# Ticks and tick-borne diseases in dogs and cats in the Nordic countries – what is changing and why?

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# White paper based on a Nordic expert group round-table discussion following the NordTick conference

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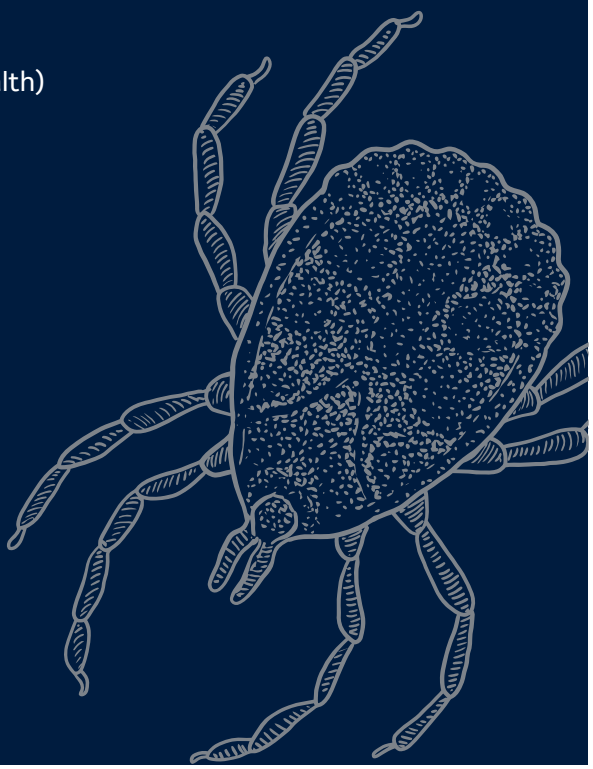

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# SUMMARY

Tick abundance and their geographical distribution have remarkably increased in the Nordic countries since the late 1970s. Climate change is one of the main factors driving the changes. Additionally, globalization, travelling with and import of dogs and cats, changes in wildlife communities, nature conservation projects, and other changes in land use, including in cities and semi-urban areas, contribute. The exposure of humans and animals to ticks has been increasing during recent decades due to the higher abundance, enlarged geographic range and longer season of ticks and because people spend more time outdoors.

Ticks are not only expanding geographically in forests and rural areas: in cities and semi-urban areas, humans create surroundings where ticks thrive e.g., in parks, gardens and near beaches. By keeping dogs and cats – suitable for ticks to feed on – we can unintentionally create microhabitats for ticks within our gardens and cities.

Migratory birds and travelling/imported dogs and cats bring ticks over long distance. In suitable climate and if supporting host communities exist, imported ticks may become established in new geographical areas. Newly introduced tick species can go unnoticed for some time, and in addition to traditional tick surveillance, they can be found with the help of media awareness and citizens. *Dermacentor, Rhipicephalus* and *Hyalomma* are of special concern.

It is unfortunate that travelling with dogs and cats and importing them without any ectoparasitic treatment is allowed. Moving dogs and cats around Europe not only exposes them to ticks and other vectors and diseases present at southern latitudes, but risks bringing the vectors and diseases to the Nordic countries. Education of pet owners is needed.

**Vector:** *An animal capable of transmitting pathogens from one host to another, to and from both humans and animals. Ticks, mosquitoes, and sandflies are examples of vectors.*

Historically, tick-borne diseases in the Nordics have been rare and mild in dogs and cats. However, as the range and abundance of ticks are increasing, the risk is likely to increase. *Borrelia* spp. infection can cause clinical disease in dogs, and *Anaplasma phagocytophilum* infection can cause disease in dogs, cats, horses, and other animals. Tick-borne encephalitis virus (TBEV) may cause severe disease in dogs and its prevalence is increasing, and there are other potentially emerging pathogens. Most of these pathogens are also pathogenic for humans.

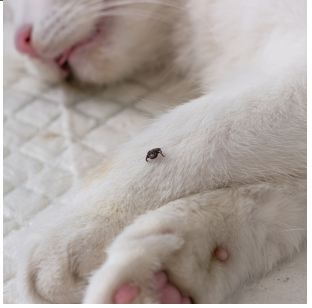
Since ticks and tick-borne diseases can affect both animals and humans within their shared environment, a One Health approach is important. Balanced and non-scary communication is needed to ensure that people can identify hazards correctly.

The health benefits from enjoying time in nature should be emphasized. People should just take a few reasonable precautions like being cautious when barefoot or in sandals, tucking trouser legs into socks, and checking themselves for ticks once a day.

Treatment of dogs and cats with efficacious products against ticks protects not only them but can indirectly protect humans from ticks by killing ticks in the garden. If dogs and cats are not treated, they may support the tick lifecycle and contribute to more tick-borne diseases in humans and animals.

Further research, surveillance and sharing of information are needed. Preparedness for emerging ticks and tick-borne diseases in dogs, cats, horses, other animals, and humans should be prioritized.

**Pathogen:** *A microorganism with disease-causing potential, such as bacterium, parasite, or virus.*



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# GEOGRAPHICAL OCCURRENCE, SEASONALITY, AND SPECIES OF TICKS ARE CHANGING

There has been a marked increase in tick abundance and geographical distribution in the Nordic countries since the late 1970s. Now there are more ticks, and there is more awareness of ticks. Climate change is one of the main factors driving changes in the geographical distribution and abundance of ticks. Additionally, globalization, travelling with and import of animals, changes in wildlife communities, nature conservation projects with or without grazing mammals, and other changes in land use including land use in cities and semi-urban areas contribute to the changes. The exposure of humans and companion animals to ticks has been increasing during recent decades because people spend more time outdoors, the weather is warmer, and tick season is longer.

Temperature and microclimate play a role in the activity of ticks. To point out any strict threshold temperature for tick activity like “ticks are active above 5 °C” is a simplification that does not fit all tick species and situations. Microclimate differs a lot locally and ground surface temperatures tends to be more extreme than the temperatures presented in weather forecasts. Basically, when it is not freezing, ticks can be active. Unfed questing ticks are more resistant and robust to harsh conditions than blood-fed/engorged ticks. Some tick species, e.g., *Dermacentor reticulatus*, feeding on a wide host range including pets, and possibly *Ixodes trianguliceps*, feeding on rodents, can stay on the host for a longer time and remain active in cold weather due to the body warmth of the host. Tick species can also adapt to local conditions, survive colder temperatures, and have different questing conditions and heights in northern Europe compared to southern Europe.

Some tick species feed on a variety of host animal species and the abundance and/or availability of hosts are drivers for the local tick situation – this also affects the pathogens. For example, ticks like to feed on roe deer, which support tick reproduction, being crucial for the tick abundance. While ticks are crucial for the circulation of pathogens, many tick-borne pathogens are host specialists. Thus, while roe deer are important for ticks, ticks do not necessarily acquire *Borrelia* bacteria from the roe deer. It also seems that some hosts are better at supporting ticks: an (unpublished) laboratory study revealed that ticks fed on dogs produced more larvae than ticks fed on cats. The individual host´s immune system also plays a role since the more the animal is exposed to ticks, the more the immune system will react to them.

**Questing:** *When a tick like Ixodes ricinus is looking to feed by sitting near the top of a grass blade waving its front legs, ready to latch onto a host.*

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## The distribution of tick species established in the Nordic countries is changing

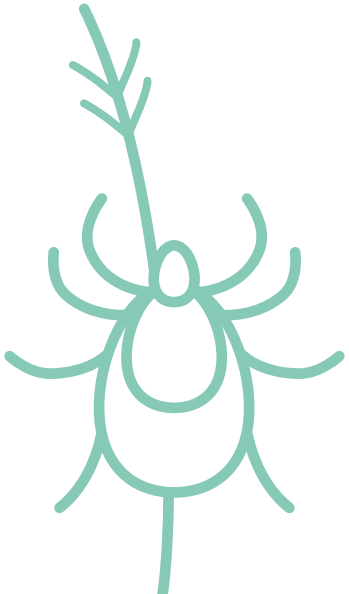
*Ixodid* tick species are expanding north. *I. persulcatus* is generally found further north than *I. ricinus*. They can only be distinguished from one another by experts and by molecular methods, and they have different pathogen profiles. *I. persulcatus* thrives in cold climates and is aggressively spreading across inner Finland, not only coastally where high tick abundance has been found historically. *I. persulcatus* is replacing *I. ricinus* in some areas. In Sweden, where only one finding of *I. persulcatus* had been reported until the 1990s, established populations have been described in 2016, and, according to a tick collection in 2019, it is now the most common tick species in Sweden's northernmost province. Current understanding is that *I. persulcatus* expansion is not driven by climate, but by random events of introduction: It was introduced from the east and can establish and spread from where it happens to land. *I. ricinus* and *I. persulcatus* can mate and create potentially sterile hybrid ticks. This has probably been the reason for the geographical barrier between the two geographical areas of distribution for these two species.

## We can unintentionally create microhabitats supporting ticks

Ticks are not only expanding geographically in the forests and rural areas. There is an anthropogenic effect involved in tick distribution as humans create surroundings in cities and semiurban areas where ticks thrive; examples include parks, gardens and even areas near beaches. Green areas in suburban or urban regions can be created in ways which either support or discourage tick populations. Nature conservation projects with big grazing mammals, like those in Denmark, are expected to support larger tick populations.

**Microhabitat supporting ticks:** *a small geographical area where temperature, humidity, and available hosts make it possible for ticks to thrive.*

By keeping dogs and cats, we can unintentionally create host communities and microhabitats supporting ticks within our gardens and cities. That might be the case when ticks are found on dogs and cats surprisingly far north, where they are not expected based on statistical distribution models developed on data from natural areas.



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# Invasive species of ticks have been found – some may become established

According to Tick maps (europa.eu), *Dermacentor reticulatus*, *Rhipicephalus sanguineus* and *Hyalomma marginatum* have not become established in the Nordic countries. Migratory birds and mammalian wildlife and travelling/imported dogs and cats can bring ticks, and when the climate and hosts are suitable for them where they drop off, they can establish populations. Newly introduced invasive tick species can go unnoticed for some time. In addition to traditional tick surveillance, new species can be found with the help of media awareness and citizens reporting unusual ticks.

## WHEN IS A TICK SPECIES ESTABLISHED?

There is a difference between establishment of self-sustaining tick populations and occasional findings of ticks introduced by travelling/imported animals, migratory birds, or mammalian wildlife. This kind of importation happens every year, but it doesn´t mean that the tick species is locally established. Tick populations are established when they can complete their lifecycle: find a partner, breed, lay eggs and when immature stages later grow into adult ticks entirely within the local geography. If the climate and hosts are suitable where an egg filled tick is dropped off, a population can establish. A slightly warmer climate in the Nordic countries makes it possible that new tick species such as ***Dermacentor* spp.** become established.

## *Dermacentor reticulatus* and *D. marginatus*

*D. reticulatus* has been sporadically found on dogs in Denmark and occasional clinical cases of *Babesia canis* infection, transmitted by *D. reticulatus,* have been detected in dogs with no history of travelling outside Denmark. *B. canis* can cause severe disease in dogs. *D. reticulatus* is not yet established in Denmark, but it is expected to establish soon.

One Norwegian dog, with no history of travelling outside Norway, has been diagnosed with clinical disease caused by *B. canis.* Only southern Norway has historically had a climate warm enough for establishment of *D. reticulatus*. In both Germany and the Netherlands, the distribution of *D. reticulatus* has been expanding northward. It is now found as far north as Hamburg in Germany and also in Latvia and Lithuania. Like Denmark, there is a risk of *D. reticulatus* establishing in Norway, Sweden, and even Finland because of the proximity to the Baltic countries – even though only sporadic cases have been reported so far. Many new tick species can go unnoticed for a long time, but *B. canis* infections are less likely to be missed due to the severity of clinical babesiosis in dogs. *D. marginatus,* a possible host for *B. canis* as well, is currently only a few hundred kilometers behind *D. reticulatus* and could possibly also establish in the Nordic area in the future.

## *Hyalomma marginatum* and *H. rufipes*

*H. marginatum* and less commonly *H. rufipes* have been found in the Nordic countries, imported by migratory birds. Often these ticks are found by horse owners while grooming their horses since adult ticks prefer to feed on large animals. It is expected that there have been *Hyalomma* ticks also on cattle, but they tend to go unnoticed. *Hyalomma* ticks need an area with sustained warmth to establish, which is not expected to happen in the Nordic countries. However, *Hyalomma* ticks will spread north across southern Europe and then more migratory birds can pick them up, so we expect to see more individual ticks in the Nordic countries. *Hyalomma* ticks can transmit several pathogens, which are dangerous especially for humans. Of particular concern are the zoonotic Crimean-Congo haemorrhagic fever virus and Alkhurma haemorrhagic fever virus. Additionally, equine piroplasms (protozoans closely related to *Babesia canis*) can be transmitted by these tick species, causing severe diseases in horses.

## *Rhipicephalus sanguineus*

*R. sanguineus* thrives indoors and can establish in the Nordic countries in indoor locations. It doesn´t necessarily need a dog to travel on, but can also travel in a suitcase from southern Europe or anywhere else in the world. It is important to prevent it, because it is very difficult to eliminate once it has infested a home, kennel, or veterinary hospital. This tick species can transmit human pathogens such as rickettsial bacteria and can also transmit several canine pathogens e.g., *Babesia vogeli*, a milder species of piroplasm, but also parasites such as *Hepatozoon canis* and bacteria, e.g., *Ehrlichia canis*.

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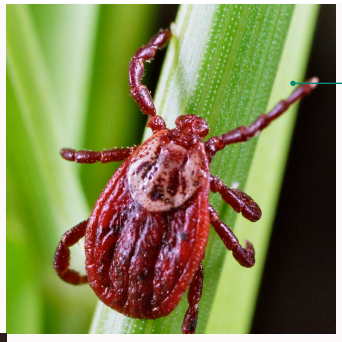
# Treatment of travelling and imported dogs and cats is important to avoid importing foreign ticks and pathogens

It is unfortunate that travelling with and importing dogs and cats without ectoparasitic treatment is allowed. Moving animals around Europe in warming climate is an invitation for introduction of new ticks. This not only exposes the travelling animals to vectors and diseases present at southern latitudes, but risks bringing the vectors and diseases back home to the Nordic countries. Education of pet owners is needed, especially from veterinarians. Many more people would proactively treat their dogs if they knew the risks posed from introducing *Dermacentor* and *Rhipicephalus.*

Black market trade, including smuggling of dogs is huge and risky. *Leishmania* parasites are a risk for importation as well. The sandfly vector is currently not endemic in the Nordic countries, but the infection can transmit directly between dogs in close contact. There are even more diseases of concern. Since travelling with and importing dogs and cats is not well-regulated by authorities, it is important that animal owners seek advice from their vets and treat their dogs and cats with antiparasitic products. Dogs and cats that do not travel outside the Nordics are at increasing risk for parasitic diseases brought into the Nordics by other travelling or imported animals.

## COMMON TICK NAMES



***Dermacentor reticulatus***
Meadow tick or
ornate dog tick
*Danish:* engflåt
*Norwegian:* engflått
*Swedish:* brokig hundfästing

***Rhipicephalus sanguineus***
Kennel tick/brown dog tick
*Danish:* kennelflåt/brun hundeflåt
*Finnish:* ruskea koiranpuutiainen
*Norwegian:* husflått
*Swedish:* kennelfästing/
brun hundfästing

***Ixodes ricinus***
Castor bean tick
*Danish:* skovflåt
*Finnish:* tavallinen puutiainen
*Norwegian:* skogflått
*Swedish:* vanlig/allmän
fästing

***Ixodes persulcatus***
Taiga tick
*Danish:* taigaflåt
*Finnish:* taigapuutiainen
*Norwegian:* taigaflått
*Swedish:* taigafästing

***Hyalomma marginatum***
Giant tick
*Danish:* kæmpeflåt/
jagtflåt
*Norwegian:* jaktflått
*Swedish:* flyttfågelfästing

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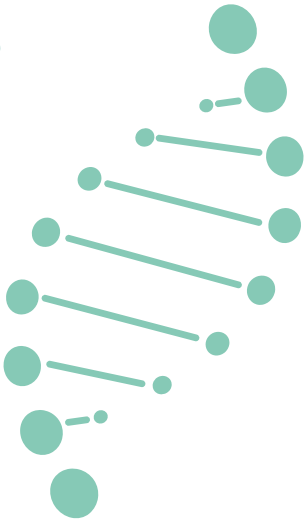
# TICK-BORNE PATHOGENS AND DISEASES AFFECT ANIMALS AND HUMANS



## Tick studies presented in the NordTick conference

Recent studies of ticks collected from dogs and cats in Finland, Denmark, Norway, and Sweden presented in the NordTick conference show the same picture: genetic material of pathogens is commonly found in these ticks.

## Interpretation of laboratory tests

Laboratory tests can find almost everything, but it is important also to consider the clinical relevance. What should be stressed as well is that modern, molecular techniques can detect the presence of genetic material (DNA/RNA) of pathogens, but it is more complicated to determine if the detected material comes from viable/active pathogens or from previous exposure via blood meals. Therefore, a given tick species cannot be declared as a competent vector on the sole basis of DNA/RNA detection of the pathogen within the tick.

## Tick collection methods affect the findings

There are interesting differences between ticks collected by flagging and ticks collected from dogs and cats. For example, more *Rickettsia* in ticks from dogs and cats have been found. The pathogens in attached ticks may come either from the tick or from the animal's blood. Also, species and life stages of ticks and the associated pathogens vary in frequency and intensity based upon the locations and sites where the ticks are collected, whether by e.g., flagging in forests, meadows, hiking or wildlife trails, or whether collected directly from a dog or cat. Dogs often travel around with their owners, while most cats usually stay near their homes. Cats more often pick up ticks in gardens and semiurban areas while dogs may accompany owners and go hiking in forests, running through fields, or play with several other dogs at parks. Differences between locations and the pathogens from such subset of ticks, should be considered in future research.

**Flagging**: *A method used to collect questing ticks directly from nature by dragging a large white sheet, "a flag" through the vegetation.*

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# Most current tick-borne infections in the Nordics are mild in dogs and cats – yet the risk is increasing

Luckily, few serious pathogens and diseases are currently present in the Nordics, but as the presence of tick species and abundance of ticks are increasing, the risk for tick-borne infections and zoonoses increases too. In the Nordic countries, there are currently tick-borne pathogens like *Borrelia* spp., *Anaplasma phagocytophilum*, *Neoehrlichia mikurensis*, *Rickettsia* sp. and more. In general, there can be high seroprevalences in dogs and cats, but most cases are asymptomatic. Therefore, we don´t really know what the true incidence is. However, more people and dogs and cats receive immunocompromising treatments, so we might see some of these otherwise mild or asymptomatic infections manifesting as severe clinical diseases in the future. Furthermore, a proportion of ticks carry multiple pathogens causing potential co-infections, which might make the clinical picture more severe. Co-infections are also a risk when bitten of several ticks at the same time. Co-infections should be investigated further.

**Seroprevalence:** *The proportion of humans or animals with antibodies against a certain pathogen. Antibodies are often present in serum without any signs of disease and may persist long after the infection has resolved.*

## Tick-borne encephalitis virus prevalence is increasing in humans

Clinical tick-borne encephalitis (TBE) is rare in dogs and uncommon in humans. However, more human cases are being seen despite increased vaccination, because tick-borne encephalitis virus (TBEV) is spreading to new areas in the Nordic countries. In Åland, Finland, as many as 40% of dogs have antibodies against TBEV, but only one fatal case in a Finnish dog has been described (unpublished). In Sweden, one fatal case in a dog has been published. Clinical disease caused by TBEV is of high concern due to the potential severity of the clinical course, including death.

In an ongoing study of seroprevalence in healthy Norwegian dogs, cats, and horses, the preliminary results from Agder, southern Norway, show that 21% of the surveyed dogs are seropositive for TBEV. This is surprisingly high. Cross-reactivity with other flaviviruses like louping ill virus (LIV) may be possible. LIV is zoonotic, of major veterinary interest and used to be highly prevalent in Norway. Co-infections of LIV and *Anaplasma* can cause severe disease in sheep.

## *Borrelia* spp. is commonly asymptomatic in dogs, but can cause clinical disease

In the United States (US), a higher tick burden has increased the incidence of clinical borreliosis in dogs (Companion Animal Parasite Council | Parasite Prevalence Maps (capcvet.org). American dogs develop arthritis probably because the genospecies *Borrelia burgdorferi sensu stricto* is more common in the US than elsewhere. This genospecies is present in the Nordic areas too, as are many other *Borrelia* genospecies. The infection risk is clear, but the relevance

of the clinical problem in animals and the contribution of each genospecies is under debate. Clinical borreliosis cases are seen in dogs, although most infections are asymptomatic. If a dog develops signs, the disease is generally mild with fever and limping. Some veterinary clinics use Point-of-Care tests and treat dogs with antibiotics. As always, the clinical picture is more important than the test result.

## *Anaplasma phagocytophilum* infects dogs, cats, horses, and humans

Clinical granulocytic anaplasmosis is not common in dogs and cats, although *A. phagocytophilum* can be seen in blood tests in granulocytes. Co-infections with TBEV might lead to more severe cases. Clinical anaplasmosis is clearly defined in horses – symptoms include fever, anemia, ataxia, and swelling. High seroprevalences are seen in Swedish horses, and equine clinics see cases every week during season. In humans, anaplasmosis in Europe is usually an asymptomatic or mild disease with fatigue and a short fever. Clinical picture may differ depending on *A. phagocytophilum* variants.

## Other detected tick-borne infections

***Rickettsia helvetica*** is endemic and is not known to be pathogenic for dogs or cats. While most cases are asymptomatic or mild in humans, central nervous system and cardiac infections have been reported. Also, other Rickettsial species exist.

***Neoehrlichia mikurensis*** is a newly found pathogen. There is one report about this pathogen in dogs, and not much is currently known about the clinical relevance. A study in humans in Norway showed that not all erythema migrans-like skin alterations are caused by *B. burgdorferi*, but in 20% of the cases, *Neoehrlichia* was found instead. In those cases, doxycycline was needed, as these cases were not responsive to penicillin.

There will be an increasing risk of ***Babesia canis*** infections in dogs in the Nordic countries if *D. reticulatus* is established. Infections are emerging in Denmark already, one case has been seen in Norway, and occasional cases in travelling/imported dogs are being diagnosed in Finland too.

*R. sanguineus* is the main vector for ***Hepatozoon canis***, but other tick species may also be involved. One Swedish dog with no history of travelling outside Sweden has been diagnosed with hepatozoonosis, and the pathogen has been found in rodents in Finland as well. The pathogen transmission to dogs is different compared to other tick-borne infections: the dog needs to eat the tick, and hence the pathogen is not transmitted through the tick bite.

**Alongshan virus**, causing severe fever with thrombocytopenia, was originally detected in China, but now has also been found in South America, and in *I. persulcatus* ticks in Finland together with *Anaplasma*. The virus is pathogenic for animals and humans.

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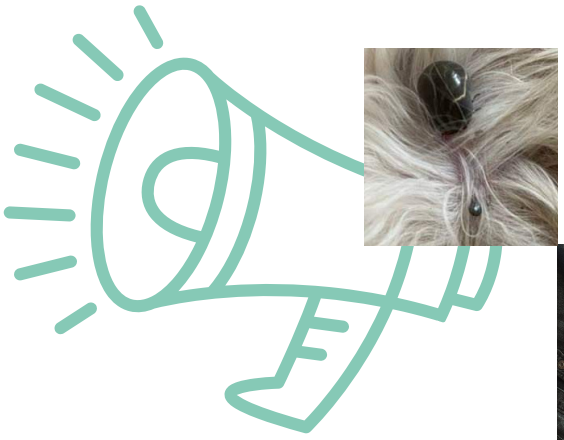
# TICKS AND TICK-BORNE DISEASES CAN BE PREVENTED – COMMUNICATION IS NEEDED

## One Health approach and balanced communication to the public

Since ticks and tick-borne diseases can affect both animals and humans within their shared environment, a One Health approach is important. Pet owners are often most concerned about their dogs and cats, but they should take care of themselves too. Balanced, non-scary and preferably positive education and communication is needed to ensure that people obtain information that helps them identify hazards correctly and increases their ability and willingness to decrease their exposure and thus decrease their risk.

People are more easily reachable through risks related to their dogs and cats; children can also share information they learn at school. We should emphasize the health benefits obtained from enjoying time in nature, with or without dogs, and just take a few reasonable precautions like being extra careful when barefoot or in sandals, tuck trouser legs into socks, and check ourselves and our family members for ticks once a day. Extra vigorous checking is needed after walking or cycling off road in a tall grassy vegetation. We also need to check ourselves after spending time in gardens, parks, fields, or forests known to harbour ticks.





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## Treatment of dogs and cats against ticks can indirectly protect humans

When a dog or cat is treated against ticks with an efficacious product, the animal gets protection. This also indirectly protects the owner by killing a portion of the ticks in the garden and by killing ticks which might drop off the animal and attach to a person. Dogs and cats get ticks in gardens, where they are often the only big mammals supporting the tick lifecycle. If dogs and cats are not treated, they could support the tick lifecycle and contribute to an increased tick population. Ticks and tick-borne pathogens, however, find their way to survive anyway, and in the wild there are many more hosts than just dogs and cats.

## Travelling with and importing dogs and cats is risky – education is needed

Dog and cat owners need education on the risks and the treatments recommended against ticks if they travel with animals, or whenever they import animals. It is important for dogs and cats and their owners not to bring ticks, tick-borne pathogens, and other vector-borne pathogens, such as *Dirofilaria sp.* and *Leishmania infantum,* to the Nordic countries. Currently only rabies vaccination (and in Finland and Norway treatment against *Echinococcus*) is mandatory for pets crossing borders. This does not prevent introduction of non-endemic ticks and tick-borne pathogens.

## Research, surveillance, and information sharing are needed

Nordic gap analysis projects regarding ticks and tick-borne infections in a One Health collaboration are needed, including topics such as what do we know, what do we need to know, what basic research is needed, streamlining, and validating the protocols for all the pathogens, and where to spend research resources most effectively.

We should have continued, systematic tick collection and surveillance which includes sharing the information about hot spots and new disease risk areas right away. Citizens can help by reporting tick findings via dedicated web sites and applications, possibly with the help of artificial intelligence.

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## Animals can be used as sentinels for infections relevant to humans

Both the exposure of humans to ticks and prevalence of human tick-borne infections are usually low. Animals are more commonly exposed to ticks than people. Therefore, it is sensible to use animals as sentinels to monitor the infection risk for humans. For example, based on a TBEV sequence from the first clinical human case from Kuhmo, Eastern Finland, it could be deduced that the virus had been there for years before being picked up by a human. Sentinels could be roe deer, reindeer, rodents, bulk milk from grazing dairy cattle, sheep and goats, horses, and cats. Dogs may move around too much with their owners to be reliable local sentinels.

## Preparedness for emerging ticks and diseases in dogs, cats, horses, and humans is needed

Emerging diseases and tick species affecting dogs, cats, horses, and humans need to be considered and prepared for. Authorities focus on production animals and have no action plan for infections relevant for dogs, cats, and horses. Examples necessitating action plans include *Babesia canis* in dogs, and emergence of American and Asian tick species in Europe – like seen with the Asian tiger mosquito over the past decades.

The dog and cat populations are increasing, and it is a big business: dogs, cats, and horses generate a huge economic turnover bringing about livelihood for many people. We have seen different disease outbreaks in humans during the past several years, and we should be prepared with plans for emerging diseases in dogs, cats, and horses too. Furthermore, pets and people live closely together, which necessitates a One Health approach.

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