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Climate change, parasites and shifting boundaries
Lydden Polley1, Eric Hoberg2, Susan Kutz1
1Department of Veterinary Microbiology, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5B4, Canada; 2National Parasite Collection, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland 20705, USA;

Approaches: Much of the information currently available on climate change and infectious disease relates to people and is based on retrospective analyses of associations between components of climate involved in climate change and the occurrence of disease in human populations [7,8]. In other instances, features of parasite ecology have been linked to model-based scenarios for future climate change to generate medium to long-term projections for parasite and disease distribution and occurrence [9,10]. Underlying these approaches are observational and experimental studies in a range of systems exploring, on a more intimate scale, the relationships between climate and parasite, and sometimes host, ecology [11-13]. All these lines of enquiry are increasing understanding of the mechanisms generating boundary shifts for parasites and diseases resulting from climate change, and are assisting proper targeting of measures to minimize their impacts on human and animal health.

Encouragingly, effective climate-based forecasting, developed decades ago for ruminant fascioliasis [14], is now a reality for some epidemic human malaria in Africa [15] and is being evaluated for other human parasitic diseases, for example human fascioliasis [16] and leishmaniasis [17] in South America. Exploration of the effects of climate change on infectious disease ecology presents many opportunities for valuable comparisons across pathogen and host groups, and across ecosystems. Central to understanding these climate change-host-parasite linkages is the ability to detect and measure shifts in key features of parasites and hosts and to assemble data unequivocally establishing or refuting links to climate change. Given relevant meteorological data, although monitoring and surveillance of parasitic infections and diseases may be possible to some extent in people and domestic animals, even in remote areas with limited infrastructure, it is usually more difficult in wildlife [18]. A particular issue for this host group, especially in Arctic and the North and other relatively isolated areas, is the currently limited understanding of climate change have proved likely to be wholly or partly the result of other factors [5,6].

Background: Around the world the three major components of climate change already evident and escalating in magnitude and significance are; 1) warming; 2) altered patterns of precipitation; and 3) an increased incidence of extreme climatic events [1]. For the structure and function of ecosystems, impacts of climate change vary with place and with time, and among the key outcomes are shifting boundaries for many components and processes within the systems. Among these components are pathogens and infectious diseases, including those caused by helminth, arthropod and protozoan parasites in people, domestic animals, and wildlife [2]. For host-parasite assemblages, boundaries potentially vulnerable to climate change include those for spatial and temporal distributions of hosts and parasites, for parasite survival and development in hosts and in the environment, for risks of transmission to hosts at critical points in parasite webs, and for health effects on hosts, including the emergence or resurgence of disease. The often complex and obscure linkages and inter-relationships among components of an ecosystem, coupled with the uncertain and variable trajectories for climate change, make it difficult to identify all these vulnerabilities, particularly in the medium to long term. Also, faced with non-overwhelming “stress” most ecosystems display a degree of resilience that may mitigate some of the consequences of climate change [3,4], and in some circumstances the significance of parasites remains essentially unchanged. Finally, some recent shifts in disease occurrence that intuition might suggest are associated with...
the parasite fauna, including species diversity and distribution, and its 
health significance, especially in the absence of obvious disease or 
mortality [19,20]. A recently initiated and very promising approach in 
northern Canada and elsewhere is to recruit, train and fund northerners, 
particularly harvesters who have frequent contact with wildlife, as health 
monitors. This program is greatly enhanced in the longer term where 
wildlife and wildlife health are introduced into curricula for schools in 
northern communities (see http://www.ccwhc.ca/Sahtu/index.php).

The fragile North: The North is among the areas of the world where climate 
change is already having significant and obvious effects and is impacting 
northerners and the animal and plant resources vital to their health and 
well-being [21,22]. For example, at risk on land are keystone wildlife 
species, including caribou, reindeer, moose, thinhorn sheep and muskoxen, 
waterfowl, and fish, together with berries and other foods of plant origin. 
In the surrounding oceans, polar bears, seals, walrus, seabirds and fish are 
all vulnerable. Among the elements of climate change threatening the 
health and sustainability of people and wildlife in the North, perhaps the 
most significant is warming, which is shifting boundaries for animals and 
plants [23], and for sea ice, permafrost, snow cover, and hydrology, as well 
as local and regional infrastructure [22]. Warming is also a cause of rising 
sea levels and the consequent erosion and flooding of coastal areas and 
disruption of coastal ecosystems and settlements [22].

People and places inhabit the North and are an array of helminth, 
arthropod and protozoan parasites. Most of these are restricted to one of 
the two host groups, but several – the zoonoses – are transmissible from 
animals to people, often through foods integral to traditional local 
cultures [18]. These zoonoses include (in North America) Trichinella, 
Anisakis, Diphyllobothrium, Echinococcus, and Toxoplasma, and perhaps 
Cryptosporidium and Giardia. All of these can cause obvious clinical disease in 
people, but not in everyone who is infected.

Host and parasite vulnerabilities: Many aspects of host and parasite 
ecology in the North and elsewhere have been identified as potentially 
vulnerable to climate change. Among possible consequences are boundary 
shifts that can alter the structure and function of host-parasite assemblages 
[24,25]. The speed and extent of these shifts vary with place and with 
time. For example, those linked to extreme climatic events may be 
rapid and localized, whereas those resulting from warming may be more 
gradual and widespread. For definitive and intermediate hosts, 
including arthropod vectors, these shifts include: 1) geographic 
distributions – expansion into new areas and/or loss from old areas and, in 
some cases, local to regional extinctions, together with shifts in migration 
routes; 2) faunal structure – qualitative changes in the composition of 
multi-species host communities, including shifts in opportunities for 
contacts between wildlife and domestic animals; 3) trophic linkages - 
including predator-prey relationships important for parasite transmission, 
especially for several zoonoses [26]; 4) phenology – especially the timing of 
breeding seasons and migrations, and the synchronization of the need for 
food; 5) level of nutrition – especially for several zoonoses [26]; 4) phenology - especially the timing of 
composition, availability, accessibility and quality of food and water; 6) 
health and wellbeing – including patterns of disease occurrence, and 
possible detrimental synergies between parasites, other infectious agents 
and other diseases; 7) host abundance – possibly affecting host density 
and thus parasite transmission dynamics; 8) behavioural patterns – 
influencing exposure to parasites and in some cases subsequent 
environmental contamination with parasites; and 9) parasite evolution [27] – 
likely to be detected first among protozoans. For people dependent to 
some extent on wildlife, as many northerners are, parasites may be one of 
the means by which climate change results in shifts in the availability and 
quality, or perceived quality, of their food and other key products (e.g. 
hides and pelts) of wildlife origin, and in the role of wildlife in their cultural 
and economic wellbeing and in the sustainability of northern communities.

For parasites, some potential boundary shifts are similar to those for hosts. 
For example, as distributions and faunal structures for hosts shift, so too will 
those for parasites. In some ecosystems, as a result of host switching, both 
immigrant (or invasive) and endemic hosts may experience new parasites, 
and some who have always been exposed to parasites may experience new, 
emergent or resurgent diseases. Shifts in parasite faunal structure may also 
result from altered trophic linkages, and the levels of nutrition, health 
and wellbeing of hosts will influence their susceptibility to parasites and other 
diseases and may lead to shifts in the role of parasites in ecosystem 
dynamics. Outside their mammalian and avian hosts, many parasites have 
life cycle stages in the environment or in ectothermic intermediate hosts 
and vectors that are exposed directly to climate. Key potential boundary 
shifts here are in parasite survival and development rates [12] and, for some 
parasites, in amplification rates for parasites developing in ectothermic hosts 
[11]. If warming from climate change enhances these rates, lengthens the 
summers vital for the transmission of many northern parasites, and shortens 
and softens the winters then, simplistically, more infective stages of 
parasites could be available sooner and the transmission period could be 
extended. In some instances, these shifts have the potential to generate 
greater parasite abundance in the definitive hosts and to increase their 
health impacts.

Sensitivity studies: Despite our currently relatively limited under-
standing of the ecology of host-parasite assemblages in the Arctic and 
the North, it is possible to speculate how some might be influenced by 
climate change. Although evidence transforming this speculation to 
certainty remains sparse, it is important to consider these issues and 
especially to identify potential high-risk scenarios for the emergence of 
significant parasitic disease in people and in wildlife.

Trichostrongyles of Ungulates: Trichostrongyles (e.g. Ostertagia 
gruenehi and Teladorsagia boreoarcticus) are non-zoonotic nematodes 
that as adults parasitise the abomasum or intestines. They have direct life 
cycles involving the development of eggs deposited in the feces to free-
living, infective larvae in the environment. Infection of ungulate hosts is 
transmitted when these larvae, by chance or due to local conditions, 
may negatively affect the hosts, may shift patterns of development for the 
parasites’ free-living stages. For example, assuming adequate moisture, 
longer, warmer summers may increase survival and development rates 
for the free-living stages leading perhaps to shorter generation times and 
to greater abundance and increased longevity for infective larvae in the 
environment. This in turn may increase the infection pressure and 
parasite loads for hosts and lead to greater adverse impacts on host 
health (e.g. weight loss and reduced conception rates) [28,29] and, for 
species important as food for northerners, on human health. In addition, 
alsed summer transmission dynamics and fall climate may shift patterns 
of larval inhibition in the gastro-intestinal mucosa, an important 
mechanism for overwinter survival by some trichostrongyles in other 
areas of the world. A useful preliminary glimpse of the links between 
climate change and altered ecology for trichostrongyles can be derived 
from basic information about pre-patent periods and the relationships 
between environmental temperatures and larval survival and 
development rates as determined in the laboratory and in the field. Data 
are plentiful on these aspects of trichostrongyles of domestic animals in 
several areas of the world [12], but caution is required when attempting 
to extrapolate these data to the species of parasites infecting free-
ranging hosts, particularly in the Arctic and the North.

Protostrongylids of Ungulates: Protostrongylid nematodes (e.g. 
Umingmaktoryngus pallikuukensis, Parelophstrongylus odocoilei and 
P. andersoni) are non-zoonotic and live as adults in the airways, lung 
parenchyma or skeletal musculature. Their life cycles are indirect, involving 
development of first-stage larvae deposited in feces to infective larvae in 
gastropod intermediate hosts. Infection of ungulates is by ingestion of infected 
gastropods or of infective larvae spontaneously emerged from the gastropods. 
The life cycle stages of these parasites outside the hosts have 
vulnerabilities to climate change generally similar to those of the 
trichostrongyles but it is possible that gastropod mobility and avoidance 
of extreme habitat conditions may protect the larvae from some of the 
effects of a changed climate [30].

For U. pallikuukensis, an empirical model derived from laboratory and field 
studies demonstrated that warming in the North probably has already 
shortened larval development times in gastropods and shifted 
transmission dynamics from a two-year to a one-year adult-to-adult cycle 
[31]. A similar model for P. odocoilei indicated that temperature 
constraints affecting larval development rates in gastropods may define 
the northern limits of the parasite’s distribution, and that warming may 
remove these and lead to an expanded parasite distribution [10]. Also, for 
U. pallikuukensis, attempted experimental infections indicated that infections of sympatric 
hosts and more closely related species with unknown as a result of 
shifts in host geographic distributions perhaps associated with climate 
change, are not susceptible to the parasite [32].

Trichinella nativa Trichinella is a genus of zoonotic nematode containing 
species that infect a range of vertebrates, including people, in many parts 
of the world. Trichinella nativa is the primary northern species. Adult 
Trichinella live in the small intestine, and the larvae produced by the
female parasites migrate to skeletal muscle and sometimes other tissues. These larvae are the parasite’s infective stage and transmission is by carnivorism, including feeding on carrion. In the North many host species are infected, and of special concern are those consumed by people, especially polar and black bear, walrus, and seal. Other than in carrion, life cycle stages of *Trichinella* are not exposed to the environment and any effects of climate change are likely to result primarily from shifts in host faunal structure and trophic linkages [26]. Outside the North, the ecology of *Trichinella* may be modified by climate-induced shifts in contacts between wildlife and domestic animals, and perhaps through behavioral shifts in the utilization of infected hosts as food for foxes.

Cryptosporidium and Giardia: Among the several species and genotypes currently established for each of these two genera of protozoans some are zoonotic and infect a range of hosts but most seem restricted to a single host species [33]. Although some species/genotypes are shared between people and domestic animals, the significance of wildlife as sources of human infections, and of people as a source of the parasites for wildlife, remain uncertain and unexplored. Both parasites live primarily in the small intestine and the life cycles are direct. Infection is by ingestion of infective oocysts (Cryptosporidium) or cysts (Giardia) from the environment or from contaminated food or water. Climate change has the potential to alter survival rates for the cysts and oocysts (which are infective when voided by the host and, once ingested, both parasites are found in surface water, shifts in local and regional hydrology may alter parasite distributions and the risks of human and animal exposure. In human settlements altered patterns of precipitation and extreme climatic events may disrupt the integrity of the infrastructure, particularly water supplies and sewage disposal, increasing the risk of human infection. In addition, these elements of the climate change may result in increased run-off and contamination of water with animal feces, and increased risk of zoonotic transmission.

Priorities for action: For people, domestic animals and especially wildlife, in many situations around the world it is difficult to identify the causes of detectable shifts in disease occurrence and, correctly, efforts are directed principally at mitigation of the disease and at effective control. Additionally, for all host groups, it may be difficult to tease parasites from among other potential contributors to disease, and to determine the role of climate in shifts in disease ecology and host health [34]. For wildlife, the detection of these shifts may also be hampered by a lack of baseline data for the occurrence and significance of pathogens and diseases. In exploring climate change as a cause of new patterns of disease, however, much can be learned from the many data-derived relationships between key climatic factors and host, parasite and disease ecology, and the integration of these with projections for climate change trajectories. This capability, coupled with an integrative, multidisciplinary and ecological approach, makes possible the identification of parasitic infections and diseases likely to be particularly susceptible to climate change and, with adjustments for regional variations, the exploration of some of the possible consequences of accelerating climate change for the occurrence of these diseases and for animal and human health. This is a very urgent need, and without such an attempt to anticipate the possible, society is likely to be a more or less impotent spectator to the certainty of continual ecological calamities.

References


4. Moore SE, Huntington HP: Animal and human health. This is a very urgent need, and without such susceptibility to climate change and, with adjustments for regional climate change trajectories. This capability, coupled with an integrative, data-derived relationships between key climatic factors and host, parasite


Spatial model outputs using observed presence and absence data for *Aedes albopictus*, an invasive species in (Southern) Europe, obtained through an international network of scientific collaborators, are then compared to potential distribution maps computed using a multicriteria decision analysis approach (MCDA) based on expert knowledge. The limits and complementary value of both approaches are discussed. The impact of wind on the dispersal of airborne vectors of disease is illustrated using as an example the current invasion of Europe by bluetongue (BTBV) through endemic midges. Understanding these dispersal patterns is an important step toward adding a dynamic component to such models and increase there predictive potential as part of planning tools for control measures: e.g. protection of cattle trough focussed vaccination. Ongoing work on the development of an airborne trapping device will further improve our knowledge of the 3D distribution patterns/ behaviour of the airborne midges and therefore the quality of the developed models. Finally the example of Vet-geoTools is used to show how an integrated spatial veterinary information system can contribute to the improved management of veterinary outbreaks.

**Conclusion:** It is concluded that the development of such an integrated approach using state of the art tools is essential to extract maximal value of geographical information science outputs. This can only be achieved through combining state of the art research with state of the art tool development: a perfect meeting place, and play ground, for academic groups and innovative SME’s.

**Further reading:** Information on all projects and outputs mentioned above can be downloaded directly from the Avia-GIS website at: http://www.avia-gis.com

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**S3**

**Vector-borne nematodes, emerging parasites in Finnish cervids**

Sauli Laaksonen, Antti Oksanen

Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit, P.O.Box 517, FI-90310 Oulu, Finland.

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**Summary:** There is a growing body of literature documenting the expansion of emerging parasites to sub-arctic areas. The potential impact of global warming on shifts in the spatio-temporal distribution and transmission dynamics of vector-borne diseases in domesticated and wild ungulates may be remarkable [1]. Recent Finnish studies have revealed an array of Filaroid nematodes and associated diseases that appear to be emerging in northern ungulates [2-4]. Members of the genus *Setaria* (Filarioidea: Onchoercidae) are found in the abdominal cavities of artiodactyls (especially Bovidae), equids and hyracoids. All produce microfilaria which are present in host blood [5], and both vectors are haematophagous mosquitoes (Culicidae spp) and horn flies (Haematobia spp) [6].

The Filaroid nematode *Setaria tundra* was first described in semi-domesticated reindeer (*Rangifer tarandus tundus*) in Arkhangelsk region, Russia [7]. *Setaria* infections appear to have emerged in Scandinavian reindeer not later than in the 1960’s. In 1973, *S. tundra* was observed for the first time in northern Norway where there was an outbreak of peritonitis in reindeer, as there was in Sweden, too. Also in 1973, tens of thousands of reindeer died in the northern part of the Finnish reindeer husbandry area. Severe peritonitis and large numbers of *Setaria* worms were commonly found. Following this, the incidence of *Setaria* in reindeer in Scandinavia diminished.

According to meat inspection data and clinical reports from practising veterinarians, the latest outbreak of peritonitis in reindeer started in 2003 in the southern and middle part of the Finnish reindeer herding area. In the province of Oulu, the proportion of reindeer viscerae condemned in meat inspection due to parasitic lesions increased from 4.9 % in 2001 to 47 % in 2004 and in Lapland from 1.4 % in 2001 to 43 % in 2006. The focus of the outbreak moved approximately 100 km northwards yearly so that in 2005 only the reindeer in the northernmost small part of Finland (Upper Lapland) were free of changes. In the same time the outbreak seems to have settled in the southern area. [2].

The causative agent was recognized both morphologically and molecular biologically as *S. tundra*. DNA sequence of *S. tundra* parasitising reindeer in North Finland was deposited in GenBank under accession number DQ097309. [2,3].
The habitus of reindeer calves heavily infected with *S. tundra* expressed decreased welfare; low body condition and undeveloped winter fur coat. The meat inspection findings of peritestinal reindeer carcasses included ascites fluid, green fibrin deposits, adhesions and live and dead *S. tundra* nematodes. Histopathologically, changes indicated granulomatous peritonitis with lymphoplasmacytic and eosinophilic infiltration. No specific bacterial growth was found. No significant impact on meat pH values nor on organoleptic evaluation of meat was found. There was a significant positive correlation between worm count and the degree of peritonitis and a negative correlation between the degree of peritonitis and back fat layer [2]. Earlier, Setariaceae yeili has been associated with low grade chronic peritonitis in Alaskan reindeer [8] and *S. tundra* with mild to severe peritonitis together with *Corynebacterium* sp. in Swedish reindeer [9]. Our studies revealed that *S. tundra* can act as a significant pathogen for reindeer, which was evident at both ante and post-mortem inspection and in histological examination. In order to monitor the *S. tundra* parasite dynamics in nature, parasite samples from wild cervids has also been collected [2]. In moose (*Alces alces*), the most abundant wild cervid in the reindeer herding area, only few cases of pre adult encapsulated *S. tundra* nematodes on the surface of the liver, but no peritonitis, were seen. The moose was evidently not a suitable host reservoir for the present *S. tundra* haplotype. The moose population in southern Finland peaked in the years 2004 and 2005. There is a previous report of a peritonitis outbreak in moose in Finnish Lapland in 1989 associated with *Setaria* sp. nematodes [10]. The parasite was genetically identified as another haplotype of *S. tundra*. Although this earlier outbreak took place within the reindeer husbandry area, no reports on associated increased morbidity in reindeer exist. According to our studies it is possible that the high percentage of the Kainuu population of wild forest reindeer (*Rangifer tarandus fennicus*) with signs of peritonitis caused by *S. tundra* (62 % of 34 animals examined) [2] is associated with the decrease of the population [11] from 1700 individuals in 2001 to 1000 in 2005. Two roe deer (*Capreolus capreolus*) examined fresh in the field had *S. tundra* nematodes in abdomen but no signs of peritonitis. According to our studies, the roe deer seems a capable host and asymptomatic carrier for *S. tundra*. This conclusion is supported by the first *S. tundra* appearance in Scandinavia in the early 1970’s [2] simultaneously with the invasion of the roe deer to North Scandinavia [12]. Further, there were minor nucleotide differences between the reindeer *S. tundra* sequence (648 bp) and that from roe deer parasites in Italy (GenBank AJ544874) [13]. In the consideration of reservoir host capacity of roe deer it is worth noting that especially young male roe deer can migrate hundreds of kilometres from their birthplace [14]. Our studies have revealed that *S. tundra* can have a significant pathogenic influence on the health of reindeer, and cause outbreaks also in moose population [10] and may further have consequences to cervid population dynamics. The *S. tundra* outbreak in Sweden in 1973 was associated with unusually warm weather and appearance of larger than usual numbers of mosquitoes and gnats [9]. The summers 1972 and 1973 were also very warm in Finland, as were 2002 and 2003 (Finnish Meteorological Institute data, personal communication S. Nikander 2004). Mosquitoes are considered vectors for *S. tundra*, but the life cycle in vectors is poorly understood. Climate change is predicted to increase insect activity and thus promote vector-borne Filaroid nematode emigration to North and becoming a threat to the wellbeing of arctic ungulates. Especially mosquito-borne diseases are among those diseases most sensitive to climate because climate change would directly affect disease transmission by shifting the vector’s geographic range and increasing reproductive and baring rates and by shortening the pathogen incubation period [15]. Our research group has studied the invasion and reservoirs of *S. tundra* in Finnish cervid populations, which studies we shortly review in this paper. We highlight the possibility that vector borne parasites may, by the impact of global change, further have consequences to wild and domestic ungulates. The study revealed the absence of baseline knowledge concerning temporal parasitic biodiversity in cervids at high latitudes. Therefore it is important to gain knowledge about these parasites’ ecology, dynamics, and the impact on man and animal health.

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**References**


**S4 Human medical view on zoonotic parasites**

**Antti Lavikainen**

Department of Bacteriology and Immunology, Haartman Institute, University of Helsinki, Finland

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**Summary:** From medical point of view, a zoonosis is any infectious disease that is naturally transmissible from vertebrate animals to humans [1]. A stricter definition is a disease that normally exists in other vertebrate animals, but can be accidentally transmitted to humans [2]. In Nordic countries, parasites are rare (and zoonotic parasites even more unusual) causative agents of human infections probably due to good hygiene and climatic conditions. In most cases, parasitic infections are of foreign origin, except for some relatively common indigenous infestations such as enterobiasis (caused by the human pinworm, *Enterobius vermicularis*) and pediculosis (caused by the human head louse, *Pediculus humanus*).

Worldwide, the most significant genus of human parasites is *Plasmodium*. It is the causative agent of malaria, a severe tropical protozoan disease, which kills globally more than one million people every year [3]. In Finland, about twenty cases of malaria are diagnosed annually [4]. In 2007, *P. knowlesi* infection was diagnosed in Finland in a tourist who had traveled in Malay Peninsula [4]. *P. knowlesi* is a *Plasmodium* of monkeys. This was second reported case of *P. knowlesi* malaria in a tourist. During the 19th century, malaria was an indoors transmitted disease in Finland, as *Anopheles* mosquitoes hibernated in peoples’ households [5].
Intestinal parasites are the most common parasitic infections. Among Finnish asymptomatic population, pathogenic intestinal parasites (mostly *Giardia lamblia*) can be found from 1.5 % of people [6]. However, only 300 cases of clinical giardiasis are diagnosed in Finland annually [7], and reported numbers of diagnosed amebiasis cases (caused by *Entamoeba histolytica*) range from 30 to more than 100 [7,8]. These protozoans are human parasites, and infections caused by them can occur through contaminated food, water or by faecal-oral route. According to the statistics of the Parasitological unit of HUSLAB (Laboratory of Hospital District of Helsinki and Uusimaa county, Finland) from 2005 to 2007, the most frequent intestinal helminths were pinworms, the human whipworm (*Trichuris trichiura*) and intestinal roundworms (*Ascaris spp.*). The swine roundworm (*Ascaris suum*), is a zoonotic parasite, but it was not routinely differentiated from human roundworm (*A. lumbricoides*).

Formerly, the broad fish tapeworm (*Diphyllobothrium latum*) was a major health problem in Finland, and it has been called “the national parasite of Finland” [9,10]. Although it has been diminished drastically, it has not been totally eradicated. Around twenty human cases are still diagnosed annually in Finland, and the situation is similar in Sweden [11]. In contrast to diphyllobothriasis, which is mostly an indigenous disease, human intestinal taeniases are imported cases. About a handful of taeniases cases are diagnosed in HUSLAB yearly, and the beef tapeworm (*Taenia saginata*) is more common finding than the pork tapeworm (*T. solium*). In the strict sense (see the definition above), diphyllobothriasis and taeniases should not be called zoonoses, since humans are important definitive hosts of *D. latum* and essential for *T. saginata* and *T. solium*, although vertebrate animals (fishes, cattle and swine, respectively) act as sources of human infections.

*Echinococcus* spp. are the most important zoonotic cestodes worldwide. Their larvae are causative agents of serious diseases called echinococcoses. Until 1960's, human cystic echinococcosis was a significant public health problem during reindeer herding Sámi population in Swedish and Norwegian Lapland [12]. Human cases were found also in Finnish Lapland, but only few reports have been published. Later, the parasite was eradicated from the reindeer-dog cycle, and endemic human cases have not been diagnosed for several decades. In the Parasitological unit of HUSLAB, eight echinococcosis cases were diagnosed between 2002 and 2008. These cases cover most of the diagnoses in Finland during that time period. All of them were caused by so-called sheep strain of *E. granulosus*. One of the patients was a Finn, but an endemic infection was excluded by the strain determination.

Another endemic zoonotic parasitosis, which seems to be disappeared from Nordic countries as a human infection, is trichinellosis. This disease caused by larvae of nematodes of the genus *Trichinella* has not been diagnosed for a long time. This contrasts the fact that *Trichinella* spp. are common in wild and domestic animals [13]. Several exotic parasites, which occur as sporadic companions of travelers, can cause tissue lesions and even human disease. For example, leishmaniasis is the term given to diseases caused by protozoans of the genus *Leishmania* [14]. These parasites are transmitted by sand flies, and small rodents and dogs are the reservoir of infection. There are two main types of clinical disease, cutaneous and systemic leishmaniasis.

Larvae of gastrointestinal nematodes of dogs and cats (*Toxocara canis* and *cati*, respectively), can cause disease called visceral larva migrans in humans, chiefly in children [15,16]. Larvae migrate through inner organs and cause mechanical damage and eosinophilic lesions. *Toxocara* spp. are geographical widely distributed. Larva migrans is obviously a underdiagnosed zoonosis, and its prevalence in Nordic countries has not been studied recently. In HUSLAB material in 2007, seven patients had positive toxocariasis serology. One of these was most probably an unspecific seroreactivity because the same sample responded also against several other helminth antigens. Six patients were children (age of 2-16 years) and one was an elderly person (75 years).

Toxoplasmosis is a disease caused by the protozoan parasite, *Toxoplasma gondii* which infects up to one-third of the world human population [17]. The most common nutritional routes are ingestion of oocysts (e.g., by eating vegetables contaminated with cat faeces or soil) or tissue cysts in meat. Toxoplasmosis in neonates and immunocompromised patients can lead to severe disease and death. It has been estimated that 50-60 infants suffer from congenital toxoplasmosis annually (prevalence 1/1000) in Finland [18]. However, reported prevalences in Sweden, Norway and Denmark are much lower (0.73-3.1/10,000) [19-21]. Anyway, due to the relatively high prevalence, indigenous occurrence and severe clinical manifestations toxoplasmosis can be considered to be one of the most important true zoonotic parasitoses in the Nordic countries. In order to understand the transmission dynamics of zoonotic parasitic infections to humans, it is essential to have knowledge on the life cycle and prevalence of infection in other animals, both domestic and wild.

**References**


**S5 Echinococcus spp. and echinococcosis**

Bruno Gottstein
Faculty of Medicine, Institute of Parasitology, University of Bern, Bern, Switzerland
E-mail: bruno.gottstein@ip.unibe.ch

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**Summary:** Echinococcus spp. are cestode parasites commonly known as small tapeworms of carnivorous animals. Their medical importance lies in...
the infection of humans by the larval stage of the parasites, predominantly including *Echinococcus granulosus*, which is the causative agent of cystic echinococcosis (CE) and *Echinococcus multilocularis*, which causes alveolar echinococcosis (AE).

A few other species or genotypes are only very rarely or not at all found in humans. Due to the emerging situation in many parts of Europe, the present article will predominantly focus on *E. multilocularis*.

The natural life cycle of *E. multilocularis* involves predominantly red and arctic foxes as definitive hosts, but domestic dogs can also become infected and represent an important infection source for humans in highly endemic areas. In the definitive host, egg production starts as early as 28 days after infection. After egg ingestion by a rodent or a human, larval maturation will occur practically exclusively within the liver tissue. The geographic distribution of *E. multilocularis* is restricted to the northern hemisphere. In Europe, relatively frequent reports of AE in humans occur in central and eastern France, Switzerland, Austria and Germany. Within the past ten years, the endemic area of Europe now includes many more countries such as Belgium, The Netherlands, Italy, and most former Eastern countries as far as up to Estonia. The Asian areas where *E. multilocularis* occurs include the whole zone from the White Sea eastward to the Bering Strait, covering large parts of Siberia, western and central parts of China and northern Japan. Worldwide there are no arctic foxes as intermediates. The overall prevalence of human AE is restricted to the areas mentioned above. Documented studies demonstrate a generally low prevalence among affected human populations. The annual mean incidence of new cases in different areas including Switzerland, France, Germany and Japan has therefore been reported to vary between 0.1 and 1.2/100,000 inhabitants.

The incidence of human cases correlates with the prevalence in foxes and the fox population density. Recently, a study documented that a four-fold increase of the fox population in Switzerland resulted in a statistically significant increase of the annual incidence of AE cases [1] (Schweiger et al., 2007). This dramatic increase in red fox populations has also been reported throughout Europe, especially in urban areas. The so-called city-fox phenomenon and, thereafter, the increased proximity of foxes with humans and an urban domestic dog – rodent cycle may, therefore, have significant public health implications [1-3].

In infected humans the *E. multilocularis* metacestode (larva) develops primarily in the liver. Occasionally, secondary lesions form metastases in the lungs, brain and other organs. The typical lesion appears macroscopically as a dispersed mass of fibrous tissue with a conglomerate of scattered vesiculated cavities with diameters ranging from a few millimeters to centimeters in size. In advanced chronic cases, a central necrotic cavity containing a viscous fluid may form, and rarely there is a bacterial superinfection. The lesion often contains focal zones of calcification, typically within the metacestode tissue. Histologically, the hepatic lesion is characterized by a conglomerate of small vesicles and cysts demarcated by a thin PAS-positive laminated layer with or without an underlying pseudocapsule [4]. Parasite proliferation is usually accompanied by a granulomatous host reaction, including vigorous synthesis of fibrous and germinative tissue in the periphery of the metacestode, but also necrotic changes centrally. In contrast to lesions in susceptible rodent hosts, lesions from infected human patients rarely show protoscolecom formation within vesicles and cysts. Genetic and immunogenetic factors are responsible for the resistance shown by some patients in whom there is an early ‘dying out’ or ‘abortion’ of the metacestode [5,6]. Therefore, not every individual infected with *E. multilocularis* is susceptible to unlimited metacestode proliferation and develops symptoms in the average within 5–15 years after infection. The host mechanisms modulating the course of infection are most likely of an immunologic nature, including primarily suppressor T cell interactions. Thus, the periparasitic granuloma, mainly composed of macrophages, myofibroblasts and T cells, contains a large number of CD4+ T cells in patients with abortive or died-out lesions, whereas in patients with active metacestodes the number of CD8+ T cells is increased. An immunosuppressive process is assumed to downregulate the lymphocyte function. Conversely, the stage of cured AE is characterised by a high vitro lymphoproliferative response. The cytokine mRNA levels following *E. multilocularis* antigen stimulation of lymphocytes show an enhanced production of Th2-cell cytokine transcripts IL-3, IL-4 and IL-10 in patients, including a significant IL-5 mRNA expression in patients and not in healthy control donors. A lack or deficiency of Th cell activity such as in advanced AIDS is associated with a rapid and unlimited growth and dissemination of the parasite in AE, recovery of the T cell status in AIDS is prognostically favorable. More detailed information about the host-parasite interplay that decides about the outcome of infection has been achieved with the murine model of AE. The involvement of cellular immunity in controlling the infection is strongly suggested by the intense granulomatous infiltration observed in the periparasitic area of lesions. Immune-deficient athymic nude and SCID mice exhibited high susceptibility to infection and disease, thus suggesting that the host cell mediated immune response plays an important role in suppressing the larval growth. *E. multilocularis* appears to induce skewed Th2 responses. Based on Th1 and Th2 dominance and Th2 dominant infections, it was associated with increased susceptibility to disease, while Th1 cell activation through IL-12, IFN-γ, TNF-α and IFN-α was suggested to correlate with a more protective immunity in AE. Nevertheless, effective suppression of larval growth by means of an immunological attack is hampered by the fact, that the parasite synthesizes a carbohydrate-rich laminated layer in order to be protected from host effector mechanisms, as outlined above.

Basically, the larval infection with *Echinococcus multilocularis* begins with the intrahepatic postoncospheral development of a metacestode that – at its mature stage - consists of an inner germinal and the outer laminated layer as discussed above [4]. Several lines of evidence obtained in vivo and in vitro indicate the important bio-protective role of the laminated layer, e.g. to protect the germinal layer from nitric oxide produced by periparasitic macrophages and dendritic cells, and also to prevent immune recognition by surrounding T cells. On the other hand, the high periparasitic NO production by peritoneal exudate cells contributes to periparasitic immunosuppression [7], explaining why NOS deficient mice exhibit a significantly lower susceptibility towards experimental infection [8]. The intense periparasitic granulomatous infiltration indicates an intense host-parasite interaction, and the involvement of cellular immunity in control of the metacestode growth kinetics is strongly suggested by experiments carried out in T cell deficient mouse strains [9]. Carbohydrate components of the laminated layer, as the Em2(G11) and Em492 components discussed above, yield immunomodulatory effects that allow the parasite to survive in the host. IL-2, the IgG response to the Em2(G11)-antigen takes place independently of alpha-beta+CD4+ T cells, and in the absence of interactions between CD40 and CD40 ligand [10]. Such parasite molecules also interfere with antigen presentation and cell activation, leading to a mixed Th1/Th2-type response at the later stage of infection. Furthermore, Em492 [11] and other (not yet published) purified parasite metabolites suppress ConA and antigen-stimulated splenocyte proliferation. Infected mouse macrophages (AE-MØ) as APCs exhibited a reduced ability to present a conventional antigen (chicken ovalbumin, C-Ova) to specific responder lymph node T cells when compared to normal MØ [12].

*Echinococcus granulosus* parasitizes as a small tapeworm the small intestine of dogs and occasionally other carnivores. The shedding of gravid proglottids or eggs in the feces occurs within 4–6 weeks after infection of the definitive host. Ingestion of eggs by intermediate host animals or humans results in the development of a fully mature metacestode (i.e. hydatid cyst) over a period of several months to years. Infections with *E. granulosus* occur worldwide, however predominantly in countries of South and Central America, the European and African part of the Mediterranean area, the Middle East and some sub-Saharan countries, Russia and China. Most cases observed in Central Europe and the USA are associated with immigrants from highly endemic areas. Various strains of *E. granulosus* have been described, and differ especially in their infectivity for intermediate hosts such as humans. The most important strains for human infection include sheep (G1) and cattle (G5) as intermediate hosts.

Cystic echinococcosis (CE) is clinically related to the presence of one or more well-delineated spherical primary cysts, most frequently formed in the liver, but other organs such as the lungs, kidney, spleen, brain, heart and bone may be affected too. Tissue damage and organ dysfunction result mainly from the gradual growth and displacement of vital host tissue, vessels or parts of organs. Consequently, clinical manifestations are primarily determined by the site, size and number of the cysts, and are therefore highly variable. Accidental rupture of the cysts can be followed by a massive release of cyst fluid and hematogenous or other dissemination of protoscolices. This can result in anaphylactic reactions and multiple secondary cystic
echinococcosis (as protoscolices can develop into secondary cysts within the same intermediate host). The parasite evokes an immune response, which is involved in the formation of a host-derived adventitious capsule. This often calcifies uniquely in the periphery of the cyst, one of the typical features found in imaging procedures. In the liver there may be cholestasis. Commonly, there is pressure atrophy of the surrounding parenchyma. Immunologically, the coexistence of elevated quantities of interferon IFN-γ, IL-4, IL-5, IL-6 and IL-10 observed in most of hydatid patients supports Th1, Th17 and Th2 cell activation in CE. In particular, Th1 cell activation seemed to be more related to proteogenic immunity, whereas Th2 cell activation was related to susceptibility to disease. Prevention of both CE and AE focuses primarily on veterinary interventions to control the extent and intensity of infection in definitive host populations, which may indirectly be approached by controlling the prevalence in animal intermediate hosts also. The first includes regular pharmacologic treatment and taking sanitary precautions for handling domestic dogs and to prevent infection and egg excretion, respectively. Regular praziquantel treatment of wild-life definitive host may contribute to lower the prevalence in affected areas.

For diagnosis, imaging procedures together with serology will yield appropriate results [13,14]. Sonography is the primary diagnostic modality for many hepatic cases [15]. False positive and false negatives occur in up to 10% of cases due to the presence of nonechinococcal serous cysts, abscesses or tumors. Computerized tomography is the best investigation for detecting extrahepatic disease and volumetric follow-up assessment; magnetic resonance imaging (MRI) assists in the diagnosis by identifying changes in the intra- and extrahepatic venous systems. Ultrasonography is also helpful in following up treated patients as successfully treated cysts become hyperechogenic. Calcification of variable degree occurs in about 10% of the cysts. Aspiration cytology appears to be particularly helpful in the detection of pulmonary, renal and other nonhepatic lesions for which imaging techniques and serology do not provide appropriate diagnostic support. The viability of aspirated protoscolices can be determined by microscopic demonstration of flame cell activity and trypan blue dye exclusion. Immunodiagnostic tests to detect serum antibodies are used to support the clinical diagnosis of both AE and CE. Assessing the parasite viability in vitro following therapeutic interventions may be of tremendous advantage when compared with the invasive analysis of resected or biopsied samples. Such alternatives may be offered by magnetic resonance spectrometry or positron emission tomography (PET). The latter technique has recently been used for assessing the efficacy of chemotherapy in AE. PET positivity actually demonstrates periparasitic inflammatory processes due to a remaing activity of the metacestode tissue. Serologic tests are more reliable in the diagnosis of AE than CE. The use of purified E. multilocularis antigens such as the EM2 antigen and recombinant antigens from the family of EMR-proteins (Eml1/3-10, EM10, EM4 and EM18, all four of them harbouring an identical immunodominant oligopeptide sequence) exhibits diagnostic sensitivities ranging between 91% and 100%, with overall specificities of 98–100%. These antigens allow discrimination between the alveolar and the cystic forms of disease with a reliability of 95%. Seroprevalence studies reveal asymptomatic preclinical cases of human AE as well as cases in which the metacestode has died at an apparently early stage of infection (see above). Serologic tests are of value for assessing the efficacy of treatment and chemotherapy only when linked to appropriate imaging investigations. Prognostically, disappearance of anti-IL-18–10 or anti-Em18 antibody levels coupled to PET negativity indicates inactivation of AE. The management of CE and AE follows the strategy recommended in the manual on echinococcosis published in 2001 by the Office International des Epizooties and the World Health Organisation.

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56

Dogs and echinococcosis in Iceland

Sigurdur Sigurdarson

The Icelandic Food- and Veterinary Authority Austurvegur 64, 800 Selfoss, Iceland

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History: Hydatid disease was first described in Icelandic literature about the year 1200. According to the first qualified physician in Iceland, Bjarni Pálsson (1719-1779) was echinococcosis about 1760 one of the most frequent diseases among the human population, and was also commonly observed in sheep and cattle. Autopsies and questionnaires indicate that 20-25% of the inhabitants might have been infected by hydatidosis about 1850. The nature of the disease was still unknown at that time. The dog population was estimated to be 15.000-20.000, or about one dog for every three or four people. At the same time there were in Copenhagen
1 dog for every 30-32 persons. Obviously there were too many dogs in Iceland. The sheep, cattle, dogs and humans lived in close contact. The dogs often shared a room and even bed with the family, and were the best playmates for the children. The people lived mostly in primitive houses at that time and under primitive hygienic conditions. It is therefore not wonder that the hydatid disease flourished as long as the nature of the disease was still obscure.

In 1849 the Danish physician P.A. Schleiner (1819–1900) concluded that one out of every six Icelanders suffered from hydatid disease. In 1862 doctor Harald Krabbe (1831–1917) from the Royal Veterinary and Agricultural University in Copenhagen studied the hydatid problem in Iceland. He found that 28 out of 100 dogs and most of the old sheep and cows that were slaughtered were infested with echinococcus cysts. Experiments he carried out in cooperation with an Icelandic physician Jón C Finsen (1826-1885) proved the relationship between taenias in dogs and the hydatid cysts in humans. Doctor H. Krabbe realized that most important was to inform the people of the nature of the disease in order to prevent the infestations of humans and animals with eggs of the intestinal parasites of the dog. H. Krabbe was a chief adviser to the Icelandic government on hydatid disease and prophylactic measures in the period 1860-1890. His recommendations were followed strictly for more than 100 years and partially they still are. New infestations by E. granulosus praevalens disappeared in Iceland the decade 1890-1900. That is based on 7333 autopsies of people performed in the period 1932-1966. And based on 15.888 autopsies 1932-1982 only few human infestations occurred after 1900. The most recent human cases are a person born in 1937 who was autopsied in 1960, another person born in 1905 operated 1984 and the most recent human case is a person born in 1937 who was autopsied 1988.

Why so successful control of hydatid disease in Iceland: Echinococcosis is a great public health and economic problem in many countries. It has been extremely difficult to eliminate it in many endemic areas. Apparently it was done in Iceland rather easily. How? The campaign against hydatid disease in Iceland was for more than one century and partially still is based on Harald Krabbe’s recommendations:

1) Successful information to the people. Most people in Iceland had lost either relatives or friends as a victim to hydatid disease and the memory of this disease was and still is dreaded. When people knew what to do, strong participition of both young and old was easy to activate. The sheep, cattle, dogs and humans lived in close contact. The sheep, cattle, dogs and humans lived in close contact. The people lived mostly in primitive houses at that time and under primitive hygienic conditions. It is therefore not wonder that the hydatid disease flourished as long as the nature of the disease was still obscure.

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3) Prevetning the dog gaining access to raw offal and burning cysts in organs
4) Caution in dealing with dogs, esp.

Outbreaks of distemper in 1870, 1888 and 1890 reduced the number of unnecessary dogs and a ban on keeping a dog without permission.

Some factors that assisted in the campaign: -Ceasing the hydatid disease was never found in horses, rodents or in wild animals in Iceland.

References

**S7**

**Toxoplasma gondii in the Subarctic and Arctic**

Kristin W Præstrud, Kjetil Åsbakk, Antti Oksanen, Anu Näreaho. 1

1 Norwegian School of Veterinary Science, Department of Food Safety and Infection Biology, Section of Arctic Veterinary Medicine, Tromsø, Norway;
2 Finnish Food safety Authority Evira, Fish and Wildlife Health Research Unit (FINPAR), Oulu, Finland; 3 Department of Basic Veterinary Sciences, Faculty of Veterinary Medicine, University of Helsinki (FINPAR), Helsinki, Finland

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**Summary:**
The coccidian protozoan *Toxoplasma gondii* has a world-wide distribution. It causes toxoplasmosis, a potentially very serious disease to humans and other warm-blooded animals. Infection has in many studies been shown to be rather common in the Nordic countries also, where its prevalence both in domestic animals and wildlife can be explained by contacts with cats and their faeces, cats and wild felids being the only definitive hosts of the parasite known. Before the discovery of the complete life cycle of the parasite, other infection routes to animals were studied e.g. in Russia, where lateral transmission of infection in a reindeer herd was reported. The vehicle of infection was apparently body fluids, such as e.g. saliva and lacrimal fluid containing parasite tachyzoites, which might invade another reindeer via mucosal membranes. According to the finding, toxoplasmosis might be apprehended to be also a sexually transmitted disease. Following the discovery of the pivotal role of the cat in the epidemiology of *T. gondii*, possible alternative pathways of infection have generally been ignored. In Fennoscandian semi-domesticated reindeer, a clear association of the seroprevalence of antibodies to *T. gondii* was seen with the degree of domestication, and, thus, with cat contacts [1].

In the high Arctic of Svalbard, there is a considerably high seroprevalence of infection both in polar bears and Arctic foxes [2-4]. The source of infection is unlikely to be found in the seals constituting the major part of the polar bear’s diet, as in one study, antibodies were not found in North Atlantic marine mammals. However, in other, less arctic and remote, cetacean and pinniped populations studied, *T. gondii* infection has been found. Because Svalbard reindeer and sibling voles studied have been free from *T. gondii* infection, it can be assumed that sexual stages of infection (in definitive hosts) leading to oocyst production is not a major part of the Svalbard *T. gondii* life cycle [2]. Then, carnivores probably get the infection with food, anyhow. Cannibalism is considered common in polar bears and Arctic foxes, and probably can explain a lot. One parasite isolate from an Arctic fox proved to belong to the Type II strain, the predominant *T. gondii* lineage in the world [3]. This somewhat objects to the suggested idea of a specific Arctic life cycle of the parasite, but incorporates the Arctic to the global *T. gondii* infection network. Further support to the hypothesis is gained from the finding that Svalbard barnacle geese (*Branta leucopsis*) are rather commonly infected. They may get the infection when wintering in Scotland. So, perhaps migratory birds are important in *T. gondii* globalisation.

Cats are crucial to *T. gondii* epidemiology. However, the Arctic example proves that the successful parasite can thrive even in the absence of cats.

**References**


**S8**

**Trichinella in the North**

Nina Airas1, Seppo Saari1, Taina Mikkonen1, Anna-Maija Virtala1, Jani Pelttika1, Antti Oksanen2, Marja Isomursu2, Antti Sukura3

1 Department of Basic Veterinary Sciences, Faculty of Veterinary Medicine, University of Helsinki, Helsinki, Finland; 2 Finnish Food Safety Authority Evira, Oulu, Finland

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**Background:**
Endemic human trichinellosis has been rare in Norway, Sweden and Finland. In Norway the last outbreak involving five persons is from 1953 and before that there were reported six epidemics with 711 patients since 1881 (reference in [1]). In Sweden 10 outbreaks involving 504 patients were documented 1917-1969 (reference in [2]). In Finland only eight human cases have been reported since 1890, the latest being three hunters at 1977 who got the infection from bear meat (reference in [1]).

Sporadic cases of trichinellosis in production animals have been detected in pig meat inspection in these countries. In Norway there was a peak of positive pigs in the 1950’s and 1960’s but since 1981 no positive finding in pigs has been reported. In Sweden, 127 positive pigs were reported 1970-1999 and no cases since 2000. The first infected Finnish pig was found 1954, and the total number of positive pigs in fifty years was up to 714 (1954-2003). There was a peak of cases in the 1980’s and 90’s when a total of 671 pigs were found positive. During 1981-2000, the positive animals originated from 0-19 farms yearly. Since...
2004 no trichinella has been found in pigs. The decrease in Trichinella prevalence and incidence in domestic swine has been speculated to be due the change in Finnish swine industry since Finland joined the EU in 1995 [3]. During recent years, the industry has moved towards large-scale enterprises with corporative ownership with new facilities. These are better protected against the Trichinella infection commonly present in surrounding wildlife in Finland [3]. High syrattic trichinosis prevalence has been reflected to farmed wild boars in which condemnation due trichinosis has been relatively more common than in pig. To clarify the spatial variation of sylvatic trichinella prevalence suggested in earlier studies, a new Finnish sample set was analyzed.

Material and methods: Muscles samples of 2487 carnivorous wild animals from eight host species during 1999-2005 were collected by volunteer hunters. Molecular identification was performed on larval isolates with multiplex PCR.

Results: Out of 2487 animals analyzed, Trichinella spp were revealed from 618 animals. Different host species showed variable sample prevalence (range: 0-46%). Almost half of the larv harboured Trichinella spp (46%); in species rank, lynx were followed by wolves (39%), raccoon dogs (28%), and red foxes (19%). Lower than ten percent prevalences were detected in sampled pine martens, badgers, beavers and otters. No larvae were detected from mink. The overall Trichinella prevalence from all sampled host species was not geographically equally distributed varying from 2.6% (Lapland) up to 67% on different game districts (P<0.001), showing obvious diminishing gradient form south to north (figure 1).

Molecular analysis was performed with 328 larval isolates. Trichinella species were successfully identified from 303 animals, from 25 animals amplification did not give specific reaction (7.6%). Four species were discovered: T. spiralis, T. nativa, T. britovi, and T. pseudospiralis. Single Trichinella species were revealed from 281 (93%) of the infected host animals and 22 (7%) showed mixed infections. T. nativa was the most common single species (80.1%) followed by T. spiralis (12.8%), T. britovi (6.0%), and T. pseudospiralis (1.1%), which was found in single infection in only three animals but in mixed infection in four more individuals. From mixed infections, never more than two different species were found, but all possible two-species combinations of four species were discovered. Species geographic distribution showed that all four species were discovered only from the southern part of the country; in the middle and northern part, only T. nativa and T. spiralis were revealed.

The parasite burden was not normally distributed. Different hosts showed variations in the infection density and also different Trichinella species made different parasite burdens. There was a significant interaction between animal species and Trichinella species showing for example that T. spiralis gave a higher larval burden in raccoon dog than in other animals. However, in raccoon dogs, the host species with the highest burden, infection densities did not differ between infecting Trichinella species.

Conclusion: In Finland sylvatic trichinosis is very common with big geographical differences showing clear diminishing along south to north gradient. T. nativa was the most prevalent species in the country but, remarkably, the domestic species T. spiralis was isolated from 15% of sylvatic isolations. T. spiralis was recovered all around in Finland. Intriguingly, T. spiralis was revealed form the very north in a fox in an area where never any domestic outbreak of trichinosis has been reported, and seldom any swine has been seen, indicating that T. spiralis may exist in sylvatic cycle without external sources from synanthropic animals.

When population sizes are considered, the major reservoir animals in Finland are the raccoon dog and the red fox.

References

59 Detection of infection with Angiostrongylus vasorum (Nematoda, Strongyloida) by PCR
Mohammad Al-Sabi1, Pia Webster2, Jacob Willesen3, Peter Deplazes4, Alexander Mathis5, Christian Kapell1
1Department of Agriculture and Ecology, University of Copenhagen, DK-1871 Frederiksberg C, Denmark; 2Department of Disease Biology, University of Copenhagen, DK-1871 Frederiksberg C, Denmark; 3Small animal hospital, University of Copenhagen, DK-1871 Frederiksberg C, Denmark; 4Institute of Parasitology, University of Zurich, CH-8057 Winterthur/herrstrasse 266A, Zurich, Switzerland
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Background: The French heart worm Angiostrongylus vasorum is a parasitic nematode of the pulmonary arteries and heart of canines often with severe and in some cases fatal outcome. The diagnosis is based on detection and species identification of larve in faeces which can be problematic in Veterinary praxis especially in cases with low excreting animals. A reliable technique is thus needed for correct diagnosis and estimation of the true prevalence of infection in a population as well as for monitoring and control campaigns.

Materials and methods: A PCR was developed from the ITS2 region of the rDNA of A. vasorum. The sensitivity of the primers was tested with DNA from adult A. vasorum from a naturally infected fox and first stage larvae (L1) from an experimentally infected foxes. The specificity of the primers was tested against DNA from the most common helmith parasites of canines in Denmark and neighbouring countries. Furthermore the PCR system was applied as a confirmative test in a screening study of Danish hunting dogs and an epidemiological study of helmith parasites of wildlife in Denmark.

Results: The designed primers were very sensitive and could detect a single A. vasorum L1. The primers were also very specific and did not react with DNA from any of the common canine helmiths. When used as a confirmative test, the PCR system proved to be robust and easy to work with detecting a single larva, and for use in post mortem examination of wildlife. There are practical problems that can face the PCR system such as isolating dead larvae from frozen samples and the known problem of intermittent larval excretion in dogs. These two problems can be solved by isolation of larvae by sieving instead of by Baermann sedimentation if samples were frozen, and examining consecutive fresh faecal samples.

Conclusions: We were able to design a new PCR to detect DNA of A. vasorum in canines. The test proved to be very sensitive and specific when tested in clinical and epidemiological studies. The test will be further applied in many epidemiological and clinical studies to come.

S10 Wild life surveillance on Echinococcus multilocularis in Sweden
Birgitta Andersson1, Bodil Christensson, Susanne Johansson, Eva Osterman Lind, Göran Zakrisson
1National Veterinary Institute, Department of Virology, Immunobiology and Parasitology, Section for Parasitological Diagnostics; SE-751 89 Uppsala, Sweden

Background: Echinococcus multilocularis is a tapeworm whose adult stages parasitize the intestine of canids such as foxes and wolves. Also domestic dogs and cats can act as definitive hosts. The sylvatic life cycle includes small rodents as intermediate hosts but humans may become accidentally infected by ingestion of eggs. Sweden, Finland, UK, Ireland, and Malta are considered to be free of this parasite and therefore have maintained their national rules as regards deworming of pets at movement into the countries. According to the EC regulation, these national rules can be applied during a transitional period to 2010. In order to confirm the absence of E. multilocularis in Sweden, monitoring of foxes is being carried out continuously. These investigations are financed by the Swedish government.
Materials and methods: In 2007, 245 red foxes were shot and sent to SVA by local hunters in different parts of Sweden. To kill potential tapeworm eggs, the carcasses were placed in –80°C for at least one week before sampling. Faecal samples were then collected from the rectum and sent to Switzerland for testing by coproantigen ELISA (Deplazes et al., 1999). Forty-eight foxes that were positive in the ELISA and additional 28 randomly selected individuals were also examined by a sedimentation technique according to the OIE guidelines.

Results and discussion: Forty-eight foxes out of 245 were positive for Echinococcus sp. by the coproantigen ELISA. With the sedimentation technique however, Echinococcus sp. was not detected in any of the examined animals, including those who had been positive in the ELISA. One possible explanation for obtaining false positive ELISA results was that some kind of cross-reaction had taken place. The majority of the foxes were infected with other parasites, for example Taenia sp., Mesocestoides sp., Alaria alta, Toxocara canis, Taoscaris leonina.

Conclusions: There is a need for good screening methods with high sensitivities and specificities. The results obtained by the sedimentation technique indicate that Sweden was still free from the fox tapeworm in 2007.

Reference

511
Emerging alveolar echinococcosis (AE) in humans and high prevalence of Echinococcus multilocularis in foxes and raccoon dogs in Lithuania
Mindaugas Sarkūnas1, Rasa Bružninkaitė1,4, Audronė Marcinkutė2, Kęstutis Strupas3, Vitalijus Sokolovas1, Alexander Mathis4, Peter Deplazes4
1Department of Infectious Diseases, Lithuanian Veterinary Academy, Tiližės str. 18, LT-47181, Kaunas, Lithuania; 2Clinic of Infectious Diseases, Microbiology and Dermatovenereology, Vilnius University, Lithuania; 3Santariškis Clinic, Vilnius University, Lithuania; 4Institute of Parasitology, WHO-Collaborating Centre for Parasitic Zoonoses, University of Zurich, Switzerland

E-mail: mirmar@vau.lt
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Summary: The presence of the most important definitive and intermediate hosts suggests that conditions for the live cycle of E. multilocularis are favorable in Lithuania. While the main rodent hosts have not been investigated systematically in Lithuania, E. multilocularis has already been identified in one of 5 muskrats (Ondatra zibethicus) captured in the Silute district. The high prevalence of E. multilocularis in red foxes and raccoon dogs as well as a notable increase of AE in humans was also recently documented [11,12].

Human infection: In the early eighties, sporadic cases of cystic echinococcosis caused by the larval stage of E. granulosus were diagnosed in humans in Lithuania. However, during the last decades, the diagnostic techniques have improved and the incidence of human AE has risen to considerable levels, with an increasing concern among the human population and the health authorities.

From 1997 to July 2008, 96 AE cases have been diagnosed at the State Hospital for Tuberculosis and Infectious Diseases in cooperation with the Santariškis Clinic (Vilnius University). Eighty-one percent of AE patients were farmers or persons involved in agricultural activities. Most of the patients (59%) owned dogs. The AE cases were recorded from many parts of the country suggesting that the whole territory of Lithuania should be considered as an endemic area [11,12].

Animal infection: The helminth fauna of carnivores from Lithuania was investigated in earlier studies, but no record was made on E. multilocularis [13,14]. The methods used in these studies are not well documented but the reported findings of E. granulosus as well as other small helminths in dogs and wolves indicate that E. multilocularis would most probably have been detected in the 122 foxes investigated, at least if highly prevalent at that time. In neighboring Poland, E. multilocularis in red foxes was recorded for the first time in the Gdansk region in 1995 [6] which is close to the Lithuanian border. Interestingly, the parasite’s prevalence in red foxes (35%) in the southern part of Lithuania [11] is comparable to the one (34.5%) reported from Poland [15]. However, based on these limited data, it remains unclear whether the East Baltic region is a newly established endemic area of an extending distribution to the eastern part of Europe, or just a hitherto unnoticed one.

In Lithuania, E. multilocularis was detected in 158 (58.7%, 95% CI 50.2–64.1%) of 269 red foxes examined. It was present in foxes from most tested localities with the highest prevalence of 62.3% (CI 49.0–74.4%) being observed in the Kaunas district. Mean worm burden was 1309 (1,209,244) worms per fox in this district [11]. It was found that 17% of the infected adult red foxes were harboring heavy infections (>1000 worms per animal) while none of the juvenile foxes were heavily infected. This finding differs from other studies suggesting that juvenile foxes play a more important role in the life cycle of E. multilocularis [16,17]. However, our result may be biased by the low number of juvenile foxes investigated. The high prevalence (58.7%) of E. multilocularis in red foxes in the examined areas suggests that these animals may play the most important role in the zoonotic transmission of this tapeworm in Lithuania.

The raccoon dog is a highly susceptible definitive host for E. multilocularis [2] and there are reports on infected animals from Germany [18], Poland [19] and Lithuania [11]. However, the prevalence of E. multilocularis in raccoon dogs is relatively low in these countries when compared to those of the red foxes (2.7%, 8% and 10%, respectively). Further, the significance of the raccoon dogs regarding the transmission of E. multilocularis to the intermediate host population is poorly understood. In addition to the morphological detection of E. multilocularis in one of 5 muskrats (Ondatra zibethicus) captured in the Šilutė district of Lithuania [10], infertile and calcified metacestodes of E. multilocularis were identified by PCR in 0.4% (3/685) of pigs, and 2 of 240 examined dogs (0.8%) from the same area excreted E. multilocularis eggs [20] as characterised by multiplex PCR using primers specific for E. granulosus, E. multilocularis and Taenia spp. according to Trachsel et. al. [21].

Conclusions: The identification of AE in pigs and of E. multilocularis in dogs demonstrates that transmission of E. multilocularis is occurring in the rural environment in close vicinity to the human population. Red foxes may be considered as the most important species for transmission of E. multilocularis to humans while the respective epidemiological importance of rural dogs and raccoon dogs is still unknown and deserves further studies.

The high number of human AE cases and the high prevalence of E. multilocularis in definitive wild hosts as well as its presence in pigs and dogs document that E. multilocularis is of emerging concern in Lithuania. Considering the long prepatent period of AE in humans we suggest that this zoonosis is present in the area investigated for at least a few decades.
Acknowledgments: The study was financially supported by the Food and Agriculture Organization of the United Nations (FAO, project TCP/LIT/3001 (T)), the SwissBaltNet (supporter: GEBERT RUF STIFTUNG), Lithuanian Veterinary Academy, Hospital of Tuberculosis and Infectious Diseases and Santariskiu Clinics of Vilnius University. The authors wish to thank Regina Virbliene and Jolanta Ziliukienė, Parasitology Laboratory, National Public Health Centre, Ašeris Barakauskiene, MD, PhD, National Centre for Pathology and Jonas Valantinas MD, PhD, Santariskiu Clinic for their valuable assistance in diagnosing human echinococcosis.

References

S12
A survey for Toxoplasma gondii in red fox (Vulpes vulpes) from Finnmark County, Norway
Renate Sjølie Andresen
Norwegian School of Veterinary Science, Department of Food Safety and Infection Biology, Section of Arctic Veterinary Medicine, Stavkevollveien 23, NO-9010 Tromsø, Norway
Acta Veterinaria Scandinavica 2010, 52(Suppl 1):S12

Summary: Samples (blood or tissue fluid) from 405 red foxes (Vulpes vulpes) from Finnmark, Northern Norway, were assayed for antibodies against T. gondii using the direct agglutination test (DAT). The proportion of seropositive animals was 42.5 %, with no significant relationship between sex and infection. The proportion of seropositives seemed to increase with age, in agreement with findings in previous studies in other species. Genotyping of brain tissue by PCR was not successful what concerned T. gondii genomic DNA. This first report of Toxoplasma gondii infection in Norwegian red foxes from Finnmark County indicates that T. gondii is fairly common in red foxes from this area, and the high seroprevalence might be explained by widespread of the parasite in the diet of the foxes. This implies that the red fox is a host of significance in the maintaining of T. gondii in this northern region.

S13
Toxoplasma gondii in Australian smallgoods
Tatjana Momcilovic
Norwegian School of Veterinary Science, P.O.Box 8146, 0030 Dep Oslo, Norway

Summary: Toxoplasma gondii is one of the most common parasitic infections of humans and other warm-blooded animals. In most adults it does not cause serious illness, but severe disease may result from infection of fetuses and immuno-compromised people. Consumption of raw or undercooked meats has been consistently identified as an important source of exposure to T. gondii. Several studies indicate the potential failure to inactivate T. gondii in the processes of cured meat products, referred to as smallgoods in Australia. This publication presents a qualitative risk-based assessment of the processing of ready-to-eat smallgoods. The raw meat ingredients are rated with respect to their likelihood of containing T. gondii cysts and an adjustment is made based on whether all the meat from a particular source is frozen. Next the effectiveness of common processing steps to inactivate T. gondii cysts are assessed, including addition of spices, nitrates, nitrites and salt, use of fermentation, smoking and heat treatment, and the time and temperature during maturation. It is concluded that processing steps which may be effective in the inactivation of T. gondii cysts include freezing, heat treatment and cooking, and the interaction between salt concentration, maturation time and temperature. The assessment is the illustrated using a Microsoft Excel based software tool which was developed to facilitate the easy assessment of four hypothetical smallgoods products.

S14
Echinococcus granulosus (‘pig strain’, GG7) in Southwestern Lithuania
Mindaugas Šarkūnas1,2, Rasa Bruzinskiate3,4, Audrone Marcinkute3,4, Alexander Mathis3, Peter Deplazes1
1Department of Infectious Diseases, Lithuanian Veterinary Academy, Kaunas, Lithuania; 2Clinical of Infectious Diseases, Microbiology and Dermatoveneriologie, Vilnius University, Vilnius, Lithuania; 3Institute of Parasitology, University of Zurich, Switzerland
Acta Veterinaria Scandinavica 2010, 52(Suppl 1):S14

Background: Cystic echinococcosis (CE) of pigs is widespread and known since many years in Lithuania [1]. Recently, the number of diagnosed
cases of human CE began to increase [2] but only limited information is available on the main epidemiological aspects of this zoonosis.

**Material and methods:*** During 2005-2006, post slaughter examination and morphological identification of cysts from pigs from small family farms (n=612) and industrial farms (n=73) was performed. Dog fecal samples (n=240) were collected in 12 villages and microscopically examined by egg flotation/sieving (F/Si) [3] and modified McMaster methods [4]. For the genetic identification of *E. granulosus* to species/strain level, PCR was performed with DNA from typical hydatid cysts from pigs (n=2), morphologically unidentifiable lesions from pigs (n=3), nonfertile cysts from cattle (n=3) and taenid eggs from dog fecal samples (n=34) [5]. Risk factors for cystic echinococcosis were evaluated by a questionnaire.

**Results:** CE was prevalent in 13.2% (81/612) of the pigs reared in small family farms and 4.1% of those reared in industrial farms. Molecular analysis of isolated taenid eggs revealed in 10.8% of the dogs investigated *Toenia* spp., in 3.8% *E. granulosus* (G 6/7) and in 0.8% *E. multilocularis*. In addition, three samples from humans and from a cow were confirmed as *E. granulosus* larval stage by PCR. Sequence analysis confirmed the ‘pig strain’ (G 6/7) in all pig, dog, cattle and human isolates investigated. No significant risk factor for infections with *E. granulosus* or *Taenia* spp. could be identified.

**Conclusion:** The ‘pig strain’ of *E. granulosus* is highly prevalent in the southwestern part of Lithuania, and transmission is more likely in small family farms indicating a high exposure to cestode eggs in rural areas. Therefore control programs should be initiated with special reference to small family farms.

**References**


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**S15 Sylvatic Trichinella reservoir not found among voles in Finland**

Hanna Välmaa1, Jukka Niemimaa1, Antti Oksanen2, Helikki Henrotton1,2 Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit (FINPAR), Oulu, Finland; 2Finnish Forest Research Institute, Vantaa Research Unit, Finland

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**Background:** Sylvatic Trichinella infection has been found to be very common in Finnish wild carnivores [1], especially locally in Southern and partly Central Finland. Cannibalism and carrion feeding have been regarded as the major source of infection to red foxes and raccoon dogs. Voles have been found the major food items of red foxes [2]. They are regarded as herbivorous, but many herbivores consume animal tissues occasionally. Therefore, voles might be assumed potentially to take part in Trichinella life cycle in the wild. *Microtus* spp and *Myodes* spp have been found to be infected with Trichinella, e.g. [3]. In Finland, refuse tip rats have been found to be rather commonly infected with *Trichinella spiralis* [4].

**Material:** A total of 1761 bank voles *Myodes glareolus*, and 138 field voles *Microtus agrestis*, trapped on 30 transect sampling locations in Finland. In addition, also 60 shrews, *Sorex* spp. accidentally found succumbed in the traps, were also included in the study. After killing, during dissection, the right hind leg of each animal was removed and frozen until thawed at laboratory. Left hind legs were spared for confirmation analyses. Following thawing, the legs were treated as meat inspection samples according to Commission Regulation (EC) No 2075/2005 utilizing pepsin-HCl digestion.

**Results and discussion:** No Trichinella spp larva was found in any of the samples. Therefore, microtid rodents in Finland cannot be confirmed to take part of the *Trichinella* spp life cycle. The opposite cannot be confirmed, either, as absence of evidence is not equal to evidence of absence. The predilection sites of *Trichinella* muscle larvae in microtid rodents are not well-known. Perhaps the right hind leg is not a good matrix for *Trichinella* larvae. In addition, even though the material consisting of 1899 small mammals may appear large at topical inspection, the potential impact of microtid rodents on Trichinella transmission biology is based on the high numbers of animals. The Finnish vole population fluctuates all the time, but during the peaks there are estimated to be about 200 000 000 voles in the country.

**References**

domestic species, the alpaca (*Vicugna pacos*) and the llama (*Lama glama*) and two are wild, the vicuña (*Vicugna vicugna*) and the guanaco (*Lama guanicoe*). These species are often referred to as the New World camels (NWCs) or the South American Camels (SACs) [1]. To the three Old World camels (OWCs) belong the bactrians or the two-humped camel (*Camelus bactrianus*). Lately it has been established that there are two different species of bactrians, one domesticated and one wild endangered species [2]. The latter lives on the border between Mongolia and China. The other domesticated OWC species is the more well known, the one-humped or the dromedary camel (*Camelus dromedarius*).

The Camelidae evolved and developed parallel to the Ruminantiae over 35 million years ago in North America [1] and have developed special anatomical and physiological features which are of great significance to their biology, well adapted to the extreme climatic environments of the rough countries of deserts and semi-deserts of Asia, the Middle East and Northern Africa (OWC) and the high altitude country of the Andes in South America (SAC/NWC), respectively. The Camelidae (long neck and small head) are members of the order of Artiodactyla (even number of digits), suborder Tylopoda (modified ruminants with pad or callosis on each foot).

All camelids have 37 pairs of chromosomes and the karyotypes are quite similar. The SACs can interbreed and produce fertile offspring.

### Important livestock
The alpacas as well as the llamas were and still are very important livestock in large areas of South America, particularly in Peru, Bolivia, Ecuador, Chile and Argentina ([3,4,1]). Since the llamas and alpacas were domesticated about 4-5000 BC [1], they have been the most important resource of human culture and survival in the high altitude environments of the Andes. The SACs are better adapted than any other domesticated species to the very cold, hard and fragile areas with very low oxygen pressure (altitudes between 4-5000m).

Alpaca provide meat, hides, fuel, manure and particularly very fine fibres (wool), which are highly priced. Today more than 500,000 peasant families are raising SACs in the Andes and these livestock are the main source of income for the campesinos. Increasing numbers of alpaca are being imported to various countries outside of South America including Europe for wool production, breeding and as companion animals. This is a fairly recent phenomenon that started with larger exports from Chile in 1983-84, first to North America [1].

### Ectoparasites
The alpacas as other livestock are exposed to and affected by a range of ectoparasites (see Table 1). Of particular importance are the mange mites, the burrowing *Sarcoptes scabiei* and the non-burrowing *Chorioptes* sp and *Psoroptes* sp and lice, both biting and sucking *Phthiraptera*. The mange mites have been reported to be common infestations on alpacas also in countries outside of South America. Problems with mange are reported frequently from several countries in Table 1 (abstract S17) Ectoparasites of alpaca belonging to the Phylum, Arthropoda

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Species</th>
<th>Disease</th>
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<tbody>
<tr>
<td>Astigmata</td>
<td>Sarcoptidae</td>
<td><em>Sarcoptes scabiei</em></td>
<td>Sarcoptic mange</td>
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<tr>
<td></td>
<td>Psoroptidae</td>
<td><em>Chorioptes sp</em></td>
<td>Chorioptic mange</td>
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<tr>
<td></td>
<td></td>
<td><em>Psoroptes sp</em></td>
<td>Psoroptic mange</td>
</tr>
<tr>
<td>Prostigmata</td>
<td>Demodicidae</td>
<td><em>Demodex sp</em></td>
<td>Demodectic mange</td>
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<tr>
<td>Metastigmata</td>
<td>Argasida (Soft ticks)</td>
<td><em>Otobius menginii</em></td>
<td>otitis</td>
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<td></td>
<td>Ixodidae (Hard ticks)</td>
<td><em>Ixodes holocyclus</em></td>
<td>Tick paralysis</td>
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<td></td>
<td></td>
<td><em>Dermacentor spp</em></td>
<td>Tick toxicosis</td>
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<tr>
<td>Phthiraptera</td>
<td>Sucking lice²</td>
<td><em>Microthoracius spp</em></td>
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<td></td>
<td>Biting lice³</td>
<td><em>Bovicola (Damalinia) brevis</em></td>
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<tr>
<td>Siphonaptera</td>
<td>Fleas</td>
<td><em>Vermipsylla sp</em></td>
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<tr>
<td>Diptera (flies)</td>
<td>Culicidae (mosquitos)</td>
<td><em>Tabanus spp</em> (horse flies, deer fly)</td>
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<td></td>
<td>Simulidae (black flies)</td>
<td><em>Musca domestica</em> (house fly)</td>
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<td></td>
<td>Tabanidae</td>
<td><em>M autumnalis</em> (face fly)</td>
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<td></td>
<td>Muscidae</td>
<td><em>Stomoxys calcitrans</em> (biting stable fly)</td>
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<td><em>Hydrotea spp</em></td>
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<td><em>Haematobia spp</em></td>
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<tr>
<td>Sarcophagida</td>
<td><em>Calliphoridae</em> (blowflies)</td>
<td><em>Calliphora sp</em></td>
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<td></td>
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<td><em>Cochliomyia hominivorax</em> (primary screw worm)</td>
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<td><em>Phaenicia spp</em> (green blow fly)</td>
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<td><em>Phormia spp</em> (black blow fly)</td>
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<td><em>Oestrus sp</em></td>
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<td><em>Cephenomyia sp</em></td>
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¹ Alpacas are at risk to be infested by native ticks e.g. in Scandinavia by various *Ixodes* and *Haemophysalis* spp, many that are known vectors of pathogens
² Suborder: Anoplura
³ Suborder: Mallophaga
Europe [5-10]. In the UK e.g. 23 % of alpaca owners were concerned [8] and in Switzerland alpaca owners regarded mange as one of the four most frequent health problems [11]. Sarcoptes scabiei var aucheniae is very prevalent in alpacas as well as in other S. var [3]. It is said to be responsible for 95 % of all losses due to ectoparasites in alpacas [12,13]. Infestations with Choriotes sp are also very common. Some regard Choriotes mites as the most common ectoparasite infesting SACs [14]. The mite is assumed to be C bovis [15,16]. Psoroptes (aucheniae) ovis can also be found to infest particularly the ears (pinna) and the outer ear canals, but can also be found elsewhere on the body of alpacas. Mixed infections occur with two and even three of the mite species [9,17,16].

Mange: Sarcoptic mange: The early acute manifestation of sarcoptic mange include milder to severe pruritus with erythema, papules and pustules, developing soon to crustings, alopecia and lichenification and thickening of the skin (hyperkeratosis), the chronic stage. Lesions may be seen on the limbs (often between the toes), medial thighs, ventral abdomen, chest, axilla, perineum, prepuce, the head including the lips and ears. Fibre-free areas are said to be more often affected. Damage to the fibre and loss of condition occur. In very severe infections the disease may result in death [3,17]. There are historical accounts of large epidemics of S scabiei var aucheniae affecting SACs in South America (1544, 1545, 1548, 1826, 1836 and 1839) causing havoc in SACs with mortality of over two thirds of the populations [3].

Prevalence of the infection among the alpaca of peasant communities in the Andes is between 20-40 % [12]. The earlier high prevalence of the infection also seen in the alpacas imported and bred in USA has been substantially reduced, most probably due to the frequent use of ivermectin [18]. In Europe there are several case reports [11,17,10, but no proper study addressing the prevalence of sarcoptic mange infections. A concern is that S scabiei has a zoontic potential and that some variants are not host-specific.

Choriotic mange: Previously Choriotes sp infestations were considered relatively rare in SACs [18,15], although Cremer [19] was of the opposite opinion. Today choriotic mange is a very common condition in many herbivores worldwide [14,20]. Clinical signs of choriotic mange may mimic sarcoptic mange, but animals affected usually exhibit a milder pruritus and sometimes none at all (subclinical). Individuals with a heavy infestation may be free of any symptoms of mange although others in the same herd with lower infestations may show severe extensive skin lesions [20]. Often alopecia and scaling are seen on the feet – often as in sarcoptic mange between the toes and the base of the tail. Lesions may spread to the ventral abdomen, medial limbs and often the ears.

Psoroptic mange: Psoroptic mange is often seen at predilection sites; pinna and outer ear canals, as erythema, crustings, papules serum exudates and alopecia. Pruritus is evident emanating from these lesions. Typical lesions seen in the outer ear canals are big flakes. Pustules are often seen which is most likely due to secondary infections. Ears and parotid regions may become grossly swollen in severe lesions [3]. However, lesions may be generalised as well as pruritus with or without involvement of the outer ear canal. Other sites with lesions reported include; nares, axillae, groin, neck and legs, abdomen, perineum, shoulders, back and its sides and the base of the tail [16]. Intermittent bilateral ear twitching and short-duration head shaking may stimulate any live ectoparasite present to move enhancing the possibility of detecting parasites which then may be isolated and identified. If no ectoparasite is found the previous described procedures follow.

In regards to Choriotes sp animals may harbour a relatively low level of infestation showing no clinical disease, while other individuals may experience a hypersensitivity reaction with moderate to severe skin lesions including pruritis, similar to a clinical reaction to acute S scabiei infections. A recommended site for performing skin scrapings in search of Choriotes sp is the dorsal interdigital (between the toes) and axillae areas [14].

Low power microscopical examination of material from superficial skin scrapings and swabs rubbed into the outer ear canal may identify Psoroptes sp. For proper identification isolates should be sent to experts in the field.

When diagnosis is not conclusive skin biopsies are recommended in skin diseases. Mites are seldom seen in acute cases in histological sections of the skin. However, in cases of chronic sarcoptic mange, S scabiei may often be seen in the epidermis.

Differential diagnosis: Any pruritic dermatitis may mimic infections/infestations by mite mites There are several other causes of skin lesions which should be mentioned as differential diagnostic possibilities apart from dermatitis of bacterial, viral and fungal etiology; e.g. immune mediated skin disease, hypersensitivity reactions, pemphigus like conditions, nutritional/metabolic disease, idiopathic hyperkeratosis, mineral deficiencies i.e. zinc responsive dermatosis. Unfortunately the latter diagnosis (zinc responsive dermatosis) has become a very popular diagnosis that is seldom proven correct.

Phthiriosis (lice): Bovicola (Lepikentron) breviceps Rudow, 1866 (the biting or more appropriate the chewing louse), varying in size from 0.5x1.2 mm to 1.5x4 mm, is more common in llamas than in alpacas. The colour of the body of the louse is white or light tan and it has a blunt broad head that is distinctly different from the elongated mouthparts of the sucking lice. Infestations are mostly seen on the dorsal midline, base of the tail, along the sides of the neck and, to a lesser extent, on the forequarters. Clinical signs of infestations are often a lack of lustre and a ragged looking coat. Infested animals exhibit pruritus. Heavy infestations result in matting and loss of fibres [15], but do not seem to have negative effects on the quality of the fibres or pose any health risk to alpacas [26]. Alpacas are more often infested with the sucking lice, Microthoracius mazzai Werneck 1932 characterized by its elongated spindle-shaped
head, which is almost as long as its abdomen. Earlier in the literature the former species has been misnamed *M. prelongiceps* [27]. Preferred sites of attachment are around the flanks, head, neck and withers. Although these lice are large enough to be seen with the naked eye, about two thirds the size of the biting lice, they are often partly imbedded in the skin taking a blood meal and thus may be difficult to see. Clinical signs are pruritus, restlessness, hair loss and poor growth. Severe infestations can cause anaemia. The biting lice may be found by parting the fibres down to the skin using a bright light in search of tiny moving specks. Nits (eggs) may be seen attached to the fibres. The smaller sucking lice can be seen clinging to the fibres close to the skin or imbedded in it.

### Treatment

A variety of insecticides and acaricides have been used on SACs with varying levels of success. In the past there have been several substances and dosage regimes employed to treat mange mites. The Peruvian Indian peasants believed that the fat of condors was a good cure. This practice was later replaced by used motor oil [3]. Relatively few of the commonly used acaricidal substances and insecticides have been scientifically tested on SACs. The modern macrocyclic lactones e.g. have been tried but not undergone proper testing for efficacy or safety on these animals that have such a unique physiology and metabolism compared to other domestic species. Pharmacokinetic studies of macrocyclic lactones as well as other well known therapeutic products are limited in SACs [28,29]. As yet there are few if any therapeutic products available licenced for these particular animals. This forces the clinicians to use off-label products licenced for other production animals, mostly ruminants. However, several well known therapeutic substances not licensed for use on camelds have been and are used on SACs, some with good results.

A number of authors have used ivermectin at 200 µg/kg by subcutaneous injection with variable but often good results against mange mite infestations and sucking lice in SACs [15,16]. Some have employed higher doses e.g. 400 µg/kg and with more frequent applications (even weekly) than the recommended standard dosages used for other livestock. Also topical use of products containing eprinomectin, doramectin and moxidectin have proved efficacious in some treatments, but not in others [16,10]. Applying injectibles (systemic therapy) in combination with topical treatments is often required to get better results [30]. Particularly patients with chronic lesions with thickened crusty hyperkeratotic skin need to be treated aggressively. In addition, perhaps an earlier recommendation to employ hand-dressing (with a brush) of the thick hyperkeratotic areas of the skin with tepid water with soap and keratolytic agents (e.g. salicylic acid solutions) would shorten the recovery time and reduce the amount of acaricides used [31,32].

Chorioptes sp infestations have often shown to be difficult to control and eradicate [9]. Also Sarcoptes scabiei infections have been very difficult to successfully treat [17]. Whether ‘fomites’ play any significant role in regard to re-infestation is debatable outside their host will not survive more than about three weeks. However, Chorioptes spp may survive for a little more than 60 days. The fibres of alpacas do not contain lanolin which is necessary for the effective spreading of topically applied products, i.e. pour-ons, formulations designed for other livestock than camels e.g. cattle and small stock. This may partly explain therapeutic failures on alpacas [6]. When using pour-ons it is essential to apply the products direct on the skin.

There are numerous insecticides including pyrethrins, chlorinated hydrocarbons, carbamates and organic phosphates which may eradicate lice, but the problem is the administration of the products. The clue to successful treatment is to establish contact with the parasites. Lice infestations are easier to treat than the above mentioned mange mites. Ivermectin at a dose rate of 200µg/kg body weight administered subcutaneously is effective against sucking lice [15], but not against the biting or chewing lice. Cypermethrin at a dose rate of 10 mg/kg has been used with good effect [33,34]. A single treatment is thought to be enough, but infestations 14 days apart is recommended as back-up [33]. Eradication of infestations require repeated treatments and isolation until the animals are found to be completely free of the parasites [33]. The results of several case reports indicate the need to treat more frequently and with higher dosages of some of the acaricidal substances used, compared to the formula for ruminants [16]. It is vital to closely monitor the results of treatment i.e. the clinical resolution following the therapies employed before deciding on whether to stop treatment or change the regimen. Successful treatment should be followed by effective biosecurity measures to prevent the risk of re-infection/infestations. In addition it is recommended to treat all the animals in the herd at the same time.

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Coccidiosis in farmed silver foxes (Vulpes vulpes) and blue foxes (Alopex lagopus) in Finland: a case report.

Tapio Juutilainen, Teija Korhonen, Antti Oksanen
Helsinki University, Faculty of Veterinary Medicine (Docent), Helsinki, Finland;
Finnish Food safety Authority Evira, Production Animal Health Research Unit, Seinäjoki, Finland;
Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit (FINPAR), Oulu, Finland
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Summary: Fur animal farming was initiated during the 1980s on Prince Edward Island in Canada. Farmed silver foxes descend from animals caught from the wild on the island. Finnish fur farming increased during the post-war period and in mid-1980s, there were about 6000 farm animal farms, mostly located in Southern Ostrobothnia (Fig), producing about 8 million fur animals annually. Currently, there are approximately 1300 fur farms and the yearly production in 2007 was about 2 million fox and 2 million mink furs. The global production in 2007 was about 2 million fox and 2 million mink furs. The global production at the same time was about 7 million fox and 58 million mink furs. An outbreak of clinical enteric coccidiosis was encountered at a fox farm with silver foxes (Vulpes vulpes) and blue foxes (Alopex lagopus) in intensive farming district of Ostrobothnia in Finland during summer 2008. The breeding animal stock of the farm consists of 1500 silver fox females and 4000 blue fox females. The whelping period of the silver foxes was from April 20 to May 25, and the whelping period of the blue foxes was from May 5 to June 10. The first clinical signs were seen on silver fox whelpes at the age of three weeks. The whelpes were unthrift, their stools were watery, and they lingered the floors of the wooden whelping boxes. Their fur was moist and clamped. The females also had moist fur coat, which clamped in the cervical and abdominal areas. There was not increased mortality. The morbidity was about 50%, with all the whelpes in affected cullings showing symptoms. At this time the females are still nursing their whelpes, and the whelpes keep themselves mostly inside the whelping boxes. After these first symptoms, all whelpes were studied clinically. They showed marked unthriftiness and poor growth. The body size of the animals was significantly smaller than the normal at this age. Affected whelpes were submitted to post-mortem examination to Finnish Food Safety Authority Evira laboratory in Seinäjoki. In parasitological flotation test from intestinal contents, coccidian oocysts were detected. Faecal samples were submitted for quantitative parasitological analysis and species identification. Of the six silver fox whelp faecal samples, coccidian oocysts were found in 4; max 5600 oocysts per gram (opg), and of the four blue fox whelp faeces, oocysts were found in two, max 120 opg. Two species of Isospora were found. Oocysts of the first one were 30-37µx24-28 µm (mean [n=20] 35.3 [SD 0.9] x 26.2 [SD 0.4] µm), and of the second species were measured 15-16x14-15 µm (mean [n=20] 15.5 [SD 0.2] µm x 14.8 [SD 0.5] µm). Sporozoites measured within sporocysts were about 13x5 µm (cannot be measured very accurately). The oocyst surface is colourless, smooth and clear. There is neither Stieda body nor micropyle in the oocyst or sporocyst. No oocyst granule, but sporocyst residuum sometimes present. This species was identified as Isospora canivelocis (Weidman, 1915) Wenyon, 1923. Duszynski et al. [1] consider it possible that this species is identical with Isospora buratica Yakimoff and Matschoulsky, 1940 in Matschoulsky, 1941 from the Corsac fox and Indian fox, and, more interestingly, with Isospora canis Nemesei, 1959 from the domestic dog. The other species oocysts measured 21-26x16-21 µm (mean [n=10] 23.4 [SD=1.2] x 18.4 [SD=1.0] µm), and sporocysts measured 11-13x10-13 µm (mean [n=10] 12.2 [SD=1.0] µm x 11.4 [SD=1.0] µm). The oocyst of this species is slightly smaller but essentially indistinguishable from Isospora ohiensis Dubey, 1975, which was described to be 24x21 (21-27x19-23) µm in size. Variation in oocyst size can be caused by e.g. crowding in heavy infections. Also the infection phase can affect oocyst size. The animals were treated with oral sulfadiazine-trimethoprim (ratio 5:1) medication at a dose of 120 g per ton of semimost feed for five days, the effect was variable, but the whelpes later gained their normal condition and started to gain weight. The treatment was judged to be satisfactory. A second outbreak was observed on the same farm in blue fox whelpes, when they reached the age of three weeks. The symptoms were similar to that of the silver foxes earlier, but more severe. The mortality was low also at this outbreak, but morbidity was higher, and the weight development was more affected. Whelpes were submitted to post-mortem examination, and coccidiosis was confirmed. The affected whelpes were treated with one individual oral dosing of toltrazuril by syringe at 10 mg per whelp and with oral sulfadiazine-trimethoprim medication for five days, similar to the silver fox whelpes. The recovery in the blue fox outbreak was pronounced, and better than that of the silver fox outbreak.

Discussion: The whelpes most probably received the infection from their dams, which are known to shed parasites at puerperal period. Also horizontal infection within litters in the whelping boxes is to be considered. The hygienic conditions on the farm deserve attention, and on this farm may have contributed to the outbreak. The farm is located in the intensive fur farming district with proximity to other fur animal farms. The spread of the parasites within the farm and possibly also between other farms may have been facilitated by black-headed gulls (Larus ridibundus), which frequently feed under the cage nettings and the feeding boards of the foxes. They may be vectors for the parasite spread with their feet. Clinical coccidiosis is reported on fur animals [2], clinical case of this severity is the first one encountered in Finland. From the Internet, it appears that in Chinese veterinary medical literature, silver fox coccidiosis is described as a well-known disease and an important problem [3]. This reported outbreak calls for closer examination of the occurrence of clinical coccidiosis amongst Finnish fox farms, the coccidian species capable of infecting both blue foxes and silver foxes, and the control measures of the clinical coccidiosis including potential infection routes, vehicles, and the therapy.

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S59

Haemorrhages in a sheep flock in North Finland
Saana-Maaria Manninen, Antti Oksanen
Finnish Food Safety Authority (FINPAR), Evira Fish and Wildlife Research Unit, Oulu, Finland

Background: In May 2008 two sheep from a farm in Ylikiminki (65°N 26°E) were autopsied at Finnish Food Safety Authority Evira in Oulu and
diagnosed with a *Haemonchus contortus* infection. *Haemonchus contortus* has a few years ago been reported on the island of Hailuoto just outside Oulu, where it led to a lethal infection. Although this to sheep highly pathogenic nematode has been detected in Finland already in 1933 by Agnes Sjöberg [1]. It has apparently never been reported so far up north in Finland. In Sweden *H. contortus* has almost reached the Arctic Circle [2]. It does not survive the Nordic winter on pasture, but with almost 100 % arrested development in the early fourth larval stage it is capable of surviving the Nordic winter within its host [3].

The farm the infected sheep originated from is a small sheep farm with also a few pigs, rabbits and other domestic animals such as horses, turkeys and rabbits. They had bought their first sheep in November 2006, part of the ewes being pregnant at time of purchase and lambed in January. The sheep are of Finnish race, Trelx-Oxford, Kainuu grey and cross-breeds. In the winter the sheep are housed in an approximately 150 m² barn with thick straw bedding and access to a corral sized about 500 m². Grazing grounds from May until snowfall (in October) consists of approximately 4 ha of pasture and 1 ha of mixed forest. According to the owner the totally about 35 sheep and 4 goats mainly used the pasture grass as their nutrition, but were also given hay in round bales, when the feeding area became very contaminated with faeces. The drinking water was accessible in the nearby river Kliminki joki. The animals were treated with fenbendazole in autumn of 2007.

In the spring of 2008 many of the sheep (age 1+) became weak and developed an oedema under the jaw. Two of these animals (one died and one shot) were autopsied and the rest of the ones with symptoms were killed and buried. The autopsy findings included oedema under the jaw, paleness due to anaemia and abomasitis caused by a severe parasite infection.

### Materials, methods and results:

Contents of the abomasum were rinsed into 2 L of water and a 200 ml sample was collected, the adult worms collected, counted and identified. In one of the sheep 300 abomasal nematodes were found, 90 % of which were identified as *Haemonchus contortus*, the rest being *Teladorsagia circumcincta*. In the faecal flotation using a modified McMaster method an egg count (epg) of 5800 was counted and epgs identified as *Trichostrongylus* spp. The other animal had a more severe infection, and approximately 1600 adult worms were found in the abomasum, also with 90 % *H. contortus* and 10 % *T. circumcincta*. The results of the faecal egg count for this individual were following: *Trichostrongylus* spp. 36 000 EPG, *Strongyloides* sp. 400 epg and *Eimeria* sp. 2040 oocysts per gram faeces.

**Discussion:** The results indicate that *Haemonchus contortus* is becoming a very severe threat to sheep in North Finland and the distribution of the nematode should be monitored. The parasite is hereby proven to cause a very severe disease in the North Ostrobothnian sheep production. Considering the effects of the climate change, that can be very affirmative for *H. contortus* life cycle, and the increasing amount of sheep has almost reached the Arctic Circle [4], the occurrence of this parasite in these latitudes should not be ignored. Moreover, *H. contortus* may be transmitted to other species such as reindeer [5]. In case of an infection with *H. contortus*, the flock could be recommended treatment with a macrocyclic lactone antiparasitics, as eradication of the parasite on an individual farm is becoming possible amount of faeces and reducing the sensitivity coefficient. The new chamber was compared with the traditional McMaster chamber in the case of an infection with *H. contortus*, the flocks could be recommended treatment with a macrocyclic lactone antiparasitics, as eradication of the parasite on an individual farm is becoming possible amount of faeces and reducing the sensitivity coefficient.

**Materials and methods:** Thirty pig, two horse and two sheep farms were randomly selected, and 815 of pig faecal samples, 264 of horse and 264 of sheep faecal samples were examined. The positive samples were identified by Henriksen and Aagaard (1976) [1] modification of McMaster method. Furthermore, experimental horse faeces were examined by [1] and Urquhart et al., 1996 [2] modifications, whereas pig and sheep faecal samples were by [1] and Kassai, 1999 [3] modifications, respectively. All samples were evaluated in two replicates: using traditional Mcmaster 0.3 ml chamber – I and newly designed 1.5 ml chamber – II [4].

In pig farms, 11.5 % and 18.2 % (chambers I and II, *P* < 0.05) of pigs were found infected with *Ascaris suum*. Furthermore, 14.6 % and 17.8 % (chambers I and II, *P* < 0.05) of pigs were found infected with *Oesophagostomum dentatum* and 3.7 % and 8.2 % (chambers I and II, *P* < 0.05) with *Trichuris suis*, respectively. In horse farms, 65.5 % and 83.7 % horses infected with strongyles were identified (chambers I and II, *P* < 0.05). In sheep farms, the number animals of positive to strongyle infection was 81.4 % and 96.2 % (I and II chambers, *P* < 0.05). The new modification of McMaster method [4] demonstrated statistically higher sensitivity for enumeration of nematode eggs and for evaluation of farms with infected animals compared to McMaster modifications described in [1-3].

**Introduction:** Faecal examination is an important tool for monitoring worm infections in farm animals and an important adjunct to maintaining effective worm control programmes. Described faecal examination methods are either qualitative or quantitative. Qualitative methods provide information on the species present, whereas quantitative methods provide an indication of the levels of infections. Both have their own importance in determining the health status of a herd and determining appropriate treatments and control measures. Quantitative examinations are performed by different modifications of the McMaster method, which is the most widely used and standard quantitative technique with sensitivity from 10 to 100 eggs per 1 g of faeces [5-15]. Furthermore, the following chambers are used for egg count: traditional McMaster chamber with two chambers (2 x 0.15 ml), Gordon-Whitlock chamber (3 x 0.15 ml), Whitlock McMaster chamber (3 x 0.3 ml), Whitlock universal chamber (4 x 0.5 ml), FECPAK 1 ml chamber (2 x 0.5 ml), and modified MAFF 1 ml chamber (2 x 0.5 ml) [5,7,16-19].

We produced a new type of chamber and tested it by the high performance modification of McMaster method using the highest possible amount of faeces and reducing the sensitivity coefficient. The new chamber was compared with the traditional McMaster chamber in both cases using the McMaster method modifications [1-3]. The traditional (I) and the new chambers (II) were used for comparative analysis to evaluate the performance and stability of faecal examination results.

### Materials and methods:

Thirty pig, two horse and two sheep farms were randomly selected, and 815 of pig faecal samples, 264 of horse and 264 of sheep faecal samples were examined. The positive samples were identified by [1] modification of McMaster method. Experimental horse faeces were examined by [1] and [2] modifications, whereas pig and sheep faecal samples were examined by [1] and [3] modifications, respectively. All samples were evaluated in two replicates: using traditional McMaster 0.3 ml chamber – I and newly designed 1.5 ml chamber – II [4]. The new egg count chamber (II) has a bead, which prevents the faeces suspension from seeping out and protects the optics of microscope from adverse effect. Comparisons were made to the number of samples found to be positive by each of the chamber.

**Results:** *Ascaris suum* infection was identified in all investigated pig farms, but the number of infected pigs estimated with the two chambers...
was significantly different – 11.5% (94/815) of pigs positive (chamber I) and 18.2% (148/815) of pigs positive (chamber II). Whipworm infection was identified only in 8 farms (chamber I) and in 11 farms (chamber II) – 3.7% (30/815) and 8.2% (67/815) of samples were positive to T. suis infection. Nodular worm infection was identified in 5 and 7 farms (chambers I and II) – 14.6% (119/815) and 17.8% (145/815) of positive pigs, respectively. The number of positive samples (chamber II) to Ascaris suum was on 1.6, Oesophagostomum dentatum on 1.2, and Trichuris suis on 2.2 times higher compared results with chamber I. In farms where up to 10% of samples were identified as infected with chamber I, the difference coefficient was lowest (1.02). However, in the farms where >50% of infected pigs were identified with chamber I, the difference coefficient was lowest (1.02).

In horse farms, 65.5% (173/264) and 83.7% (221/264) of horses were identified infected with strongyles (chambers I and II, P<0.05). The number of samples positive to Strongylus spp. was on 1.2 times and to Parascaris equorum on 3.4 times higher with chamber II compared to chamber I. In sheep farms, the number of animals positive to strongyle infection was 81.4% (215/264) and 96.2% (254/264) (I and II chambers, P<0.05). The number of samples identified as infected with Trichostrongylus spp. was 1.3 times higher for chamber II compared to chamber I, 3.1 times higher for Toxocara vitulorum, 2.5 times higher for Nematomus filicollis, and 1.9 times higher for Trichurus spp., respectively.

Conclusion: The experimental examination of pig, horse and sheep faeces using the new 1.5 ml chamber (II) helped to identify a higher percentage of infected animals compared to the traditional McMaster 0.3 ml chamber (I). The new modification of chamber (4) demonstrated statistically higher sensitivity for enumeration of nematode eggs and for evaluation of farms with infected animals compared to McMaster modifications described in [1-3].

References
was not detected in domestic pigs in a large study done in all Nordic countries in 1980’s [1]. It was also not found in a study of Danish organic swine herds [2]. In natural wild boar in many countries this parasite is common [3-6]. In the modern pig industry this infection seems to have been disappeared, because there is no contact with the intermediate host, the earth worms. However, in the farmed wild boar, and in situations where pigs are kept outdoors, *Metastrongylus* spp. should be considered as a possible cause of poor growth and respiratory signs.

References


**S22**

**Rare canine parasites survive in the wild fox population**

Marja Isomursu*, Niina Salin, Antti Oksanen

Finnish Food safety Authority Evira, Fish and Wildlife Health Research Unit, Oulu, Finland


**Summary:** Members of the canid family – e.g. domestic dog *Canis familiaris*, wolf *Canis lupus*, red fox *Vulpes vulpes* and raccoon dog *Nyctereutes procyonoides* – share a wealth of parasite species. Nowadays, the diversity of the parasitic fauna of domestic dogs is reduced by antiparasitic medications and disposal of faeces, but a thriving population of wild foxes can host even rare parasite species. Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit, examines approx. 250 fox carcasses for zoonoses every year. Some rarely seen canine endoparasites were observed in the winter 2007-2008.

In January 2008, one of the first Finnish domestic cases of *Spirocerca* sp. infection was observed in a fox hunted from North Lapland fjeld area in Utsjoki (69° N 27°E). The previous one reported was imported from Tanzania [1]. A 30 x 15 mm granuloma containing two large, red, coiled nematodes was formed on the curvatura major of the stomach. The fox was a male individual in good condition.

A massive liver fluke *Metorchis albidus* infection was observed in an aged (6.5 yrs) female fox from Virolahti, Southeast Finland. The flukes had caused a severe cholangitis. Although *Metorchis* is a very occasionally seen parasite in Finland, it is regarded as common in Germany [3].

In addition to these isolated cases, a small survey of the occurrence of the bladder hairworm *Capillaria plica* was conducted in February 2008. Scrapings of urinary bladder wall were taken from 44 foxes from North Lapland and 7 of them (16%) were positive for eggs or worms. In a Danish study, about 80% of foxes examined were found infected with this parasite [2]. All four parasite species mentioned above have at least one intermediate or paratelic host which may facilitate their persistence in the nature.

It is interesting to notice that a similar amount of raccoon dogs are also examined and comparable findings to the abovementioned have not been made. The raccoon dog often harbours higher *Trichinella* infection densities than the red fox does, and this has been speculated to be caused by some innate or acquired cause of immunoincompetence (unpublished). Therefore, raccoon dogs might be expected to harbour occasional parasite infections even more commonly than foxes.

**References**


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**S23**

**Control of livestock ectoparasites with entomopathogenic fungi: a review**

Stephen Abilins, Richard Wall*  
Veterinary Parasitology & Ecology Group, School of Biological Sciences, University of Bristol, Woodland Road, Bristol, BS8 1UG, UK


The abundance of ectoparasites requires ongoing management and this is most commonly achieved with insecticides or endectocides. However, the growth in resistance, the slow rate of development of new actives, coupled with environmental and health concerns associated with the continued use of some of the existing neurotoxic insecticides, suggest that alternative approaches to their management need to be identified. Here one possible alternative approach, the use of entomopathogenic biological control agents, is reviewed highlighting the remaining obstacles that should be overcome to enable their practical application.
benzimidazoles (BZ), imidazothiazoles-tetrahydropyrimines and macrocyclic lactones has been reported [1].The time from introducing a new class of anthelmintic drugs until resistance has been detected seems to be less than 10 years [1]. As time has passed problems of multiresistance to more than one class has occurred as well. Multiresistant Haemonchus contortus has become a major threat to the whole small ruminant industry in part of South Africa and in the South-East of USA [2,3]. At present, resistant nematode populations are detected in all our naturally grazing species; sheep, goats, cattle and horses [1]. In pigs, resistance to pyrantel, levamisole and benzimidazoles in Oesophagostomum spp have been detected [4,5].

**Development of anthelmintic resistance:** Anthelmintic resistance (AR) is defined by Køhler as genetically transmitted loss of sensitivity of a drug in worm populations that were previously sensitive to the same drug [6]. In a worm population, alleles coding for resistance will be present as a result of mutations, also in unexposed populations. Resistance will develop if there are survival advantages for parasites carrying these alleles [7]. Treating worms with drugs corresponding to the “resistance” alleles will give these worms an advantage and the frequency of resistant worms in the population will increase. The frequency of alleles coding for resistance at the time of exposure to a drug will be important for the rate of the development of a resistant population.

The anthelmintic drugs used and the duration of exposure will influence the development of AR. Therefore, it is important to establish de-worming strategies that take this into consideration. Parasite control programs must have a specific aim and the use of drugs must be kept to a minimum to achieve this aim. For horses a reasonable aim of a parasite control program would be to eliminate the large strongyles and have the cyathostomes and Parasarinus equorum infestations under control. The prepatent period of a parasite will be of importance. Species with short prepatent periods will have more generations during a grazing season. Frequent anthelmintic treatment will then expose more generations of these parasites than species with longer generation intervals. The trichostrongyles in ruminants (prepatent period approx. 3 weeks) and cyathostomes in horses (prepatent period 6-8 weeks) are examples of short generation interval species. Strongylus vulgaris has, however, a prepatent period of 6 months. This difference in generation interval might be the reason why resistance is common in cyathostomes and has not been reported in S. vulgaris so far.

Parasites in refugia represent the fraction of the worm population not exposed to the drug when animals are treated. The free living stages of the parasites are the most important part of the refugia. The higher the proportion of parasites in refugia the slower the development of resistance as the selection pressure of the whole population is lower [8,9]. The importance of refugia can be illustrated by looking at the difference in development of resistance in Australia compared to New Zealand. In New Zealand, where the climate is wet, up to 75% of the H. contortus population is larval stages on the pasture [10], which is considerably higher than in the more dry climate in Australia. In spite of the fact that the benzimidazoles and levamisole have been used over the same period in different countries: AR most likely represents a problem of all Nordic countries although few studies have been performed in Finland and Iceland (Oksanen and Sigurdsson, personal communication).

The Danish veterinary parasitologists have been important expanding our knowledge of AR in the Nordic countries. In the early 90s the Centre for Experimental Parasitology in Copenhagen, lead by the enthusiastic Professor Peter Nansen, performed many studies and research programs in this field involving PhD students from many countries. The Centre through Dr. Henrik Bjørn, also inspired research on anthelmintic resistance in Sweden and Norway together with Dr. Peter Waller.

In Denmark, several studies have been performed on AR in small ruminants, horses and swine. The first study on resistance in sheep nematodes in Denmark was published in the early 90s where resistance to levamisole in Ostiterta circumcincta was described [24]. Later Maingi et al. [25] reported evidence of BZ, ivermectin and levamisole resistance in caprine trichostrongyles in a survey from 15 Danish goat herds. Most other studies concerning AR in sheep nematodes in Denmark have focused on comparison of different in vitro tests with the faecal egg count reduction test and to my knowledge no surveys have been performed to evaluate changes in the resistance situation over the last 10-15 years. In Sweden there are no published surveys on resistance in small ruminant nematodes while there is one single report on the situation in Norway [26]. In this report BZ-resistance was detected in four out of 26 herds. Resistance in O. circumcincta was found in all 4 herds while resistance in Nematodirus battus and H. contortus were suspected in one of these herds.

In swine, Roepstorff et al. [4] confirmed resistance to pyrantel citrate in Oesophagostomum spp. in Denmark. Later Bjørn et al. [27] confirmed side-resistance between levamisole and pyrantel and in the same species. To my knowledge no studies on AR in swine parasites have been conducted in the other Nordic countries. The prevalence of resistant Oesophagostomum spp. is reported from Germany is estimated to 2-3.5 % [5]. No studies concerning resistance in cattle nematodes have so far been published from the Nordic countries. Worldwide there are however studies confirming resistance in all three major classes of anthelmintic drugs in cattle nematodes [1]. Looking at the experience of other countries, anthelmintic resistance in cattle nematodes might be a threat to the cattle industry in our countries as well. Anthelmintic resistance in intestinal parasites of the horse is without doubt the area where most studies concerning AR are conducted in the Nordic countries. In Sweden Nilsson et al. [28] reported BZ-resistance in...
Reducing the development of AR: AR is a major problem when controlling parasite infections in production animals and horses worldwide. As documented, the reason for development of resistance to anthelmintics is a selection of resistant individuals in the worm population as a result of anthelmintic exposure. Therefore, efforts to reduce this exposure will slow down further development of resistance but do not reverse the existing resistance in a population. The most obvious way to reduce the exposure is to reduce the use of anthelmintic drugs and look to other ways to control parasites beside anthelmintic use.

As no new broad-spectrum anthelmintic drugs with new modes of action have been introduced since the macrocyclic lactones in the 80s, it is necessary to take the warnings of AR as a major problem seriously. Improvement of the grazing management is important in reducing the use of anthelmintics. Reduction of the stocking rate, reducing the grazing season on the pastures and mixed grazing between animal species are all key factors. Furthermore, the animals have to be treated at times when the effect of treatment is best and underdosing is to be avoided.

Biological control of nematodes is an interesting way of reducing the use of anthelmintics. The principle of biological control is the use of the natural enemies of the nematodes to reduce the infection level on pastures [37]. These methods have no intention of eliminating the free natural enemies of the nematodes to reduce the infection level on pastures [37]. Most studies on the effect of feeding D. flagrans have been based on daily intake of the fungi through feed supplementation. Mineral blocks containing fungal spores or slow-release devices might be practical ways of feeding the fungal material in the future and make the method practical in commercial farming.

Development of effective vaccines against intestinal parasites will allow the opportunity to reduce the use of antiparasitic drugs. In spite of great efforts making vaccines protecting grazing animals against helminth infections, only a vaccine against the bovine lungworm Dicyocaulus viviparus is commercially available [42].

How to deal with the challenge of AR in the Nordic countries: Keeping in mind that new classes of anthelmintic drugs with different mode of action have not been introduced since the 80s and that the AR problem seems to escalate worldwide, we have to take action. Monitoring the resistance situation by systematic surveys in different worm populations is an important means to control AR. I think that the agricultural industry has to be financially responsible for this work through their organisations. We have good knowledge on the development of AR and we know how to deal with it, but we lack information on the development AR over time in our region.

Prescription from veterinarians must be the only way for the farmers to obtain anthelmintics. This will subsequently demand a qualified advice from the veterinarians in order to give the best advice concerning type of preparations and frequency to treat the animals to achieve the best effect of the treatment and at the same time take development of AR into consideration. This is a challenge in the education of both veterinary students and veterinary colleagues.

References


S25Parasite surveillance and novel use of anthelmintics in cattle Johan Höglund
Department of Biomedical Sciences and Veterinary Public Health, Div. of Parasitology and Virology (SWEPAR), Swedish University of Agricultural Sciences (SLU), SE-751 80 Uppsala, Sweden
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Background: Cattle are economically the most important livestock for farmers in Sweden. However, both dairy and beef production has been subjected to considerable structural change over recent decades. Currently, there are approximately 1.5 million cattle, including ≈370,000 dairy cows producing milk worth 1 me [1]. The trend is that the numbers of dairy cows are decreasing slowly, while beef cows are somewhat increasing. At the same time as the productivity has been intensified since the 1950’s in the cattle sector, herd size has increased and the number of production units, especially the number of dairy farms, have been dramatically reduced. In contrast, the numbers of organic farms are steadily increasing. The goal of the Swedish government is to increase the Swedish organic production of agricultural commodities to 20% within a three-year period.

According to the Swedish animal welfare regulations, both conventional and organic cattle must have access to pasture for a period of 2–3 months per year [2]. The grazing season normally occurs between early May and October. As pasture-borne parasites are ubiquitous wherever animals are grazing, they remain one of the most important productivity constraints in Swedish cattle production. These parasites have in common that they often exhibit simple direct life cycles with infective stages transmitted on pasture by the faecal–oral route. The most important pasture-borne parasites of grazing cattle in Sweden are the gastrointestinal (GI) nematodes Ostertagia ostertagi and Cooperia oncophora. To a lesser degree, the lungworm Dictyocaulus viviparus, and also the coccidian Eimeria alabamensis, are important pathogens. Furthermore, in wet areas the liver fluke Fasciola hepatica, with a complex life cycle, sometimes cause problems.

The importance of GI-nematodes and lungworms on the productivity in first-season grazing (FSG) cattle has been demonstrated in a range of independent grazing trials conducted at SWEPAR over the last decade [3-8]. According to the results, the weight-gain penalties in unprotected set stocked FSG animals were on an average in the range of 20 to 65 kg, compared to simultaneously grazed calves but that were fully protected from parasites by the use of effective anthelmintics. Combined, these trials demonstrate the importance of nematode parasites on animal productivity under Swedish climatic and management conditions. They also show that good levels of nematode control can be achieved through the correct use of anthelmintics. However, at the same time there are concerns that over-dependence on ‘chemical’ control may lead to long-term difficulties. This occurs partly through development of anthelmintic resistance, but also because these substances are not widely accepted among consumers. Routine prophylactic use of anthelmintics is not accepted in organic livestock farming [9]. However, “blanket” treatment of the whole grazing group or herd is accepted, even on organic farms, in response to a worm problem after it has been diagnosed.

Although the results from our grazing trials also have shown that good levels of parasite control can be achieved without anthelmintics, some of the alternative non-chemical parasite control approaches that we have tested are impractical. For example, when it comes to the use of natural pasturelands there are situations where high grazing pressure must be maintained in order to maintain a profile necessary for the generation of subsidies. Young and adult stock on Swedish dairy farms are also often grazed on dedicated pastures, which omits the opportunities for mixed grazing between different age groups. There are many examples of organic cattle farmers who have obtained exemptions to the Swedish guidelines because their animals have suffered from nematode parasites.

In this contribution, the focus is on diagnostic methods that can be used for individual and/or herd parasite monitoring in parasite surveillance programmes. I will also briefly discuss future ways to refine the use of anthelmintics through targeted selective treatments (TSTs). The latter is a sustainable deworming method that can be applied in both conventional and organic cattle production. Finally, some results from an ongoing EU project (PARASOL, http://www.parasol-project.org/) will be presented.

Sustainable use of anthelmintics: For the foreseeable future it can be assumed that anthelmintics will constitute the cornerstone of most parasite control programmes, irrespective of whether they are used alone or in an integrated programme. However, to preserve the efficacy and to reach a wider level of acceptance, including organic producers, it is unavoidable to refine the ways in which anthelmintics are used. One possibility is to replace current treatment regimes with TSTs. Today in Sweden, anthelmintics are either administered at strategic times to all first grazing season cattle at risk (e.g. against GI-nematodes), or given as prophylactic mass treatments following the appearance of clinical signs in some animals in a grazing group (e.g. against lungworm). In order to create low input and sustainable programs for nematode control, TST strategies must not only be further developed but also validated under practical farming conditions. The long-term aim with TST is to minimise the number of whole herd/flock anthelmintic treatments by directing treatments towards only those animals/herds that are likely to suffer from...
disease and production loss. Overall, this will reduce the opportunities for any associated environmental and health risks, while maintaining agricultural productivity.

The concept of TST is simple and easy to accept, especially in situations where animals with a high worm burden are easily identified, for example by showing clinical signs such as coughing, diarrhoea, emaciation or reduced productivity. However, it is well recognised that the greatest losses associated with pasture-borne nematode parasites in grazing livestock are sub-clinical. Economic assessments have also shown that the financial costs associated with sub-clinical parasitism are enormous [10]. It can also be argued that it is suboptimal and often too late to treat the helminthic when clinical signs are observed, as animals showing signs of disease are most likely to propagate infection. Essential for the TST approach is that there be access to good and reliable indicators, and identification of treatment thresholds.

Potential TST indicators: There are many potential TST indicators, which can be grouped according to whether they are parasitological, pathophysiological or performance factors. Those indicators based on traditional parasitological techniques, such as faecal egg counts (FEC), and in particular pasture larval counts and tracer tests, are generally impractical, as they are either extremely laborious and/or non-informative when required [11]. Accordingly, it can be expected that they will not be feasible as indicators for the purpose of monitoring cattle health. One exception might be the recently developed FECPAC technology (http://www.fecpak.com/), which might serve its purpose. However, this technology must first be carefully tested and evaluated in field before it can be recommended as a routine measure.

Among the serological tests there are several promising candidates. Recently it has been demonstrated that both serum pepsinogen concentrations (SPC) and antibody levels at housing provide very useful information about previous exposure to nematode parasites. SPC is a pathophysiological indicator measuring the damage caused to the abomasal mucosa, and it has been shown to correlate with the occurrence of parasitic gastroenteritis, both in naturally infected animals [12] and in young cattle experimentally infected with different levels of O. ostertagi [13]. However, the use of SPC is restricted, as it can only be used to predict exposure of FSG animals to this particular parasite.

Another option is to detect specific IgG antibody serum levels with immunological methods using ELISA. Currently there are several in-house ELISAs for the detection of Ostertagia and Cooperia spp. Of particular interest is the ELISA using crude proteins from whole worm extracts of O. ostertagi, as it has been demonstrated that this ELISA not only reflects parasite exposure [13] but also reflects the damage caused in terms of reduced production traits and milk yield [14,15]. Interestingly, this test was recently evaluated to measure antibody levels against this abomasal parasite in bulk tank milk [16]. To what level parasite exposure in cows is correlated with the situation found in heifers and calves on the same farm remains obscure. Although this aspect is currently being investigated within PARASOL, it is certainly a test results; Also, the milk samples were analysed in a similar fashion using the O. ostertagi-ELISA from SVANOVA biotechnology, Uppsala, Sweden.

It was found that the majority of the herds were stabled in September to October. However, the housing dates varied a lot. Notably, some farmers housed their animals in late December. In both years, most farmers treated their FSG with an anthelmintic. However, a large proportion (38%) was left untreated. The preferred anthelmintic in 2006 was the oxfenbendazole intermittent release device (Systamex Repidose®). This drug was used on 85% of the farms. No samples had a serum pepsinogen concentration that exceeded the proposed cut-off concentration of 3.5 tyrosin, indicative of subclinical ostertagiosis. The highest value measured was 2.9 tyrosin. Still, both the mean pepsinogen concentrations and serum antibody levels against O. ostertagi were on an average higher for calves from the untreated herds. However, there was only a weak positive correlation between the Ostertagia- antibody levels and pepsinogen concentrations when the results of the same serum samples was compared (R=0.34).

Furthermore, there was no association between the Ostertagia- antibody levels in bulk tank milk and in sera from the FSG from the same herd. On the other hand, there was a good agreement between OD values obtained in different years, and in particular for the milk samples.

A retrospective study was also carried out to assess the possibility of using daily weight gain in first-season grazing cattle (FSG) as a marker for treatment decisions to prevent parasite-induced losses caused by gastrointestinal (GI) nematodes. Data were combined from three independent grazing trials, each of which was repeated over 2–3 years, in order to investigate the influences of parasites on the performance of FSG cattle subjected to different levels of parasite control. ROC analyses showed that anthelmintic treatment of animals with a daily weight gain (Dwgt) of <0.75 kg/day by mid-season had a sensitivity of ~70% and a specificity of ~50%. It thus seems feasible to base a targeted selective treatment for FSG cattle on Dwgt recorded approximately 4–8 weeks after turn-out, provided that it is accepted that some animals will be dewormed without need. However, these data were pooled from a number of disparate trials, so that these sources of variation were included in the experiment but their individual effects cannot be determined. The next stage is to validate the conclusions in a controlled field trial.

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S26 Changes in production systems and effects on parasitic infections
Allan Roepstorff1, Stig Milan Thamsborg, Helena Mejer
Danish Centre for Experimental Parasitology, Department of Disease Biology, Faculty of Life Sciences, University of Copenhagen, Denmark
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Summary: A plurality of parasites of great diversity is the rule for all animals in nature. A successful parasite has to be transmitted from one host to the next and this transmission is often the weakest point in the life cycle, as the parasites depend on the surrounding environment for days to months to become infective either as free-living stages or within intermediate hosts. For domestic animals, housing and other factors characterizing the production system thus have a great impact on transmission, the ectoparasites being an exception due to their transmission by physical contact between host animals. In the present paper, the effects of production systems on parasitic infections are discussed with focus on pigs. During the last century pigs have moved from traditional husbandry systems with poor hygiene and access to outdoor areas towards highly intensive, exclusively indoor industries, a process which has gradually reduced the number of endoparasite species. Furthermore, ectoparasitic arthropods are easily eradicated by drug treatment in modern pig enterprises. It is thus only a small number of protozoan parasites that are common across farms. At present, the trend of decreasing parasitism is for the first time reversed. Organic pigs or other free-range pigs make up the best and most extreme example, and these pigs may harbour many more parasites than conventional pigs. Only a small minority of domestic pigs, however, live in organic/free-range herds. It may therefore be more important in the future that conventional pig herds are also changing their housing system due to animal welfare issues; straw bedding is being reintroduced, the pregnant sows are untethered to become free-moving, and facilities may include water sprinkling devices which will increase the humidity and thereby the survival of transmission stages. The future challenge of domestic pigs may therefore, for the first time, be to control an increasing parasite load.

S27 Alternative approaches to control of parasites in livestock: Nordic and Baltic perspectives
Stig Milan Thamsborg1, Allan Roepstorff, Peter Nejsum, Helena Mejer
Danish Centre for Experimental Parasitology, Department of Veterinary Disease Biology, Faculty of Life Sciences, University of Copenhagen, Denmark
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Introduction: It is evident from several on-farm surveys that levels of parasite infections vary markedly between livestock holdings and from one farm to another [1]. The background for these differences relates to livestock breeds, different management factors and other practices that directly or indirectly affect parasite infections, and also to farmers’ attitudes e.g. the chosen threshold for intervention. This paper deals with practices or interventions that can be actively applied by farmers aiming specifically at control of mainly helminth infections, either by reducing the parasite infestations directly, e.g. by means of antiparasitic crops, or by limiting the uptake of external stages, e.g. by pasture management. The term “alternative” approaches has been applied (despite several options not being very alternative or novel but relatively old) to denote only limited focus on use of commercial anthelmintics. Focus will be on approaches relevant to primarily ruminant pig and production and which can be applied in the Nordic-Baltic context after some modification or which may serve as a guideline for relevant research in our region. For practical reasons the options will be dealt with one at a time although, as pointed out in several reviews [2,3], the combination of two or more options, or the combination with limited use of anthelmintics, will in many cases be the optimal approach.

Pasture management: The basic principle of pasture management is limiting the intake of infective stages of pasture-borne parasite infections. Pasture management encompasses practices related to grazing: time of turn-out, length of grazing period, age composition of flocks, co-grazing with other species and frequency of pasture changes, although other factors like type of herbage and productivity, stocking rates and parasite contamination levels at turn-out also are very important. On most ruminant farms, pasture management is guided by nutritional requirements of animals in combination with customary practices, and in general little attention is paid to parasites when the season’s grazing is planned. Pasture management practices aiming at parasite control have been extensively researched (and reviewed by [2,4,5]) and in most cases demonstrated to be quite successful in controlling mainly gastrointestinal nematodes of ruminants. The strategies can be grouped as preventive i.e. starting off with low (or nil) infection levels in animals and on pastures, evasive i.e. moving animals away from pastures before harmful contamination levels are generated, or dilutive strategies i.e. lowering the ratio between susceptible and resistant animals (or lowering the overall stocking rate). Despite obvious benefits, these strategies are not readily adopted by cattle farmers, although still more by organic than conventional farmers [6,7], and this may be related to the relative ease and low cost of using anthelmintics compared to labour-intensive fencing and moving. Furthermore, in sheep grazing management is difficult to practice totally without drugs.

In dairy cattle, the most susceptible group of animals, i.e. first season grazing calves, is unaffected at turn-out and if placed on an uninfected (or lightly contaminated) pasture this will result in good control for the first half of the season. By repeated moves to clean pastures (e.g. 2-3 times), excellent control is obtained for the entire season [8]. Even though the first paddock is contaminated, infections are reduced if the flock is moved by 15 July to a paddock ungrazed the same year [9]. A recent Swedish study showed very convincingly that a practice of turning out first year grazing steers (castrated bulls) on paddocks grazed by second year grazers in the previous season combined with a mid-summer move to clean pasture, result in acceptable control of gastrointestinal nematodes [10]. Male animals are generally more susceptible to parasites than females and steers are believed to have intermediate susceptibility in steers to very similar to that of heifers [9]. Several studies have indicated an exacerbating effect of high stocking rates on gastrointestinal nematode infection levels in both cattle and sheep [12,13] whereas the effect is less clear in outdoor pigs [14], which presumably is because pigs tend to stay in the feeding area instead of utilising the paddocks evenly.
Coccidia in ruminants are often transmitted by overwintering pasture infections from one year’s young stock to the next [15], and pasteure at turn-out (read ungrazed the previous year) are thus crucial in control [16]. This is a fact often overlooked by sheep or cattle farmers, e.g. if they have a permanent, after-lambing collecting paddock or if calves as a rule are grazed in close vicinity of the farm [17]. In the case of sheep, similar management practices may also result in problems of nematodirosis in early season ("lamb-to-lamb" disease) as observed in Denmark [18]. Increasing problems with liver flukes (Fasciola hepatica) are becoming evident in many places in Northern Europe where grazing of cattle is re-introduced on natural wetlands for aesthetical reasons and to maintain biodiversity [9]. In many cases control is achieved by strategic application of flukicides but it would be relevant to employ evasive grazing i.e. a move in mid-August as a means of control. However, few studies, if any, have addressed this approach.

The majority of the pig production in Nordic countries is indoor but pasture management is relevant in conventional outdoor and organic farming where the breeding stock, or all stock, have to be outside for a part of the year. The most common helminths (Ascaris suum and Trichuris suis) are characterized by hard-shelled eggs and thus sustained longevity on pasture – up to 10 years (reviewed by [1]), despite initial high death rates [20]. Ongoing Danish experiments using parasite-naive pigs to trace the dynamic relationship on pastures and therefore have yielded 2 interesting results: firstly, transmission levels are increasing the first 2 years, indicating an unexpected slow development to infectivity; secondly, infection levels were not markedly decreased after 4 years (Mejer and Roepstorff, 2006, unpublished data). This demonstrates fully that at present we cannot provide evidence-based recommendations with regard to paddock rotation in pigs – 2-3 years are obviously not enough! In contrast, it seems that Oesophagostomum spp. have a poor survival over winter [14,21,22] and do not constitute a problem in strictly outdoor sow herds [23] whereas the coccidian parasite Isospora suis seems to be controlled by routine moving of the farrowing huts between farrowings [24].

The principles of pasture management may be applied to indoor stabling of pigs in large pens with plenty of straw bedding, e.g. deep-litter farrowings [24]. In small ruminants, extensive studies worldwide on bioactive crops have focused on forages rich in condensed tannins (4-8% of dry matter) and their effect on gastrointestinal nematodes [26,27]. The relevant secondary metabolites related to plant defence against herbivory and their protein-binding capacity (tanning!) [28]. The variability is large within a number of other parameters like the ratio between prodelphinidins and procyanidins [29]. It has long been debated whether the effects are direct by harming residing/incoming nematodes, or indirect by improving immunity through more rumen-by-pass protein [28]. Recent studies have clearly indicated direct effects of condensed tannins from condensed sainfion including inhibited exsheathment of infective larve, diminished pathological changes in larve following short term exposure and reduced penetration of abomasal mucosa (29,30); Severine Brunet, pers. communication, 2008). A leafy cultivar of chicory (Cichorium intybus) suitable for ruminant grazing, although not rich in condensed tannins, does exhibit similar effects on nematodes, and this forage may prove to be more appropriate in the Nordic context [31,29].

It has been known for more than a decade that structure and composition of the feed may influence establishment and fecundity of intestinal nematodes of monogastric animals [32]. A low fibre content and high level of easily fermentable carbohydrates may lower parasitism. Roots of chicory (Cichorium intybus) and seeds of lupin are rich in such fermentable carbohydrates, particularly fructans (inulin). In pigs, almost complete reduction of the egg output of Oesophagostomum spp. has been achieved by adding purified inulin [33] or dried chicory roots to the diet [22]. High reductions in worm counts have been observed in some studies [33,34] but not in all [22]. Incomplete elimination of worms may be a matter of why deposition of egg excretion has been partially inversible as egg counts were shown to increase when the carbohydrates were withdrawn from the diet [33]; Helena Mejer, unpublished data, 2008). The fermentable carbohydrates are only partially degraded in the small intestine, and the mechanism of action is most likely related to the production of short chain fatty acids during their fermentation in the large intestine [35]. It is believed that the short chain fatty acids directly or indirectly cause adverse conditions for residing nematodes just as there is a shift in microbial composition [36]. Consequently, T. suis, another inhabitant of the large intestine, is moderately affected but results are inconsistent [37-39]. Furthermore, early larval stages of A. suum penetrate the large intestine before the migratory liver phase and establishment of incoming infections may be affected [22] but not established adult infections (Helena Mejer, unpublished data, 2008). As the major targets of nematode control in pig outdoor production in the Nordic context are indeed A. suum and T. suis, these findings need further investigation to be of practical relevance.

Selective breeding for host resistance: In ruminants, faecal egg counts, nematode worm counts and related morbidity markers, like pepsinogen for cattle and anaemia scores for sheep with haemonchosis, show moderate heritabilities (0.3-0.4), and this forms the basis for a breeding approach to control of gastrointestinal nematodes, as reviewed by e.g. [40] and [41]. In large wool producing countries (New Zealand and Australia) selective breeding for host resistance is now implemented on many commercial enterprises. Quantitative Trait Loci (QTLs) have been identified and a first DNA test for sheep is now commercially available (Catapult Genetics NZ) but breeding values are in most instances still based on faecal egg counts. Reduction rates in faecal egg counts are estimated to be approx. 2% annually [42] but the reduction in anthelmintic treatment frequency remains to be demonstrated. Selective breeding for resistance has been associated with disadvantages, e.g. low productivity when unexposed, or increased tendency towards sensitization associated with larval exposure, due to higher immunological responsiveness [43]. Combining low faecal egg counts with other traits, e.g. productivity, in a selection index is therefore presently considered most suitable [41].

In pigs, Danish studies based on examination of 200 offspring of known matings revealed heritabilities of faecal egg counts of A. suum of 0.3-0.4 and of T. suis of 0.4-0.7 [44]. For T. suis the heritabilities depended on time in relation to start of infection: during the early expulsion phase heritabilities were highest, probably indicating close genetic control of the onset of immunity. For Ascaris a number of other parameters like actual worm burden, total egg output and antibody-levels were also identified as important, whereas there is no beneficial effect of the species of the worms (Peter Nejsum, unpublished data, 2009). It is obvious that breeding for increased host resistance is also an option within the pig industry and may be highly relevant in free-range systems.

Conclusions: Other options, apart from those mentioned above, remain, including biological control with nematode-trapping fungi against free-living larvae, copperoxide needles against abomasal nematodes,
vaccination against gastrointestinal nematodes of sheep, etc. For different reasons these options are not expected to be available in the Nordic or Baltic context in the foreseeable future. In contrast, many forms of grazing management do work in ruminants and should always form the backbone of any control program. Nutritional supplementation to grazing ruminants is also immediately available but the costs and benefits need to be considered – if herbage amount and quality is sufficient very little extra is gained by additional supplementation. Selective breeding is an obvious option in small ruminants and perhaps in pigs and beef/dual purpose cattle. More basic research is needed on bioactive forages with regard to mode of action and possible active compounds in order to select the most appropriate forage species/cultivars. None of these approaches should be considered ‘stand alone’ control measures due to their moderate efficacy and integration with anthelmintics will continue to be a necessity.

Today it is widely recognized that with the limited arsenal of anthelmintics and the constant spread of anthelmintic resistance, we cannot keep livestock free of nematodes during their entire production life by drug application alone. We need to provide support for the susceptible young stock, e.g. optimal nutrition and limited parasite challenge, during the phase of acquisition of immunity until they can cope with infections. Thus, our mission as veterinarians and parasitologists has changed accordingly and a new approach to achieve sufficient levels of immunity with acceptable levels of production loss and uncompromised animal welfare by prudent (read minimal) use of anthelmintics has emerged. This represents a shift in paradigm, because previously the issue of most concern was achieving the highest production possible. Now we must consider how to transfer this new message ‘across the fence’ to farmers and extension staff. The future challenges are indeed numerous.

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References


Table 1 (abstract S28) Median egg count values (epg) of Trichostrongylidae spp. in 13 beef cow herds

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<tr>
<th>Farm 1</th>
<th>calves in summer</th>
<th>calves in autumn</th>
<th>heifers insummer</th>
<th>heifers in autumn</th>
<th>cows in summer</th>
<th>cows in autumn</th>
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S28 Gastrointestinal helminths and lungworms in suckler cow beef herds in Southern Finland, a pilot study

U Eerola 1, H Harteli 1, A Oksanen 1, T Soveri 1
1 Private Practitioner, Hämennie 22, 16900 Lammi, Finland; 2 LSO Foods Oy, Animal Health Service, Forsa, Finland; 3 Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit, Oulu, Finland; 4 Department of Production Animal Medicine, Faculty of Veterinary Medicine, University of Helsinki, Finland
E-mail: ulla.eerola@luukku.com

Introduction: The number of sucker cow beef herds is increasing in Finland. Prevalence studies about gastrointestinal parasites and lungworms of grazing beef cattle in southern Finland are not available. Systematic anthelmintic treatment is not widely used and there is no recommended treatment protocol available. The aim of this study was to obtain basic knowledge of the prevalence of gastrointestinal parasites and lungworms in grazing sucker cow beef herds in southern Finland.

Materials and methods: The study was conducted in summer 2002. It included 13 voluntary beef cattle herds (herd size 26 – 95 adult animals) in southern Finland. None of the herds had clinical symptoms of parasitic infection. None of the herds was treated in the spring and 11 of the herds had not used anthelmintic treatments within a year. The first set of faecal samples were taken from 4-10 calves on 10 farms, 4-10 heifers on 7 farms and 8-12 cows on 13 farms. The first sampling was done more than 3 weeks after the beginning of the grazing period and the second sampling was done at the end of the grazing period in autumn. Faecal samples were investigated at Finnish Food Safety Authority Evira, Oulu. The methods used were modified McMaster for gastrointestinal helminth eggs and the Baermann technique for detecting Dictyocaulus viviparus. Egg count less than 50 eggs/gram faeces (epg) was considered low infection, 50-500 epg moderate infection and more than 500 epg heavy infection considering Trichostrongylidae spp. Dictyocaulus viviparus infections were evaluated on herd level as negative or positive.

Results: Trichostrongylidae spp were found in all herds in all groups examined. The egg counts in individual calves varied from 0 to 1540 epg at the first and from 0 to 780 epg at the second sampling. Egg counts in heifers varied between 0 - 120 epg and 0 - 140 epg, in older cows between 0 - 360 epg and 0 - 200 epg, respectively. Only three individual samples had egg count higher than 500 epg. Median values for calves, heifers and cows are presented in Table 1.

Notes: 1 Dictyocaulus viviparus positive herd
2 M = Information missing
**Dicycaulus viviparas** was detected in two herds. Other than *trichostrongylid* gastrointestinal parasites (*Capillaria* sp., *Nematodirus* sp., *Moniezia* sp., *Paramphistomum* sp.) were detected in very few samples at low levels.

**Discussion:** Gastrointestinal parasites, mainly *Trichostrongylidae spp.*, were found widely in beef cattle, but the parasite egg counts were low or moderate at all farms in all groups of animals. None of the herds had clinical signs of infection and did not seem to need regular anthelmintic treatment. However, summer 2002 was exceptionally dry and warm in southern Finland which may be one reason for low egg counts. Other gastrointestinal parasites (*Capillaria* sp., *Nematodorus* sp., *Moniezia* sp., *Paramphistomum* sp.) were rarely and considered not important.

The most important finding of this study was some farms having a subclinical *Dicycaulus viviparas* infection. In light of the low incidence of disease in Finland, subclinical infections are a risk in cattle trade and should be considered.

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**S29**

The prevalence of internal parasites in wild boar farms in Finland

Outi Hälli*, Eve Ala-Kunika, Olli Peltoniemi, Mari Heimonen

Department of Production Animal Medicine, University of Helsinki, Saarentaus, Finland

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**Background:** In Finland, the most important internal parasites in domestic pigs are nematode *Ascaris suum* and coccidia *Isospora suis*. As the environmental conditions and management practices in wild boar (*Sus scrofa*) outdoor farming are suitable for parasites during most seasons, we wanted to explore the parasite burden of wild boars in Finland. This kind of research has not been carried out earlier in our country. Economical losses caused by internal parasites, especially ascarids, are mainly due to reduced daily weight gain and feed conversion ratio [1].

**Materials and methods:** Based on a national record of wild boar farmers, a sampling frame of farms was compiled. Every farm on that list was contacted first by mail and the non-responders received a phone call from research group personnel. All volunteer farms that still had wild boars were included. From all animals slaughtered in study farms during the study period (autumn 2007 – spring 2008), a faecal sample was obtained directly from rectum after slaughter. Faecal egg or oocyst counts regarding *Ascaris suum*, coccidia, *Strongyulus* and *Trichurus suis* were counted by the concentration McMaster technique. The number of positive farms (at least one animal with parasite eggs in faecal sample) and summary statistics of egg counts for every parasite type was calculated.

**Results:** Altogether 113 samples were collected from 22 farms, a median of 4 samples (1-15) per herd. The median age of sampled wild boars was 18 months. Mean age was found to be 21,5 months (standard deviation 14,5). The number of positive farms can be seen in Figure 1 and summary statistics for egg or oocyst counts for different parasites studied can be found in Table 1.

**Conclusion:** Almost all farms were positive regarding coccidia. The exact diagnosis of the species of the oocysts was not reached, whether they were *Isospora* or *Eimeria*. Although the established oocyst counts probably are harmless for adult animals, the risk for piglets could be substantial because of environmental contamination, especially in case of *Isospora*. Smaller number of animals and farms were *Strongyulus* or *Ascaris suum* positive. Adult animals are known to be able to develop immunity towards ascarids, thus the low egg burden in sampled animals was quite expected.

**Reference**


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**S30**

Cross-infection of gastrointestinal nematodes between winter corralled semi-domesticated reindeer (*Rangifer tarandus tarandus*) and sheep (*Ovis aries*)

Saana-Maaria Manninen*, Antti Olkanen, Sauli Laaksonen

Finnish Food Safety Authority Evira, Fish and Wildlife Health Research Unit, Oulu, Finland

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**Summary:** The increasing number of sheep (*Ovis aries*) in the reindeer (*Rangifer tarandus tarandus*) herding area in North Finland and supplementary winter feeding of reindeer in corrals shared with sheep causes potential for cross-infection of gastrointestinal nematodes between reindeer and sheep. The aim of this study was to elucidate this potential. The study included 46 animals, of which 12 reindeer and 8 sheep had shared a corral. Twelve reindeer had no known contact with sheep. Both reindeer groups shared free ranging areas with wild moose (*Alces alces*). Two moose were included in this study, as were 12 sheep which had no contact with other ruminants. After slaughter in September-November abomasal and proximal small intestines were collected and examined for gastrointestinal nematodes. The parasites were collected, counted and identified. Following species were found in reindeer: *Ostertagia gruehneri*, *Ostertagia arctica*, *Spiculopteragia dagestanica*, *Nematodirus tarandi*, *Nematodirella longissimespiculata* and *Bunostomum trigonocelphalus*. Sheep were infected with *Teladorsagia circumcincta*, *Teladorsagia trifurcata*, *Ostertagia gruehneri*, *Ostertagia arctica*, *Nematodirus filicollis* and *Nematodirus spathiger*. *Spiculopteragia dagestanica* and *Ostertagia gruehneri* were identified in moose. *Ostertagia gruehneri*, which is considered to be a reindeer parasite, was only found in the sheep that had shared a corral with reindeer. These sheep were not found to be infected with other abomasal nematodes. The reindeer that had shared a corral with sheep were not infected with nematodes usually having sheep as their primary host.

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**Table 1 (abstract S29) Summary statistics for egg counts (epg) for coccidia, *Strongyulus*, *Ascaris suum* and *Trichurus suis***

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Mean, epg</th>
<th>SD, epg</th>
<th>Min, epg</th>
<th>Max, epg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coccidia</td>
<td>6 118</td>
<td>1967</td>
<td>0</td>
<td>102 000</td>
</tr>
<tr>
<td>Strongyulus</td>
<td>300</td>
<td>945</td>
<td>0</td>
<td>6 150</td>
</tr>
<tr>
<td>Ascaris suum</td>
<td>29</td>
<td>15</td>
<td>0</td>
<td>1 450</td>
</tr>
<tr>
<td>Trichurus suis</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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**Figure 1 (abstract S29)** Number of farms with at least one pig positive for different parasites in fecal examination (22 farms included in the study).
Intestinal parasite infection exposes grouse to canine predators

Marja Isomursu, Osmo Rätti, Pekka Helle, Tuula Hollmén
Finnish Food Safety Authority Evira, Research Department, Fish and Wildlife Health Research Unit, P.O.Box 517, FI-90101 Oulu, Finland; Arctic Centre, University of Lapland, P.O.Box 122, FI-96110 Rovaniemi, Finland; Finnish Game and Fisheries Research Institute, Oulu Game and Fisheries Research, Tuttijantie 2 E, FI-90570 Oulu, Finland; Alaska Sealife Center, 301 Railway Avenue, P.O. Box 1329, Seward, AK 99664, USA

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Background: Sublethal parasite infections may cause mortality indirectly by exposing the host to predation. The best known example of this among birds is red grouse in which caecal nematode infection causes increased risk of predation and can even affect population dynamics [1]. Intestinal helminth parasites are common in forest grouse, capercaillie Tetrao urogallus, black grouse Tetrao tetrix and hazel grouse Bonasa bonasia [2], and these grouse are valuable prey for several species of predators. We evaluated the hypothesis that parasite infection makes the host more vulnerable to predation by comparing the intestinal parasite infection status of grouse hunted with a trained dog to that of grouse hunted without a dog. Hunting with a dog can be regarded as close simulation of natural predation because the dog presumably locates the prey by the same cues as wild canine predators.

Material and methods: We collected whole grouse intestines from hunters and received 623 samples of which the bird species, age class and sex were determined. All sample birds were shot with a shotgun during legal hunting season in September and October. Intestines were cut open and parasites visible to naked eye or stereomicroscope were extracted and identified. The associations between host sex, age, species, the month of sampling, the use of dog and the occurrence of intestinal helminths were studied using hierarchical loglinear modelling with backward elimination procedure (P = 0.05) (SPSS programme ver. 11.5). Two different models were studied, one for cestodes (all three species pooled together) and one for nematodes.

Results and conclusions: Grouse were infected by four helminth species: a nematode Ascaridia compar and cestodes Skrjabinia cesticillus, Paroniella urogaalli and Hymenolepis sp. Nematode infection was not connected to dog-assisted hunting. However, there was a significant interaction between cestode infection and the use of dog (P < 0.01). Cestodes were more common in grouse hunted with a dog (see Figure 1). Cestodes were mostly parasites of juvenile grouse but even among juveniles only, cestodes were more prevalent in the dog-assisted hunting bag. The results suggest that mammalian predators prey more selectively on parasitized individuals and that intestinal parasites may contribute to the high mortality of juvenile grouse through increased predation.

This abstract is based on a recent paper published in Annales Zoologici Fennici by the same authors [3].

References

Figure 1 (abstract S31) Prevalence of cestodes in grouse hunted with a dog or without a dog. Shaded bars = with dog, open bars = without dog.