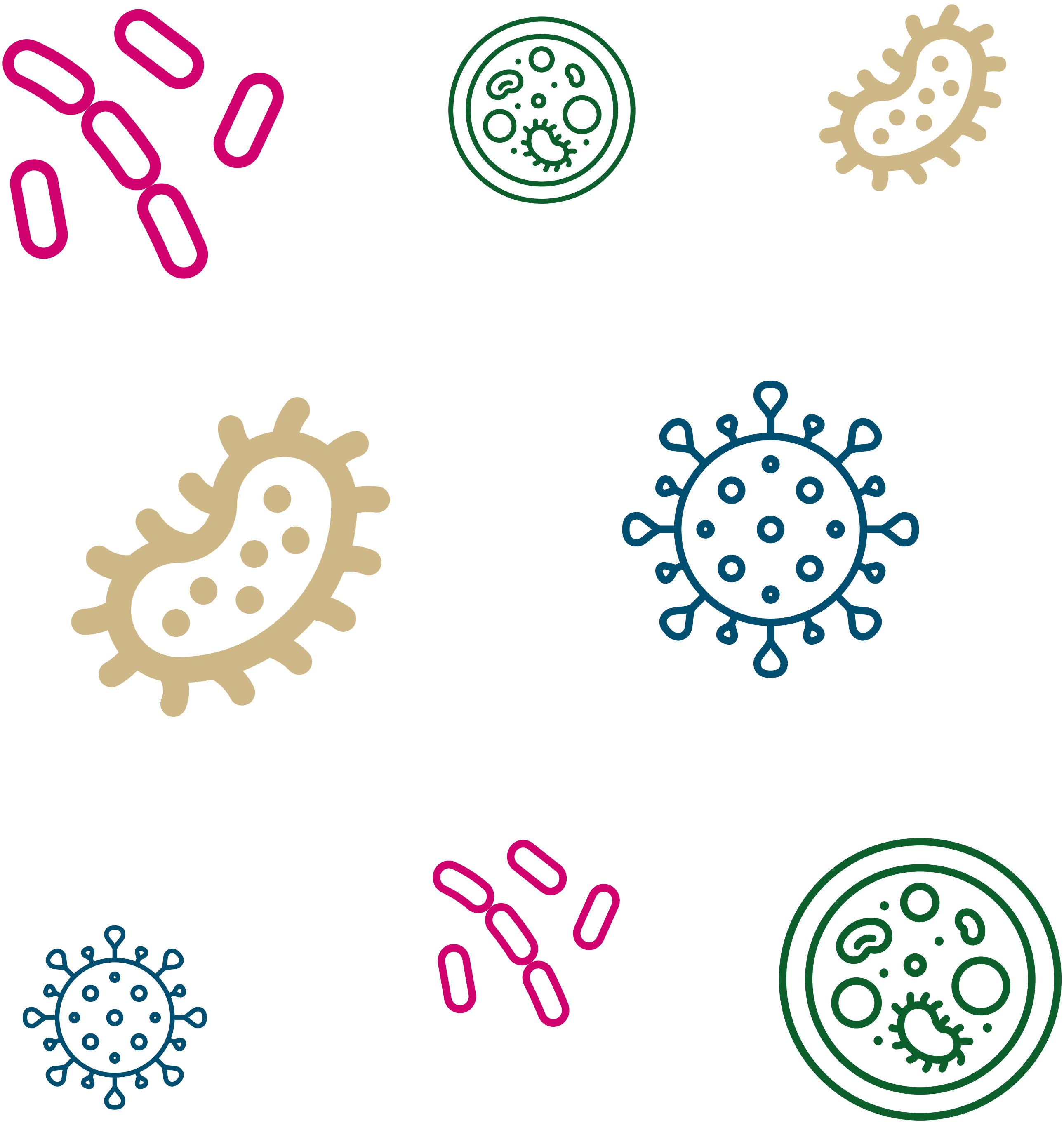
FINNISH FOOD AUTHORITY
Ruokavirasto • Livsmedelsverket

Research Reports
4/2023

Zoonoses on Finnish fur farms – risk profile



We thank all operators and experts who contributed information or comments for this risk profile. We also thank the Finnish Food Authority's Animal Health Diagnostic Unit for providing laboratory results.

This risk profile was commissioned by the Finnish Food Authority's Animal Health and Welfare Department and funded by the Finnish Food Authority.

This report is based on information available in March, 2023. As more information becomes available, the conclusions presented in this report may over time turn out to be outdated.

Finnish Food Authority Research Reports 4/2023

Zoonoses on fur farms – risk profile

FINNISH FOOD AUTHORITY
Ruokavirasto • Livsmedelsverket

Description

Publisher	Finnish Food Authority, Risk Assessment Unit
Authors	Heidi Rossow, Leena Seppä-Lassila, Suvi Joutsen, Terhi Järvelä, Pirkko Tuominen
Title of publication	**Zoonoses on fur farms – risk profile**
Series and publication number	Finnish Food Authority Research Reports 4/2023
Publications date	3/2023
ISBN PDF	978-952-358-051-0
ISSN PDF	2490-1180
Pages	44
Language	English
Keywords	Fur farming, zoonosis, disease risk, transmission route, disease control
Publisher	Finnish Food Authority
Layout	Finnish Food Authority, In-house Services Unit
Distributed by	Online version: foodauthority.fi

Abstract

This risk profile assessed the disease risk to humans caused by fur farming in Finland. Fur farming creates favourable conditions for the spread of pathogens and the mutation of some of them. Mink in particular is an effective reservoir for many different viruses. As very few samples are taken from fur animals for disease examination, it is not possible to estimate the presence of diseases in Finnish fur animals.

Pathogens and other microbes, which are transferred between humans and fur animals, are especially respiratory viruses, faecal pathogens, and antimicrobial resistant bacteria. They pose a health risk to fur farm workers and their contacts. In particular, influenza viruses in fur animals can transform into a serious and easily spreading disease, which is also contagious to other mammals.

The main sources of pathogens for fur animals are people, feed, and other animals. In fur farms, biosecurity measures are often insufficient. The enhancement of biosecurity and proper risk management of the feed chain would improve the prevention of infections.

Kuvailulehti

Julkaisija	Ruokavirasto, riskinarvioinnin yksikkö
Tekijät	Heidi Rossow, Leena Seppä-Lassila, Suvi Joutsen, Terhi Järvelä, Pirkko Tuominen
Julkaisun nimi	**Turkistarhojen zoonoosit – riskiprofiili**
Julkaisusarjan nimi ja numero	Ruokaviraston tutkimuksia 4/2023
Julkaisuaika	3/2023
ISBN PDF	978-952-358-051-0
ISSN PDF	2490-1180
Sivuja	44
Kieli	Englanti
Asiasanat	Turkistarhaus, zoonoosi, tautiriski, tartuntareitti, tautisuojaus
Kustantaja	Ruokavirasto
Taitto	Ruokavirasto, käyttäjäpalvelujen yksikkö
Julkaisun jakaja	Sähköinen versio: ruokavirasto.fi

Tiivistelmä

Riskiprofiilissa arvioitiin turkistarhauksen aiheuttamaa tautiriskiä ihmisille Suomessa. Turkistarhaus luo otolliset olot taudinaiheuttajien lisääntymiselle, leviämiselle ja useiden taudinaiheuttajien muuntumiselle. Erityisesti minkki on tehokas useiden eri virusten säilymö. Turkiseläimistä otetaan hyvin vähän näytteitä tautitutkimuksiin, joten niiden perusteella ei voida päätellä tautien esiintymisestä suomalaisilla turkistarhoilla.

Ihmisten ja turkiseläinten välillä leviäviä taudinaiheuttajia ja muita mikrobeita ovat erityisesti hengitystievirukset, ulosteperäiset taudinaiheuttajat ja antibiooteille resistentit bakteerit. Ne aiheuttavat terveysriskin turkistarhojen työntekijöille ja heidän lähipiirilleen. Erityisesti influenssavirukset voivat turkistarhaoloissa muuntua vakavaksi eri nisäkkäisiin helposti leviäväksi taudiksi.

Turkiseläinten taudinaiheuttajien tärkeimpiä lähteitä ovat tarhalla käyvät ihmiset, rehu ja muut eläimet. Turkistarhoilla tautisuojaustoimenpiteet ovat usein puutteellisia. Niiden kohentaminen ja rehuketjun asiallinen riskinhallinta parantaisivat taudeilta suojautumista.

Beskrivning

Utgivare	Livsmedelsverket, enheten för riskvärdering
Författare	Heidi Rossow, Leena Seppä-Lassila, Suvi Joutsen, Terhi Järvelä, Pirkko Tuominen
Publikationens titel	**Zoonoser på pälsdjursfarmar – en riskprofil**
Publikationsseriens namn och nummer	Livsmedelsverkets forskningsrapporter 4/2023
Utgivningsdatum	3/2023
ISBN PDF	978-952-358-051-0
ISSN PDF	2490-1180
Sidantal	44
Språk	Engelska
Nyckelord	Pälsdjursuppfödning, zoonos, sjukdomsrisk, smittväg, smittskydd
Förläggare	Livsmedelsverket
Layout	Livsmedelsverket, enheten för interna stödtjänster
Distribution	Elektronisk version: livsmedelsverket.fi

Referat

I riskprofilen utvärderades sjukdomsrisken för människor orsakade av pälsdjursuppfödning i Finland. Pälsdjursuppfödning skapar gynnsamma förutsättningar för förökning och spridning av patogener och andra mikrober, och deras omvandling. I synnerhet är mink en effektiv reservoar för många olika virus. Endast få prover tas från pälsdjur för undersökning av sjukdomar, så man inte kan dra slutsatser om förekomsten av sjukdomar i finska pälsfarmer.

Patogener och andra mikrober som särskilt överförs mellan människor och pälsdjur är respiratoriska virus, fekala patogener och antibiotikaresistenta bakterier. De orsakar en hälsorisk för pälsfarmararbetare och deras närmaste krets. Särskilt influensavirus kan på pälsfarmen mutera till en allvarlig och lättspridande sjukdom som också smittar andra däggdjur.

De huvudsakliga källorna till patogener hos pälsdjur är människor på pälsfarmar, foder och andra djur. Smittskyddsåtgärderna på pälsfarmar är ofta otillräckliga. Förbättring av smittskydd och ordentlig riskhantering av foderkedjan skulle förbättra skyddet mot sjukdomar.

Content

1 Terms and abbreviations

Definitions of the terms and abbreviations used in this report

Antibiotic resistance	The ability of microbes to resist the effects of antimicrobials.
Cadaver	A fur animal that has died of natural causes or was culled and has not been pelted.
Carrier	An asymptomatic human or animal infected with a pathogen.
Category 1 by-products	For example, TSE risk material, specified risk material and animals containing specified risk material, mixtures of category 1 and 2 and category 1 and 3 material, pets, infected wild animals, and animal by-products that contain prohibited substances or environmental contaminants in excess of the limits laid down in legislation.
Category 2 by-products	Animal by-products, for example, animals that have died of natural causes or have been culled, parts of animals rejected in a meat inspection because of infection, manure and other intestinal content, animals with a disease risk other than TSE risk, mixtures of category 2 and category 3 material, by-products containing residues of antibiotics or medicinal products in excess of the limits laid down in legislation. Category 2 by-products suitable for use as feed may be used as feed for fur animals.
Category 3 by-products	Animal by-products from animals approved for human consumption that are not used for human food. Category 3 by-products originate in slaughterhouses, meat and fish production facilities or other food production facilities, hatcheries and egg packing facilities, and processing plants. They can be used as feed for pets or fur animals and as feed for food-producing animals within certain limits.
cfu	Colony-forming unit.
Contamination	Presence of a microbe or substance in an unwanted place or material.
ESBL	Extended-Spectrum Beta-Lactamase, an enzyme produced by bacteria that can break down antibiotics and cause antibiotic resistance.
Fur animal carcass	A fur animal that has been pelted.
GAP	Good Agricultural Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Points
Import	EU internal trade and non-EU country imports
Internal market trade	Trade between EU and EEA countries.
Isolate	A pure culture of a single microorganism.

Microbe	A microscopic organism such as a bacterium, a virus, a protozoan, or a microfungus.
MRSA	Methicillin-resistant *Staphylococcus aureus*
Mutation	Microbial mutation is a change in the genetic material of a microbe.
Pandemic	An epidemic that becomes global.
Pathogenic	Capable of causing a disease.
Pests	An animal in a place where it could be detrimental to human activity, e.g. rodents, birds, insects or pets on a fur farm.
Reservoir	An organism or an environment in which pathogens reproduce and/or remain transmissible.
RNA virus	A virus that has ribonucleic acid as genetic material.
SARS-CoV-2	The Severe Acute Respiratory Syndrome Coronavirus 2 that causes the COVID-19 disease.
Serotype	Term used in connection with Salmonella classification.
Third country imports	Imports from non-EU and non-EEA countries.
TSE	Transmissible spongiform encephalopathies or prion diseases that include the transmissible mink encephalopathy (TME) that causes central neural system symptoms in mink.
WOAH	World Organisation for Animal Health (previously OIE).
Zoonosis	A disease than can spread between animals and humans.
Zoonotic pathogen	A pathogen that can be transmitted between animals and humans (a bacterium, virus, parasite, fungus, prion).

2 Introduction

The role of fur farming and especially mink in the circulation of zoonotic pathogens was highlighted during the SARS-CoV-2 pandemic. The shelters of animals on fur farms are quite exposed, and as carnivores, their feed includes large quantities of by-products of animal origin that can also include zoonotic pathogens. Especially mink are susceptible to viruses carried by humans and other animals, which can make them mixing vessels enabling reassortment and mutation of viruses.

This project examined zoonotic pathogens significant to public health whose route of transmission enables them to be transmitted to fur animals and from them to humans. These include respiratory viruses and faecal pathogens. In addition, antibiotic resistance, and the MRSA and ESBL bacteria found especially in livestock production were examined. Zoonotic diseases that can be found in fur animals but that are unlikely to be transmitted from fur animals to humans (e.g. toxoplasmosis and botulism) were excluded, as were diseases such as rabies that are not currently occurring in Finland. Other health hazards may be present on fur farms, most of which are a risk only to individual employees; these were also excluded in this project.

This project focused on assessing the disease risk to humans posed by fur farming in Finland. The high animal density on fur farms enables high transmission rates and provides suitable conditions for pathogens to mutate. Preventing the transmission of pathogens both between animals and between employees and animals can sometimes be challenging in fur farming.

3 Fur farming in Finland and globally

There are approximately 550 fur farms in Finland. The primary animals farmed for fur in Finland are mink (*Neovison vison*), raccoon dogs (Finnraccoon, *Nyctereutes procyonoides*), foxes (*Vulpes vulpes*), and arctic foxes (*Vulpes lagopus*). In addition, the silver fox colour variant of fox and blue fox variant of arctic fox are bred and cross-bred. By the number of individual animals, mink and blue fox are the most significant fur animals in Finland, with more than a million individuals annually. In addition, in 2021, there were 50,000 blue foxes and 100,000 each of raccoon dogs and colour variant foxes.

Finland is the only country in Europe that has the European Commission's authorisation to farm raccoon dogs for fur, as the raccoon dog is an invasive alien species. Most fur farms are near the west coast, in Ostrobothnia, South Ostrobothnia, Central Ostrobothnia, and North Ostrobothnia. The number of fur farms in Finland has reduced in recent years.

The number of animals on fur farms varies according to the farms' production stages, and it is at its lowest early in the year before litters are born and at its largest after the litters are born and before pelting at the end of autumn. In this assessment, we used the annual number of living animals on the fur farms as the number of animals, which in practice is the combined number of dams and their offspring.

On fur farms, the animals are kept in cages with a wire mesh floor that allows faeces and urine to fall under the cage. The cages are often placed in two rows in roofed sheds with no walls on either side. Mink are also kept in cages in large barns, in which case the faeces is removed and taken outside the building. According to legislation, the cages must have a nest or shelf and additional enrichment devices such as sticks or other objects (Valtioneuvoston asetus turkiseläinten suojelusta 1084/2011, 2011 [Government Decree]).

Fur farming is prohibited in 16 European countries, in addition to which several countries have adopted legislation that significantly restricts fur farming or are planning to prohibit fur farming entirely in the near future. Finland is currently one of the largest fur production countries in Europe (EFSA and ECDC, 2021), but fur animals or samples from them are only rarely tested for zoonotic pathogens. Sick animals are culled on the farms and not sent to be examined, which is why there is a very limited amount of information about the pathogens possibly carried by fur animals.

4 Zoonoses

Zoonoses are diseases that can be transmitted between humans and animals. They can be caused by a virus, a bacterium, a parasite, a fungus or a prion. Zoonoses can be transmitted directly between animals or humans, or indirectly through feed or work equipment, for example. Many infectious diseases that are found in fur animals are potentially zoonotic. Mink farmed for fur are susceptible to many pathogens from humans and other animal species (Fenollar et al., 2021). Avian influenza, swine influenza and SaRS-CoV-2 have caused high mortality rates in mink farmed for fur (Agüero et al., 2023a; Clayton et al., 2022; Cossaboom et al., 2022; Oreshkova et al., 2020; Åkerstedt et al., 2012). In addition, Aujeszky's disease (or pseudorabies, caused by Suid herpesvirus 1) has caused high mortality in farmed mink (Wang et al., 2018). According to reports made to the WOAH, bovine tuberculosis, echinococcosis, mycoplasma infections, influenza A infections (e.g. several strains of avian influenza, both high and low pathogenic), leptospirosis, paratuberculosis, rabies, SaRS-CoV-2 infections, trichinosis, and tularaemia have been found in wild mink, foxes and raccoon dogs. Very little research data exist on fur animal zoonoses, so the overall situation is unknown.

4.1 SARS-CoV-2

Coronaviruses are common pathogens for various animals. They are enveloped RNA viruses and usually rather host-specific, but SARS-CoV-2 has been capable of transmitting to an unexpected number of species, including humans.

Mink are innately very susceptible to SARS-CoV-2 infections. Of all fur animals, they are the most susceptible to being infected with SARS-CoV-2 and to transmitting the coronavirus to humans and other animals (EFSA AHAW Panel et al., 2023). The virus replicates effectively in the mink respiratory system, and a strain mutated in mink has been proved to have been transmitted back to a human (EFSA AHAW Panel et al., 2023; Koopmans, 2021; Oude Munnink et al., 2021). The source of SARS-CoV-2 infection for animals kept in captivity is almost always a human; after the first infection, the virus spreads between the animals in their enclosures (Cossaboom et al., 2022; EFSA and ECDC et al., 2021; Hobbs & Reid, 2021; Mahdy et al., 2020).

Early in the pandemic, SARS-CoV-2 caused wide-scale epidemics on mink fur farms in the Netherlands, Denmark, Italy, Spain, Sweden, the United Kingdom, Greece, France, Lithuania and Poland, among others (EFSA and ECDC et al., 2021; Pomorska-Mól et al., 2021). After the virus enters a fur farm, it spreads quickly between the animals through direct contact or droplets, aerosols or dust. For example, in the Netherlands, more than half of all mink farms in the country had reported infections in just a few months (Lu et al., 2021; Sikkema et al., 2022). The epidemic also progressed similarly in Denmark (Boklund et al., 2021). The clinical symptoms of infected mink vary from a slight nasal discharge to severe pneumonia and death. Most mink with a SARS-CoV-2 infection had rather unspecific symptoms such as reduced feed consumption and various respiratory symptoms. In the reported cases, the infection spread quickly to almost all the animals on the farm. The mortality rate of adult mink was approximately two% in the Netherlands, whereas the normal rate is 0.6% (Oreshkova et al., 2020). In necropsy, acute pneumonia was found to be the primary cause of death (Molenaar et al., 2020). Experiences from Denmark and the Netherlands have proved that after the virus enters a farm, it may be impossible to stop its spread.

In an extensive epidemiological study of 12 farms carried out in the United States, mink were found to show symptoms very quickly, only one to two days after an infected employee had been less than two metres away from the animals (Cossaboom et al., 2022). It is also possible that the animals were infected before the employee started showing symptoms. In some cases, the high mortality rate was the first symptom observed by the farmer, but in other cases, the mink also showed clear signs of illness such as coughing and reduced feed consumption before the mortality rate increased. The mortality rate can vary greatly between farms, and a farm's plasmacytosis (Aleutian disease) situation and production stage can affect it. The omicron variant has also been proved to transmit to mink (Virtanen et al., 2022) and to cause a similar disease as other SARS-CoV-2 variants. In experimental exposure, the omicron variant was also found to be highly transmissible between individuals by aerosols.

By August 2022, SARS-CoV-2 had caused outbreaks on 500 mink farms in 12 countries (Cossaboom et al., 2022). Compared to mink, significantly less information exists about the susceptibility of foxes and raccoon dogs to SARS-CoV-2, but infections have been found in both species (WOAH, 2023a). In experimental exposure, SARS-CoV-2 was found to infect raccoon dogs, which were asymptomatic but still infectious, i.e. they are a possible reservoir (Freuling et al., 2020). Fur farms are feared to become SARS-CoV-2 reservoirs in which the virus mutates and from which it is then transmitted back to humans (EFSA AHAW Panel et al., 2023; WOAH, 2020).

The SARS-CoV-2 tests carried out in Finland in between 2020 and 2022 are presented in Table 1. The share of tested individuals of the total population was 0.03% for mink and 0.01% for farmed raccoon dogs in 2020, and 1% of mink and 0.9% of farmed raccoon dogs in 2021. The data for 2022 was not accessible at the time this report was drafted. By February 2023, no SARS-CoV-2 infections had been found on Finnish fur animals. The final number of analysed samples was significantly smaller than the number proposed in the monitoring plan (Finnish Food Authority, 2021b) A small number of samples enables the detection of an infection only if the disease is already highly prevalent on the farm (Finnish Food Authority, Risk Assessment Unit, 2020).

Table 1. *Number of samples from animals tested for SARS-CoV-2 by the Finnish Food Authority. Source: Laboratories of the Finnish Food Authority.*

Species	2020	2021	2022
Mink	284	9,551	8,442
Raccoon dog	18	875	1,735
Fox	-	-	5

4.2 Influenza viruses

Influenza viruses are highly mutable RNA viruses that have caused several pandemics. Many of the influenza viruses circulating in animals can occasionally infect humans and cause a disease that can vary from mild to severe. These viruses can also cause pandemics such as the 2009 influenza pandemic, which was caused by the influenza A (H1N1) 2009 virus that was transmitted from pigs to humans. Mink have been proved to be highly susceptible to human, swine and avian influenza viruses (Agüero et al., 2023a; Clayton et al., 2022; Sun et al., 2021). Influenza viruses can spontaneously mutate in mink so that they are more readily able to transmit to other mammals as well. Alternatively, different influenza viruses can reassort if an individual mink is simultaneously infected with viruses from different sources. This can result in an influenza virus with a new combination of genes, which could have pandemic potential (WOAH, 2023b). Mink farms can act as a reservoir for pandemic viruses even after the pandemic passes. For example, the pandemic influenza A (H1N1) 2009 virus (swine influenza) caused an epidemic on a mink farm in Canada in 2011 (Åkerstedt et al., 2012). In 2015, a H5N1 subtype influenza virus caused an outbreak on two mink farms in China. In both cases, the mink mortality rate was very high: 56% (128/230) and 64% (242/376) (Jiang et al., 2017). In 2019, the pandemic influenza A (H1N1) 2009 virus caused an epidemic on a mink farm in Utah (Clayton et al., 2022). In three weeks, ten% of mink kits on the farm died. In necropsy, the kits' cause of death was found to be acute pneumonia. The source of the infection was suspected to be a farm employee, as the employee had respiratory symptoms at the time of the event.

In 2022, an outbreak of the highly pathogenic A (H5N1) avian influenza virus occurred on a Spanish mink farm (Agüero et al., 2023a; Xunta de Galicia, 2022). The mink on the farm had respiratory symptoms, a loss of appetite, central nervous system symptoms and a higher mortality rate. The infection spread between individual animals, and new mutations of the virus were found compared to a similar virus isolated from birds (Agüero et al., 2023b; Vries & Haan, 2023). The avian influenza A virus (H5N1) has also been found to be capable of infecting foxes, in which it causes serious neurological symptoms (EFSA, 2022; Rijks et al., 2021). Influenza infections caused by the virus type have also been found in raccoon dogs (EFSA, 2022). In recent years, avian influenza has also been found to be more readily transmitted to other mammals, which is worrying because cross-species transmission is associated with an increased risk of mutation (ECDC, 2022a). H5N1 seems to have already developed the ability to transmit between mammals. This is a mechanism that enables the virus to potentially cause an avian influenza pandemic.

In recent years, highly pathogenic avian influenza has been found in wild birds in Finland (Rossow et al., 2023; Finnish Food Authority, 2022c). The largest avian influenza epidemic in Europe has been ongoing since the autumn of 2020 and has killed millions of birds and resulted in the need to cull a large number of birds in the poultry industry (EFSA, 2022). The number of reported avian influenza (H5N1) infections in mammals has also been increasing globally (WOAH, 2023b). Between 2017 and 2022 in Finland, the highly pathogenic avian influenza (H5N1) was found in a wild Eurasian lynx, a wild Eurasian otter and two red foxes, which died showing neurological symptoms (Tammiranta et al., 2023). This was considered a sign of an increased risk of spillover from birds to mammals. In recent years, the avian influenza virus has been found more often in samples taken from the brains of infected mammals than in samples taken from other tissue types (ECDC, 2022b).

In Finland, fur animals are tested for influenza very rarely. No animals were tested in 2022, samples from four mink were tested in 2021, and one mink was tested for influenza in 2020. Between 2017 and 2022, samples from only 22 fur animals were tested for influenza. Besides mink, no other fur animals have been tested for influenza in the last five years. The share of the tested animals has been 0–0.0004% of the total population. Since the size of the fur animal population is in the millions, it can be said that there is virtually no information about the influenza situation of Finnish fur animals. The symptoms of an influenza infection can be mild, or the infection may be asymptomatic, in which case no animals are tested in a system where tests are carried out when required.

4.3 Salmonella

Salmonella bacteria are among the most significant causes of food poisoning in industrial countries, which is why there has been major investment in food production to combat them in Finland since the 1950s. In 1994, Finland introduced a national Salmonella Control

Programme with the aim of keeping its prevalence below one per cent in pork, beef and poultry meat production and egg production. For years, the prevalence rate has remained below the target. Because of the control programme, products derived from certain animals may not be imported into Finland unless the products have been tested and proved free of salmonella.

Salmonella is a bacterium species found in humans and several animal species. Salmonella are classified into approximately 2,500 serotypes that vary in virulence and environmental persistence. Salmonella can also reproduce in habitats other than the gastrointestinal tract (Semenov et al., 2010). The symptoms of a salmonella infection vary from no symptoms to fatal symptoms, depending on the salmonella serotype and the individual infected. Salmonella usually cause a gastrointestinal infection with diarrhoea and a fever also in mink. Other possible symptoms include loss of appetite, fatigue, vomiting, and spontaneous abortion and endometritis. Mink seem particularly susceptible to salmonella infections when they are pregnant (Dietz et al., 2006), and the risk of spontaneous abortion is high.

All fur animals can be infected with salmonella, but the Finnish Salmonella Control Programme does not apply to them. Animal production with high animal density is considered a possible salmonella reservoir and a source of salmonella infections of humans and other animals. Agga et al. (2022) proved that salmonella infections found in mink were connected to salmonellosis found in humans and certain other animals. Finnish studies have also found connections between the salmonella infections of production animals and fur animals (Pelkonen et al., 2022; Ranta et al., 2020) but were unable to prove the direction of transmission.

In Norway, salmonella was found in samples taken from faeces of wild red foxes, especially in the late winter (10.5% positive in February and 14.3% in March) (Handeland et al., 2008). In Poland, prevalence in foxes was lower – 2.45% of rectal swabs taken from foxes tested positive for salmonella (Nowakiewicz et al., 2016).

In a US mink farm study, 26.2% of the analysed faeces samples tested positive for salmonella (Agga et al., 2022). In Poland, salmonella bacteria were found in 16.5% of samples collected from the fresh faeces of asymptomatic farmed silver foxes (Siemionek et al., 2020). In farmed silver foxes, experimental infections were asymptomatic (Handeland et al., 2008).

Danish fur farms had an extensive salmonella epidemic in 2000. The source of infection could not be identified, but a compound feed plant that produced the feed used on the farms was strongly suspected (Dietz et al., 2006).

In Finland, salmonella infections are found on a few fur farms each year (Finnish Food Authority, 2020a, 2021a). In 2021, a larger epidemic affecting dozens of farms was discovered that was possibly associated with the feed used (Finnish Food Authority, 2022b). Salmonella testing carried out on fur animals and the share of positive samples are presented in Figure 1. The number of tested samples is small. The number of tested samples has reduced for all species, while the number of positive results has increased. The large number of positive test results seen in 2021 reflects the epidemic related to feed.

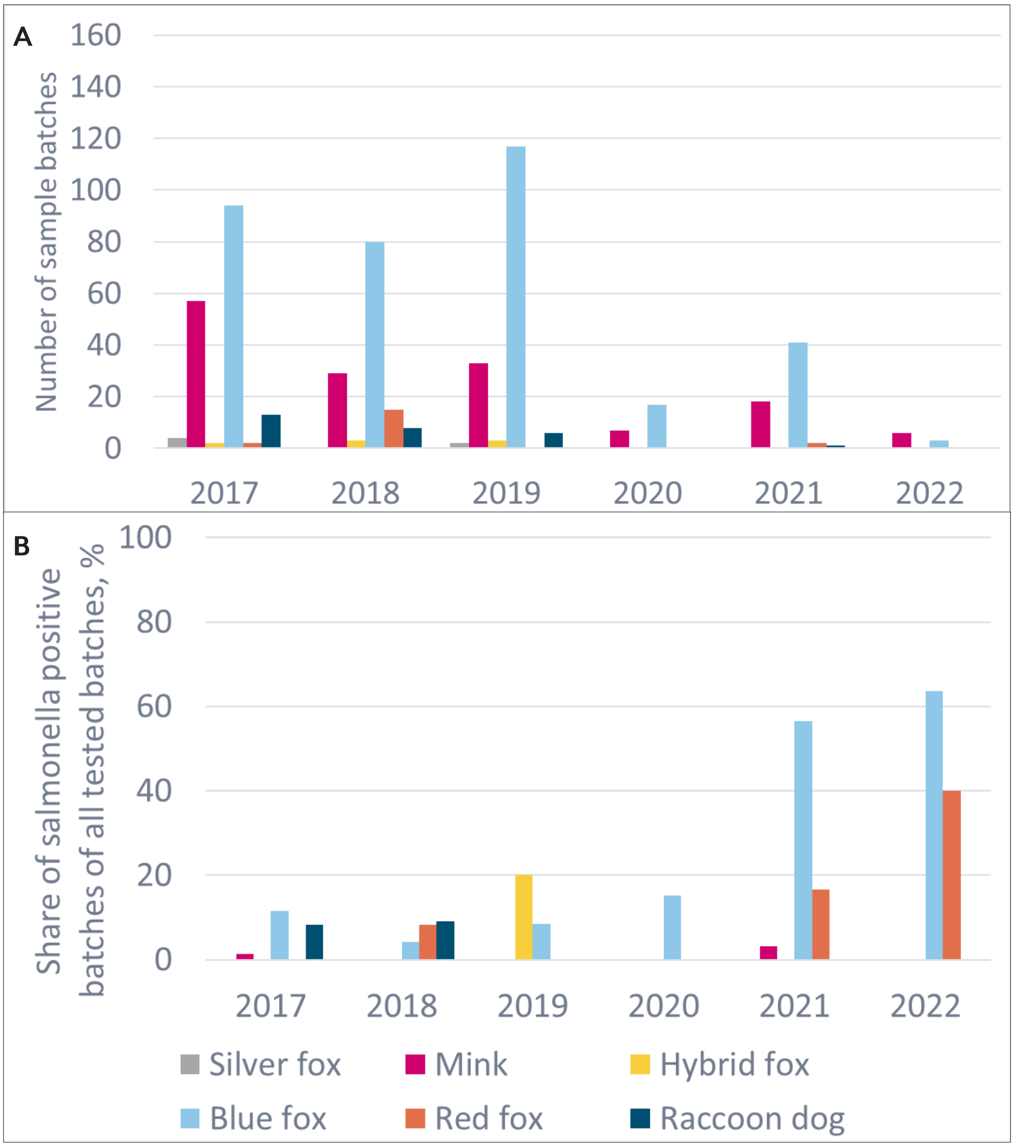


Figure 1. *Number of sample batches tested for salmonella (A) and share of salmonella-positive sample batches of all tested samples (B) in 2017–2022 in Finnish fur farms. 'Sample batch' means the batch of samples sent by an individual farm. Several batches from the same farm may have been tested, but these cannot be identified from the data.*

4.4 Campylobacter

Bacteria from the *Campylobacter* genus are commonly found in nature and production animals, especially in the gastrointestinal tract of poultry. The genus is large, and the most significant zoonotic pathogens within it are *C. jejuni* and *C. coli*. Humans can contract campylobacteriosis through food or water.

Campylobacter is highly adapted to living in the gastrointestinal tract of birds, which is why Finland has a national Campylobacter Control Programme (Finnish Food Authority, 2022a). Of neck skin samples from slaughtered broiler chickens, approximately five per cent tested positive for campylobacter, while less than 0.2% of samples from carcasses had campylobacter in excess of the set limit value (<1,000 cfu/g) (Finnish Food Authority, 2022a). The share of broiler chickens with a campylobacter colonisation level exceeding 10 cfu/g was 2.2% (González et al., 2016). Culled egg production hens and poultry by-products are used as feed for fur animals.

In a Finnish study, 31% (189/608) of rodents caught on agricultural farms tested positive for campylobacter (Ranta et al., 2020). *C. jejuni* was found in nearly all animal species collected in the study and in at least one sample from each farm that provided caught animals.

In the United States, two farms that fed their mink with wet feed had large numbers of animals that tested positive for campylobacter. On a third farm that used pelleted feed, no animals tested positive for campylobacter (Bell & Manning, 1990).

In Finland, in the last five years, a slightly smaller number of samples from fur farms has been tested for campylobacter than for Salmonella (Figure 2A). Usually, more than half the tested sample batches have been positive for campylobacter (Figure 2B). The number of samples from all fur animals has decreased.

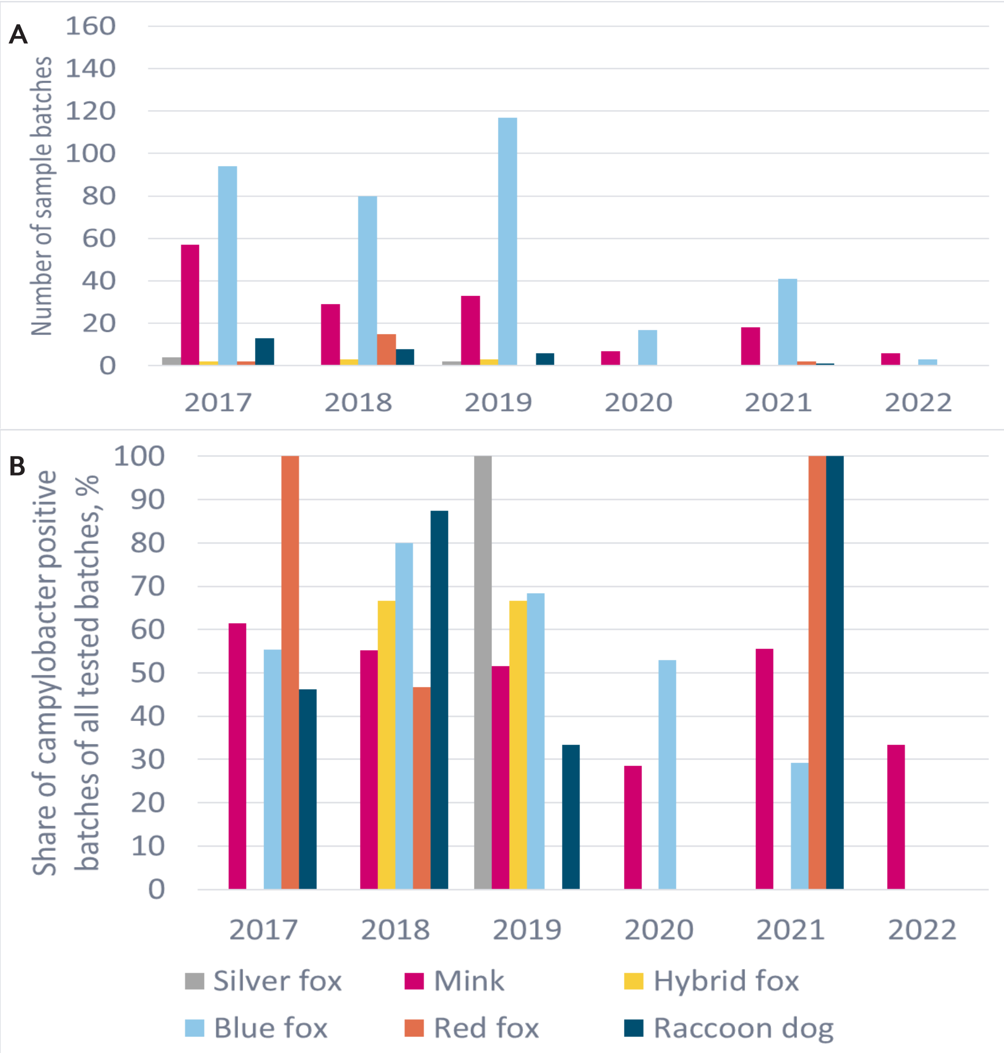


Figure 2. *Number of sample batches tested for campylobacter (A) and share of campylobacter-positive sample batches of all tested samples (B) in 2017–2022. 'Sample batch' means the batch of samples sent by an individual farm. Several batches from the same farm may have been tested, but these cannot be identified from the data.*

4.5 Cryptosporidium

Cryptosporidium is a genus of parasites, most of which are specific to a certain animal species. Some members of the genus, such as *Cryptosporidium parvum*, can infect and cause symptoms in several host species. The *C. parvum* species is typically found in humans, bovines and cervids (Helmy & Hafez, 2022). Many animal species also have their own Cryptosporidium species, which they can carry with or without mild symptoms. Of human Cryptosporidium infections, 90% are caused by *C. hominis* or *C. parvum*, but several other Cryptosporidium species (*C. meleagridis, C. baileyi, C. andersoni, C. canis, C. felis, C. bovis, C. suis, C. fayeri, C. scrofarum, C. tyzzeri, C. erinacei* and *C. muris*) have also been found in both humans and animals (Helmy & Hafez, 2022).

In a Chinese study, several Cryptosporidium species were found in mink, blue foxes and raccoon dogs. Of the samples from mink, 12.1% (26/214) were positive, and *C. parvum* was identified in two of the samples (Qian et al., 2020). The other species found in the mink were either of the potentially zoonotic species *C. canis* (7 samples) or of a Cryptosporidium species commonly found in mink (17 samples). For blue foxes and raccoon dogs, all positive samples (1/35 and 8/39) had *C. canis* species. Although the zoonotic *C. parvum* was only found in a few samples, all the identified species and genotypes have also been found in humans, which means the role of fur animals in zoonotic Cryptosporidium infections must be considered (Qian et al., 2020).

In Finland, mink only from one farm were tested for Cryptosporidium in 2017 (3 samples), and blue foxes from three farms were tested in 2020 (11 samples total). In 2020, an untyped Cryptosporidium parasite was found on one farm, which belonged to a species other than the zoonotic *C. parvum*.

4.6 Antibiotic resistance

Antibiotic resistance is not only found in pathogenic bacteria but also in other bacteria. The resistance genes can be transferred between bacteria, and they can be transferred from other bacteria to pathogenic bacteria and therefore hinder pharmacotherapy. Use of antibiotics on production animals favours resistant bacteria, which means they become more common.

Antibiotic-resistant bacteria may enter fur animals through their environment, from humans and other animals, or through feed. The resistant bacteria can then be transferred from the fur animals to other fur animals and even to the farm employees or the environment through faeces. Environments such as fur farms where animal density is high enable the bacteria and their resistance genes to extensively spread to other animals.

The antibiotic resistance of pathogenic bacteria isolated from farmed mink was studied in Denmark between 2014 and 2016, and it was found that more than 80% of the *E. coli* isolates were resistant to ampicillin, and more than 40% to streptomycin, sulfonamides, tetracyclines and trimethoprim (Nikolaisen et al., 2017). Of these isolates, 12% were susceptible to all 17 studied antibiotics, and 60% were resistant to three or more of the studied pharmaceuticals. In a study of mostly Danish farms that included a few Icelandic and Dutch farms, large quantities of *E. coli* and *Staphylococcus delphini* strains were found that were resistant to tetracyclines (Nikolaisen et al., 2022).

In a US study, nearly all mink faeces and feed samples were found to include resistant *E. coli* bacteria (Agga et al., 2021). Resistance to tetracyclines and third-generation cephalosporins was particularly common, but some ESBL-producing bacteria were also found. The samples of mink faeces were also tested for antibiotic resistance genes in bacteria, and these were usually related to five groups of antibiotics: macrolide, lincosamide and streptogramin (MLS) antibiotics; tetracyclines; beta-lactam antibiotics; aminoglycosides; and fluoroquinolones. Another US study examined the resistance of Salmonella species isolated from the faeces and feed of farmed mink (Agga et al., 2022). Of the 12 isolates of Salmonella isolated from the faeces samples, two were multi-resistant to the ampicillin-streptomycin-sulfafurazole (sulfoamide)-tetracycline combination. Other isolated isolates carried different resistance genes.

The prevalence of antibiotic-resistant bacteria in Finnish fur animals is reported in the annual FINRES-Vet reports, the latest of which was for the 2020–2021 period (Finnish Food Authority, 2022e). Of the 22 to 28 *C. jejuni* strains isolated from fur animals during this period, 23% were resistant to nalidixic acid, 18% to the fluoroquinolone ciprofloxacin, 18% to tetracyclines, and one strain to erythromycin. Gentamicin resistance was not found. Samples from farmed mink (231 animals, 57 farms), blue foxes (32 animals, 13 farms), and raccoon dogs (29 animals, 11 farms) were analysed for ESBL-, AmpC- and carbapenemase-producing *E. coli* bacteria and MRSA bacteria. Positive isolates were rare: one AmpC-producing *E. coli* strain was found in 2020, and one ESBL-producing *E. coli* strain in 2021. MRSA was not found in any of the samples. The samples tested for ESBL-, AmpC- and carbapenemase-producing *E. coli* bacteria were rectal swabs, and the samples tested for MRSA were nasopharyngeal and paw swabs. In 2017, rectal swabs from 100 foxes from one Finnish farm were tested for MRSA and ESBL, and none of the samples was positive (Verkola and Heikinheimo, unpublished study). In a study of *Streptococcus halichoeri* bacteria isolated from Finnish dogs and fur animals, resistance to erythromycin and clindamycin was found common in strains isolated from dogs but less common in the strains isolated from the 23 fur animals, and 70% of the strains were found susceptible (Eklund et al., 2020).

In Denmark, around a third of samples from fur farms were positive for LA-MRSA CC398 (MRSA associated with production animals), and Danish fur farms are suspected to be a reservoir for LA-MRSA CC398 (Hansen et al., 2017). In the study, mink oral swabs and paw swabs especially tested positive for MRSA, but rectal swabs did not. This could indicate that mink are continuously contaminated with MRSA on the farms but do not serve as carriers (Hansen et al., 2017). On the mink farms where MRSA was found, it was also found to have been transmitted to mink kits either through the dams or the contaminated environment (Fertner et al., 2019b).

In Denmark, contact with mink was added as a risk factor for human MRSA infections in 2016 (the Danish Health Authority, 2016). In pig production, the most significant MRSA exposure risk to humans is visiting a pig farm, but the risk caused by fur animals to their keepers remains unknown. The open structures of fur farms may reduce exposure via dust, but the exposure risk from bites and scratches from handling the mink and the risk from handling their feed can be greater than the exposure risk related to working on a pig farm (Fertner et al., 2019b; Hansen et al., 2017).

The connection between antibiotic use and the antibiotic resistance of *E. coli* and *Staphylococcus delphini* bacteria was examined in a study that mostly included Danish mink farms but also two farms from both Iceland and the Netherlands (Nikolaisen et al., 2022). A significant connection between resistant bacteria and the use of specific antibiotics was found; the short-term use of tetracyclines during the growth period was connected to the tetracycline resistance of *E. coli* bacteria during the same period, and the long-term use of macrolides and tetracyclines was connected to the erythromycin resistance of *S. delphini* during weaning period and to the tetracycline resistance of the same during the growth period. A significant number of resistant strains was also found in the same study on fur farms that did not use antibiotics, indicating that resistant strains are very persistent or have extensively spread to the environment.

In Finland in 2020 and 2021, the annual production amount of fur animal feed containing antibiotics or antiparasitics was approximately 1.6 million kilograms, of which around 200 kilograms were active substances. The reported amount has reduced compared to previous years, in which the annual amount of medicated feed was close to or even more than 4 million kilograms. Sulfadiazine-trimethoprim is the most commonly used antibiotic, and its use in medicated feed increased in 2020 and 2021 in particular (Finnish Food Authority, 2022f). Usually, medication is prescribed by farm or by animal group and not by individual animal, which means healthy animals are unnecessarily medicated.

Significance of feed in the spread of antibiotic-resistant bacteria

The feed produced with ingredients from food-production animals is an important factor in the transfer of antibiotic-resistant bacterial strains to fur animals (Agga et al., 2021). Nearly all mink faeces and feed samples collected in a US study were found to include resistant *E. coli* bacteria (Agga et al., 2021). Another US study examined the resistance of Salmonella species isolated from the faeces and feed of farmed mink (Agga et al., 2022). Some isolates were connected to Salmonella isolated from humans and meat-production animals, which indicates that feed produced from food-production animals is the source of the resistant Salmonella found in fur animals (Agga et al., 2022).

An experimental study by Fertner et al. (2019a) demonstrated that MRSA bacteria could spread to mink through contaminated feed. In the study by Fertner et al. (2019b), samples from two farms out of the total five tested positive for MRSA bacteria, and 20 to 29% of the tested mink were found to be MRSA-positive. The feed used came from the same compound feed plant, and the MRSA bacterium isolated in the study was also found in pigs. The microbiological quality of feed is connected to the use of antibiotics on fur farms. The lower the feed quality, the more antibiotics were given to mink within one month (Jensen et al., 2016). Jensen et al. (2017) came to the same conclusion: the increase of faecal cocci in feed is connected to the increased use of antibiotics in mink.

In a Danish study, most LA-MRSA CC398 strains isolated from mink (82%), and mink feed (63%) and in human infections related to mink (70%) belonged to the MRSA lineages that generally circulate in the Danish pig population (Hansen et al., 2020). The study showed that the most probable source of the MRSA strains found in mink was contaminated mink feed originating in the Danish pig production industry, and possibly contaminated import feed.

MRSA bacteria are also found in Finnish pork, and the share of positive samples has increased in recent years. Of the 206 samples taken from pork sold at retail stores in 2021, 12.6% tested positive for MRSA, and all but one of the positive samples came from Finnish products (Finnish Food Authority, 2022e).

5 Pathogen routes of transmission

Fur farms serve as crossroads of several material streams from livestock production (Figure 3).

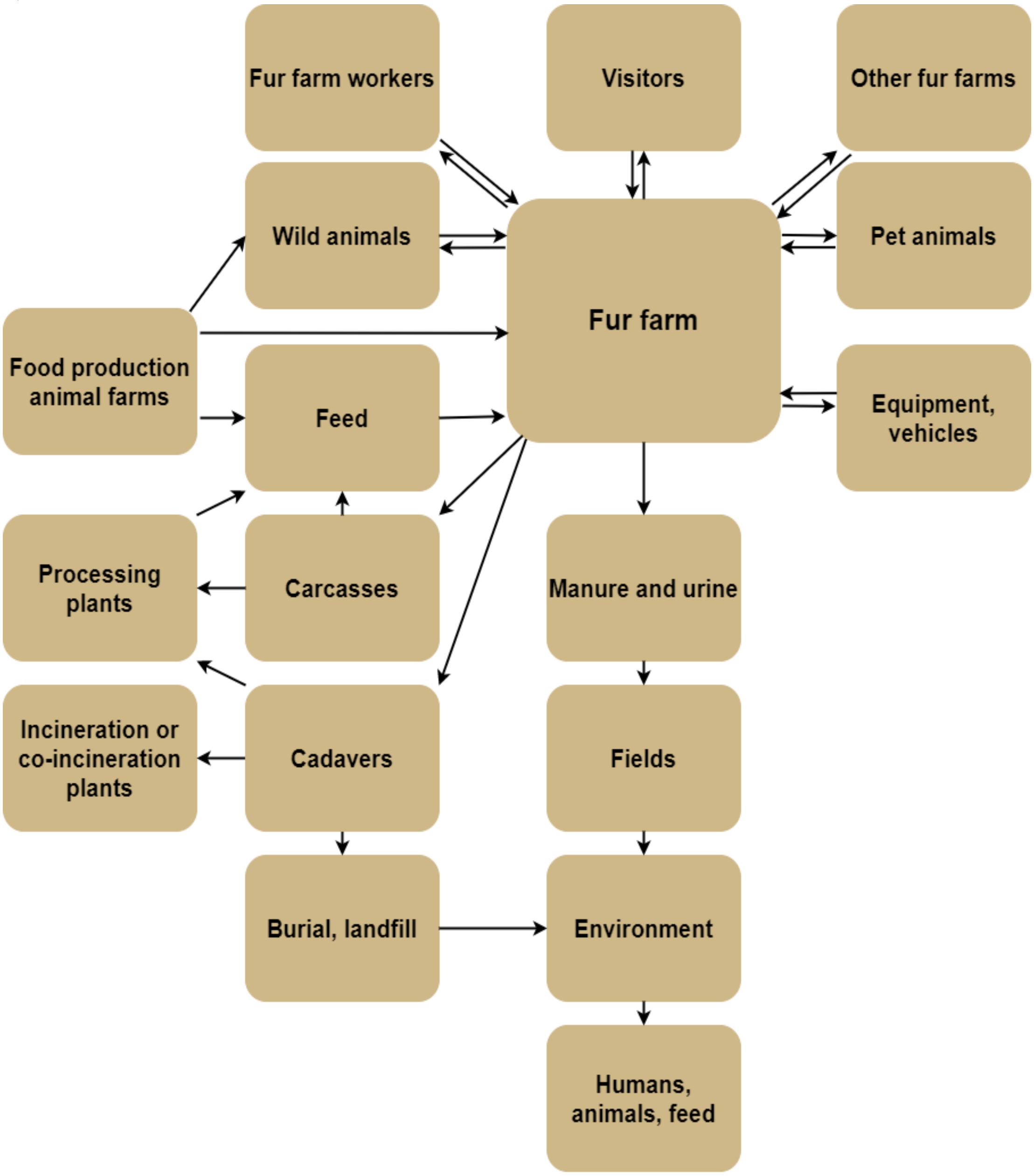


Figure 3. *Contacts and materials streams in fur farming.*

Fur animals can contract diseases from pathogens transmitted from other farmed animals, humans, feed, work equipment or vehicles, or through contact with other animals. Figure 4 shows possible routes of transmission on fur farms. Pathogens can be transmitted from fur animals to humans, other animals, or the environment, for example, to fields through manure, or as contaminants to the feed or food production chain or to water.

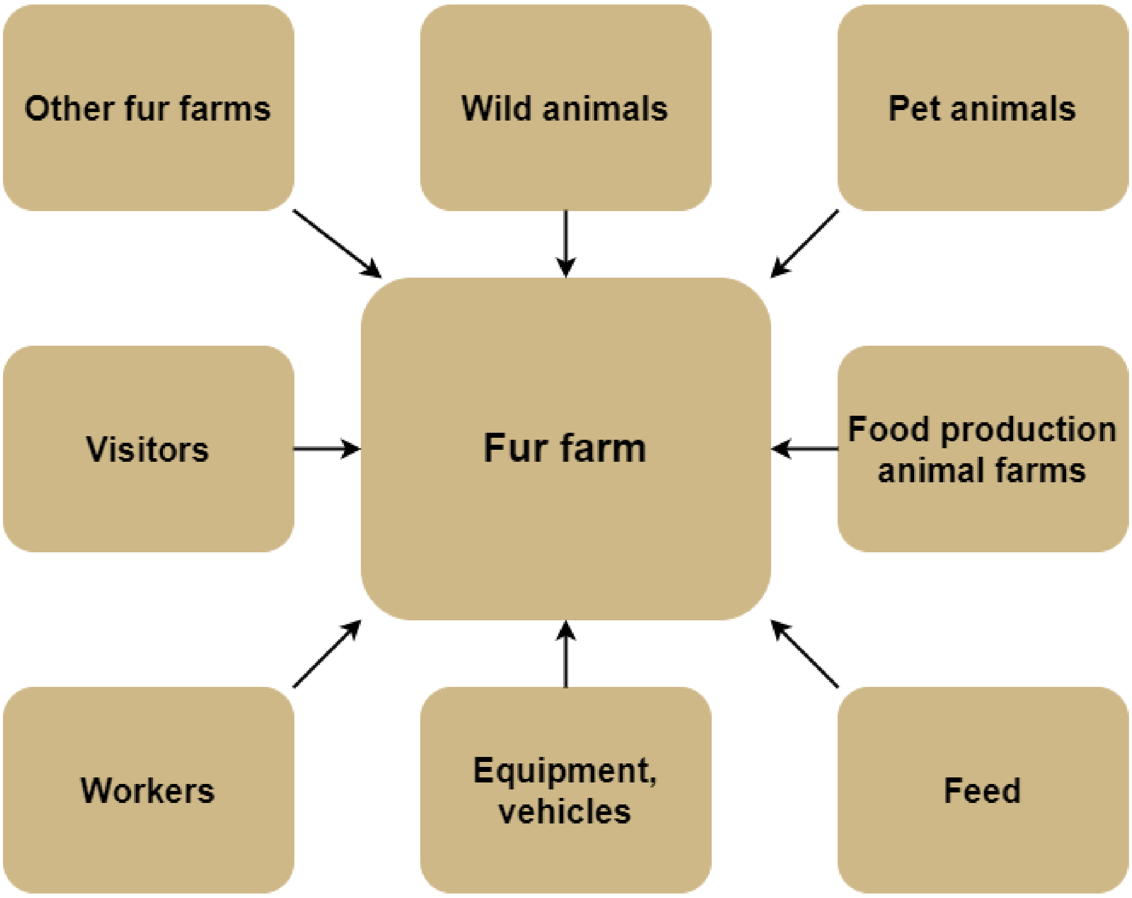


Figure 4. *Possible routes of transmission on fur farms.*

5.1 Humans

Humans can carry all zoonotic pathogens. In particular, fur animals are highly susceptible to human respiratory viruses that are transmitted via droplets or aerosols. The transmission of faecal pathogens from humans to animals is also possible especially if a fur farm does not provide sufficient facilities for washing hands or has other hygiene deficiencies.

Fur farm employees are in contact with the animals daily, and other people sometimes visit farms as well. The staffing needs of fur farms vary depending on the production stage, and temporary workers are hired during the mating and pelting seasons in particular. Employees moving from one farm to another can carry pathogens with them.

5.2 Animals

Purchased animals

Animals purchased for fur farms can carry diseases, and when the animals are moved, pathogens move with them from one farm to another. Animal traffic between fur farms is relatively limited. Breeding animals are purchased from other farms, and some farms specialise in growing the animals from kits to pelting, which means they take in animals from other farms.

Fur animals imported into Finland

Like purchased animals, fur animals imported into Finland can bring pathogens with them that can then spread in Finland. During the SARS-CoV-2 pandemic in 2021 and 2022, no fur animals were imported into Finland. A total of 2,157 animals were imported into Finland in seven batches from Denmark and Norway in 2018. In 2019, 148 animals in two batches, and in 2020, 150 animals in one batch, were imported into Finland from Norway (Finnish Food Authority, 2019a, 2020b, 2021c, 2022d).

Wild animals

Many wild animals such as rodents and birds, e.g. western jackdaws and gulls, live around fur farms. They can bring pathogens onto fur farms and transmit them from fur farms to other locations. The structures on fur farms are relatively open, which means pests cannot be completely prevented from entering the animal facilities. Birds and especially rodents can relatively easily access the feed processing facilities, structures of the sheds and the feed laid out for the fur animals. Among others, Salmonella and Campylobacter have been found in birds, rodents and other small mammals that lived near fur farms, including in Finland (Andrés-Barranco et al., 2014; Backhans et al., 2013; Meerburg et al., 2006; Ranta et al., 2020). The highly pathogenic avian influenza virus A (H5N1) that caused an outbreak on a Spanish mink farm was probably transmitted by a bird (Agüero et al., 2023a).

Wild animals can become infected from the feed or manure on fur farms and then spread the infection to the environment and other animals. In a Finnish study, a fur farm was found be connected to an increased risk of Salmonella infection on cattle and pig farms less than one kilometre from the fur farm (Ranta et al., 2020). Determining the direction of the infection requires a different study design and closer studies of the strains found.

Pets

Pets can carry zoonotic pathogens or be infected by them. In both cases, pets can transmit the pathogens to other animals and humans. If a pet is in direct or indirect contact with a fur animal, pathogens can transmit in both directions. The close relationships of humans and their pets can contribute to the transmission of pathogens between species. Cats living on and freely roaming around fur farms have been found to become infected with SARS-CoV-2 and to transmit it to their surroundings (Amman et al., 2022; Yoo & Yoo, 2020). Cats and dogs can also be carriers of Salmonella and Campylobacter bacteria, in which case they can transmit pathogens between humans and other species (Marks et al., 2011; Thépault et al., 2020).

5.3 Feed

Animal by-products are used as ingredients of fur animal feed, and the by-products can contain pathogens or spoilage bacteria and serve as a good growth medium for them throughout the feed chain. In Europe, Salmonella is considered the most significant pathogen for production animals, but findings of *Listeria monocytogenes*, *E. coli* O157:H7 and Clostridium, as well as antibiotic-resistant bacteria and resistance genes, among others, are also possible (EFSA et al., 2008). In addition to bacteria, feed can have viruses, parasites, mould or mycotoxins that endanger the health of the animals.

Figure 5 has a diagram of the fur animal feed chain. The information box has a description of the various feed chain operators. Feed mainly consists of production animal or fish by-products and fish, as well as cereals and mineral, trace element and vitamin supplements (Koskinen, 2007). Animal by-products are formed in connection with livestock production, slaughter, meat inspection, and meat cutting that are not suitable for human consumption. Of category 2 by-products, animals that have died of natural causes or that have been culled can also be used for fur animal feed, as long as the processing standards laid down in the Commission Implementing Regulation ((EU) 142/2011, 2022) are met.

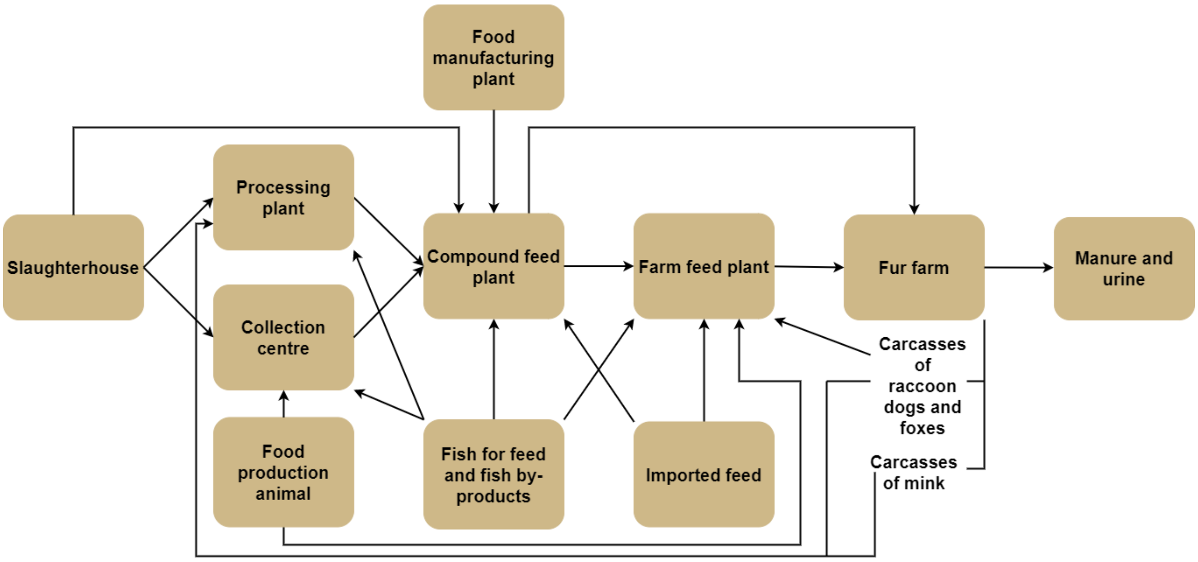


Figure 5. *Fur animal feed chain in general.*

The feed for Finnish fur animals is usually produced in Finland, but it can include ingredients and components originating elsewhere (Finnish Food Authority, 2021d), which highlights the importance of being familiar with the entire production chain. In 2021, approximately 240 million kilograms of fur animal feed was produced in Finland (Fifur, 2023). Of the ingredients, some two thirds came from animals. In 2021, a total of 28 million kilograms of feed was imported into Finland, most of which (93%) came from the EU or the EEA (Finnish Food Authority, 2022j). The exact amount used as feed for fur animals is unknown, and the figures also include ingredients for pet feed, for example. With a few exceptions, category 3 by-products can be imported into Finland for use as fur animal feed, and category 2 by-products can be imported with a permit (Finnish Food Authority, 2022i, 2022k).

Subject to a permit, intraspecies recycling is also allowed for foxes and raccoon dogs if certain conditions are met. Intraspecies recycling means that feed made with carcasses from one species can be given as feed to animals of the same species. More than half of fox and raccoon dog farms engage in intraspecies recycling (Finnish Food Authority, Animal Health and Medication Unit, verbal communication on 10 March 2023). Intraspecies recycling is prohibited for mink.

Fur animal feed chain operators

Slaughterhouses

Slaughterhouses provide by-products to collection centres, processing plants and compound feed plants. Category 2 and 3 by-products are used for fur animal feed. By-products used for fur animal feed do not need to be pre-processed at the slaughterhouse (Finnish Food Authority, 2019b).

Collection centres

The collection centres treat the by-products either with heat at temperatures of 80 °C or with acid with a pH of less than 4.2. After heat treatment, the by-products are refrigerated or frozen for storage. Fish by-products can also be frozen and stored at a temperature under -18 °C. Collection centres may also accept culled hens, chickens, and turkeys that have not been pre-processed if there is no reason to suspect they contain communicable diseases that can spread to humans or other animals (Maa- ja metsätalousministeriön asetus eläimistä saatavista sivutuotteista 783/2015, 2015 [Decree of the Ministry of Agriculture and Forestry]).

Processing plants

Processing plants produce fur animal feed from the carcasses of production animals from which any TSE risk material has been removed (Finnish Food Authority, 2019b). Several processing methods are allowed, and the method is chosen according to the by-product category ((EU) 142/2011, 2022). Finland has six processing plants that accept dead fur animals (Finnish Food Authority, 2023). The largest of these is Honkajoki Oy, which accepts all production animals. In 2021, the plant processed more than 20 tonnes of mink carcasses, and slightly less than 200 tonnes of fox carcasses (Finnish Food Authority, 2022b).

Compound feed plants

Compound feed plants, also called ‘feed kitchens’ in Finland, produce fur animal feed for their customer farms. Compound feed plants mix the feed ingredients and sometimes also heat them into a porridge-like compound mass that is delivered to the customer farms within the same day. In 2021, nine Finnish compound feed plants produced fur animal feed (Finnish Food Authority, 2022g).

Farm feed plants

Some fur farms have their own feed plants in which they produce feed for their farm (Finnish Food Authority, 2021d). Farm feed plants can engage in interspecies recycling, i.e. using the carcasses of foxes or raccoon dogs culled on the farm for the feed given to another fur animal species. The use of mink carcasses as an ingredient in farm feed plants is prohibited. In farm feed plants, the carcasses of foxes and raccoon dogs must be heated at a temperature of more than 100 °C for 30 minutes. Of other culled animals, farm feed plants may accept only healthy hens, chickens and turkeys that are not suspected of having, or have been proved not to have, any communicable diseases that can spread to humans or other animals. The carcasses must still be treated with acid or heat before they are used for feed (Maa- ja metsätalousministeriön asetus eläimistä saatavista sivutuotteista 783/2015, 2015 [Decree of the Ministry of Agriculture and Forestry]). There were 60 farm feed plants in Finland in 2022 (Finnish Food Authority, 2022b).

Food industry

Like slaughterhouses, meat and fish production plants supply by-products for fur animal feed. In addition, old food products that are still viable for use as feed can be used as fur animal feed as they are, which means that they do not need to be treated. If an untreated by-product is supplied for feed use after 24 hours of its collection, it must be kept refrigerated or frozen (Finnish Food Authority, 2019b, 2022i).

Harmful microbes can end up in feed through its ingredients or through post-process contamination. The microbes can spread through the feed unless the feed production methods destroy or reduce them in the intended way to a safe level – in other words, if treatment with heat or acid is insufficient or inappropriate (Axmann et al., 2017; EFSA et al., 2008; Pelyuntha et al., 2022). Epidemics caused by salmonella or avian influenza viruses transmitted through feed and the spread of MRSA on fur farms have been studied in several countries. Table 2 summarises feed-related epidemics and results from the feed chain found in the literature and control results.

Pathogens that spread through feed can cause extensive epidemics on fur farms because each feed batch is quickly dispensed and fed to a large number of animals. The feed chain is large with many branches, and ingredients of animal origin can end up on a farm through several operators. Feed can be contaminated with pathogens even if the feed chain is tightly controlled because no treatment method can fully destroy all pathogens, and sampling can never be sufficiently extensive to ensure all pathogens are found. A timely and correctly targeted control system with sampling that covers feed production from primary production to the end product (GAP, GMP and HACCP) is considered a comprehensive method for controlling the number of harmful microbes. A deficient system or control can cause massive damage (Häggblom, 2009). In inspections of authorities, deficiencies have been found in the labelling of by-products and in self-monitoring plans (Finnish Food Authority, 2022b), which can lead to the use of inappropriate treatment and storage methods, which in turn introduces a risk of post-process contamination and enables the survival and spread of microbes. Category 2 by-products are sometimes intentionally labelled as category 3 by-products, in which case the operator gains financial benefit but endangers the health of humans and animals (Stjerna et al., 2015). Transport also exposes feed to contamination. Feed and its ingredients are even transported between countries.

Table 2. *Feed-related epidemics on fur farms and results from the feed chain in 2000s.*

Country	Pathogen	Sample from	Results	Notes	Reference
Denmark	*Salmonella* Dublin	Compound feed plant, strong suspicion	Outbreaks on 22 mink farms, 2 fox farms, and 1 mink and fox farm	In 2000	Dietz et al., 2006
	Salmonella Typhimurium + MRSA	Three mink feed production plants	1 Salmonella-positive test result in a raw ingredient made with pork 3 MRSA-positive test results in raw ingredients made with pork and poultry	In 2016–2017	Lyhs et al., 2019
The United States	Feed: *Salmonella* Cerro Faecal sample result: *Salmonella* Uganda, *S.* Reading, *S.* Heidelberg and *S.* Orion Antibiotic resistance	Feed, suspicion Faecal samples were also tested	1 mink farm: 1/8 (13%) of feed samples and 11/42 (26%) of faecal samples were Salmonella-positive 2/12 (17%) of the isolates isolated from faecal samples were multi-resistant, and resistance genes were also found in other isolates.	In 2017	Agga et al. 2022
Finland	*Salmonella* Poona	Fur animal feed	Primarily found in fur animal feed	In 2003–2015	Pelkonen et al., 2022
	Salmonella ssp. I.	Complete feed, compound feed plant	1/7 (14%) of samples positive	National feed control plan in 2013	Evira, 2014
	Salmonella spp.	Compound feed plant and processing plants	Some findings in production environments, raw materials and final feed products	Self-monitoring samples in 2015–2017	Evira, 2016 Evira, 2017b Evira, 2018
	Salmonella Derby	Complete feed	Feed sample batch positive	Self-monitoring sample. Raw materials and feed consumed on the farm before action could be taken in 2016	Evira, 2017b
	Salmonella Derby	Complete feed	1/11 (9%) of samples positive	National feed control plan in 2016	Evira, 2017a
	Salmonella Poona	Compound feed plants, farm feed plants	1/99 of samples Salmonella-positive (10 compound feed plants). No findings from farm feed plant samples (0/15).	Finnish Food Authority's project in 2020	Unpublished data
	Salmonella Enteritidis	Feed-related suspicion	Feed-related infections on dozens of fox farms	In 2021	Finnish Food Authority, 2022b

Country	Pathogen	Sample from	Results	Notes	Reference
Denmark	MRSA	Feed: Pork production by-products and import feed, suspicion. Fur animal cadavers and humans were also tested	The lineages L1 to L3 of the LA-MRSA CC398 strain commonly circulating in Danish pigs were found in mink feed (63%), mink (82%), and humans who had been in contact with mink (70%)	In 2014–2016	Hansen et al., 2020
	MRSA	Feed: Pork production by-products, suspicion. Fur animal cadavers and mink were also tested	20/108 (19%) of feed samples were MRSA-positive 20/58 (34%) of cadavers were MRSA-positive 20/50 (40%) of mink farms were MRSA-positive	In 2015–2016	Hansen et al., 2017
	MRSA	Feed: Pork production by-products, suspicion. Mink and samples from the farm environment were also tested	2/5 of feed samples from the farm were MRSA-positive All five of the tested mink farms were LA-MRSA-positive 4/5 of the mink on the farm were LA-MRSA-positive, MRSA-positive environmental samples were found on all farms The apparent prevalence of LA-MRSA on the tested mink was 20–29%	In 2017	Fertner et al., 2019b
Canada	Influenza A (H3N2) virus	Pork production by-products, suspicion.	Symptomatic influenza infection in mink.	In 2007	Gagnon et al., 2009
Finland	*Clostridium botulinum,* type C	Non-acid-treated poultry by-product, suspicion	44,130 fur animals died or were culled. 8,033 with milder symptoms survived. All-cause mortality 21.7%	In 2002	Lindström et al., 2004
	Clostridium limosum	Raw acid-treated meat production by-product, suspicion	Cadavers with endometritis as the primary finding on 22 mink farms. All the infected animals were pregnant.	In 2013	Biström et al., 2015

5.4 Manure and urine

On fur farms, manure falls out of the cages onto the ground and outside the building through the wire mesh floor. Some feed and litter material may also be included (Lehtoranta et al., 2020; Ministry of the Environment, 2018). Use of litter in manure is recommended, as it reduces the number of fly eggs laid in the manure. In 2016, Finnish fur animals produced more than 200 million kilograms of manure (Lehtoranta et al., 2020). Fox manure is removed from beneath the sheds once or twice a year, and mink manure three to five times a year (Ministry of the Environment, 2018). After the manure is removed, it is either composted (approx. 40%) or temporarily stored in heaps before it is spread on fields (approx. 60%) (Lehtoranta et al., 2020). The manure should be composted to eliminate pathogens (Ministry of the Environment, 2018). Although manure storages can be uncovered (Lehtoranta et al., 2020), they should still be watertight (Ministry of the Environment, 2018). Ultimately, the manure is used as fertiliser in fields. Urine and water are collected through a membrane into septic tanks placed under the sheds and used as fertiliser (Lehtoranta et al., 2020).

Processing fur animal manure into safe fertiliser is important for preventing the spread of zoonotic bacteria, for example. A temperature of 70 °C should be achieved in composting and maintained for at least an hour to ensure the manure is sanitised (Luostarinen et al., 2011). However, not all microbes and bacterial spores can be destroyed via composting, even at the above temperature (Franke-Whittle & Insam, 2013).

5.5 Cadavers

In remote areas in Finland, fur animal cadavers and offspring born dead can be buried in the ground or delivered to authorised landfills ((EC) 1069/2009, 2019; Laki eläimistä saatavista sivutuotteista 517/2015, 2015 [Animal By-Products Act]). The entire area of Finland is considered a remote area except for Western Finland, with its numerous fur farms; the municipalities falling under its collection area are listed in a decree of the Ministry of Agriculture and Forestry (Maa- ja metsätalousministeriön asetus eläimistä saatavista sivutuotteista 783/2015, 2015 [Decree of the Ministry of Agriculture and Forestry]) (amendment 1142/2022).

Except for offspring born dead, cadavers may not be buried in the ground in this collection area, and they must be delivered to a processing or incineration plant ((EC) 1069/2009, 2019; Laki eläimistä saatavista sivutuotteista 517/2015, 2015 [Animal By-Products Act]; Maa- ja metsätalousministeriön asetus eläimistä saatavista sivutuotteista 783/2015, 2015 [Decree of the Ministry of Agriculture and Forestry]; Finnish Food Authority, 2022h). Farms can have their own incineration or co-incineration plants where they may incinerate whole cadavers. If animals that have died of a disease or offspring born dead are buried in the ground or delivered to a landfill, they can transmit pathogens to the environment.

6 Biosecurity on fur farms

Biosecurity means practices that aim to prevent the animals being exposed to pathogens. External biosecurity aims to prevent the entry of pathogens onto the farm, and internal biosecurity aims to prevent the spread of pathogens in the animals on the farm, either between animal units or individual animals, as well as between animals and humans.

On fur farms, external biosecurity includes the fences required by legislation on the borders of the farms or other structural solutions. The purpose of fencing is to prevent fur animals escaping, but it also prevents large wild animals entering the farm. However, fur farms are often placed near each other, which enables airborne transmission of pathogens between farms (Finnish Food Authority, Risk Assessment Unit, 2020). In addition, fencing does not prevent birds or rodents entering or leaving farms. The most effective method for reducing the number of birds entering a farm is to make the farm area as unappealing to them as possible, i.e. to ensure there are no appealing spots for the birds to land, and that there is no exposed feed in the area. In rodent prevention, keeping feed covered during storage is essential, as is cleaning away any feed waste after the feed is mixed and dispensed. The number of rodents can also be controlled with traps and bait, but prevention by keeping the area clean and well-maintained is more effective.

The number of human visitors to fur farms is relatively low, and most humans visiting farms are employees or owners. In peak seasons such as the mating and pelting season, seasonal workers may work for several farms at the same time. Fur farms do not have any other external connections either like petting zoos.

In a Canadian survey, no farms (11 total) reported that their employees or visitors wash their hands before entering the animal sheds or handling the animals, and only half the farms (45.5%, 5/11 farms) reported that their employees washed their hands after handling the animals (Compo et al., 2017). In Finland, owners and employees have been instructed to ensure good hand hygiene and to use face masks due to the coronavirus risk. Farm employees should also use protective clothing provided by the farm and work shoes. In practice, facilities available for handwashing on farms are often lacking (Finnish Food Authority, Risk Assessment Unit, 2020).

Whenever new animals are introduced, a separate space should be available for quarantine purposes. The air in the quarantine areas should be prevented from mixing with the air in the spaces where other animals are kept, and employees must be able to wash their hands inside the quarantine area. The quarantine area should also have separate work equipment. The order of work should also be planned to progress from tasks involving the pre-existing animals to tasks involving the quarantined animals to ensure that no pathogens carried by the quarantined animals can spread to the other animals. If animals are imported, it should be verified with health inspections that they are free from infectious diseases. Current import requirements are relatively lax.

In recent years, many fur farms have ceased production. When a fur farm ceases, the breeding animals can be sold to other fur farms, sometimes in quantities that are unusually large. The receiving farm must ensure that it has sufficient space to quarantine the new animals, and that the spaces reserved for quarantine purposes are appropriate for such a use.

In addition to humans, feed is a significant route of transmission. Raw materials of fur animal feed must be treated in a manner that ensures to a sufficient degree that all pathogens are destroyed. However, no method can completely eradicate all pathogens, and good hygiene during storage is very important for ensuring the feed is safe. Feed can be contaminated after it is produced, both in the production facility and on the fur farm when the feed is mixed and stored. Systemic prevention of pests, rodents and birds is an integral part of fur farm feed hygiene and requires that feed that falls to the ground is regularly cleaned away, and that the feed is stored in a place where pests cannot enter, for example.

Fur animal feed can attract cats and dogs, especially if the feed is insufficiently covered during storage. Pets should be kept out of fur farms to prevent the spread of zoonotic pathogens.

Based on expert interviews conducted in 2020, the level of biosecurity on farms varied, and the level of internal biosecurity was particularly low (Finnish Food Authority, Risk Assessment Unit, 2020). Farmers committed to abiding by the biosecurity measures determined for the 2021–2022 period (Turkistuottajan sitoumus ja siitoseläinmääräilmoitus, 2023 [Fur farmer's commitment and declaration of the number of breeding animals]), which allowed the number of samples collected in connection with SARS-CoV-2 control to be reduced.

7 Summary of risks

Table 3 below has a summary of the pathogens discussed in this risk profile. The likelihood of zoonotic spillover to fur animals and from fur animals to humans is given on a word-based scale in accordance with the definitions in Table 4. Likelihoods of different routes of transmission have not been estimated.

Table 3. *Risk of exposure to zoonotic pathogens of fur animals for humans on fur farms.*

Risk	Likelihood of fur animal infections	Likelihood of spillover from animals to humans	Severity to humans	Notes
SARS-CoV-2	Likely	Likely	Mild–severe	Spillover between species is associated with an increased risk of virus mutation.
Influenza viruses	Possible	Possible	Mild–severe	Spillover between species is associated with an increased risk of virus mutation.
Salmonella	Likely	Possible	Moderate	Severe secondary diseases possible.
Campylobacter	Likely	Possible	Mild	Severe secondary diseases possible.
Antibiotic resistance	Likely	Possible	Mild–moderate	Increasing threat.
Cryptosporidium	Possible	Possible	Mild–moderate	Entry to irrigation water could cause an extensive epidemic.

Table 4. *Definitions used in the likelihood and consequence assessments.*

Likelihood		Severity	
Unlikely	The event will only occur in extraordinary circumstances. Mostly possible only in theory.	Negligible	No significant danger to health.
Possible	The event could occur or has already occurred.	Mild	Single cases with mild symptoms.
Likely	The event occurs often, or there are frequent close calls.	Moderate	Severe symptoms or several outbreaks.
		Severe	Severe chronic harm to health, extensive epidemic, or death.

8 Conclusions

Finland is currently one of the largest fur production countries in Europe, but **fur animals or samples from them are rarely tested for zoonotic pathogens**. Very little data therefore exist on the prevalence of fur animal pathogens in Finland. Fur animals can serve as hosts of zoonotic pathogens and enable the pathogens to reproduce and viruses to mutate possibly into more threatening variants.

There are no fur animal diseases whose prevention is regulated by legislation or any control plans associated with them, except for the national TME and SARS-CoV-2 monitoring. SARS-CoV-2 monitoring will change at the start of April 2023. **Very few samples from fur animals are sent to the Finnish Food Authority that are not related to monitoring, which is why no conclusions on the prevalence of diseases on fur farms can be drawn**. If the infrequent sampling related to the investigation of the cause of a disease is only targeted at animals showing symptoms, asymptomatic diseases are not found at all, or they are found with an extensive delay.

The high animal density on fur farms also provides optimal conditions for pathogens to reproduce and spread. Farmed mink are especially susceptible to viruses carried by humans and other animals. For example, influenza viruses carried by mink can mutate into variants that are transmitted to humans and other mammals more easily and can spread between them. The influenza situation has become increasingly severe in the last two years, which has also increased the risk of infection on fur farms. During the coronavirus pandemic, SARS-CoV-2 caused extensive epidemics on mink farms in several countries, and in Finland too, the risk of infection is still high for mink, as is the risk of spillover from mink to humans.

Salmonella caused a large epidemic on Finnish fur farms in 2021, and several Salmonella epidemics have also been found in other countries. In Finland, samples from fur animal feed test positive for Salmonella nearly every year. Campylobacter is found in fur animals. Inappropriately treated poultry-based raw ingredients have been suspected to be the origin of the Campylobacter infections. Antibiotic-resistant strains have also been found in the Campylobacter bacteria isolated from fur animals. The significance of the feed chain in the spread of Salmonella and Campylobacter should be investigated. **Both Salmonella and Campylobacter can infect humans and cause a gastrointestinal infection. Humans can also spread them outside fur farms to other humans or livestock farms, for example**.

Antibiotic resistance has been found in bacteria samples collected from fur animals. No MRSA strains have been isolated from fur animals in Finland, and an ESBL-positive strain has only been found once. However, the number of samples tested is relatively low. In Denmark, animal by-products from meat production used to produce feed for mink are considered to be the source of the MRSA commonly found in mink. MRSA is also found in Finnish pork, which means that the use of pork production by-products can also expose fur animals to MRSA here. **Potential MRSA in fur animals is a risk to fur farm employees and people close to them**.

As carnivores, fur animals can consume a variety of livestock by-products. However, these can contain harmful microbes, and they provide a good growth medium for bacteria. **If feed raw material treatment is not controlled, and post-process contamination happens, the risk of harmful microbes infecting fur animals increases**. Contaminated feed quickly spreads to several farms where the feed is not necessarily heated again before it is given to the animals. Poor hygiene at feed production and storage facilities increases the risk of post-process contamination.

The most significant sources of fur animal pathogens are humans visiting the farm, feed and pests. Pets allowed to enter the farm can also bring in pathogens. They can also be infected by pathogens on the farms. Pathogens can be controlled with biosecurity measures such as washing hands and work clothes and preventing direct and indirect contact between groups of animals. Nevertheless, biosecurity and its practices on farms have not been studied.

Manure is often exposed to weather and is accessible to any pets or pests roaming around the farms. Not all manure produced on fur farms is composted, which means **pathogens can spread through inappropriately processed or unprocessed manure into the environment**.

Several zoonotic pathogens have been found in fur animals. From the fur animals, the zoonotic pathogens can be transmitted to the humans working on or visiting fur farms, to other animals or to the environment. There is little information about the disease situation on Finnish fur farms due to a lack of monitoring and research. These must be increased. Fur animal populations may insidiously become the source of the next pandemic through a mutated influenza virus, for example.

9 Recommendations

We recommend the following measures for mitigating the risk of zoonotic spillover:

- Fur farms must have effective biosecurity measures that protect animals and humans on farms.
- Employees must be provided with training in the practices and principles of biosecurity. The training must highlight the importance of personal protection, and this must be enabled for the employees.
- The prevalence of zoonotic pathogens on fur farms must be monitored with systematic laboratory studies.
- Epidemics on fur farms must be investigated in collaboration with the authorities, especially when a zoonotic pathogen is involved.
- Systematic records must be kept and are required of any symptoms observed on fur farms and of animal mortality and feed consumption, and these must be reviewed regularly to ensure that any changes in the situation are identified and can be reacted to.
- Feed safety must be ensured in terms of zoonotic pathogens and bacteria with antibiotic-resistant genes.
- Feed must be stored and processed to prevent contamination throughout the feed chain.
- Manure hygiene must be ensured (e.g. by composting) before it is spread on fields.
- Attention should be paid to study the pathogens and antibiotic resistance transmitted through fur animal manure and urine.
- Extensive import requirements must be established for import animals either through legislation or with agreements within the industry.

10 References

Agga, G. E., Silva, P. J., & Martin, R. S. (2021). Third-generation cephalosporin- and tetracycline-resistant *Escherichia coli* and antimicrobial resistance genes from metagenomes of mink feces and feed. *Foodborne Pathogens and Disease, 18*(3), 169–178. https://doi.org/10.1089/fpd.2020.2851

Agga, G. E., Silva, P. J., & Martin, R. S. (2022). Prevalence, serotypes, and antimicrobial resistance of *Salmonella* from mink feces and feed in the United States. *Foodborne Pathogens and Disease, 19*(1), 45–55. https://doi.org/10.1089/fpd.2021.0037

Agüero, M., Monne, I., Sánchez, A., Zecchin, B., Fusaro, A., Ruano, M. J., Arrojo, M. del V., Fernández-Antonio, R., Souto, A. M., Tordable, P., Cañás, J., Bonfante, F., Giussani, E., Terregino, C., & Orejas, J. J. (2023a). Highly pathogenic avian influenza A(H5N1) virus infection in farmed minks, Spain, October 2022. *Eurosurveillance, 28*(3), 2300001. https://doi.org/10.2807/1560-7917.ES.2023.28.3.2300001

Agüero, M., Monne, I., Sánchez, A., Zecchin, B., Fusaro, A., Ruano, M. J., Arrojo, M. del V., Fernández-Antonio, R., Souto, A. M., Tordable, P., Cañás, J., Bonfante, F., Giussani, E., Terregino, C., & Orejas, J. J. (2023b). Authors' response: Highly pathogenic influenza A(H5N1) viruses in farmed mink outbreak contain a disrupted second sialic acid binding site in neuraminidase, similar to human influenza A viruses. *Eurosurveillance, 28*(7), 2300109. https://doi.org/10.2807/1560-7917.ES.2023.28.7.2300109

Amman, B. R., Cossaboom, C. M., Wendling, N. M., Harvey, R. R., Rettler, H., Taylor, D., Kainulainen, M. H., Ahmad, A., Bunkley, P., Godino, C., Tong, S., Li, Y., Uehara, A., Kelleher, A., Zhang, J., Lynch, B., Behravesh, C. B., & Towner, J. S. (2022). GPS tracking of free-roaming cats (*Felis catus*) on SARS-CoV-2-infected mink farms in Utah. *Viruses, 14*(10), Art. 10. https://doi.org/10.3390/v14102131

Andrés-Barranco, S., Vico, J. P., Garrido, V., Samper, S., Herrera-León, S., de Frutos, C., & Mainar-Jaime, R. C. (2014). Role of wild bird and rodents in the epidemiology of subclinical salmonellosis in finishing pigs. *Foodborne Pathogens and Disease, 11*(9), 689–697. https://doi.org/10.1089/fpd.2014.1755

Axmann, S., Kolar, V., Adler, A., & Strnad, I. (2017). Efficiency of organic acid preparations for the elimination of naturally occurring *Salmonella* in feed material. *Food Additives & Contaminants: Part A, 34*(11), 1915–1924. https://doi.org/10.1080/19440049.2017.1363415

Backhans, A., Jacobson, M., Hansson, I., Lebbad, M., Lambertz, S. T., Gammelgård, E., Saager, M., Akande, O., & Fellström, C. (2013). Occurrence of pathogens in wild rodents caught on Swedish pig and chicken farms. *Epidemiology and Infection, 141*(9), 1885–1891. https://doi.org/10.1017/S0950268812002609

Bell, J. A., & Manning, D. D. (1990). Prevalence of *Campylobacter jejuni* in ranch mink at pelting: Cultural, serological, and histological evidence of infection. *The Canadian Veterinary Journal, 31*(5), 367–371.

Biström, M., Moisander-Jylhä, A.-M., Heinikainen, S., Pelkola, K., & Raunio-Saarnisto, M. (2015). Isolation of *Clostridium limosum* from an outbreak of metritis in farmed mink. *Acta Veterinaria Scandinavica, 58*(1), 49. https://doi.org/10.1186/s13028-016-0230-7

Boklund, A., Hammer, A. S., Quaade, M. L., Rasmussen, T. B., Lohse, L., Strandbygaard, B., Jørgensen, C. S., Olesen, A. S., Hjerpe, F. B., Petersen, H. H., Jensen, T. K., Mortensen, S., Calvo-Artavia, F. F., Lefèvre, S. K., Nielsen, S. S., Halasa, T., Belsham, G. J., & Bøtner, A. (2021). SARS-CoV-2 in Danish mink farms: Course of the epidemic and a descriptive analysis of the outbreaks in 2020. *Animals, 11*(1), 164. https://doi.org/10.3390/ani11010164

Clayton, M. J., Kelly, E. J., Mainenti, M., Wilhelm, A., Torchetti, M. K., Killian, M. L., & Van Wettere, A. J. (2022). Pandemic lineage 2009 H1N1 influenza A virus infection in farmed mink in Utah. *Journal of Veterinary Diagnostic Investigation, 34*(1), 82–85. https://doi.org/10.1177/10406387211052966

Commission Regulation (EU) No. 142/2011, Pub. L. No. 142/2011 (2022). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02011R0142-20220417&from=EN

Compo, N., Pearl, D. L., Tapscott, B., Storer, A., Hammermueller, J., Brash, M., & Turner, P. V. (2017). On-farm biosecurity practices and causes of preweaning mortality in Canadian commercial mink kits. *Acta Veterinaria Scandinavica, 59*(1), 57. https://doi.org/10.1186/s13028-017-0326-8

Cossaboom, C. M., Wendling, N. M., Lewis, N. M., Rettler, H., Harvey, R. R., Amman, B. R., Towner, J. S., Spengler, J. R., Erickson, R., Burnett, C., Young, E. L., Oakeson, K., Carpenter, A., Kainulainen, M. H., Chatterjee, P., Flint, M., Uehara, A., Li, Y., Zhang, J., … Barton Behravesh, C. (2022). One Health investigation of SARS-CoV-2 in people and animals on multiple mink farms in Utah. *Viruses, 15*(1), 96. https://doi.org/10.3390/v15010096

Dietz, H. H., Chriél, M., Andersen, T. H., Jørgensen, J. C., Torpdahl, M., Pedersen, H., & Pedersen, K. (2006). Outbreak of *Salmonella* Dublin-associated abortion in Danish fur farms. *The Canadian Veterinary Journal, 47*(12), 1201–1205.

ECDC. (2022a). *Avian influenza overview: Latest situation update of the avian influenza situation in EU/EEA*. European Centre for Disease Prevention and Control. https://www.ecdc.europa.eu/en/avian-influenza-humans/surveillance-and-disease-data/avian-influenza-overview

ECDC. (2022b). *Testing and detection of zoonotic influenza virus infections in humans in the EU/EEA, and occupational safety and health measures for those exposed at work: Operational guidance*. Publications Office. https://data.europa.eu/doi/10.2900/852604

EFSA. (2022). *Avian influenza overview June – September 2022 | EFSA*. https://www.efsa.europa.eu/en/efsajournal/pub/7597

EFSA AHAW Panel, EFSA Panel on Animal Health and Welfare (AHAW), Nielsen, S. S., Alvarez, J., Bicout, D. J., Calistri, P., Canali, E., Drewe, J. A., Garin-Bastuji, B., Gonzales Rojas, J. L., Gortázar, C., Herskin, M., Michel, V., Miranda Chueca, M. Á., Padalino, B., Pasquali, P., Roberts, H. C., Spoolder, H., Velarde, A., … Ståhl, K. (2023). SARS-CoV-2 in animals: Susceptibility of animal species, risk for animal and public health, monitoring, prevention and control. *EFSA Journal, 21*(2), 1–108. https://doi.org/10.2903/j.efsa.2023.7822

EFSA ja ECDC, Boklund, A., Gortázar, C., Pasquali, P., Roberts, H., Nielsen, S. S., Stahl, K., Stegeman, A., Baldinelli, F., Broglia, A., Van Der Stede, Y., Adlhoch, C., Alm, E., Melidou, A., & Mirinaviciute, G. (2021). Monitoring of SARS-CoV-2 infection in mustelids. *EFSA Journal, 19*(3), e06459. https://doi.org/10.2903/j.efsa.2021.6459

EFSA, Panel on Biological Hazards, Directorate General, & European Commission on Microbiological Risk Assessment in feedingstuffs for foodproducing animals. (2008). Microbiological risk assessment in feedingstuffs for food-producing animals—Scientific Opinion of the Panel on Biological Hazards. *EFSA Journal, 6*(7), 720. https://doi.org/10.2903/j.efsa.2008.720

Eklund, M., Aaltonen, K., Sironen, T., Raunio-Saarnisto, M., Grönthal, T., Nordgren, H., Pitkälä, A., Vapalahti, O., & Rantala, M. (2020). Comparison of *Streptococcus halichoeri* isolates from canine and fur animal infections: Biochemical patterns, molecular characteristics and genetic relatedness. *Acta Veterinaria Scandinavica, 62*(1), 26. https://doi.org/10.1186/s13028-020-00525-3

Evira. (2014). *Rehujen tuotevalvonnan analyysitulokset 2013* (Reg.no 5711/0411/2014).

Evira. (2016). *Rehuvalvonnan raportti 2015* (Reg.no Evira/1454/0411/2016).

Evira. (2017a). *Rehujen tuotevalvonnan analyysitulokset 2016* (Reg.no 2217/0411/2017).

Evira. (2017b). *Rehuvalvonnan raportti 2016* (Reg.no Evira/2236/0411/2017).

Evira. (2018). *Rehuvalvonnan raportti 2017* (Reg.no Evira/2355/0411/2018).

Fenollar, F., Mediannikov, O., Maurin, M., Devaux, C., Colson, P., Levasseur, A., Fournier, P.-E., & Raoult, D. (2021). Mink, SARS-CoV-2, and the human-animal interface. *Frontiers in Microbiology, 12*. https://doi.org/10.3389/fmicb.2021.663815

Fertner, M., Pedersen, K., & Chriél, M. (2019a). Experimental exposure of farmed mink (*Neovison vison*) to livestock-associated methicillin-resistant *Staphylococcus aureus* contaminated feed. *Veterinary Microbiology, 231*, 45–47. https://doi.org/10.1016/j.vetmic.2019.02.033

Fertner, M., Pedersen, K., Jensen, V. F., Larsen, G., Lindegaard, M., Hansen, J. E., & Chriél, M. (2019b). Within-farm prevalence and environmental distribution of livestock-associated methicillin-resistant Staphylococcus aureus in farmed mink (*Neovison vison*). *Veterinary Microbiology, 231*, 80–86. https://doi.org/10.1016/j.vetmic.2019.02.032

Fifur. (2023). *Ruokinta kasvun mukaan*. Finnish Fur Breeder's Association. https://fifur.fi/ruokinta-kasvun-mukaan

Finnish Food Authority. (2019a). *Eläinten, alkioiden ja sukusolujen sisämarkkinakaupan valvonta 2018* (2692/00.01.02.00.01/2019).

Finnish Food Authority. (2019b). *Sivutuotteet turkiseläinrehussa*. Finnish Food Authority. https://www.ruokavirasto.fi/globalassets/tietoa-meista/asiointi/oppaat-ja-lomakkeet/yritykset/rehuala/ohjeet/sivutuotteet_turkiselainrehussa.pdf

Finnish Food Authority. (2020a). *Eläintaudit Suomessa 2019* (No. 3/2020; Finnish Food Authority Publications).

Finnish Food Authority. (2020b). Eläinten, alkioiden ja sukusolujen sisämarkkinakaupan valvonta 2019 (241/00.01.02.00.01/2020).

Finnish Food Authority. (2021a). *Eläintaudit Suomessa 2020* (No. 4/2021; Finnish Food Authority Publications).

Finnish Food Authority. (2021b). *Eläintautien valvonta- ja seurantaohjelmat 2022* (Reg.no. 7406/04.01.00.01/2021).

Finnish Food Authority. (2021c). *Eläinten, alkioiden ja sukusolujen sisämarkkinakaupan valvonta 2020* (995/00.01.02.00.01/2021).

Finnish Food Authority. (2021d). *Turkiseläinten rehu*. Finnish Food Authority. https://www.ruokavirasto.fi/elaimet/rehut/rehut-ja-rehualan-toimijat/elaimista-saatavien-sivutuotteiden-kaytto-elainten-ruokinnassa/turkiselainten-rehu/

Finnish Food Authority. (2022a). *Elintarviketurvallisuus Suomessa 2021* (No. 3/2022; Finnish Food Authority Publications).

Finnish Food Authority. (2022b). *Eläimistä saatavien sivutuotteiden valvonta 2021* (Reg.no. 6500/00.01.02.00.01/2021; Finnish Food Authority Report).

Finnish Food Authority. (2022c). *Eläintaudit Suomessa 2021* (No. 4/2022; Finnish Food Authority Publications).

Finnish Food Authority. (2022d). *Eläinten, alkioiden ja sukusolujen sisämarkkinakaupan valvonta 2021* (6500/00.01.02.00.01/2021).

Finnish Food Authority. (2022e). *FINRES-Vet 2021 Finnish Veterinary Antimicrobial Resistance Monitoring and Consumption of Antimicrobial Agents* (No. 6/2022; Finnish Food Authority publications).

Finnish Food Authority. (2022f). *Turkiseläinten lääkerehujen valmistus—Tillverkningen av läkefoder för pälsdjur*. Finnish Food Authority. https://www.ruokavirasto.fi/globalassets/yritykset/rehuala/tilastot/laakerehut_turkiselaimet.pdf

Finnish Food Authority. (2022g). *Rehuvalvonnan raportti 2021* (1045/00.01.02.00.01/2022; Finnish Food Authority Report).

Finnish Food Authority. (2022h). *Polttaminen*. Finnish Food Authority. https://www.ruokavirasto.fi/elaimet/elaimista-saatavat-sivutuotteet-ja-kuolleet-elaimet/kuolleet-elaimet/polttolaitosten-hyvaksynta/

Finnish Food Authority. (2022i). *Eläimistä saatavien sivutuotteiden käsittely ja valvonta hyväksytyissä elintarvikehuoneistoissa Ohje 1746/04.02.00.01/2020/8*. https://www.ruokavirasto.fi/globalassets/tietoa-meista/asiointi/oppaat-ja-lomakkeet/yritykset/elintarvikeala/elintarvikehuoneistot/elaimista_saatavien_sivutuotteiden_kasittely_ja_valvonta_hyv_elintarvikehuoneistoissa.pdf.

Finnish Food Authority. (2022j). *Rehuaineiden, rehun lisäaineiden ja esiseosten tuonti—Import av foderämnen, fodertillsatser och förblandningar*. https://www.ruokavirasto.fi/globalassets/yritykset/rehuala/tilastot/tuonti_rehuaineet_ja_lisaaineet.pdf

Finnish Food Authority. (2022k). *Turkiseläinten rehuksi tuotavat sivutuotteet*. Finnish Food Authority. https://www.ruokavirasto.fi/teemat/tuonti-ja-vienti/tuonti-eun-ulkopuolelta/elaimet-ja-elainperaiset-tuotteet/sivutuotteet/turkiselainten-rehuksi-tuotavat-sivutuotteet/

Finnish Food Authority. (2023). *Section IV Processing plants Article 24 of Regulation (EC) No. 1069/2009*. Finnish Food Authority. https://www.ruokavirasto.fi/globalassets/yritykset/elainala/sivutuotelaitoslistat/section_iv.pdf

Finnish Food Authority, Risk Assessment Unit. (2020). *Koronaviruksen zoonoosiuhka – SARS-CoV-2 ja minkkitarhat*.

Franke-Whittle, I. H., & Insam, H. (2013). Treatment alternatives of slaughterhouse wastes, and their effect on the inactivation of different pathogens: A review. *Critical Reviews in Microbiology, 39*(2), 139–151. https://doi.org/10.3109/1040841X.2012.694410

Freuling, C. M., Breithaupt, A., Müller, T., Sehl, J., Balkema-Buschmann, A., Rissmann, M., Klein, A., Wylezich, C., Höper, D., Wernike, K., Aebischer, A., Hoffmann, D., Friedrichs, V., Dorhoi, A., Groschup, M. H., Beer, M., & Mettenleiter, T. C. (2020). Susceptibility of Raccoon Dogs for Experimental SARS-CoV-2 Infection. *Emerging Infectious Diseases, 26*(12), 2982–2985. https://doi.org/10.3201/eid2612.203733

Gagnon, C. A., Spearman, G., Hamel, A., Godson, D. L., Fortin, A., Fontaine, G., & Tremblay, D. (2009). Characterization of a Canadian mink H3N2 influenza A virus isolate genetically related to triple reassortant swine influenza virus. *Journal of Clinical Microbiology, 47*(3), 796–799. https://doi.org/10.1128/JCM.01228-08

González, M., Mikkelä, A., Tuominen, P., Ranta, J., Hakkinen, M., Hänninen, M.-L., & Llarena, A.-K. (2016). *Risk assessment of Campylobacter* spp. *In Finland* (Nro 2/2016; Evira Research Report).

Handeland, K., Nesse, L. L., Lillehaug, A., Vikøren, T., Djønne, B., & Bergsjø, B. (2008). Natural and experimental *Salmonella* Typhimurium infections in foxes (*Vulpes vulpes*). Veterinary *Microbiology, 132*(1), 129–134. https://doi.org/10.1016/j.vetmic.2008.05.002

Hansen, J. E., Larsen, A. R., Skov, R. L., Chriél, M., Larsen, G., Angen, Ø., Larsen, J., Lassen, D. C. K., & Pedersen, K. (2017). Livestock-associated methicillin-resistant *Staphylococcus aureus* is widespread in farmed mink (*Neovison vison*). *Veterinary Microbiology, 207*, 44–49. https://doi.org/10.1016/j.vetmic.2017.05.027

Hansen, J. E., Stegger, M., Pedersen, K., Sieber, R. N., Larsen, J., Larsen, G., Lilje, B., Chriél, M., Andersen, P. S., & Larsen, A. R. (2020). Spread of LA-MRSA CC398 in Danish mink (*Neovison vison*) and mink farm workers. *Veterinary Microbiology, 245*, 108705. https://doi.org/10.1016/j.vetmic.2020.108705

Helmy, Y. A., & Hafez, H. M. (2022). Cryptosporidiosis: From prevention to treatment, a narrative review. *Microorganisms, 10*(12), Art. 12. https://doi.org/10.3390/microorganisms10122456

Hobbs, E. C., & Reid, T. J. (2021). Animals and SARS-CoV-2: Species susceptibility and viral transmission in experimental and natural conditions, and the potential implications for community transmission. *Transboundary and Emerging Diseases, 68*(4), 1850–1867. https://doi.org/10.1111/tbed.13885

Häggblom, P. (2009). *The feed borne outbreak of* Salmonella *Tennessee in Finland in the spring of 2009* (Nro 2009/607). National Veterinary Institute.

Jensen, V. F., Sommer, H. M., Struve, T., Clausen, J., & Chriél, M. (2016). Factors associated with usage of antimicrobials in commercial mink (*Neovison vison*) production in Denmark. *Preventive Veterinary Medicine, 126*, 170–182. https://doi.org/10.1016/j.prevetmed.2016.01.023

Jensen, V. F., Sommer, H. M., Struve, T., Clausen, J., & Chriél, M. (2017). A cross-sectional field study on potential associations between feed quality measures and usage of antimicrobials in commercial mink (*Neovison vison*). *Preventive Veterinary Medicine, 143*, 54–60. https://doi.org/10.1016/j.prevetmed.2017.04.012

Jiang, W., Wang, S., Zhang, C., Li, J., Hou, G., Peng, C., Chen, J., & Shan, H. (2017). Characterization of H5N1 highly pathogenic mink influenza viruses in eastern China. *Veterinary Microbiology, 201*, 225–230. https://doi.org/10.1016/j.vetmic.2017.01.028

Koopmans, M. (2021). SARS-CoV-2 and the human-animal interface: Outbreaks on mink farms. *The Lancet. Infectious Diseases, 21*(1), 18–19. https://doi.org/10.1016/S1473-3099(20)30912-9

Koskinen, N. (2007). Experiences with acidified raw materials and acids in fur animal feed in Finland: Formic acid in blue fox feed, long term effects. *Acidified Raw Materials and Acids in Fur Animal Feed: Effects of Acids on Animal Health, Workshop, Aarslev Kro, Aarhus, Denmark, March 2007*, 98–108.

Laki eläimistä saatavista sivutuotteista, Pub. L. No. 517/2015 (2015). [Animal By-Products Act] https://www.finlex.fi/fi/laki/ajantasa/2015/20150517

Lehtoranta, S., Johansson, A., Malila, R., Rankinen, K., Grönroos, J., Luostarinen, S., & Kaistila, K. (2020). *Vaihtoehtoja kestävämpään turkiseläinten lannan hyödyntämiseen* (Nro 35/2020; Suomen ympäristökeskuksen raportteja). Suomen ympäristökeskus. https://helda.helsinki.fi/handle/10138/318398

Lindström, M., Nevas, M., Kurki, J., Sauna-aho, R., Latvala-Kiesilä, A., Pölönen, I., & Korkeala, H. (2004). Type C botulism due to toxic feed affecting 52,000 farmed foxes and minks in Finland. *Journal of Clinical Microbiology, 42*(10), 4718–4725. https://doi.org/10.1128/JCM.42.10.4718-4725.2004

Lu, L., Sikkema, R. S., Velkers, F. C., Nieuwenhuijse, D. F., Fischer, E. A. J., Meijer, P. A., Bouwmeester-Vincken, N., Rietveld, A., Wegdam-Blans, M. C. A., Tolsma, P., Koppelman, M., Smit, L. A. M., Hakze-van der Honing, R. W., van der Poel, W. H. M., van der Spek, A. N., Spierenburg, M. A. H., Molenaar, R. J., Rond, J. de, Augustijn, M., … Koopmans, M. P. G. (2021). Adaptation, spread and transmission of SARS-CoV-2 in farmed minks and associated humans in the Netherlands. *Nature Communications, 12*, 6802. https://doi.org/10.1038/s41467-021-27096-9

Luostarinen, S., Paavola, T., Ervasti, S., Sipilä, I., & Rintala, J. (2011). *Lannan ja muun eloperäisen materiaalin käsittelyteknologiat* (MTT raportti 27; MTT raportti). MTT. https://jukuri.luke.fi/handle/10024/438229

Lyhs, U., Frandsen, H., Andersen, B., Nonnemann, B., Hjulsager, C., Pedersen, K., & Chriél, M. (2019). Microbiological quality of mink feed raw materials and feed production area. *Acta Veterinaria Scandinavica, 61*, 56. https://doi.org/10.1186/s13028-019-0489-6

Maa- ja metsätalousministeriön asetus eläimistä saatavista sivutuotteista, Pub. L. No. 783/2015 (2015). [Decree of the Ministry of Agriculture and Forestry] https://finlex.fi/fi/laki/alkup/2015/20150783

Mahdy, M. A. A., Younis, W., & Ewaida, Z. (2020). An overview of SARS-CoV-2 and animal infection. *Frontiers in Veterinary Science, 7*, 596391. https://doi.org/10.3389/fvets.2020.596391

Marks, S. l., Rankin, S. c., Byrne, B. a., & Weese, J. s. (2011). Enteropathogenic bacteria in dogs and cats: Diagnosis, epidemiology, treatment, and control. *Journal of Veterinary Internal Medicine, 25*(6), 1195–1208. https://doi.org/10.1111/j.1939-1676.2011.00821.x

Meerburg, B. G., Jacobs-Reitsma, W. F., Wagenaar, J. A., & Kijlstra, A. (2006). Presence of *Salmonella* and *Campylobacter* spp. In wild small mammals on organic Farms. *Applied and Environmental Microbiology, 72*(1), 960–962. https://doi.org/10.1128/AEM.72.1.960-962.2006

Ministry of the Environment. (2018). *Turkistarhauksen ympäristönsuojeluohje* (Publication series No. 2/2018; Environmental Administration Guidelines). Ministry of the Environment. https://julkaisut.valtioneuvosto.fi/handle/10024/161033

Molenaar, R. J., Vreman, S., Honing, R. W. H. der, Zwart, R., Rond, J. de, Weesendorp, E., Smit, L. A. M., Koopmans, M., Bouwstra, R., Stegeman, A., & Poel, W. H. M. van der. (2020). Clinical and pathological findings in SARS-CoV-2 disease outbreaks in farmed mink (*Neovison vison*): *Veterinary Pathology*. https://doi.org/10.1177/0300985820943535

Nikolaisen, N. K., Fertner, M., Lassen, D. C. K., Chehabi, C. N., Ronaghinia, A. A., Chriél, M., Jensen, V. F., Jensen, L. B., Pedersen, K., & Struve, T. (2022). Association between antibiotic consumption and resistance in mink production. *Antibiotics, 11*(7), 927. https://doi.org/10.3390/antibiotics11070927

Nikolaisen, N. K., Lassen, D. C. K., Chriél, M., Larsen, G., Jensen, V. F., & Pedersen, K. (2017). Antimicrobial resistance among pathogenic bacteria from mink (*Neovison vison*) in Denmark. *Acta Veterinaria Scandinavica, 59*(1), 60. https://doi.org/10.1186/s13028-017-0328-6

Nowakiewicz, A., Zięba, P., Ziółkowska, G., Gnat, S., Muszyńska, M., Tomczuk, K., Majer Dziedzic, B., Ulbrych, Ł., & Trościańczyk, A. (2016). Free-Living species of carnivorous mammals in Poland: Red fox, beech marten, and raccoon as a potential reservoir of *Salmonella, Yersinia, Listeria* spp. and Coagulase-Positive *Staphylococcus. PLoS ONE, 11*(5), e0155533. https://doi.org/10.1371/journal.pone.0155533

Oreshkova, N., Molenaar, R. J., Vreman, S., Harders, F., Oude Munnink, B. B., Hakze-van der Honing, R. W., Gerhards, N., Tolsma, P., Bouwstra, R., Sikkema, R. S., Tacken, M. G., de Rooij, M. M., Weesendorp, E., Engelsma, M. Y., Bruschke, C. J., Smit, L. A., Koopmans, M., van der Poel, W. H., & Stegeman, A. (2020). SARS-CoV-2 infection in farmed minks, the Netherlands, April and May 2020. *Eurosurveillance, 25*(23). https://doi.org/10.2807/1560-7917.ES.2020.25.23.2001005

Oude Munnink, B. B., Sikkema, R. S., Nieuwenhuijse, D. F., Molenaar, R. J., Munger, E., Molenkamp, R., van der Spek, A., Tolsma, P., Rietveld, A., Brouwer, M., Bouwmeester-Vincken, N., Harders, F., Hakze-van der Honing, R., Wegdam-Blans, M. C. A., Bouwstra, R. J., GeurtsvanKessel, C., van der Eijk, A. A., Velkers, F. C., Smit, L. A. M., … Koopmans, M. P. G. (2021). Transmission of SARS-CoV-2 on mink farms between humans and mink and back to humans. *Science, 371*(6525), 172–177. https://doi.org/10.1126/science.abe5901

Pelkonen, S., Kontturi, M., Kuronen, H., Heinikainen, S., Pohjanvirta, T., Lienemann, T., Rossow, H., Tuominen, P., Seppä-Lassila, L., Pirhonen, M., Ranta, J., Ruoho, O., Salmenlinna, S., Vainio, A., & Laitinen, S. (2022). *Salmonellan leviäminen suomalaisille sika- ja nautatiloille* (Sarjajulkaisu 2022:5; Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja). Valtioneuvoston kanslia. https://julkaisut.valtioneuvosto.fi/handle/10024/163763

Pelyuntha, W., Yafa, A., Charoenwong, B., & Vongkamjan, K. (2022). Effectiveness of the organic acid-based antimicrobial agent to prevent bacterial contamination in fish meal. *Animals, 12*(23), 3367. https://doi.org/10.3390/ani12233367

Pomorska-Mól, M., Włodarek, J., Gogulski, M., & Rybska, M. (2021). Review: SARS-CoV-2 infection in farmed minks – an overview of current knowledge on occurrence, disease and epidemiology. *Animal, 15*(7), 100272. https://doi.org/10.1016/j.animal.2021.100272

Qian, W., Zhang, Y., Jiang, Y., Zhao, A., Lv, C., & Qi, M. (2020). Molecular characterization of *Cryptosporidium* spp. In minks (*Neovison vison*), blue foxes (*Vulpes lagopus*), and raccoon dogs (*Nyctereutes procyonoides*) in farms from Xinjiang, Northwest China. *Parasitology Research, 119*(11), 3923–3927. https://doi.org/10.1007/s00436-020-06909-8

Ranta, J., Rossow, H., Seppä-Lassila, L., Simola, M., Olkkola, S., Tuominen, P., Huitu, O., Henttonen, H., Niemimaa, J., Hallanvuo, S., Hakola, S., Hakkinen, M., Nykäsenoja, S., & Myllyniemi, A.-L. (2020). *Haittaeläinten vaikutus zoonoosien säilymiseen ja leviämiseen tuotantotiloilla (HAITTAELÄIN)—Loppuraportti*. Zenodo. https://doi.org/10.5281/zenodo.5166725

Regulation (EC) No. 1069/2009 of the European Parliament and of the Council, Pub. L. No. 1069/2009 (2019). http://data.europa.eu/eli/reg/2009/1069/2019-12-14/eng

Rijks, J. M., Hesselink, H., Lollinga, P., Wesselman, R., Pier, P., Weesendorp, E., Engelsma, M., Heutink, R., Harders, F., Kik, M., Rozendaal, H., van den Kerkhof, H., & Beerens, N. (2021). Highly pathogenic avian influenza A(H5N1) virus in wild red foxes, the Netherlands, 2021. *Emerging Infectious Diseases, 27*(11), 2960–2962. https://doi.org/10.3201/eid2711.211281

Rossow, H., Seppä-Lassila, L., Tuomola, J., Lehtiniemi, T., Valkama, J., Tammiranta, N., Gadd, T., & Tuominen, P. (2023). *Siipikarjan lintuinfluenssariski Suomessa – riskiprofiili* (Nro 1/2023; Ruokaviraston tutkimuksia).

Semenov, A. M., Kuprianov, A. A., & van Bruggen, A. H. C. (2010). Transfer of enteric pathogens to successive habitats as part of microbial cycles. *Microbial Ecology, 60*(1), 239–249. https://doi.org/10.1007/s00248-010-9663-0

Siemionek, J., Przywara, K., & Szczerba-Turek, A. (2020). The Prevalence of *Salmonella* spp. In Two Arctic Fox (*Alopex lagopus*) Farms in Poland. *Animals, 10*(9), 1688. https://doi.org/10.3390/ani10091688

Sikkema, R. S., Begeman, L., Janssen, R., Wolters, W. J., Geurtsvankessel, C., de Bruin, E., Hakze-van der Honing, R. W., Eblé, P., van der Poel, W. H. M., van den Brand, J. M. A., Slaterus, R., La Haye, M., Koopmans, M. P. G., Velkers, F., & Kuiken, T. (2022). Risks of SARS-CoV-2 transmission between free-ranging animals and captive mink in the Netherlands. *Transboundary and Emerging Diseases*, 10.1111/tbed.14686. https://doi.org/10.1111/tbed.14686

Stjerna, R., Sahlström, L., & Lyytikäinen, T. (2015). *Eläinperäisten luokan 2 sivutuotteiden maahantuloon liittyvät vaarat—Riskiprofiili* (Nro 4/2015; Eviran tutkimuksia). Evira. https://helda.helsinki.fi/handle/10138/157821

Sun, H., Li, F., Liu, Q., Du, J., Liu, L., Sun, H., Li, C., Liu, J., Zhang, X., Yang, J., Duan, Y., Bi, Y., Pu, J., Sun, Y., Tong, Q., Wang, Y., Du, X., Shu, Y., Chang, K.-C., & Liu, J. (2021). Mink is a highly susceptible host species to circulating human and avian influenza viruses. *Emerging Microbes & Infections, 10*(1), 472–480. https://doi.org/10.1080/22221751.2021.1899058

Tammiranta, N., Isomursu, M., Fusaro, A., Nylund, M., Nokireki, T., Giussani, E., Zecchin, B., Terregino, C., & Gadd, T. (2023). *Highly Pathogenic Avian Influenza a (H5n1) Virus Infections in Wild Carnivores Connected to Mass Mortalities of Pheasants in Finland* [SSRN Scholarly Paper]. https://doi.org/10.2139/ssrn.4339801

The Danish Health Authority. (2016). *Guidance on Preventing the Spread of MRSA*. https://www.sst.dk/-/media/Udgivelser/2017/MRSA-EN/Guidance-on-preventing-the-spread-of-MRSA-3rd-edition-2016.ashx

Thépault, A., Rose, V., Queguiner, M., Chemaly, M., & Rivoal, K. (2020). Dogs and Cats: Reservoirs for highly diverse *Campylobacter jejuni* and a potential source of human exposure. *Animals, 10*(5), 838. https://doi.org/10.3390/ani10050838

Turkistuottajan sitoumus ja siitoseläinmääräilmoitus. (2023). https://www.ruokavirasto.fi/globalassets/viljelijat/elaintenpito/elaintaudit/covid-19/tuottajan_sitoumus_fi_220310.pdf.

Valtioneuvoston asetus turkiseläinten suojelusta, Pub. L. No. 1084/2011 (2011). [Government Decree] https://www.finlex.fi/fi/laki/ajantasa/2011/20111084

Virtanen, J., Aaltonen, K., Kegler, K., Venkat, V., Niamsap, T., Kareinen, L., Malmgren, R., Kivelä, O., Atanasova, N., Österlund, P., Smura, T., Sukura, A., Strandin, T., Dutra, L., Vapalahti, O., Nordgren, H., Kant, R., & Sironen, T. (2022). ExperimentaliInfection of mink with SARS-COV-2 omicron variant and subsequent clinical disease. *Emerging Infectious Diseases, 28*(6), 1286–1288. https://doi.org/10.3201/eid2806.220328

Vries, E. de, & Haan, C. A. de. (2023). Letter to the editor: Highly pathogenic influenza A(H5N1) viruses in farmed mink outbreak contain a disrupted second sialic acid binding site in neuraminidase, similar to human influenza A viruses. *Eurosurveillance, 28*(7), 2300085. https://doi.org/10.2807/1560-7917.ES.2023.28.7.2300085

Wang, G., Du, Y., Wu, J., Tian, F., Yu, X., & Wang, J. (2018). Vaccine resistant pseudorabies virus causes mink infection in China. *BMC Veterinary Research, 14*(1), 20. https://doi.org/10.1186/s12917-018-1334-2

WOAH. (2020). *OIE statement on COVID-19 and mink*—WOAH. WOAH - World Organisation for Animal Health. https://www.woah.org/en/oie-statement-on-covid-19-and-mink/

WOAH. (2023a). *WAHIS*. https://wahis.woah.org/#/analytics

WOAH. (2023b). *Statement on avian influenza and mammals—World Organisation for Animal Health*. WOAH - World Organisation for Animal Health. https://www.woah.org/en/statement-on-avian-influenza-and-mammals/

Xunta de Galicia. (2022). *La Xunta detecta un foco de influenza aviar en una explotación de visones en la provincia de A Coruña*. Xunta de Galicia; Xunta de Galicia. https://www.xunta.gal/notas-de-prensa/-/nova/73686/xunta-detecta-foco-influenza-aviar-una-explotacion-visones-provincia-coruna

Yoo, H. S., & Yoo, D. (2020). COVID-19 and veterinarians for one health, zoonotic- and reverse-zoonotic transmissions. *Journal of Veterinary Science, 21*(3), e51. https://doi.org/10.4142/jvs.2020.21.e51

Åkerstedt, J., Valheim, M., Germundsson, A., Moldal, T., Lie, K.-I., Falk, M., & Hungnes, O. (2012). Pneumonia caused by influenza A H1N1 2009 virus in farmed American mink (*Neovison vison*). *The Veterinary Record, 170*(14), 362. https://doi.org/10.1136/vr.100512

FINNISH FOOD AUTHORITY

Ruokavirasto • Livsmedelsverket

ruokavirasto.fi