Austria
- Switzerland
- Czech Republic
- Slovakia
- Hungary
- Turkey
- (probably Northern Italy and Greece)

Some older reports indicate that *E. multilocularis* has also been found in Latvia, Azerbaijan, Bosnia, Bulgaria, Croatia, Romania and Slovenia.

2.1.1. Wild animals

E. multilocularis can spread into Finland via infected red foxes, arctic foxes, raccoon dogs and wolves. Intermediate hosts may also spread the parasite, if they are eaten by definitive hosts in Finland. This, however, is unlikely as the range of movement of the intermediate hosts is very limited. Therefore, the risk imposed by wild animals to the spread of the parasite is primarily influenced by the prevalence of the infection among definitive hosts.

Because the densities of medium-sized carnivores have increased in recent years in NW Russia, the number of animals crossing the Finnish-Russian border continues to increase. The animals most likely to bring the infection into Northern Finland are red foxes, arctic foxes and wolves, whereas along the south-eastern border red foxes, raccoon dogs and wolves that are the most likely carriers. The infection could also be introduced across the

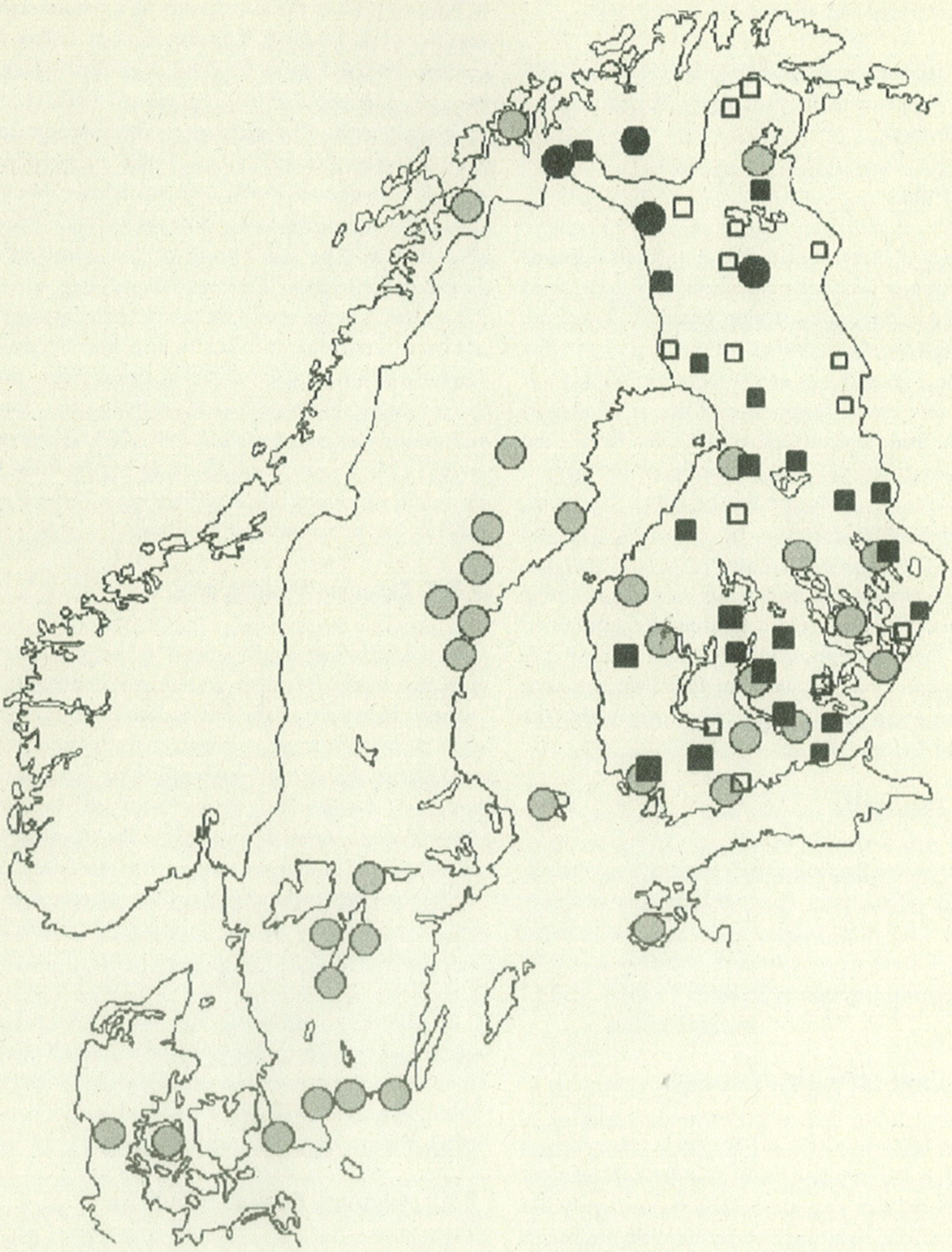

Figure 2. Areas used by Finnish vole researchers for trapping voles, and the estimated number of voles dissected at each site (Source: METLA/ Henttonen, Kaikusalo and Haukisalmi)

Legends:

● Long-term, continuing surveillance (25-50 years), trapping twice a year. Several thousand voles per site.

● Vole material collected for parasitological research. Trapping usually only once per site. 50-200 voles per site.

■ Standard surveillance trapping for national monitoring of the vole population, still continuing, in operation at least 12 years. Trapping twice a year. Total material consists of about 6 000 voles.

□ Standard surveillance trapping for national monitoring of the vole population, still continuing, in operation less than 12 years, or have been done at irregular intervals.

Gulf of Finland, particularly by wolves during the winter provided that the sea has frozen over.

The eradication of *E. multilocularis* from the wild animal populations is difficult due to the nature of its life cycle.

2.2.2. Pets

The infection level among dogs and cats depends on the prevalence of the parasite in their country of origin, and on the deworming practices. There are no comprehensive statistics on where and in what numbers dogs and cats are brought into Finland. It is likely that a large proportion of imported animals originate from regions near by, i.e. from Russia, the Baltic countries, the other Nordic countries and Central Europe. It should also be noted that travel, even of a short duration, by a Finnish dog and a contact with intermediate hosts, e.g. through hunting activities, may lead to infection. As worming medication has no effect on the eggs contained within the segments, the timing of worming is important in order to allow the dog sufficient time to defecate and expel the infectious eggs within the segments before arriving to Finland.

2.2.3. Foodstuffs

It is possible that importing foodstuffs, contaminated by fox faeces (particularly low-growing berries, wild mushrooms and vegetables), from countries were *E. multilocularis* is prevalent, could introduce the parasite to Finland.

2.3. Exposure assessment

If the *Echinococcus multilocularis* spreads into Finland, it is likely to occur via individual animals. Therefore, the spread of the parasite within Finland would be strongly dependent on the animal populations exposed to the infection by the carrier. *Echinococcus* infection is characterised by endemic areas of infection, wherein the prevalence of the parasite may reach significant levels.

2.3.1. Exposure through wild animals

If *E. multilocularis* spreads into Finland via wild animals, the definitive hosts most susceptible to the infection would be red foxes, raccoon dogs, hunting dogs and feral cats. The most susceptible intermediate hosts would be voles, lemmings and muskrats. The humans at risk would include all those in close contact with wildlife, i.e. hunters, hikers, forestry workers and farmers.

The main reason for the absence of the parasite in Finland is likely the low density of medium-sized carnivores in Finland. The fox density is low in eastern and northern Finland, but the fox and raccoon dog populations in southern Finland are now fairly large. The increase in the raccoon dog population in the 1970s and 1980s changed the overall situation in Finland; the total number of medium-sized carnivores is now significantly larger than before. The monitoring of fox numbers is based on the so-called "game triangles" (e.g. counting of tracks in the snow), of which there, however, are not sufficient amount in the northermost Lapland. The local inhabitants there claim that fox numbers have increased since hunting with poisonous bait was prohibited in 1988. However, there is no research evidence to support these claims. Because raccoon dogs hibernate, there is no reliable way to assess their numbers.

2.3.2 Exposure through pets

If the infection would spread via dogs and cats, humans would be most at risk, particularly pet owners. However, if the fox and vole populations were sufficiently large near human habitation, wild animals would also be susceptible to *Echinococcus* infection. Furthermore, if the faeces of domesticated animals ended up in a refuse tip, the number of voles, rats and foxes exposed to the infection would increase. Any eggs in the watercourses would increase the risk of exposure, in particular to the muskrat.

In addition, importing infected hunting dogs would increase the exposure of wild animals to the parasite, as the carrier can expel eggs in its faeces. The eggs survive well in the wild and hunting dogs which cover a large area when working.

2.3.3. Exposure through foodstuffs

Any imported foodstuffs which are contaminated by *E. multilocularis* eggs (berries, mushrooms, vegetables, fruit) could spread the infection, particularly to humans. As humans are incapable of spreading the infection any further, this route does not offer a direct means for the spread of the parasite. However, it could be possible that spoilt berries etc. would be disposed of in a refuse tip where voles, rats etc. could eat them.

2.4. Consequence assessment

If *E. multilocularis* did spread into Finland, it would have a very small impact on the red fox and arctic fox populations; primary hosts usually remain asymptomatic. It would have no impact on the intermediate host populations. The spread of the infection would mean an increased need to treat dogs and cats against tapeworms because of the zoonootic nature of this parasite, but even these animals would act only as asymptomatic carriers.

If *E. multilocularis* did spread into Finland, the consequences would be primarily centred on its zoonotic nature. The consequences would be both health related and economic. The occurrence of the parasite would also have an impact on human behaviour.

A direct health risk would be imposed particularly on those who have considerable contact with wildlife or with infected domestic animals (e.g. farmers, forestry workers, veterinary surgeons, hunters, dog owners, biologists). An intermediate risk would be imposed on anyone who eats contaminated foodstuffs. As the incubation time in humans is long, the source of infection is rarely identified.

In endemic regions in Central Europe the public has been given advice on the correct handling of berries, fruit and vegetables picked from the wild, as they may spread the parasite. Hiking, hunting, forestry and agriculture are all activities with an increased risk of the infection, should it be present in the nature.

The spread of the parasite could therefore have a direct economic effect on the berry and mushroom picking industry, horticulture and tourism. As far as these industries are concerned it must be assumed that even a small local outbreak of *E. multilocularis* would have a detrimental effect on the whole industry.

2.5. Risk estimation

2.5.1. Risk of *E. multilocularis* spreading into Finland

The risk of the parasite spreading to Finland via wild animals is greatest from the regions closest to Finland. There is a risk of it spreading from the regions beyond the White Sea. The parasite could enter Finland from Spitsbergen via dogs which have not been wormed, which at this moment should not be possible. The likelihood of the parasite spreading into Finland from the area beyond the south-eastern border is unclear.

The risk that the parasite is introduced to Finland via dogs and cats is real. This is because animals are imported into Finland, and because Finnish cats and dogs visit many of the countries where the parasite is prevalent, yet no systematic administration of tapeworm medication is required at present. The likelihood that imported dogs and cats bring the parasite into Finland is increased by the fact that endemic areas are expanding and the parasite has been identified in new countries (e.g. Denmark).

There is very little information available on the risk caused by foodstuffs, but even this route of infection is possible depending upon the foodstuffs' country of origin, and also depending upon the final disposal of such foodstuffs.

2.5.2. Risk of *E. multilocularis* spreading within Finland

If the infection is introduced into Finland, it can spread wherever the population density of the definitive hosts exceeds the transmission threshold density. In the beginning, the occurrence of the parasite would probably be sporadic, as with trichinosis. The risk of the infection spreading within Finland is moderate, and it would take years for the parasite to have spread throughout the whole country. The Japanese island of Hokkaido serves as a good example, having conditions applicable to Finland, with first cases in 1965, and it took 30 years for the parasite to cover the entire island. It was identified on the northernmost part of the main island of Japan (Honshu) in mid 1990s. Hokkaido corresponds well with the conditions in south and central Finland as far as climate and fauna (voles, foxes, raccoon dogs etc.) are concerned.

3. Risk management options to prevent the spread

If *E. multilocularis* did spread to Finland, it would most likely occur via foxes, raccoon dogs, dogs or cats, and therefore any risk management measures taken should be aimed to control these routes of infection and also to prevent the further spread of a possible infection within Finland. It is difficult to prevent the spread of infectious diseases among wild animals, and therefore the most effective preventative measure to be taken is to stop the infection being introduced in the first place. In practice, it is very difficult to inspect foodstuffs for the presence of the parasite, and therefore no good risk management options exists for foodstuffs, except that of taking into account the *Echinococcus* situation of the country of origin during the importation process. Even this may prove to be problematic in practice.

3.1. Prevention of the spread of the parasite into Finland

There are no standard measures to be taken to control the entry of wild animals into Finland, and therefore the probability of the spread of the parasite into Finland via this route is dependent on the situation in the regions near Finland and on the risk management measures carried out in these regions.

It could be requested that dogs, imported from areas where echinococci are endemic, are to be wormed with praziquantel-containing antihelminth prior to importation. It would be most important that the medication would cover dogs which have had free access to the wild in their country of origin (e.g. hunting dogs). Information on the importance of deworming could be supplied to dog owners and veterinary surgeons.

3.2. Prevention of the spread of the parasite within Finland

It is important for the life cycle of the parasite that the numbers of both intermediate and definitive hosts are sufficient. Therefore the probability of the spread of the parasite within Finland is dependent on the variations in the size of the vole populations, and further dependent on the resulting fox populations. Therefore, the stabilisation in the vole populations seen in Lapland followed by the stabilisation in the fox population, and the possible increase in fox numbers reported in the most northerly part of Lapland, may all be considered as particular risk factors. Presumably the spread of the parasite within Finland could be best stopped by keeping the numbers of foxes and raccoon dogs sufficiently low to prevent the parasite taking hold in these animal populations. There are very few risk management options left as far as wild animals are concerned, unless the population numbers are to be reduced. This in itself is difficult, partly because the animals roam widely and also because of ethical issues. The latter refers to the use of poisonous baits, which has been prohibited since 1988. Deworming wild animals with the use of antihelminth baits has been tested in Germany and the USA, but the results are still in the preliminary stages. The bait trial of city foxes in particular has been hampered by other animals (such as dogs, cats, rats) who eat the baits before foxes get to them.

For dogs and cats the first choice risk management measure is the frequent and correctly timed administration of tapeworm medication. For example, in Bern, Switzerland, it is recommended that all domestic cats and dogs, who might come into contact with voles, be dewormed once a month.

From the risk management point of view it is also important to follow the incidence of human cases. However, as the incubation period of the disease is very long, any risk management measures based only on this type of monitoring may be too late. Therefore, improving the surveillance of the incidence of the parasite, particularly in the carnivorous wild animal population, using modern techniques would give a more reliable picture of the current situation and its development.

4. Related literature

Abuładze, K.I. Taeniata of Animals and Man and Diseases Caused by Them. Israel Program for Scientific Translations. Jerusalem 1970: 549.

European Commission. Opinion of the Scientific committee on veterinary measures relating to public health on food-borne zoonoses. 12th April 2000.

Henttonen, H., Haukisalmi, V. Echinococcus multilocularis - ihmisen vaarallisin loinen Euroopassa: elämänkierto ja levinneisyyden nykytilanne. (Echinococcus multilocularis: life cycle and an update of the current situation in Europe.) Suomen Riista 46: 48-56 (2000).

Lunden, J. Ekinokokkilajit ja ekinokokkoosi Suomessa. (Types of echinococci and echinococcosis in Finland). Advanced studies 1996, University of Helsinki, Faculty of Veterinary Medicine, 50 pp.

Thompson, R.C.A. & Lymbery, A.J. (eds) 1995. Echinococcus and Hydatid Disease. - CAB International, UK, 477 pp.

Osamu, S. Outfoxing echinococcus. Look Japan, August 1999, 29.

Saitoh, T. & Takahashi, K. 1998. The role of vole populations in prevalence of the parasite (Echinococcus multilocularis) in foxes. Res. Popul. Ecol. 40: 97-1105.

Tapeworm zoonoses an Emergent and Global problem. NATO - Advanced Research Workshop, 10th-13th September, Poznan, Poland.

WHO: Guidelines for surveillance, prevention and control of echinococcosis / hydatidosis. Eds: Eckert J, Gemmell MA, Matyas Z, Soulsby EJL. Geneva 1984.

WHO: Guidelines for treatment of cystic and alveolar echinococcosis. Bull. WHO 74:231-242, 1996.