Risk assessments regarding open trade in live animals to Iceland

Report

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To whom it may concern

Bern, 19 March 2013

Formal review of import risk assessments for Iceland

General approach
The documents reviewed provided the general description of the methodologies used for hazard selection and risk assessment. Additionally, the results of the assessments conducted for the selected hazards were presented. After commenting on a first version of the documents, I also saw revised versions (dated March 15 and March 18, 2013), on the basis of which the following comments were made.

Chapter 6: The approach described is logical, systematic and comprehensive. The WAHID list is internationally accepted and although there is some under-reporting affecting the quality of information included there, this is very unlikely to be an issue in the countries relevant here. The approach used for hazard selection therefore follows accepted methods commonly used in import risk assessments in Europe and elsewhere.

Chapter 8: This chapter outlines the general approach taken to the risk assessments. Chapter 8 also provides qualitative risk assessments for equine viral arteritis (EVA), equine herpes virus 1 (EHV-1), equine influenza virus (EIV) as well as maedi visna/caprine arthritis and encephalitis. Results of quantitative risk assessments are reported for bovine virus diarrhoea (BVD), *Salmonella* Dublin (SD), Q fever (QF) and paratuberculosis (PTB). The rational for using qualitative rather than quantitative outcomes for some hazards is based on data availability and knowledge gaps. Knowledge gaps are a common challenge in risk assessments and a common reason for qualitative approaches. Qualitative risk assessments are regularly used in the context of trade and are perfectly acceptable under the Sanitary and Phytosanitary (SPS) Agreement of the World Trade Organisation (WTO). In fact, the SPS Agreement does not specify the methods to be used but demands that a science-based approach is to be applied. Also, principles of consistency, transparency, equivalence and minimised trade restrictions should be applied. The latter mainly relate to risk management, not specifically to risk assessment.

In the risk assessments considered here, sufficient evidence is provided on individual hazards, using recent and appropriate literature referencing. References of the World Organisation for Animal Health (OIE) are accepted standards under the SPS agreement and meant to inform trade decisions by WTO Member States. It is therefore good practice to adhere to these standards whenever possible. The risk assessments presented here were all based on the OIE standards using the frameworks and terminology suggested there. The method is therefore appropriate.

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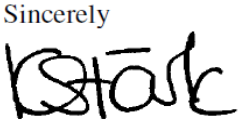
Denmark is used as a reference country for a number of import scenarios. This appears to be justified due to the relevance of trade links and other similarities.

The time horizon used in the risk assessments ranges up to 20 years. This is an unusually long time period. Most risk assessments focus on one year or sometimes up to 5 years. This is due to the fact that assumptions on changes in husbandry practices and general disease situations are becoming highly uncertain beyond this horizon. As each additional year increases the risk, a long interval invariably leads to higher risk estimates. In terms of risk management, a realistic time period and the level of acceptable risk should be considered.

For diseases where quantitative assessments were conducted (BVD, SD, QF, PTB), the means of the simulation results are reported. In skewed distributions, the mean is likely to be a biased estimate providing either under- or over-estimated results. The most likely value (mode) may therefore provide a more relevant measure to inform risk management.

Conclusion
Based on the documents provided, I conclude that the risk assessments presented here were conducted according to current best practice and in compliance with international standards.

Sincerely



Prof. Katharina D.C. Stärk

Executive Summary

An overview of the historical occurrence of foreign animal diseases in Iceland is given in Chapter 1. The Icelandic horse, cattle, sheep and goat breeds have developed as isolated breeds since the settlement and these are the only breeds of their species to be present in the country. Due to their relative isolation, the Icelandic animal populations have been mostly free from infectious diseases. Imports of live animals in the last centuries have, however, in many cases brought diseases with them, such as sheep scabies, Scrapie, and the so-called Karakul diseases: Maedi/Visna, Jaagsiekte and paratuberculosis. The previous experiences in Iceland with the three diseases Maedi/Visna in sheep, Infectious Pyrexia and the disease caused by a "new" strain of the bacterium *Streptococcus equi* subsp. *zooepidemicus* (ST2309) in horses, clearly demonstrate the vulnerability of the native animal populations in Iceland.

In Chapter 2 the Icelandic experience with importation of paratuberculosis with sheep from Germany in 1933 is described in more details, and it is also referred how other countries have had similar experience with this infection in cattle. Other infections are also described to have been imported to free regions and herds with transfer of live animals. Biosecurity at the national and herd levels should recognize such transfer of live animals as probably the most serious threat to remaining free from a series of specific infections.

Chapter 3 outlines the animal health policy in Iceland regarding infectious diseases, including the current legislation on notifiable diseases, the veterinary services and the strict import bans and conditions for exceptions.

Animal husbandry in Iceland is described in Chaper 4 including lesgislation, sizes and locations of the farms and animals and geographical movement restrictions, where they exist. The geographical clustering of farms and animals is very pronounced in Iceland, which is an important factor when it comes to the potential threats of spread of infectious diseases entering the country.

Chapter 5 contains the lists of notifiable diseases and infections as well as surveillance and eradication data for diseases and infections in Iceland. For most of the diseases and infections the surveillance data sustantiate their absence from the Icelandic animal populations, while sporadic occurrence is still found for scrapie and paratuberculosis caused by the S-strain of *Mycobacterium paratuberculosis*.

The initial step in identifying hazards which are relevant to include in detailed risk assessments is described in Chapter 6. The procedure established by the World Association for Animal Health (OIE) for countries considering participating in bilateral import-export is described. The reasons for the selection of Denmark as the exporting country are explained, as are the Icelandic expert opinions defining the expected annual size of the importation of cattle, sheep and horses.

With Denmark as the exporting country, the result of executing the on-line screening procedure for identification of potential hazards was a shortlist of 7 diseases and infections:

Cattle
- Bovine Virus Diarrhoea (BVD)
- Q-fever (*Coxiaella burnetii*)

Sheep
- Maedi – Visna
- Caprine Arthritis and Encephalitis (CAE)

Horses
- Equine influenza (EI)
- Equine herpesvirus 1 (EHV-1)
- Equine Virus Arteritis (EVA)

Finally, Chapter 6 describes a series of limitations of the methodology applied.

Chapter 7 describes the efforts to identify additional potentially hazardous diseases and infections in order to compensate for some of the methodological limitations mentioned in Chapter 6. Comparisons were carried out of the notifiable diseases listed in the Icelandic animal health regulations with the Danish status for those diseases and infections. A list was established for those diseases and infections existing or suspected in Denmark but absent in Iceland which were not already covered by the OIE listed diseases and infections considered in Chapter 6. For two of these conditions, both in cattle, detailed information on the prevalence and impact in Denmark is available from on-going control programs, and these two were added to the shortlist of 7 diseases and infections produced in Chapter 6:

- *Salmonella* Dublin
- Paratuberculosis strain C infections

For an additional approximately 20 infections such details were not available, although sketchy data suggest that they occur or are suspected to occur in Denmark. These diseases and infections will not be considered further in this report.

Before going into the detailed risk assessments for the 9 selected infections, Chapter 8 describes the internationally recognized principles of import risk assessment according to the World Trade Organization (WTO) and the World Organization for Animal Health (OIE) as the standard setting body for animal health issues. The individual steps of hazard identification, entry (release) assessment, exposure assessment, consequence assessment, and the final risk assessment are described and the nomenclature and the category definitions are explained for each step. Two different procedures are used for the entry assessments: a quantitative simulation model approach and a qualitative descriptive approach, depending on the amounts and degree of details of the Danish data for the prevalence of the disease/infections at the herd and within-herd levels.

A summary of the results are presented in the tables below:

Table 1 Entry probabilities for 4 cattle disease/infections from Denmark to Iceland under the given cattle import scenarios

Disease/infection	After 1 year	After 5 years	After 10 years	After 15 years	After 20 years
Bovine virus diarrhea (BVD)	0.41%	-	4.04%	-	7.92%
Q-fever (*Coxiella burnetii*)	Set I: 96% Set II: 100%	100%	100%	100%	100%
Paratuberculosis strain C	Set I: 93.1% Set II: 82.9%	100%	100%	100%	100%
Salmonella Dublin	57.3%	98.3%	100%	100%	100%

Table 2 Results of the steps in the 8 qualitative risk assessments

Disease/infection	Entry (release) probability	Exposure probability	Consequence impact	Risk assessment
Bovine virus diarrhea (BVD)	very low to low	high	high	very low to low
Q-fever (*Coxiella burnetii*)	high	high	low to moderate	low to moderate
Paratuberculosis strain C	high	high	high	high
Salmonella Dublin	moderate to high	high	high	moderate to high
SRLV infections: Maedi/Visna and CAE	unknown	high	high	high
Equine herpesvirus 1 (EHV-1)	high	high	high	high
Equine Viral Artheritis (EVA)	high	high	high	high
Equine influenza (EI)	high	high	high	high

Chapter 1 Overview of the occurrence of foreign animal diseases in Iceland

Introduction

Since its settlement, Iceland has been mostly isolated from the outside world as regards its animal populations. The settlement is considered to have started in the year 874 and settlers brought with them from Scandinavia their own livestock: sheep, horses, cows, pigs, poultry and goats. The only mammal native in Iceland before the settlement was the arctic fox. The Icelandic horse, cattle, sheep and goat breeds have developed as isolated breeds since the settlement and these are the only breeds of their species to be present in the country. Due to their relative isolation, the Icelandic animal populations have been mostly free from infectious diseases. Previous imports of live animals in the last centuries have, however, in many cases brought diseases with them, such as sheep scabies, Scrapie, and the so-called Karakul diseases: Maedi/Visna, Jaagsiekte and paratuberculosis. Due to these diseases the imported sheep and their off-springs were destroyed and did not have any genetic influence on the native breed. In order to combat the Karakul diseases a unique system of 38 fenced off quarantine zones was established in the 1950´s. Maedi/Visna and Jaagsiekte were eradicated by 1965, but the quarantine zone system has been maintained to eradicate paratuberculosis and Scrapie. However, due to the relative success in eradicating these diseases, the zones are now down to 24.

Imports in the 18th century

Sheep farming has always been an important part of Icelandic agriculture, both for meat production and for the use of the wool to produce yarn for making clothes. In order to improve the quality of sheep wool, some 10 rams were imported from England in 1756 and there were repeated imports for the next 5 to 6 years until 1761, when it was realized that a new disease had been imported with the sheep. This turned out to be Sheep scabies caused by *Psoroptes ovis* which caused grave problems to the sheep farmers due to damage to the wool and to the growth of the animals in a very harsh climate. After several years of attempting to stop the spread of the disease a special decree was enacted by the authorities in 1772, mandating all sheep with or suspected of the disease to be destroyed and sheep houses to be burned in order to eradicate the disease. Not all areas of Iceland were affected and clean animals could be sent for replacement to the diseased areas. By 1779 this process was over, but the loss of animals and profits from them was enormous. Before the Sheep scab was brought to the country in 1760, the number of sheep was estimated at around 360 000, but by 1780 only some 80 000 animals had survived.

Imports in the 19th century

In spite of the disastrous effects of the live sheep imports in the 18th century, farmers did import some live sheep in 1855 and this led to another epidemic of sheep scab, which was in fact not eradicated until the beginning of the 21st century or after 150 years. This time there was more opposition to the stamping out methods and the control relied on dipping of the sheep, but the chemicals used were not very effective. Several laws and regulations were enacted in attempts to eradicate the sheep scab. In the end final eradication was achieved by treating each animal in the infected areas with injections of parasiticides and using insecticides after cleaning of the sheep houses. During those 150 years not so many sheep were lost as before, but the total costs to the farmers were huge due to repeated dipping requirements, which were practised every year for many decades. The dipping was always carried out during the winter months and this could

cause hardship to the animals. Furthermore, environmentally harmful chemicals such as Benzene-hexachloride were used for decades for the dipping.

Scrapie

In the year 1878, there was another import of live sheep and this time Scrapie was introduced. Firstly, it spread slowly between farms in Mid – North Iceland, but some 75 years after introduction it started spreading more rapidly around the country. A proper diagnosis of this disease was not possible at this time and when a special project with exchange of sheep was started to eradicate the Karakul diseases, it is believed that sheep from areas supposedly free from those diseases and sent to the diseased areas, may have been in the very long incubation phase of Scrapie. Some of the farms in Mid-North Iceland where Scrapie and the Karakul diseases had been a problem did get Scrapie again after 3 years of depopulation and after receiving replacement lambs from areas that had never had any problem with Scrapie. Thus it became evident that the Scrapie agent was surviving on the farm for at least this time. Later experience in Iceland has now shown that this agent can survive for up to 18 years on a farm that received clean lambs after 18 years of depopulation. In this second wave of the spread, Scrapie turned out to be a much more serious disease than before. On some farms between 10 – 15% of the breeding sheep were dying and even up to 50% on a small number of farms. Such huge losses due to this disease are unknown in other countries. Therefore it was decided in 1978 to start to combat the increased spread and to minimise losses, and a programme was started where diseased sheep were culled on farms in the quarantine zones where Scrapie was known to exist, but when the disease was diagnosed on a farm in a previously free quarantine zone, the whole herd was culled.

By 1986 there were still more than 100 known Scrapie farms in 25 quarantine zones out of 38, and it was obvious that this method was not effective enough and the future of sheep farming in Iceland was at stake. Therefore it was decided to start a much more stringent programme of eradication with the active cooperation of the sheep farmers, the Veterinary Services and the financial assistance of the relevant ministries, providing necessary compensation to the farmers. In the new programme, all diagnosed cases resulted in whole herd depopulation, followed by thorough cleaning and disinfection of sheep houses and the surroundings, and replacement sheep could not be bought in for two years. Bio-security measures were also strengthened, as movement of sheep over the fenced quarantine zones was forbidden and all stray sheep between the quarantine zones had to be culled. Furthermore, all movements of sheep inside the quarantine zones where Scrapie had been diagnosed was forbidden, as direct contact of sheep housed together during the winter was known to be one of the main factors in the transmission of the disease.

During the earlier days of the combat against Scrapie it had been noticed, that some genetic lines of sheep on the same farms seemed to be more resistant to the disease. However, attempts to breed for resistance did not prove successful and it later became evident that the genetic type of ARR, believed to be the most resistant type, does not exist in the Icelandic sheep breed. This may be one of the reasons why Scrapie became such a serious disease in Iceland, coupled with the fact that sheep have to be housed during the long winter periods. Artificial insemination of sheep has been used very successfully in Iceland and has helped breeding improvements in quarantine zones where all movements of rams were forbidden. In recent years rams selected for the artificial insemination stations have to be negative for the VRQ genetic type that is believed to be the most sensitive type for Scrapie.

This very stringent programme has proved to be successful, and in the period from 2007 – 2012 only one or two cases per year have been diagnosed and in some years only atypical Scrapie of the NOR98 type has been found. Earlier cases of NOR98 have undergone exactly the same eradication programme as carried out for classical scrapie, total depopulation of sheep for two years on the farms involved. One case of NOR98 was diagnosed in January 2012 and this time, only partial depopulation was carried out, due to recent epidemiological information and to the change in the OIE Terrestrial Animal Health Code in 2008, when atypical Scrapie/NOR 98 was no longer a part of the chapter on classical Scrapie. Therefore the eradication programme for Scrapie is considered to be well under way and more and more quarantine zones in Iceland have been declared Scrapie free. That classification is only given after the absence from Scrapie on all farms in the quarantine zone for more than 20 years. However, it has to be realised that it may still take decades before

Scrapie can be considered eradicated from Iceland. This is due to several factors, for example the ability of the prion agent responsible for Scrapie, to persist for a very long time in the environment and the long incubation of the disease, coupled with the inability to test for the disease in live animals.

From the start of the first eradication programme in 1978 and until 2003, there has been total depopulation of about 800 sheep flocks, with an estimated 150 000 sheep slaughtered. Depopulation is always carried out as soon as possible after the diagnosis of Scrapie and therefore at all times of the year. Earlier all carcasses of both adults and lambs were sent to special burial sites, but recently incineration facilities have also been used.

Imports in the 20th century

In the summer of 1932 some 25 sheep were imported from Scotland with the aim of improving the meat quality of the sheep breed. Later it was discovered that Actinobacillosis, which had never been found in Iceland previously, could be traced back to this import.

In 1933 five Scottish beef cattle were imported and kept in quarantine on an island where there was also one farm with cattle. Soon after the import, infection with ringworm was recorded for the first time in Iceland. Firstly, the disease was detected only in the imported animals, but later also in the cattle on the farm and the people there. Attempts were made to treat it, but this failed. All cattle on the island were then destroyed in order to prevent the spread to animals on the mainland. Since that time infections with ringworm have been recorded on farms in 1966, 1987 and 2006, and always successfully terminated with partial stamping out and bio-security measures. In 1966 and 1987 it was traced to foreign farm workers, but the cause in 2006 could not be established.

Jaagsiekte, paratuberculosis and Maedi/Visna

It was also in 1933 that the worst case of imports of sheep occurred, when 20 sheep of the Karakul breed were imported from Germany for production of skins from young lambs. The animals came from a university farm and with certificates of freedom from known diseases. Nevertheless, Jaagsiekte, paratuberculosis and Maedi/Visna were introduced to Iceland with this import from Germany. The animals were kept in quarantine on an island for two months only and then distributed to various locations in Iceland. These diseases are all untreatable and progressively fatal and spread rapidly around Iceland, until preventive measures were taken to combat them.

The first indication that a new disease had been brought to Iceland with this import from Germany was in one of the rams in the winter months of 1933/1934. This animal died in the summer of 1934 and in the winter thereafter, sheep on the farm became ill with pneumonia like disease, including signs of heavy breathing and collection of fluid in the lungs. Later this was found to be the viral disease Jaagsiekte, to be found in other countries, but never before in Iceland. This disease spread to various parts of Iceland, before it was realised, that this was a new disease which turned out to be very serious on some farms where almost 50% of the sheep died every year.

Then in 1938 paratuberculosis was diagnosed in a sheep in Eastern Iceland and this was traced back to one of the Karakul sheep that had been brought to the area. Later the infection was confirmed with Johnin skin tests in sheep and cattle in many areas of Iceland. Fortunately, the infection was due to a variant of the bacteria *Mycobacterium paratuberculosis* that is of the sheep strain. The disease has therefore not been a serious problem in cattle in Iceland, but mainly causing a problem due to latent bovine carriers on farms, where sheep were slaughtered to eradicate these Karakul diseases. The replacement sheep after 3 years then became infected, presumably from the latent carrier cattle on the farm. On the other hand, paratuberculosis has caused serious problems and heavy losses in sheep farming, due to clinically ill animals that wasted away and could not be treated or sold for slaughter. Also, some farmers lost ca. 8 – 9% of their herd every year. It is estimated that well over 100 000 animals died from this disease before a specific vaccine made at the Keldur Institute was introduced. After that the disease has been kept to a minimum and it has been possible along

with bio-security measures to eradicate it in some quarantine zones. From 1966 it has been compulsory to vaccinate all replacement lambs in infected quarantine zones.

The last of these diseases to be identified was the Maedi/Visna disease complex in 1939 in North East of Iceland. This disease had never been described before in the world, but it could certainly be traced back to the imports in 1933. This disease was determined to be clinically different from Jaagsiekte and later it was found to be due to a different virus. The Maedi/Visna virus was first isolated and described by Icelandic scientists in the late 1950´s and given these Icelandic names. Maedi and visna are caused by antigenically related strains of the same lentivirus. Maedi, meaning "laboured breathing", was a fatal, untreatable progressive pneumonia of mature sheep. Visna, meaning "wasting" was a meningo-encephalitis that was also untreatable and causing progressive paralysis and death.

In the years after its discovery the disease was found in other parts of Iceland and it turned out to cause far greater damage than in other countries. Recent research has shown that in comparative trials involving other breeds, the Icelandic sheep breed was the most sensitive breed to this disease. This disease had a longer incubation period than Jaagsiekte, often between 2-4 years. Some farms affected with Maedi/Visna experienced great losses of adult sheep every year and had to use up to 25 – 40% of lambs for restocking, resulting in much fewer lambs that could be sent for slaughter and hence lead to severe financial losses.

Other countries, for example Norway and Great Britain, have had the same experience as Iceland, that slow progressive viral diseases like Maedi/Visna can be imported with live sheep. In Great Britain, Maedi/Visna virus was first detected in the 1970´s in exotic sheep imported from continental Europe, and in indigenous breeds that had been in contact with exotic sheep. However, apparently the disease has not caused a big problem in that country. In Norway, the disease is currently under control and being eradicated.

The Icelandic experience with Maedi/Visna highlights the problem that imports of live animals has created for the country. At the time of the export of the Karakul sheep to Iceland, the disease was not known to science. The disease became clinically evident, detected and described for the first time, only when the virus was brought to Iceland with live imported sheep, which infected the indigenous sheep that were totally immunologically naive and genetically highly susceptible to the virus. The Karakul sheep were imported in 1933, and after 4-5 years it was obvious that the diseases that they brought to the country and had spread to most areas were causing so harmful effects on the sheep farming, that the government had to step in with new laws and regulations in order to bring the situation under control and reverse it. In 1936, temporary laws were enacted to control these diseases, and in 1941 a special law was passed by parliament to control the spread of Jaagsiekte and Maedi/Visna, including the fenced off quarantine zones, depopulation of infected farms, restocking of lambs from disease free zones and compensation to affected farmers. In 1956 these laws were revised to also include Scrapie and Actinobacillosis, as especially Scrapie had started to become a big problem to many farmers.

As mentioned before, a unique system of 38 fenced off quarantine zones was established in the late 1940´s and early 1950´s. The first fences had been erected in 1937 followed by the first formal depopulation and restocking, that was going to last for almost 30 years or until 1965. This method of controlling and eradicating Maedi/Visna and Jaagsiekte proved to be very successful, with Jaagsiekte being eradicated by 1952 and Maedi/Visna by 1965. The quarantine zone system has been kept in order to eradicate paratuberculosis and Scrapie, and as from 2010 there are 26 quarantine zones in place.

It can be concluded that, in the period from 1933 with the introduction of Maedi/Visna and Jaagsiekte and until the final eradication was successful in 1965, these diseases had cost the Icelandic farmers and the state enormous sums of money and causing psychological stress to the farmers having to destroy all their sheep, often valuable breeding stock. Therefore, the harmful effects that imports of live animals can have, is a constant remainder to prevent such disasters from happening again. Therefore, there is a strict law in Iceland that bans the imports of live animals. Imports can only be allowed with a special permission from the Minister for Agriculture after careful evaluation and recommendation by the Chief Veterinary Officer.

After the imports in 1933, there was a great reluctance to allow any imports, however, in 1947 some live sheep were imported from Scotland and quarantined. These animals turned out to be infected with Foot rot and were destroyed in the quarantine.

Since that time there have been several problem-free imports of genetic material for the improvement of Icelandic livestock other than the original horses, cattle, sheep and goats. In 1965, semen of the Galloway breed was imported and used for donor cows in a quarantine station which was built by the state for this purpose. The calves born from this import were not allowed out of the quarantine, only their offspring once it had been established that no diseases had been carried with this import. Similar imports were then carried out later, all successfully. Around 1990 a quarantine station was built by pig farmers to import live animals and semen, and it has been used for imports from Finland and Norway. Since 1995 regular imports of fertile poultry eggs have been received from Sweden and Norway, and they are incubated and the chickens are reared in quarantine stations, before being released to the poultry farmers. Fur farmers have for some time imported breeding animals once a year both from Finland and lately from Denmark, and they are kept in quarantine for about 6 months before being released to the farmers.

Disease risks for the horse population in Iceland

The Icelandic horse has developed as an isolated breed since the settlement of the country in the 9th and 10th centuries, and it is the only breed of horses in the country. Due to geographic isolation and strict import rules, the breed has remained free of the most serious contagious diseases, e.g. Equine influenza, Equine rhinopneumonitis (EHV-1), Equine viral arthritis and Strangles. The horses are for the same reason extremely vulnerable to all new agents that might be introduced.

In the year 2011 the native horse population counted approximately 80.000. The management of horses in Iceland is traditionally extensive where most of the horses, including the breeding mares, foals and young horses up to 3-4 years, are free roaming and fed outside during the winter, often with the possibility of free access to housing. The horses are often kept in large fields, in flocks of 10 – 100 individuals. Good health is a prerequisite for this method of management as weather conditions can be very harsh.

This management, characterized by freedom of movement and low infection risk does also encourage good health and welfare. Problems with foaling are hardly seen and infections in foals are rare. Natural breeding is most common as venereal diseases have not affected the population. The use of medicines to horses in these flocks is limited to deworming and anaesthesia for castration. Vaccinations are not needed.

Housing is mostly used for horses in training but also sometimes for young horses for breeding. Up to 10.000 horses are housed during the period January – May. The legislation allows rather dense stabling (4.0 m^2 for each horse in a box) and small pens. The stables are often built in clusters, in specifically designated areas in outskirts of towns, resulting in high density of horses in small areas.

During recent years the population has been exposed to infectious agents that apparently are new in the country. This resulted in two epidemics which caused considerable economic losses for the horse industry.

The total absence of specific immunity was the most important presumption for both of the epidemics. The management method appeared, however, to have a great effect on the infectious load and thereby on the severity of the clinical signs and their duration. The dense stabling, sometimes with poor ventilation and limited outdoor facilities appeared to be advantageous for the infective agents and intensified the contagion. Collecting the free roaming horses onto smaller fields/paddocks or housing them, for better supervision and care, clearly resulted in more stress, increased infectious load and risk of complications.

Good outdoor management appeared to create the best situation for the horses during the epidemics.

An epidemic of Infectious Pyrexia in horses in Iceland

In 1998 a mild infection of the digestive system (Infectious pyrexia), characterized by elevated body temperature, reduced appetite and increased risk of secondary complications, became an epidemic. The infectious agent was considered to belong to the picorna-virus family. It had not previously been described as a possible pathogen for horses.

The first cases of pyrexia of unknown aetiology were recorded in a stable near to Reykjavík on February 9th in 1998. Based on the clinical symptoms, the preliminary diagnosis was foodborne listeriosis. One week later the contagious nature of the disease was confirmed.

An announcement where people were urged to take care in their handling of horses followed by a regulation banning all movement of horses in the whole of Iceland was passed in the next days. By then, however, some spread had already taken place from where the disease spread over the whole west and south part of the country within two months. In a new regulation the country was divided into infected areas, buffer zone and non-infected areas. Transport of horses was allowed within the areas, but not between them. Large areas without horses, along with the official restrictions, prevented the spread of the disease to the north and east part of the country for three months. In the beginning of May, the first cases were detected in North Iceland. Subsequently, the restrictions of movement of horses were lifted. After the great horse event, Landsmót, in the middle of July, the disease spread throughout the whole country.

Most horses were mildly affected with slightly elevated body temperature and reduced appetite. However, some horses had a temperature of up to 42°C and went off their feed for some days. Some got diarrhoea after the fever top and a few were affected by severe colic as a complication. Eclampsia was seen in pregnant mares close to parturition and in lactating mares, especially in periods with bad weather.

The morbidity was high and most likely 100%. The mortality was low, approximately 0.2% of the population died due to complications. The incubation time was from two up to ten days depending on the infection load. The disease could be transmitted with faeces from infected horses. It spread both by direct contact between horses and indirectly by people and equipment. Spread did also occur between horses kept outside on farms, without any contact with other horses. Therefore, windborne transmission was suspected. By this mode the disease could spread up to ten kilometres across fences and rivers.

It can be concluded, that the isolation of the Icelandic horse population together with the density of horses stabled in the Reykjavík area give new infectious agents an opportunity to multiply and to become epidemic. Therefore, even low-pathogenic agents may cause serious situations for the horse industry in Iceland.

Outbreak of respiratory tract infection in the Icelandic horse population

In 2010, a "new" strain of the bacterium *Streptococcus equi* subsp. *zooepidemicus* (ST209) was introduced into the horse population resulting in an epidemic of a mild respiratory tract infection. No records are to be found internationally of a comparable epidemic caused by this bacterium. Coughing and muco-purulent discharge could persist up to 10 weeks.

Prior to these symptoms, serous discharge was often observed. Temperature remained normal in most horses. The duration of clinical symptoms varied from 2 - 10 weeks, most commonly 4 - 6 weeks.

The first cases were reported on the 7th of April 2010 from the equine center at Holar University College, located in the north of Iceland. Within a few days, it became apparent that the disease was already widespread throughout the country and that an epidemic could not be avoided.

Although the exact location of the index case has not been determined, epidemiological studies revealed one training station in the south of Iceland as the first centre of transmission. The first infected horses were transported from there on the 19th of February. During February and March the disease was transmitted to at least 18 new premises: the secondary centres of transmission. A questionnaire which was sent to 200 trainers and breeders all over the country in June, with a follow up in September, confirmed the distribution of the disease to the south-, west- and north of the country already in the first week of April, when the disease was

first reported. For stabled horses, the epidemic was at its peak in the beginning of May. The free roaming horses became infected in the next two months. As the most traditional way of horse breeding is keeping broad mares (often with their new born foal) with a stallion for free mating in a flock of 20 – 30 mares, a second peak of the disease was identified during the summer.

The entire equine population in Iceland (80.000 horses) appeared to be susceptible to the disease, resulting in 100% morbidity. Direct contact with infected horses was the most prevalent mode of transmission, but the disease could also be spread indirectly with riding equipment and fomites. The incubation time was approximately 2 weeks. Different stable conditions (ventilation, density of horses and time of outdoor resting) resulted in a diverse infection load, affecting both the latent period, the gravity of the clinical signs and their duration. The mortality was very low, although a few deaths were associated with disease complications.

In spite of extensive virological investigations, no viruses could be detected as a possible primary cause of the present epidemic.

Cultivation and testing by PCR for *Streptococcus equi* subsp. *equi* were negative.

The bacteria *Streptococcus equi* subsp. *zooepidemicus* (*S. zooepidemicus*) was cultivated from almost all nasal swabs taken from coughing horses with mucopurulent nasal discharge. Pure cultures of *S. zooepidemicus* were isolated from nasal, pharyngeal and tracheal swabs taken from experimentally infected horses at autopsy. Characterisation by MLST (Multilocus Sequence Typing) of strains isolated during the outbreak and comparison to strains previously isolated from horses in Iceland, indicated an introduction of a new strain of the bacteria to the country. Introduction of the new strain of *Streptococcus equi* subsp. *Zooepidemicus*, to the isolated population of horses in Iceland resulted in an epidemic of a mild, but sometimes prolonged respiratory tract infections. Only a few examples of complications were associated with the disease, and generally the horses recovered fully. However, the disease paralyzed the equine industry for three months with grave economic losses.

Although this strain has been described to cause similar symptoms in horses in other countries, it has not previously caused a comparable epidemic outbreak.

Geographic isolation and the absence of protective immunity in the entire population was the main reason for the epidemic. The management (such as dense stabling during the winter and free mating during the summer) was also advantageous for spreading the infectious agent, resulting in a high infectious load in many places.

Due to the mild symptoms and long incubation time, together with the tradition of frequent transport of horses between premises across the country, the disease was already widespread when first reported by practitioners. No measures were therefore taken by the Icelandic Food and Veterinary Authority to stop the epidemic. Measures to minimise the infectious load and the severity of clinical symptoms included recommending resting horses with clinical signs, reducing contact between stables, feeding the horses outdoors and putting them on pasture as soon as possible.

The experiences in Iceland with the three diseases Maedi/Visna, Infectious Pyrexia and the disease caused by a "new" strain of the bacterium *Streptococcus equi* subsp. *zooepidemicus* (ST209), clearly demonstrate the vulnerability of the native animal populations in Iceland.

Chapter 2 Examples of occurrence and consequences of the introduction of animal diseases and infections

Introduction of paratuberculosis to Iceland

(Modified from: Fridriksdottir V, Gunnarsson E, Sigurdarson S, Gudmundsdottir KB (2000). Paratuberculosis in Iceland: epidemiology and control measures, past and present. Vet. Microbiol. 77, 263 – 267.)

In 1933, 20 sheep of the Karakul breed were imported from Halle in Germany in order to improve the quality of the skin of the Icelandic sheep ***(1, 2)***. The imported sheep appeared healthy and had certificates of good health control. After 2 months of quarantine, they were distributed to 14 farms in the main sheep farming areas.

The import of these 20 Karakul sheep had disastrous effects on sheep farming which was and still is the main farming industry in Iceland. Some of the imported sheep were unapparent carriers of slow infectious diseases which they introduced into the Icelandic sheep population ***(1, 3)***. These included paratuberculosis, Maedi/visna and jaagsiekte, commonly called the ``Karakul diseases'' in Iceland.

Although they transmitted infection to the Icelandic sheep population, the imported animals never showed any signs of these diseases ***(3).***

The first clinical case of paratuberculosis in sheep was diagnosed in 1938 or 5 years after the arrival of the sheep ***(1, 3)***. Paratuberculosis appeared in sheep on at least 5 out of the 14 original farms during the next few years.

Gradually, the infection spread from these five original locales to surrounding farms, and over the next 18 years, 440 farms or 20-30% of the farms in the main sheep breeding areas were infected ***(1, 2)***. About 7 years after the first clinical case appeared in sheep, paratuberculosis was observed in cattle, all of which came from farms with infected sheep ***(4).***

The Icelandic strain of Mycobacterium avium subsp. paratuberculosis appeared to be of a comparatively low virulence for cattle as infection had been prevalent in sheep for years on these farms before cattle showed any signs of infection. Production losses and mortality from paratuberculosis in cattle were moderate on most of the farms, although few farmers experienced high mortality ***(2).***

Paratuberculosis was confirmed in goats in 1969 and it is suspected that a reindeer may have been infected ***(2).***

Farms in infected areas held about one fourth of the total sheep population in Iceland ***(2).*** The annual mortality of sheep during the epidemic averaged 8-9% in these areas and could approach 40% on individual farms. It is estimated that the total losses during the epidemic were around 100,000 sheep

(3).

Extensive measures were used to try to eradicate paratuberculosis and the other Karakul diseases in Icelandic sheep. The country was divided into infected and non-infected zones ***(1)***. Hundreds of kilometres of fences were put up and used together with natural barriers such as big rivers, glaciers and mountains to control the movement of sheep. Guards controlled the fences, animals crossing the lines were slaughtered, and the transport and sale of sheep between zones was prohibited ***(3)***.

These measures alone did not help and in order to try to eradicate the Karakul diseases all sheep, a total of 102,000 in two of the main paratuberculosis areas were slaughtered and restocked with healthy uninfected sheep 1 year later. These measures eradicated maedi/visna and jaagsiekte in Iceland, but paratuberculosis reappeared a few years later ***(1).*** It is suspected that cattle remaining on the infected farms spread the infection to the new sheep.

The history of paratuberculosis should stand out as a warning both to Iceland and other countries. The story could repeat itself in our country with any species of domestic animals which all have lived in isolation for centuries.

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Effect of management practices on paratuberculosis prevalence in Danish dairy herds

(Modified from: Nielsen SS, Toft N (2011). Effect of management practices on paratuberculosis prevalence in Danish dairy herds. J. Dairy Sci. 94, 1849–1857.)

Multivariable analyses suggested that only the proportion of purchased animals (>15% purchased animals as well as 0 to 15% purchased animals compared with no purchased animals in the herd), culling of repeated test-positive animals, and use of waste milk from specific cow groups influenced the decrease in prevalence of MAP-specific antibodies.

The proportion of purchased animals was expected to be associated with the prevalence, as this has been found in other studies.

To conclude, culling of repeated antibody-positive cows can be associated with a decrease in the prevalence of MAP-specific antibodies over a period of 4 yrs.; however, the proportion of purchased animals had more influence on changes in prevalence. Use of waste milk from repeated antibody-positive cows may also influence the prevalence of MAP-specific antibodies, but too few herds practiced this to make useful interpretations. No other management factors associated with a decrease in the prevalence of MAP infections was detected, but longer-term studies are required to elucidate these effects.

Paratuberculosis in cattle: A disease of current interest in Norway

(Modified from: Djønne B, Halldorsdottir S, Holstad G, Sigurdardottir O, Ødegaard Ø (1998). Paratuberkulose hos storfe: En sykdom som har fått ny aktualitet i Norge. Norsk VetTidsskr. 110, 713 – 717.)

Paratuberculosis was first described in Norway in 1908 in cattle, and in 1934 in goats, but the disease had likely been present in the country much earlier. It seems to have been quite common in the first half of the twentieth century and was considered present on certain farms. It was especially prevalent in Vestlandet, but the disease was also present in certain districts in Østlandet. Later the disease appeared to become less important as the number of bovine cases decreased. The last known cases of paratuberculosis were found in 1978 and 1979 at Veitastrond in Sogn.

However, paratuberculosis in goats in Norway has been quite important, but a vaccination program has kept the disease under control. It is so far uncertain if there was an association between paratuberculosis in goats, sheep and cattle, or if there exists a specific goat pathogenic strain. The infection has anyway not been seen since 1979 in other species than the goat in Norway.

In 1994, paratuberculosis was diagnosed in a group of cattle imported from Denmark. They had been tested by fecal examination before being shipped from Denmark, but the results were not available until after the arrival to the quarantine in Norway. When the results showed that one animal shed paratuberculosis bacteria, all animals were destroyed.

In 1997, paratuberculosis was diagnosed again in two cattle herds in Norway. The animals had been imported from Finland and Denmark in 1992 and 1994, respectively. They had been through quarantine and were tested serologically and bacteriologically with negative results. In 1997 the animals showed serological reactions, but no clinical signs of paratuberculosis. Later that diagnosis was confirmed by pathology and bacteriology from organs. During the years before the detection, these animals had spread the infection to other herds. So far paratuberculosis has been found in four herds, which have all been slaughtered. In addition more than 100 additional farms have been placed under restrictions due to contact with the infected herds.

The economic impact of Johne's disease in an Irish dairy herd: A case study

(Modified from: Barrett DJ, Good M, Hayes M, More, SJ (2006). The economic impact of Johne's disease in an Irish dairy herd: A case study. Irish Vet. J. 59, 282 – 288.)

Johne's disease can cause significant economic loss in affected herds. Losses are associated with reduced milk yield, reduced reproductive efficiency, premature culling and reduced values of cull cow. Though this disease has been present in Irish cattle herds for decades, it has become more widespread only since the introduction of the Single European Market in 1992. Johne's disease has been a scheduled and notifiable disease in the Republic of Ireland since 1955 and prior to the mid 1990's it was uncommon with only 92 cases diagnosed between 1932 and 1992; these cases were primarily in imported animals (Department of Agriculture and Food records). In 1992, the single European market was introduced, facilitating the free movement of goods and services within the EU and, thereby, increasing the opportunity for the importation of cattle from continental Europe. The single market removed the pre-import test certification requirements for Johne's disease and also the requirement for imported livestock to be placed in quarantine for up to six months after arriving in Ireland. During quarantine, imported animals had been subjected to additional tests for Johne's disease.

In the 12 years up to May 2004, approximately 85,000 cattle were imported from continental Europe, the bulk of which were potential breeding animals; of these, 8,223 came from the Netherlands, 6,832 from Denmark and 29,105 from France (Central Statistics Office, personal communication). In the years 1995 to 2002 (inclusive), the Department of Agriculture and Food received notification of 232 Johne's disease-infected cattle in 106 herds. In 1997, the absorbed ELISA test was used to conduct a serological survey on 224 imported animals in 36 herds and it revealed that 36% of the herds involved had at least one positive animal ***(1).*** When the same test was used in a random sample of 143 herds in three counties, more than 30% of herds had one or more reactors (J. Egan, personal communication). The indications are that the prevalence of Johne's disease in Ireland has increased since the introduction of the single European market. Following the introduction of the single market the importation of livestock into Ireland from continental Europe increased significantly. The main countries from which cattle were imported were France, the Netherlands and Denmark.

A case study of the economic impact of Johne's disease in an Irish dairy herd is described. Dutch cattle were imported into the herd that is the subject of this paper. The farmer's motivation to do so was to improve the genetic merit of his herd tempered by the fear of introducing brucellosis with native-sourced cattle.

A detailed epidemiological examination was carried out to determine how Johne's disease had entered and spread within the herd. This investigation concluded that Johne's disease was introduced to the herd through the purchase of a cohort of 20 heifers from the Netherlands in 1993. Four of these imported animals went on to develop clinical signs consistent with a diagnosis of Johne's disease, but this was not confirmed by laboratory diagnosis. At least five of the progeny of these imported animals were subsequently diagnosed with Johne's disease. There was no evidence to suggest that Johne's disease was in the herd prior to the introduction of the Dutch cattle in 1993. The purchase of infected cattle is a significant method of introducing Johne's disease into herds ***(2, 3).*** Therefore it is reasonable to suggest that these imported Dutch cattle introduced Johne's disease to the herd. The farmer was anxious to implement the control programme due to the significant economic loss caused by the disease. He was a successful farmer prior to the emergence of Johne's disease in his herd. Reduced milk yield, reduced feed conversion efficiency, increased involuntary culling, increased replacement rates, reduced fertility, increased mortality and reduced cull cow values are all synonymous with Johne's disease ***(4)***. DairyMIS data revealed that average herd yields, milk protein content,

margin per 1,000 litres of milk produced, margin per cow and culling rates were superior or equal to those of his peers until the late 1990's. However, from the mid-1990's there was a steady decline in farm performance until 2002 when the Johne's disease control programme was introduced on the farm. There was a 24% difference between the best (1997) and the worst (2002) annual average milk yield over the course of the study period. It was not possible to determine how much of this reduction in milk yield was directly attributable to Johne's disease. Data from North America have documented reductions of 19.5% and 15% respectively among cows clinically and sub-clinically infected with Johne's disease ***(5).*** While this case study relates to only one herd, and is possibly subject to herd biases, the fact remains that substantial economic loss occurred consequent to the entry of Johne's disease into the herd.

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Cattle movements and bovine tuberculosis in Great Britain

(Modified from: Gilbert M, Mitchell A, Bourn D, Mawdsley J, Clifton-Hadley R, Wint W (2005). Cattle movements and bovine tuberculosis in Great Britain. Nature 435, 491 - 496.)

Movements of infected animals have long been considered a critical factor in the spread of livestock diseases, as reflected in strict import/export regulations, the extensive movement restrictions imposed during the 2001 foot-and-mouth disease outbreak, the tracing procedures after a new case of bovine tuberculosis (BTB) has been confirmed and the Government's recently published strategic framework for the sustainable control on BTB. Since January 2001 it has been mandatory for stock-keepers in Great Britain to notify the British Cattle Movement Service of all cattle births, movements and deaths. Here we show that movements as recorded in the Cattle Tracing System data archive, and particularly those from areas where BTB is reported, consistently outperform environmental, topographic and other anthropogenic variables as the main predictor of disease occurrence.

The British Cattle Movement Service and the Cattle Tracing System were set up to ensure the identification and traceability of individual cattle during the recovery period after the BSE crisis; they were not intended to serve as a disease-control support system for fast-moving diseases, such as the outbreak of foot-and-mouth disease that occurred in 2001. However, as the number of detected BTB cases continues to rise exponentially, the need to identify critical risk factors becomes ever more important. These results demonstrate that the movement of animals, especially from locations where BTB is present and particularly to locations outside endemic core areas, is one such critical factor. These findings support the case for movement controls, especially from 'core' to 'remote' locations, as a disease control measure.

The spread of pathogens through trade in small ruminants and their products

(Modified from: MacDiarmid SC: Introduction to the spread of pathogens through international trade; and: Sherman DM (2011). The spread of pathogens through trade in small ruminants and their products. Rev. Sci. Tech. 30, 13- 17; 207-217.)

The fear of spreading animal diseases from country to country is a major barrier to trade in animals and animal products. The World Organisation for Animal Health (OIE) was founded in 1924 in response to the introduction of rinderpest into Europe through the importation of cattle, and history provides a number of similar examples. However, the risks of such spread have decreased in the decades since the OIE was founded, partly as a result of the improvement of the global animal health situation and partly because of the work of the OIE in the development and implementation of international sanitary standards that ensure the safety of traded animals and animal products. Nevertheless, with increasing globalisation, concern about the risks of spreading pathogens through trade in animals and animal products remains high amongst veterinary authorities.

There are notable historical incidents in which the movement of small ruminant breeding stock has been associated with the spread of disease. For example, scrapie was introduced into Australia, New Zealand, India, South Africa, Kenya, Brazil, and Colombia as a result of sheep importations from the UK occurring between the 1930s and 1970s. Australia and New Zealand subsequently eliminated the disease in the 1950s and have remained free through surveillance and strict importation rules. South Africa's last reported case was in 1972.

In the 1970s, pure-bred dairy goats of the European breeds were exported from the United States and Europe to various locations and this resulted in the introduction of caprine arthritis encephalitis (CAE) virus infection into some importing countries, notably Kenya. Both CAE and scrapie are chronic diseases and the carrier states were difficult to detect using the diagnostic techniques available at the time. Paratuberculosis due to M*ycobacterium paratuberculosis* is another chronic disease of small ruminants with a long incubation period, during which reliable detection of infection is difficult. This disease also poses risks in the trade of breeding animals. Although a causal relationship has not been definitively established, there are proposed associations between paratuberculosis in ruminants and Crohn's disease in humans, adding a potential public health dimension to concerns about trade.

Owing to its clinical severity, high mortality and its expanding distribution, Peste des petits ruminants (PPR) has emerged as the major disease constraint on small ruminant production in much of Asia and Africa. Trade in small ruminants, both regulated and unregulated is contributing to the widening dissemination of the disease. For example, trade in sheep and goats was implicated in the spread of an epizootic of PPR in Bangladesh in 2001. The author was asked to investigate this epizootic in 2002 and learned that it had originated in western Bangladesh. The epizootic occurred in association with a large influx of goats and sheep into the country from neighbouring India in the period preceding the festival of Eid ul-Adha. The epizootic spread eastward as goats were moved to the capital city and environs to meet demand for animals for ritual slaughter during the Eid festival.

The 2007 outbreak of equine influenza in Australia: lessons learned for international trade in horses

(Modified from: Watson J, Daniels P, Kirkland P, Carroll A, Jeggo M (2011).The 2007 outbreak of equine influenza in Australia: lessons learned for international trade in horses. Rev. Sci. Tech. 30, 87-93.)

In August 2007 Australia experienced its first outbreak of equine influenza. The disease occurred first in a quarantine station for imported horses near Sydney and subsequently escaped into the general horse population. After an extensive campaign the disease was eradicated and Australia is again recognised as free of this disease. Equine influenza was then, and is now, recognised to be the major disease risk associated with live horse imports into Australia and measures designed to mitigate this risk formed the basis of the quarantine protocols then in place. Subsequent investigations into the cause of the outbreak identified failures in compliance with these quarantine requirements as a contributing factor. It is also likely that the immunity of horses vaccinated as part of the import protocol was less than optimal, and that this had a significant role to play in the escape of the disease from quarantine.

It was concluded that EI had most probably arrived in Australia from Japan, having recently arrived there from the United States. However, the possibility of direct transport from the United States could not be entirely excluded.

In hindsight, the situation in August 2007, with a large group of 52 horses (several with dubious vaccination status) and poorly enforced biosecurity procedures, can be seen as an animal disease catastrophe waiting to happen.

Bluetongue detected in imported animals in Northern Ireland and Wales

(Modified from: Anon. (2008): Bluetongue detected in imported animals in Northern Ireland and Wales. Vet. Rec. 162, 227.)

Twenty-three cows and their calves have been culled in Northern Ireland following the detection of bluetongue virus in an animal imported from the Netherlands. On February 15, 2008 Northern Irelands minister for agriculture and rural development, Ms. Michelle Gildernew, confirmed that routine postimport testing had detected the virus in a cow on a farm in north Antrim. The cow was culled, and restrictions were placed on the remaining animals in the herd.

In Wales, a sheep imported from the Netherlands tested positive for bluetongue virus on February 14. The animal was one of a group of 14, and was detected in routine post-movement testing at a farm in Llandysul, Ceredigion. It was slaughtered to minimize the risk of transmission.

Emergence of Porcine Reproductive and Respiratory Syndrome in Sweden

(Modified from: Carlsson U, Wallgren P, Renström L H M, Lindberg A, Eriksson H, Thorèn P, Eliasson-Selling L, Lundeheim N, Nörregard E, Thörn C, Elvander M (2009). Emergence of Porcine Reproductive and Respiratory Syndrome in Sweden: Detection, Response and Eradication. Transbound. Emerg. Dis. 56, 121–131.)

On 5 July 2007, the results of a blood test within the national PRRS surveillance program indicated an infected herd (16 out of 20 pigs were positive in ELISA). The results of this first diagnosed infected premise (IP-A) were confirmed positive by IPMA test the following day. On that day seven herds in the close vicinity of the index case were sampled as an immediate action, resulting in the detection of a second infected herd (IP-B).

By this time, little was known about the actual spread of PRRSV in Sweden. To rapidly gain knowledge about the situation, at least 20 blood samples were collected from each slaughter batch at three abattoirs representing the region where the first cases were found. In addition, randomly selected herds in the county of Skåne were tested on site. This survey was carried out within four days of the first confirmed case. Samples from pigs at market weight (6–7 months of age) were collected from 125 herds, of which one was diagnosed as infected with PRRSV (IP-C). Thus, the results indicated that the infection was not widespread and suitable control measures were decided by SJV.

From 9 July the sampling focused on risk herds, known contacts and herds located within a 5-km radius of the initially positive herds. Samples were also collected from herds of specific interest i.e. large sow herds, breeding herds and other selected herds. This resulted in one additional herd being found to be antibody positive to PRRSV (IP-E). The remaining three infected herds (IP-D, IP-F and IP-G) were identified through the epidemiological investigations and follow-up testing. The infected premises were located in two clusters in the county of Skåne in southern Sweden. Within the infected premises a high prevalence of PRRSV antibodies in pigs was observed. During 2007, about 11 000 blood samples from 369 herds were analysed for the presence of antibodies to PRRSV. These figures do not include the samples collected within the national screening program. Apart from the abovementioned antibody positive herds, all others were found to be negative.

The route of introduction of PRRSV into Sweden remains unclear. There was no indication of airborne spread from Danish pigs in transit through Sweden. This is consistent with others who claimed that airborne transmission between herds is not of major importance or may itself depend on isolate pathogenicity.

Another possible source could be sows transported for slaughter to Germany since herds from both clusters were involved in this trade. The ability of PRRSV to survive during transport has been demonstrated previously and it is important that vehicles are sanitized and left to completely dry to safeguard recipient farms. However, even if there are strict rules for cleaning and disinfections for all vehicles transporting pigs both within Sweden and abroad, the rules do not include driver cabins or utensils.

A third possible source could be the transmission of virus from Denmark since PRRSV is widespread there, and transport of people and goods between Denmark and southern Sweden is frequent.

Vaccine associated introduction of PRRS infection in Denmark

(Modified from: Mortensen S, Stryhn H, Søgaard R, Boklund A, Stärk KDC, Christensen J, Willeberg P (2002): Risk factors for infection of sow herds with porcine reproductive and respiratory syndrome (PRRS) virus. Prev. Vet. Med. 53, 83-101.)

In 1992, the porcine reproductive and respiratory syndrome virus (PRRSV) of European type (PRRSV-EU) was introduced in Denmark. By 1996, the virus had spread to approximately 25% of the Danish herds. In January 1996, a modified-live vaccine based on the American type of the virus (PRRSV-US) was used in replacement boars for Danish artificial insemination (AI) centres and from July 1996, the vaccine was used in PRRSV-EU infected herds for prevention of disease. Soon after vaccine introduction, PRRSV non-infected herds experienced outbreaks of disease due to infection with PRRSV-US. In this study, we investigated the risk factors (biosecurity level, animals, exposure from PRRSV-US-infected neighbour herds, semen, herd size, pig density and herd density) for infection with PRRSV-US in a cohort of 1071 sow herds; we used a nested case-control study. The retrospective observation period lasted from June 1996 (when they all were non- infected) to October 1997. Seventy-three non-vaccinated, closed sow herds became infected with the vaccine strain during this period. Each case herd was matched with two control herds from the cohort (controls had not been infected at the time of infection in the case herds). The data were analysed using a Cox-regression model. The hazard of infection increased significantly with exposure from PRRSV-US-infected neighbouring herds, purchase of animals from herds incubating PRRSV-US infection, increasing herd size and purchase of semen from boars at PRRSV-US- infected AI centres. The results are consistent with the modified-live vaccine strain spread to other herds by trade with animals and semen and by neighbour (area) transmission. We suggest that virus spread with aerosols was a frequent mode of transmission.

Risk Factors for Changing Test Classification in the Danish surveillance Program for *Salmonella Dublin* in Dairy Herds

(Modified from: Nielsen LR, Warnick LD, Greiner M (2007). Risk Factors for Changing Test Classification in the Danish surveillance Program for Salmonella in Dairy Herds. J. Dairy Sci. 90, 2815–2825.)

Herd owners should be aware of the infection risk when purchasing new livestock from an infected herd and the risk of having infected neighbours. High external biosecurity is necessary in such herds. There is a need to inform organic farmers, herds in high cattle density areas, and herds with test-positive neighbours how to control and eradicate *Salmonella* Dublin. High internal and external biosecurity is required, not just control of within-herd transmission that tends to be the main focus in infected herds. The results provided support for trade restrictions upon purchase of cattle from infected herds in the surveillance program because there was in fact a high risk of infection associated with this behaviour. The risk of changing was also higher ($P < 0.0001$) if a herd had purchased animals from test positive herds in the previous quarter than if it had only purchased animals from test-negative herds or not purchased animals at all. Other studies, however, support the finding that the risk of becoming infected increases with purchase from other herds, and biologically it makes sense that this risk is mainly increased if the source herd is infected and thus test-positive. The number of purchased cattle from test-positive herds was associated with becoming infected. Other studies have found purchase of live animals a significant risk factor for introduction of *Salmonella* infection to the herd.

Chapter 3 Animal health policy in Iceland regarding infectious diseases

Legislation

Animal diseases and animal health services

Act No 25/1993 on animal diseases and preventive measures against them

Act No 25/1993 on animal diseases and preventive measures against them, is the general legislation on animal health. The purpose of the Act is:

To promote the good health of animals in the country and to prevent the entry of new contagious diseases to Iceland.

To monitor and prevent the spreading of animal diseases and to work toward their eradication.

To ensure that livestock products, produced in Iceland, are as wholesome as possible.

This is to be achieved by notification obligations, disease diagnosis and various preventive measures attempting to restrict dangers that could stem from sick animals. These preventive measures can apply to animals, livestock products, feed and fertilisers from animals, buildings, work sites, machinery, tools, vehicles and keepers of animals. This Act includes provisions on:

Notification obligations.

Disease diagnosis.

Preventive measures.

Cost and compensation.

Isolation measures and transportation of animals.

Penalties.

The Act defines livestock as follows: Horses, cattle, sheep, goats, pigs, fur-bearing animals, rabbits, and poultry, as well as farmed fish and other animals kept for domestic purposes. In the event of conflicts arising over the definitions of livestock, the Minister of Fisheries and Agriculture shall rule on the matter. The Act defines animals as follows: animals, both vertebrates and invertebrates. The Act applies to all diseases in animals, both domestic animals and pets, as well as wild animals. Animal diseases are defined as follows: Contagious diseases caused by bacteria or parasites, metabolic diseases, genetic diseases, poisoning and other diseases covered by this Act.

Act No 66/1998 on veterinarians and animal health services

The general Act covering the organization of veterinary matters is the Act on veterinarians and animal health services, No 66/1998, as subsequently amended. The purpose of this Act is to organise the services of veterinarians in order to:

Safeguard the health of animals in Iceland.

Promote their improved health.

Increase profitability of livestock raising and ensure good living conditions for and proper treatment of animals.

Guard against the injury to individuals or society as a whole due to animal diseases.

This is to be achieved by attempting to restrict dangers that could stem from sick animals and the consumption of spoiled or contaminated animal products, the import of living animals and animal products, tools or objects which could carry contaminants. This Act includes provisions for:

Supervision by authorities.

Rights and obligations of veterinarians.

Organization of veterinary districts.

Veterinary specialists.
Penalties etc.

This Act applies to each and every veterinarian who is appointed provisionally or permanently or hired to work on behalf of the State and to veterinarians who work under licenses issued under this law.

Act No 96/1997 on raising and health of slaughter animals, slaughtering, processing, health inspection and quality grading of slaughter products, as subsequently amended

This Act lays down the food safety rules for slaughter products. The purpose of the Act is to ensure the quality, healthfulness and wholesomeness of slaughter products, that they are unadulterated and produced under satisfactory sanitary conditions, classified according to type and quality, and that labelling and information is correct. This Act includes provisions on:
Raising and health of slaughter animals.
Slaughtering, dressing, deboning and processing of slaughter products in slaughter houses.
Production of meat products in slaughterhouses and processing plants producing slaughter products for export.
Storage and transport of slaughter products and the facilities and treatment of such products for export.
Health inspection and testing of slaughter animals and slaughter products.
Classification and health marking of meat.
Wild game, processed in meat processing centres.

Import of animals

Act No 54/1990 on the import of animals

The purpose of this Act is to control all imports of animals and to prevent animal diseases from spreading domestically. The Act defines animals as: all live terrestrial animals; vertebrates, invertebrates and aquatic animals which live partly or completely in fresh water.

According to the first paragraph of Article 2 of the Act, the main rule is that importing any tame or wild animals, as well as their genetic substances, into the country is prohibited. Acts implementing international conventions apply to trade in species of wild animals or plants in danger of extinction.

Notwithstanding the first paragraph of Article 2, live fish, crustaceans or molluscs may be imported from an aquaculture station, regardless of maturity, including roe and milt, and including animals which originally lived in the wild but are intended for raising in an aquaculture station; such import shall be subject to the conditions of regulations adopted by the Minister of Fisheries and Agriculture, after receiving the opinions of various parties. These exceptions are in accordance with provisions of the EEA Treaty.

According to the fourth paragraph of Article 2 of the Act, the Minister of Fisheries and Agriculture, upon recommendation by the Chief Veterinary Officer (CVO), may derogate from the main rule in the first paragraph of the Act to allow the import of animals and genetic substances, provided that the instructions entailed in the Act and Regulations issued on its basis are strictly observed.

The CVO can deviate from general ban on animal import and can authorise the import of pet animals and their genetic material, provided the species of animals is currently present in the country.

Animals imported without permit shall be immediately put down and the carcasses destroyed to prevent hazard. Eggs, sperm and embryos shall likewise be destroyed, as well as the animals that may have been artificially inseminated or used as surrogate mothers, and the offspring which may have been born after such illegal import.

Article 3 of the same Act stipulates that when the CVO recommends the import of animals and genetic substances, he shall present a well-grounded report on the health situation in the relevant country or region, and his recommendation shall be accompanied by certificates from the relevant health authorities indicating that the animals have not shown any signs of diseases that could be hazardous to animals in Iceland.

The CVO is permitted to deviate from the ban on import of animals regarding pets. Regulation No 935/2004 on the importation of pets (companion animals) and dog semen into Iceland is set in accordance with Act No 54/1990 on Import of Animals. According to Article 4a of this Act the CVO has the authority to permit the importation of pets and dog semen otherwise prohibited by Article 2. The permit is based on the condition that the importer commits to complying in every respect with all conditions of Regulation No 935/2004. In Regulation No 935/2004 all the requirements in order to obtain an import permit and the certificates needed are listed. In accordance to this MAST has stipulated instructions explaining the procedures in accordance to Regulation No 935/2004 and these are available in English on the website of MAST[1].

Regulation No 935/2004 on the importation of pets includes provisions on:
Certain dangerous breeds of dogs that cannot be imported.
Requirements for evaluation of temperament of certain breeds of dogs.
Vaccinations and titre for rabies antibodies.
Certain tests and examinations.
Treatment for parasites.
Arrival procedures.
Isolation for four weeks.
Tests in isolation.

The requirements for import of dog semen are based on very similar provisions for the donor animal as for live animals.

Regulation No 432/2003 on isolation stations for pets is also set in accordance with Act No 54/1990 on Import of Animals and includes provisions on:
permit for the station
preventative measures for contagious diseases – outside and inside the station
construction and outlay of the buildings
structure and sizes of pens
transport to and from the station
official and private veterinary control
welfare of the animals
special issues regarding isolation of other pets, for ex. ornamental fish, rodents, rabbits, birds in cages

Act No 60/2006 on prevention of fish diseases

The purpose of the Act on prevention of fish diseases, No 60/2006, is to protect the aquatic biosphere and wild and farmed aquatic animals in both fresh and sea water by combating infectious diseases and parasites.

The Act applies to live freshwater fish and import of live eggs into Icelandic territory. It includes provisions on:

- Import of live, freshwater fish.
- Import of live, ornamental fish.
- Temporary stopover of fish in transport.
- Sterilization of fishing gear and fishing equipment.
- Import of dead fish.

[1] http://www.mast.is/index.aspx?GroupId=1278

Veterinary medicinal products

Act No 93/1994 on medicinal products

Act No 93/1994 on medicinal products applies to all veterinary medicinal products. The objective of this Act is to ensure an adequate supply of necessary medicinal products in Iceland, and that they are as efficiently distributed as possible on the basis of fair and equitable competition, and in accordance with the rules which apply in the European Economic Area or in accordance with the European Free Trade Association (EFTA) Treaty. It is, furthermore, the objective of this Act to ensure as far as possible the quality and safety of medicinal products and services, increase public education on the use of medicinal products, counter their excessive use and keep costs to a minimum.

The Act on Marketing of Medicinal Products No 30/1963 applies to all veterinary medicinal products and the activities of veterinarians regarding the use of VMP.

Act No 96/1997 on the raising and health of slaughter animals, slaughtering, processing, health inspection and quality grading of slaughter products and Regulation no 653/2001 on maximum residue limits of veterinary medicinal products in foodstuffs of animal origin

The Ministry of Fisheries and Agriculture is responsible for the implementation of EC Regulations amending Council Regulation (EEC) No 2377/90 laying down a Community procedure for the establishment of maximum residue limits of veterinary medicinal products in foodstuffs of animal origin. The Minister of Fisheries and Agriculture issues these regulations in accordance with Act No 25/1993 on animal diseases and preventive measures against them and Act 96/1997 on the raising and health of slaughter animals, slaughtering, processing, health inspection and quality grading of slaughter products. The regulation in force is Regulation No 653/2001 on maximum residue limits of veterinary medicinal products in foodstuffs of animal origin (slaughter products, eggs and milk) as subsequently amended.

Institutions

Act No 80/2005 on the Icelandic Food and Veterinary Authority (MAST)

This Act applies to the operations of the Icelandic Food and Veterinary Authority (MAST). In the veterinary field, MAST's role is to fight infectious diseases in animals, prevent the introduction of foreign infectious agents, eradicate endemic diseases, control the transmission of infectious agents between animals and man, and improve the general health and welfare of animals.

The Authority's functions in the field of veterinary issues include:
Animal health.

Surveillance, contingency plans and preventive measures against animal diseases, control of imports and exports of animals and animal products, supervision of veterinary practitioners, registration of animal diseases and control of the use of veterinary medicinal products and reporting on the status of animal diseases in Iceland.

Animal welfare.

Inspection of animal housing and conditions, and intervention in response to reports of animal abuse.

Veterinary legislation.

Legal work, pertaining to legislation on animal health and welfare.

Act No 67/1990 on the Institute for Experimental Pathology of the University of Iceland

The Institute for Experimental Pathology of the University of Iceland is situated at Keldur in Reykjavík. The Institute is responsible to the Ministry of Education, Science and Culture. It operates according to Act No 67/1990 on the Institute for Experimental Pathology of the University of Iceland. It is an institution of the University of Iceland, affiliated with the Faculty of Medicine, with a special governing board and an independent budget. According to the Act the main objectives of the Institute are the following:

- To carry out basic research in biology and diseases of animals and humans.
- To carry out applied veterinary research, health control, and diagnostic services for animal diseases in collaboration with MAST and develop methodology in these fields.
- To develop, produce, import and distribute veterinary vaccines and drugs for animal diseases.
- To provide research facilities for academic staff of the University who have been appointed to carry out teaching and research in fields related to the activities of the Institute.
- To provide continuing education and information for veterinarians in collaboration with MAST.
- To provide laboratory animals for research in Iceland.
- To participate in research and development to promote biotechnology and the biotech industry in Iceland.

The Institute for Experimental Pathology of the University of Iceland at Keldur has been accredited according to the International Quality Standard ISO/IEC 17025 - General requirements for the competence of testing laboratories. The Institute received its accreditation certificate on 8 June 2006. The accreditation was administered by the Icelandic Patent Office (the governmental agency for accreditation in Iceland) and SWEDAC (The Swedish Board for Accreditation and Conformity Assessment).
The accreditation includes its quality system and the following microbiological methods:

- Prionprotein (TSE) ELISA
- Prionprotein (TSE); confirmation of suspected positive samples
- Salmonella isolation (NMKL no. 71)
- Salmonella isolation (NMKL no. 187)
- Detection of VHS, IHN and IPN virus
- Detection of Infectious Salmon Anemia virust (ISAV) – One step RT-qPCR
- Isolation of Viral DNA
- Detection of Infectious Salmonid Alpha Virus (SAV) – One Step RT-qPCR
- Detection of Infectious Pancreatic Necrosis virus (IPNV) – One step RT-qPCR

In 2013 the Institute will receive accreditatjon for two additional methods; Campylobacter culture and Trichinella testing

Act No 50/1986 on the research department of fish diseases

This Act applies to the operations of the Fish Disease Laboratory, which is part of the Institute for Experimental Pathology of the University of Iceland. The purpose of the Act is to encourage and strengthen research on fish diseases in Iceland and ensure regular supervision of the health of ova, fry and farmed fish.

The Fish Disease Laboratory has a defined role in research of fish diseases according to the Act. It is a national reference laboratory in Iceland in the field of fish and shellfish diseases. Its responsibilities include basic research in biology and medicine of fish and shellfish and applied veterinary research, health control, and diagnostic services for aquatic animals. Supervision of university students' research projects is also carried out at the Laboratory. Such projects include work on fish diseases and prophylaxis such as virulence of infecting agents, pathology, immunology, development of diagnostic tests, epidemiology etc.

The tasks of the Fish Disease Research Laboratory include:

Carrying out research on fish diseases.
Diagnosing diseases which may arise in farmed fish.
Inspecting, if necessary, farmed fish which have been given pharmaceuticals.
Providing aquaculture stations with all types of assistance and advice which may be of use to prevent the spread of diseases and ensure health of fish.
Issuing health certificates in accordance with proposals of MAST and in compliance with foreign requirements for exports. Health certificates are based on regular surveillance and taking samples from aquaculture stations, together with taking samples from wild fish selected for on-rearing.
To carry out other related tasks as determined by the director.

Act No 68/2006 on Icelandic Food Research Ltd.

This Act applies to the operations of MATÍS - Icelandic Food Research Ltd. MATÍS is a limited company which was created by a merger of three former public food research institutes. The state is the owner of all the company's stock. The company is responsible to the Minister of Fisheries and Agriculture.

According to the Act the purpose of the company is to carry out research and innovation in the food sector, to the benefit of business and industry, public health and food safety, and financial operations based on the relevant acts and regulations, as well as carrying out other related activities. MATÍS Ltd. is obliged to maintain specific security services in the field of food research for the Icelandic population, as defined in detail in a contract with the company. The company must carry out testing for food surveillance by public authorities, as provided for in detail in a contract.

The company operates inter alia laboratories that possess facilities and scientific knowledge to provide priority and emergency services in case of immediate outbreak of food-borne diseases. The objective is to provide food safety and priority services in microbiological testing with the best known technology available. The industry and official authorities have access to services and consultation in the field of microbiological and chemical testing of food and feed.

Organization and powers of institutions

The Ministry of Fisheries and Agriculture

The Minister of Fisheries and Agriculture is responsible and supervises the implementation of the following acts:
Act No 25/1993 on animal diseases and preventive measures against them.
Act No 66/1998 on veterinarians and animal health services.
Act No 96/1997 on raising and health of slaughter animals, slaughtering, processing, health inspection and quality grading of slaughter products.
Act No 103/2002 on livestock management etc.
Act No 54/1990 on import of animals.
Act No 60/2006 on prevention of fish diseases.
Act No 80/2005 on the Icelandic Food and Veterinary Authority.
Act No 50/1986 on the Research Department of Fish Diseases.
Act No 68/2006 on Icelandic Food Research Ltd.

The Ministry of Fisheries and Agriculture is therefore responsible for secondary legislation in this field. The Ministry prepares new legislation regarding veterinary matters in conjunction with MAST.

Act No 25/1993 on animal diseases and preventive measures against them

In accordance with the Act, MAST shall assist the Minister and consult with him on all matters relating to animal diseases and the implementation of this Act. District veterinarians, each in their own district, are to

monitor and work towards improved animal health, and be on guard against new animal diseases which may enter Iceland or be transferred between animal disease isolation zones.

Act No 66/1998 on veterinarians and animal health services

In accordance with this Act MAST advises the Minister and Government on all matters regarding animal health and hygiene in the manufacture and handling of livestock products.

District veterinarians in each district provide surveillance of slaughter animals, slaughter products, and production centres and the healthfulness, care, living conditions and facilities of cattle on farms where milk is produced for sale. They are responsible for the performance of disinfection procedures and must provide surveillance of livestock and other animals. Insofar as possible, the control work of veterinarians and general veterinary services shall be kept separate.

Veterinary specialists shall be employed by MAST for each of the following fields: Poultry diseases, fish diseases, horse diseases, cattle and sheep diseases, udder diseases, fur-bearing animal diseases and swine diseases. In addition, a veterinarian with expertise in the public health control of slaughter animals shall be employed, and a veterinarian to monitor the import and export of livestock products. Veterinary specialists, each in their own area, shall, in consultation with district veterinarians, work toward the improved health of livestock and disease prevention with specialized procedures, general training, instructions and preventive efforts. Veterinary specialists may be delegated other projects, provided that such projects are included in their formal statement of duties. A veterinary specialist may not practice general veterinary medicine in their field of specialty.

The Minister of Fisheries and Agriculture in consultation with MAST appoints a Veterinary Council, consisting of four veterinarians, for a five-year term. The Council shall act as a consultant for MAST. The Council shall always be consulted on the import of livestock and, if requested, its genetic material. The Council shall also be consulted on the import of other animals, animal products and other factors related to animal health matters and animal products. The Council may, if circumstances require, call on specialists for advice. The Minister and MAST can refer disputed matters concerning veterinary services to the Council.

Act No 96/1997 on the raising and health of slaughter animals, slaughtering, processing, health inspection and quality grading of slaughter products

MAST shall assist and advise the Minister of Fisheries and Agriculture on all matters concerning implementation of the Act.

Act No 103/2002 on livestock management etc.[2]

Municipalities may adopt by-laws on livestock management. The Minister of Fisheries and Agriculture is to approve such by-laws and publish them in the Law and Ministerial Gazette of Iceland, after obtaining the opinion of the Farmers' Association of Iceland. By-law, municipalities may decide that certain types of livestock management are completely prohibited or limited to specific areas within the municipality concerned. If a livestock owner suffers commercial loss due to a prohibition or restriction on livestock management which is liable for compensation, such compensation shall be paid from the municipality's revenue. Assessment of compensation is dealt with by an expropriation assessment committee.

Municipalities shall keep a record of all owners of livestock. The register must be updated annually and sent no later than 15th of January each year to the Agricultural Associations, district veterinarians and MAST, which shall maintain a register for the entire country.

[2] A new law was passed in April 2013 with effect from 1. January 2014.

Municipalities must engage one or more livestock inspection officers, depending upon the scope of livestock raising in the area, and provide them with the necessary facilities and equipment. Livestock inspection officers are to supervise grazing density, facilities and treatment, feeding and grazing, as well as other tasks assigned to them. Persons chosen for such positions must have at least qualifications equal to a Diploma from an Agricultural College. Before commencing work, livestock inspection officers must attend a special course arranged by the Farmers' Association of Iceland, which also co-ordinates livestock supervision. The Farmers' Association of Iceland shall prepare a special manual for livestock inspection officers containing the main information needed. The cost of livestock supervision shall be paid by the municipalities.

If feeding or livestock management is not satisfactory then the livestock inspection officers shall inform the municipalities and MAST immediately.

Act No 54/1990 on the import of animals

The Minister of Fisheries and Agriculture can deviate from the general ban of animal import upon recommendation from the CVO. The CVO may make exceptions to the ban on animal imports and authorize the import of pets and their genetic material which are not regarded as a new animal species or which are foreign species which already exists in Iceland.

Despite the general ban on animal import, the import of fish and aquaculture animals and their products such as ova, embryo and semen is permitted according to Chapter 1 of Annex I to the EEA Agreement. In some cases the Minister must first obtain the recommendations of the Fish Diseases Committee, Institute of Freshwater Fisheries and the Committee for Genetics in Agriculture.

Upon receiving recommendations from MAST and the Farmers' Association of Iceland, the Minister of Fisheries and Agriculture issues regulations on further implementation of the Act.

Act No 60/2006 on prevention of fish diseases

MAST is responsible for the implementation of this Act. The Minister of Fisheries and Agriculture appoints a five-person Fish Diseases Committee. One member shall be appointed following nomination by the Institute for Experimental Pathology of the University of Iceland at Keldur, one following nomination by the Marine Research Institute, one following nomination by the Institute of Freshwater Fisheries, one following nomination by the Directorate of Fisheries and the CVO, who shall furthermore chair the committee. Alternates shall be appointed in the same manner. The Fish Diseases Committee shall advise the Icelandic Food and Veterinary Authority on all matters regarding implementation of the Act. MAST shall promote research in fish diseases and make proposals to the Minister on methods to prevent spread of fish diseases, as referred to in the Act, and other matters concerning fish diseases.

The Minister for the Environment is responsible for and supervises the implementation of Act No 15/1994 on animal welfare and secondary legislation in this field.[3]

However, in accordance with of the Act No 103/2002 on Livestock Management etc., the Ministry of Fisheries and Agriculture is responsible for legislation on and supervision of animal welfare when livestock is transported and slaughtered. DVOs and OVs have also the obligation to intervene in response to reports of animal abuse.

[3] A new law was passed in April 2013 with effect from 1 January 2014 - where the new Ministry for Industries and Innovation will be responsible for all legislation and supervision regarding animal welfare issues.

Ministry of Health

The Minister of Health is responsible for and supervises the implementation of the Act No 93/1994 on Medicinal Products which applies to all veterinary medicinal products and is responsible for secondary legislation in this field. All legislation regarding veterinary medicinal products is fully harmonized with the EEA legislation

In accordance with the Medicinal Products Act, the Icelandic Medicines Control Agency (IMCA) is an independent regulatory authority, under the auspices of the Ministry for Health and Social Security. One of its main functions is to issue marketing authorizations for medicines in Iceland in collaboration with regulatory authorities in the European Economic Area (EEA), ensure control and surveillance of the pharmaceutical industry in Iceland, and contribute to making available to health professionals and consumers independent, professional information on medicines. Safety and health issues are the main reasons why medicines are assessed by the authorities before they are placed on the market. Before a new medicinal product can be placed on the market, the applicant must perform extensive toxicological, quality and clinical studies. The regulatory authorities consequently assess the results of these studies in order to confirm the quality and safety of the medicine. Only then can the medicine be released on the market to the consumers. Further requirements are made of veterinary medicines on maximum residues.

In accordance with the Medicinal Products Act, the Pharmaceutical Committee serves as the advisory committee of the Agency. The Committee is comprised of five persons with the broadest possible expertise in medicine and pharmaceutics. The Minister appoints the Chairman and subsequently other members in consultation with the Chairman. When veterinary medicinal products are dealt with, the Chief Veterinary Officer and a veterinarian appointed by the Minister attends. The Committee is appointed for a four-year term.

MAST however, supervises veterinary practitioners and controls the use of veterinary medicinal products according to Article 11 of Act No 93/1994 on Medicinal Products.

Veterinary Services

Six district veterinary officers are employed by MAST. They monitor the health and welfare of livestock and are also responsible for the control of milk production and meat inspection. The DVOs tend exclusively to control work. Official Veterinary Officers (OVOs), employed by MAST assist the DVOs in the control and disease prevention. Furthermore, veterinarians in private practice may be employed by MAST from time to time on an hourly basis to work as meat inspectors in slaughterhouses, under the supervision of the DVOs.

All veterinarians must have a license from the Ministry for Fisheries and Agriculture before they can work in Iceland. Veterinarians holding degrees from Veterinary Universities in EEA countries and Switzerland need only to study Icelandic laws in the Veterinary field to the satisfaction of the Chief Veterinary Officer (CVO) before they can obtain a license from the Ministry, but veterinarians from other countries must be able to provide degrees from EEA countries before they can obtain the license. There is no Veterinary Faculty at any Icelandic University and most Icelandic veterinarians hold degrees from Scandinavian countries, Germany, Austria and Scotland. There are also a number of foreign veterinarians working in Iceland; they are required to have a good command of the Icelandic language before they can be employed full time by MAST. There are now 151 veterinarians with a license to work in Iceland.

Chapter 4 Animal Husbandry

Livestock management and animal welfare regulation

Act No 103/2002 on livestock management etc.[4]

The purpose of the Act on livestock management, No 103/2002, is to ensure good conditions for livestock, that it is always provided with sufficient grazing, feed and water; that only healthy and sound animals are used for production of livestock products, and furthermore to set rules on the keeping of livestock and collection of statistics.

The goals are to be achieved, for instance, through surveillance of grazing density, facilities and treatment, buildings and/or shelter, feeding and grazing, as well as registration of parties keeping livestock, its counting and compilation of inspection reports. The Act includes provisions on:
Ultimate responsibility for these matters.
Restrictions on livestock management.
Keeping of livestock.
Inspection and counting of livestock.
Penalties, for non-compliance.
The Act defines livestock as poultry, goats, horses, rabbits, fur-bearing animals, cattle, sheep and swine. In case of dispute as to what is included under the term livestock, the Minister of Fisheries and Agriculture shall resolve the matter.

Act No 15/1994 on animal welfare

The purpose of the Act No 15/1994 on animal welfare is to ensure the proper treatment of all animals. Animals may not be taunted or injured. Efforts shall be made to avoid overtaxing their strength and endurance.

For this purpose, the owners and keepers of animals must, for instance, monitor their health and take suitable measures to prevent the suffering of animals. The Act covers all animals, but especially those kept by or under the supervision of humans. The Act includes provisions on:
Treatment of animals, their quarters and care.
Commercial animal raising apart from livestock.
Operations on animals.
Hunting.
Animal experiments.
Arrangements for animal welfare.
Supervision of implementation of the Act and penalties.

Movement restrictions

To prevent spreading of diseases, the country is divided into surveillance/quarantine/movement restriction zones, separated by natural barriers or fences, see fig. 1. The zones were first established in 1937. For decades the number of zones was 36 but due to improved animal health status within the zones, some zones have been merged and the number is now 26. The zones are categorized according to the status of the most important infectious diseases. Sheep in each zone are ear-tagged with special colour, according to an official map. Transport of sheep, goats and cattle between zones is prohibited or strictly controlled, depending on the disease status of the zones, and sheep straying over boundaries are killed. Movement of cattle between

[4] A new law was passed in April 2013 with effect from 1. January 2014.

zones is only allowed upon approval by the veterinary authority. Transport of sheep within scrapie-infected zones is prohibited or strictly controlled. Transport of hay and agricultural machinery between zones is prohibited without a special permission.

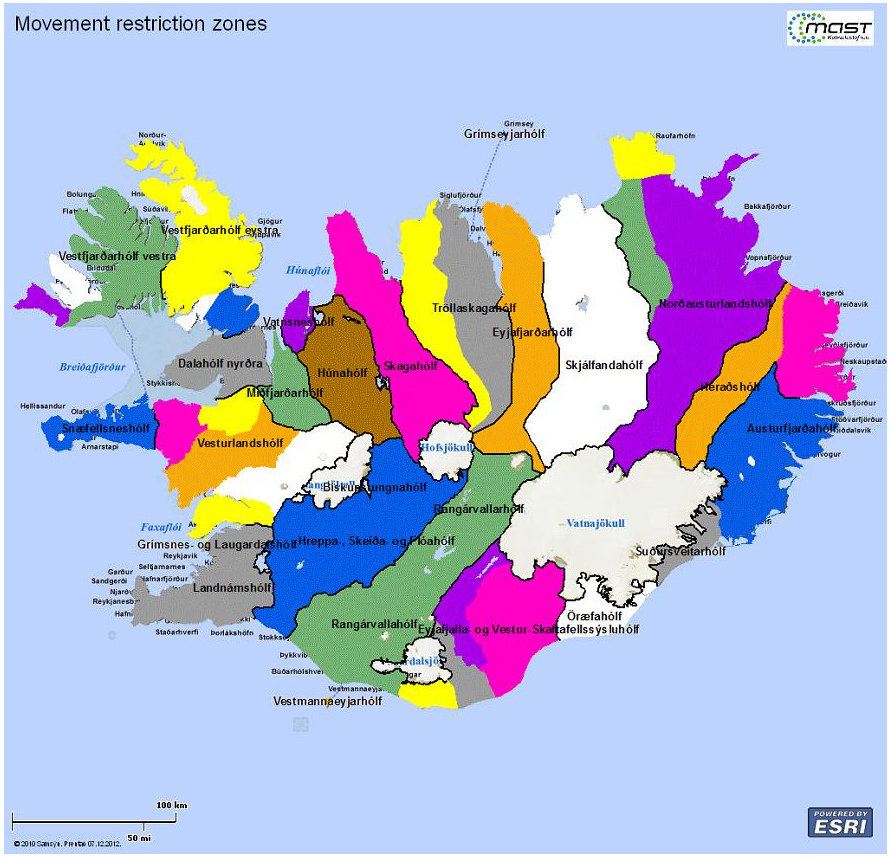


Figure 1 Movement restriction zones

Transmission routes for infectious agents

The means of transmission for infectious agents between farms are with live animals, visitors, feed and equipment. Transmission by wildlife is a very unlikely route as the only wild animals related to livestock breeds are the reindeers and they are not often seen in the lowlands during the cattle grazing period. The sheep and the reindeers share grazing area in the highlands during the summer, but the area is large and the animals are quite spread.

Number of farms

In 2011 the total number of cattle was close to 73 thousand, thereof about 26 thousand lactating cows. Number of farms with dairy cows was 727 and number of farms with beef-cows was 123. The number of ewes was about 374 thousand on 2684 farms and winterfed sheep was approximately 475 thousand. Registered horses were about 78 thousand and number of horse farms/stalls was close to 2700. Number of sows was around 3500 and slaughter pigs about 22 thousand. Laying hens were approximately 220 thousand and broilers around 98 thousand. The table below shows numbers of livestock and farms for the years 2010 and 2011. All dairy cattle, sheep, goats and horses are of special Icelandic breeds which originate from the settlement of Iceland, 1100 years ago.

Table 3 Number of livestock and farms

	2011		2010	
	Animals	Farms	Animals	Farms
Cattle (total)	72.773	-	73.781	-
Dairy cows	25.661	727	25.711	731
Beef cows	1.639	123	1.672	126
Sheep (winter fed)	474.759	2.684	479.605	2.659
Ewes	373.603	2.642	374.332	2.623
Goats	818	76	666	53
Horses	78.277	2.699	77.196	2.697
Pigs (total)	34.281	19	40.016	20
Sows	3.549	16	3.549	17
Poultry	370.063	434	323.414	411

Number of livestock and farms according to veterinary districts

The country is divided into six veterinary districts; South, East, North-East, North-West, West and South-West, see figure below. Number of livestock within each district is indicated in the tables below. Cattle and horses are most numerous in the South-district, sheep in the North-West and West and pigs in the South and South-West.

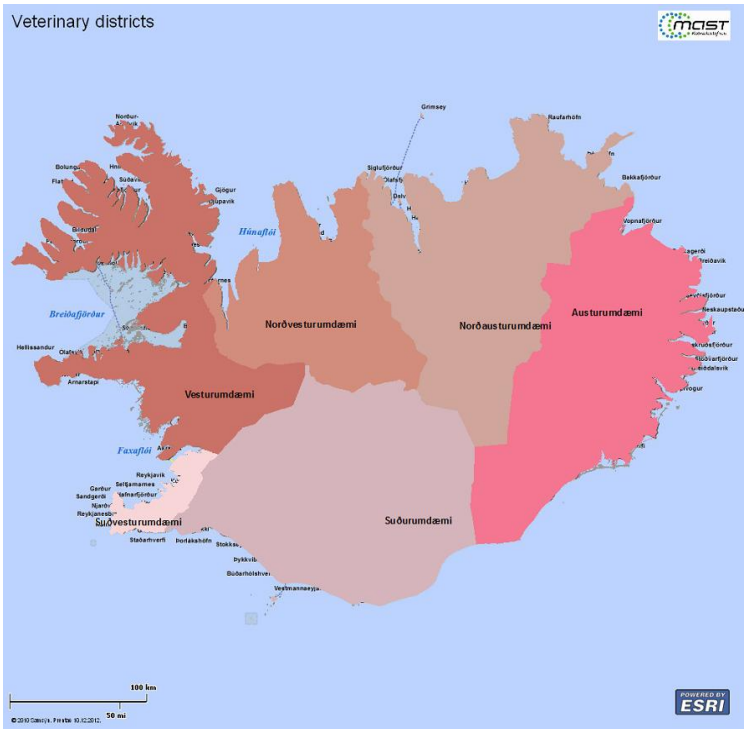


Figure 2 Veterinary districts

Table 4 Number of dairy-cattle and dairy-farms according to veterinary districts in 2011

Veterinary district	Dairy-cattle farms	Dairy-cows total	Average per farm
South (Suðurumdæmi)	251	9.636	38
East (Austurumdæmi)	50	1.554	31
North-East (Norðausturumdæmi)	164	6.211	38
North-West (Norðvesturumdæmi)	116	3.794	33
West (Vesturumdæmi)	135	4.148	31
South-West (Suðvesturumdæmi)	11	318	29
Total	**727**	**25.661**	

Table 5 Number of ewes and farms with ewes according to veterinary districts in 2011

Veterinary district	Sheep farms with ewes	Ewes total	Average per farm
South (Suðurumdæmi)	621	62.674	101
East (Austurumdæmi)	322	62.890	195
North-East (Norðausturumdæmi)	480	59.529	124
North-West (Norðvesturumdæmi)	472	92.240	195
West (Vesturumdæmi)	645	92.843	144
South-West (Suðvesturumdæmi)	102	3.427	34
Total	**2.642**	**373.603**	

Table 6 Number of horses according to veterinary districts in 2011

Veterinary district	All horses
South (Suðurumdæmi)	28.159
East (Austurumdæmi)	3.417
North-East (Norðausturumdæmi)	7.658
North-West (Norðvesturumdæmi)	19.523
West (Vesturumdæmi)	10.703
South-West (Suðvesturumdæmi)	8.817
Total	**78.277**

Table 7 Number of sows and sow farms according to veterinary districts in 2011

Veterinary district	Farms with sows	Sows	Average per farm
South (Suðurumdæmi)	5	1.050	210
East (Austurumdæmi)	1	10	10
North-East (Norðausturumdæmi)	2	497	249
North-West (Norðvesturumdæmi)	2	6	3
West (Vesturumdæmi	2	579	290
South-West (Suðvesturumdæmi)	4	1.407	352
Total	**16**	**3.549**	**222**

Dairy cattle

Location of farms

Distribution of dairy farms is shown in the figure below.

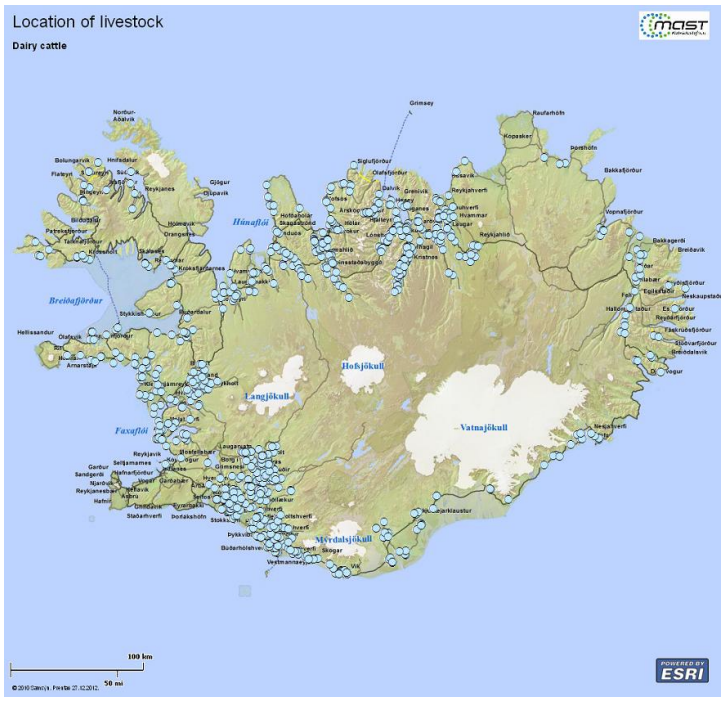


Figure 3 Distribution of dairy farms

Herd size

Most dairy farms have less than 50 cows, see tables below, but the tendency is towards fewer and bigger farms.

Table 8 Number of dairy farms according to number of cows in 2011

Number of dairy-cows	Number of dairy-cattle farms
1-50	578
51-100	135
101-150	12
151-200	1
>200	1
Total	**727**

Table 9 Number of dairy farms according to total number of cattle in 2011

Number of cattle	Number of dairy-cattle farms
1-50	191
51-100	289
101-150	153
151-200	54
>200	40
Total	**727**

Housing and grazing

In 2011 the number of dairy farms was 727. 53% of the farms had a tie-up housing system with barn milking, 10% of the farms had a tie-up system with a milking parlour, 21% had a loose housing system with a milking parlour and 15% had a loose housing system with a milking robot. 52% of dairy cows were in a loose housing system in 2011 and 54% of the total milk production came from cows within a loose housing system.[5] The grazing period is normally from late May to early September. According to Icelandic regulations dairy cattle must have access to outdoor area at least 8 weeks every summer.[6]

Movement of animals and other transmission routes for infectious agents

No cattle markets exist and trade with live cattle is quite limited. The main movement of cattle between farms is when farmers with beef-cattle buy calves and dairy farmers buy heifers.

Main contacts between dairy-farms are by people and vehicles, e.g. the milk tanker, inseminators, veterinarians and claw-trimmers. During ploughing, sowing and harvesting, the same equipment is sometimes used on many premises.

[5] Snorri Sigurðsson. 2011. Þróun fjósgerða og mjaltatækni á Íslandi 2009-2011. Unnið fyrir Landssamband kúabænda. Skýrsla LBHÍ.

[6] Torfi Jóhannesson. 2010. Agriculture in Iceland: Conditions and Characteristics.

Beef-cattle

Location of farms

Distribution of farms with beef-cattle is shown in figure below.

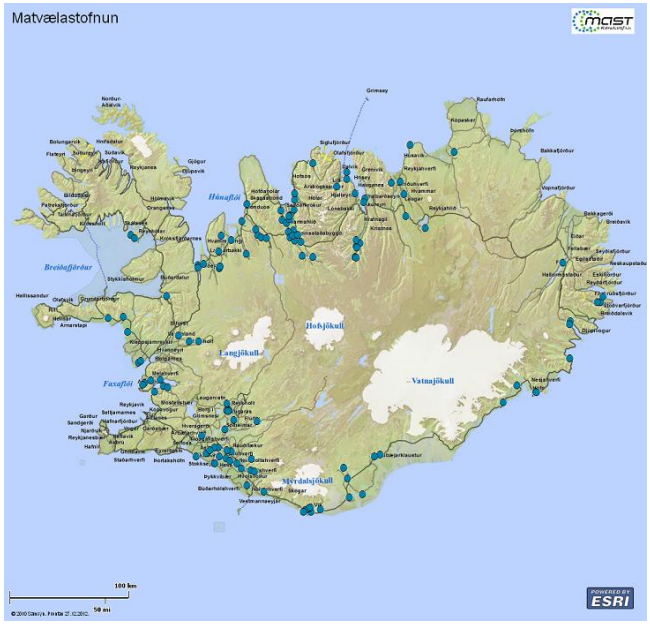


Figure 4 Distribution of beef-cattle farms

Herd size

Most beef-cattle farms are small, see tables 8 and 9. In 2011 only 31 farms out of 124 had more than 100 cattle.

Table 10 Number of beef-cattle farms according to cows in 2011

Number of beef cows	Number of beef-cattle farms
1-50	116
51-100	7
101-150	0
151-200	0
>200	0
Total	**123**

Table 11 Number of beef-cattle farms according to total number of cattle in 2011

Number of beef-cattle	Number of beef-cattle farms
1-50	66
51-100	27
101-150	11
151-200	3
>200	17
Total	**124**

Housing and grazing

Most of the beef production is supplementary to milk production. At farms with beef-cattle only, the cows, heifers and calves less than one year of age are usually kept outside, but the bulls are kept inside until slaughtering.

Movement of animals and other transmission routes for infectious agents

No cattle markets exist and trade with live cattle is quite limited. The main movement of cattle between farms is when farmers with beef-cattle buy calves and dairy farmers buy heifers.

Very little contacts are between beef-farms. Artificial insemination is not widely used and veterinarians are seldom called. During harvesting, the same equipment is sometimes used on many premises.

Sheep

Location

Distribution of sheep farms is shown in figure below..

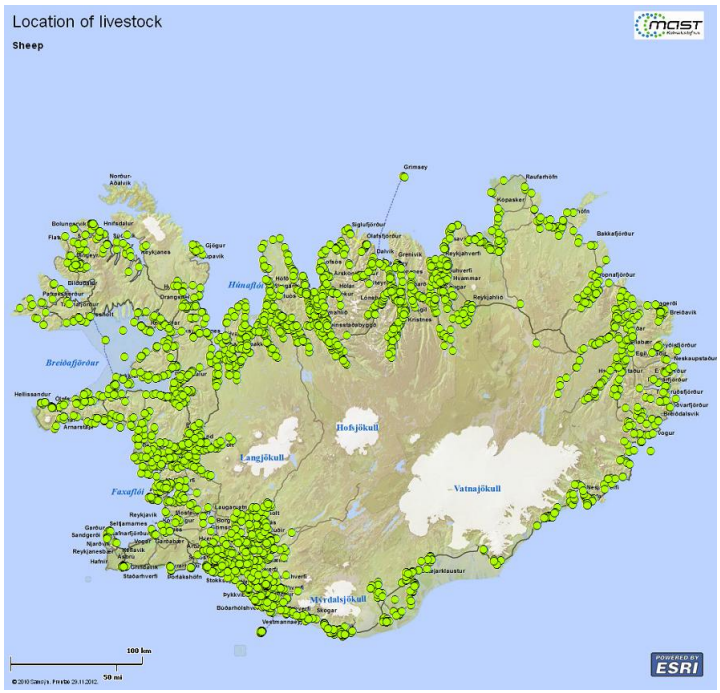


Figure 5 Distribution of sheep farms

Herd size

The majority of sheep farms have more than 50 winter fed sheep, but there are also a numerous hobby farms with less than 50 sheep, see tables below.

Table 12 Number of sheep farms according to number of ewes in 2011

Number of ewes	Number of sheep farms
1-50	1132
51-100	329
101-200	440
201-400	536
>400	205
Total	**2642**

Table 13 Number of sheep farms according to total number of winter fed sheep in 2011

Number of winter fed sheep	Number of sheep farms
1-50	1044
51-100	317
101-200	414
201-400	528
>400	381
Total	**2684**

Housing and grazing

The feeding period is usually from November to the end of May. It can be longer, depending on weather conditions. During the feeding period the sheep are usually kept in sheds, only on very few farms are sheep kept and fed outside. Most of the ewes lamb in May and usually the lambing takes place inside the sheds. A few weeks after lambing most of the sheep are sent to graze in common mountain pastures until autumn, but some are kept on home pastures. In the mountain pastures are large areas where sheep from many farms go together, but they are divided by fences or natural barriers like rivers, lakes and glaciers.

Movement and other transmission routes for infectious agents

No sheep markets exist and trade with life sheep is quite limited. Occasionally sheep shows are set up, but official permission is required for that kind of arrangements. Certain restriction zones are considered free of scrapie and paratuberculosis, and buying of live sheep is only allowed from these zones and must be approved by the veterinary authority. Movement of sheep between herds within zones where scrapie exist is prohibited.

Contacts between sheep-farms are mainly through common grazing in the highland, of thousands of sheep from farms in large areas. The sheep are collected in the autumn in flocks that sometimes count thousands. Other important transmission routes are through people who carry out shearing and claw trimming, and the equipment used in that context. Equipment for harvesting used on many premises is also a potential transmission route as well as hay transported from one farm to another.

Horses

Location

Distribution of horse farms and stalls is shown in figure below.

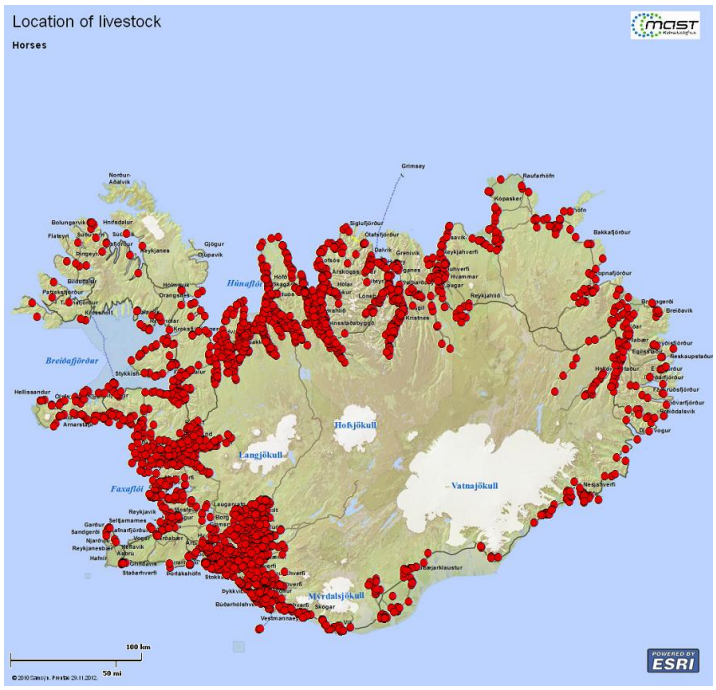


Figure 6 Distribution of horse farms/stalls

Herd size

Horses are kept at numerous farms and stalls around the country, but most of them have less than 30 horses, see table below.

Table 14 Number of horse farms/stalls according to number of horses in 2011

Number of horses	Number of farms/stalls
1-10	922
11-30	994
31-50	407
51-100	274
>100	102
Total	**2699**

Housing and grazing

A large proportion of the horses in Iceland are kept on pasture all year round, usually given hay during the period from December to May, depending on weather conditions. Riding horses, foals and horses that need special care, are kept in stables during the winter months but on pasture during the summer. On the outskirts of most towns and villages there are clusters of stables owned by individual horse owners. Most farmers keep a few horses as a hobby or to use for gathering the sheep from pasture in the autumn. Number of horses per owner varies tremendously. People, who have riding as a hobby, only keep a few horses per person, but those who breed and train horses for competition or sale or keep horses for meat production may have tens or even hundreds.

Movement of animals and other transmission routes for infectious agents

There is considerable movement of horses around the country in the context of training, shows, competitions etc. There are no restrictions on movement of horses.

Horses are often brought to training on premises where many horses from various other farms/stalls are kept for a short or a longer period. Shows, competitions and various social events organized by horse owners also pose a risk of disease transmission. The same applies for people who travel between horse farms/stalls, such as veterinarians and farriers, and hay that horse owners buy from different farms.

Pigs

Location

Distribution of pig farms is shown in figure below.

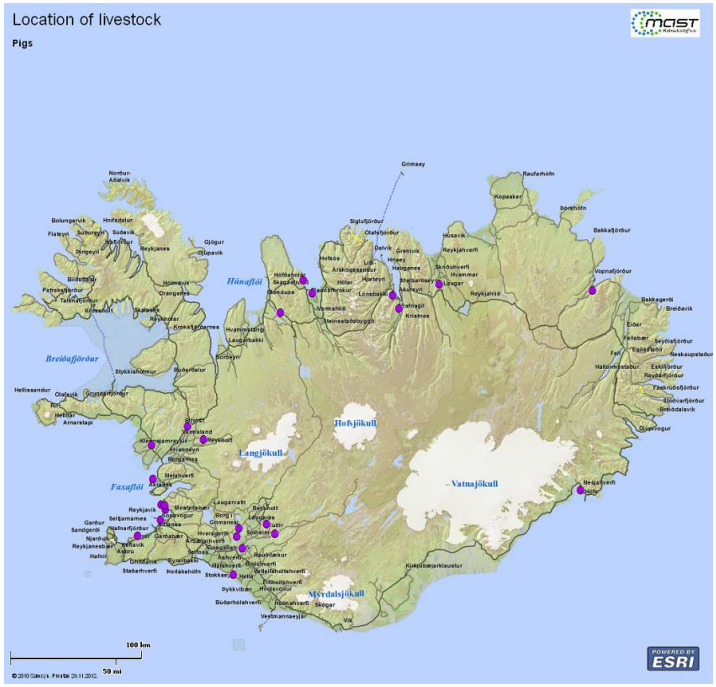


Figure 7 Distribution of pig farms

Herd size

Farms with slaughter pigs were only twenty five in 2011. Thirteen of them had between one hundred and a thousand slaughter pigs but six had more than a thousand, see table below.

Table 15 Number of pig farms according to number of sows in 2011

Number of sows	Number of pig farms
1-50	5
51-100	0
101-200	6
201-400	1
>400	4
Total	**16**

Table 16 Number of pig farms according to number of slaughter pigs in 2011

Number of slaughter pigs	Number of pig farms
1-100	6
101-1000	13
1001-2000	3
2001-3000	1
>3000	2
Total	**25**

Housing and grazing

Pigs are kept in houses, which usually have a good biosecurity. Pigs are very seldom kept outside.

Movement of animals and other transmission routes for infectious agents

The main movement of pigs is between compartments within the farms and between different premises owned by the same farmer, which sometimes are in different parts of the country.

The main potential transmission routes, other than live animals for infectious agent between pig farms, is fresh semen, the bulk feed transport vehicle, workers and veterinarians.

Chapter 5 Notification and animal disease surveillance

Compulsory notification and general surveillance

In Act No 25/1993, notifiable diseases are arranged into three groups (A, B and C) according to importance (see the full list below). On behalf of MAST (the Icelandic Food and Veterinary Authority), district veterinary officers are responsible for monitoring animal health within each district. All private practicing veterinarians are obliged to be alert and to report any suspicion regarding the diseases, to MAST. Furthermore, any person who has a reason to believe that an animal is suffering from an infectious disease covered by the act, shall immediately report this to any veterinarian who can be reached or to the police, who shall immediately contact a veterinarian. If a veterinarian sees a reason to take action, he/she shall immediately take steps to confirm the diagnosis and prevent the disease from spreading. If testing shows or a suspicion arises of an infectious disease, previously unknown in the country or specified in Appendix 1 of Act No 25/1993, MAST shall immediately be informed and precautionary biosecurity measures applied.

Appendix 1A (A-diseases) to Act No 25/1993

Notifiable diseases

Multiple species:		
B052	Aujeszkys-veiki	Aujeszky´s disease – Pseudorabies – Herpesviridae
A090	Blátunga	Bluetongue – Reoviridae
A010	Gin- og klaufaveiki	Foot and Mouth Disease – Picornaviridae
B352	Hérasótt	Tularemia – Francisella tularensis
B058	Hundaæði	Rabies – Rhabdoviridae
B051	Miltisbrandur	Anthrax – Bacillus anthracis
A020	Munnblöðrubólga	Vesicular stomatitis – Rhabdoviridae
A080	Rift Valley veiki	Rift Valley fever – Bunyaviridae
B103/B253	Smitandi fósturlát/Brúsellósa	Brucellosis – Brucella-abortus/B. suis/B. melitensis

Horses		
A110	Afríkönsk hrossapest	African horse sickness – Reoviridae
B202	Dúrín	Dourine – Ondartet beskjelersyke – Trypanosoma equiperdum
B205	Smitandi blóðleysi	Equine infectious anemia (EIA) – Retroviridae
B209	Sníf	Glanders – Pseudomonas mallei

Cattle:		
B105	Berklar	Tuberculosis – Mycobacterium bovis/tuberculosis
A070	Húðþrimlaveiki	Lumpy skin disease – Poxviridae
A060	Illkynja brjósthimnubólga	Contagious bovine pleuropneumonia – Mycoplasma mycoides mycoides
B115	Kúariða	Bovine spongiform encephalopati (BSE) – Prion
A040	Nautapest	Rinderpest – Kvegpest – Pestis bovum – Paramyxoviridae
B110	Smitandi barkabólga/fósturlát	IBR/IPV – Herpesviridae
B108	Smitandi hvítblæði	Enzootic bovine leucosis (EBL) – Retroviridae

Sheep and goats		
I301	Bítlaveiki	Border disease – Hairy shaker disease – Flaviviridae
A100	Fjárbólusótt/geitabólusótt	Sheep pox and goat pox – Poxviridae
A050	Fjárpest	Peste des petits ruminants (PPR) – Paramyxoviridae
B156	Fósturlát í ám	Enzootic abortion of ewes (EAE) – Chlamydia psittaci
B155	Geitakregða	Contagious caprine pleuropneumonia – Mycoplasma F38
B154	Kregðujúgurbólga	Contagious agalactia – Mycoplasma ssp.
B161	Mæði (þurramæði)/Visna	Maedi/Visna – Retroviridae
B160	Riðuveiki	Scrapie – Prion
B159	Salmonella-fósturlát	Salmonellosis – Salmonella abortus ovis
B153	Smitandi liða- og heilabólga í geitum	Caprine arthritis and encephalitis (CAE) – Retroviridae
B157	Votamæði	Jaagsiekte – Ovine pulmonary adenomatosis – Retroviridae

Pigs		
A120	Afríkönsk svínapest	African swine fever (ASF) – ASF-like virus
I401	Blöðruþot í svínum	Vesicular exanthema of swine (VES) – Caliciviridae
A140	Illkynja grísalömun	Teschen disease – Picornaviridae
B254	Smitandi maga- og garnabólga	Transmissible gastroenteritis (TGE) – Coronaviridae
A030	Svínafár	Swine vesicular disease (SVD) – Picornaviridae
A130	Svínapest	Classical swine fever – Hog cholera – Flaviviridae

Dogs, cats and fur animals		
B353	Lifrardrep	Rabbit haemorrhagic disease (VHD) – Parvoviridae
I501	Maurakláði	Sarcoptes mange – Sarcoptes spp.
I502	Plasmacytósa	Plasmacytosis – Aleutian disease – Parvoviridae
I503	Refafár/Minkafár	Distemper – Paramyxoviridae
I504	Sullaveikifár	Echinococcosis – Echinococcus multilocularis

Poultry		
A150	Hænsnapest	Avian influenza (AI) – Fowl plague – Orthomyxoviridae
B313	Hænsnatyfus	Fowl typhoid – Salmonella gallinarum
B308	Kjúklingasótt	Pullorum disease – Salmonella pullorum
I601	Nef- og barkabólga	Avian rhinotracheitis (ART) – Pneumoviridae
A160	Newcastle-veiki	Newcastle Disease (ND) – Paramyxoviridae
B302	Smitandi kverka- og barkabólga	Infectious laryngotracheitis (ILT) – Herpesviridae
B305	Veirugarnabólga í öndum	Duck virus enteritis (DVE) – Herpesviridae
B304	Veirulifrarbólga í öndum	Duck virus hepatitis (DVH) – Picornaviridae

Fish		
B413	EHN-veiki	Epizootic haematopoietic necrosis – Iridoviridae
B415	Herpesveiki/OMV-veiki	Herpesvirus salmonis/H. scophthalmi Oncorhynchus masou virus disease
B405	IHN-veiki	Infectious haematopoietic necrosis – Rhabdoviridae
I701	IPN-veiki	Infectious pancreas necrosis – Birnaviridae
I702	ISA-veiki	Infectious salmon anemia – Orthomyxoviridae
I703	Roðflyðrusýki	Gyrodactylosis – Gyrodactylus salaris
B404	SVC-veiki	Spring viraemia of carp – Rhabdoviridae
B401	VHS-veiki	Viral haemorrhagic septicaemia – Rhabdoviridae
I704	VNN-veiki	Viral nervous necrosis – Nodaviridae

Molluscs		
B434	Marteilíuveiki	Marteiliosis – Marteilia refringens/M. sydneyi
B436	Mykrocytos-veiki	Mikrocytosis – Mykrocytos mackini/M. roughleyi
B431	Ostruveiki	Bonamiosis – Bonamia ostreae/B. sp.
B433	Perkinsus-veiki	Perkinsosis – Perkinsus marinus/P. olseni
B432	Sumarveiki í ostrum	Haplosporidiosis – Haplosporidium costale/H. nelsoni
I801	Velar-veiki	Oyster velar virus disease – Iridoviridae

Crustaceans		
I901	Humarveiki	Gaffkemi – Aerococcous viridans
I902	Krabbapest	Crayfish plague – Aphanomyces astaci

Appendix 1B (B-diseases)

Notifiable diseases

Multiple species		
I001	Blóðsviti	Parafilariosis – *Parafilaria* spp.
C702	Fótrot	Footrot – *Fusobacterium necrophorum*
B059	Garnaveiki	Paratuberculosis – *Mycobacterium avium paratuberculosis*
I002	Hringskyrfi	Ringworm – *Microsporum* spp./*Trichophyton* spp.
B107	Hrýfi	Dermatophilosis – *Dermatophilus congolensis*
B056	Leptóspírósa/Gulusótt	Leptospirosis – *Leptospira* spp.
I003	Neosporosis	Nesosporosis – *Neospora caninum*
B057	Q-hitasótt	Q-fever – *Coxiella burnetii*
C619/C855	Salmonella-sýkingar	Intestinal salmonella infections – *Salmonella* spp. (Other than *Salmonella gallinarum/S. pullorum*)
B104	Smitandi fósturlát	Bovine genital campylobacteriosis – *Campylobacter fetus fetus*
B053	Sullaveiki	Echinococcosis – Hydatidosis – *Echinococcus granulosus*
B255	Tríkínuveiki	Trichinosis – *Trichinella spiralis*

Horses		
B206	Hestainflúensa	Equine influenza – *Orthomyxoviridae*
B210	Hrossabóla	Horse pox – *Poxviridae*
B213	Hrossakláði	Sarcoptic mange – *Sarcoptes scabiei var equi*
C753	Kverkeitlabólga	Strangles – *Streptococcus equi equi*
B208	Smitandi háls- og lungnakvef	Equine viral rhinopneumonitis/Equine abortion virus (EHV-1/EHV-4) – *Herpesviridae*
B204	Smitandi heilabólga	Eastern & Western equine encephalomyelitis – *Alphaviridae*
B201	Smitandi legbólga	Contagious equine metritis (CEM) – *Taylorella equigenitalis*
B211	Smitandi slagæðabólga	Equine viral arteritis (EVA) – *Arteriviridae*
B203	Smitandi sogæðabólga	Epizootic lymhangitis – *Histoplasma farciminosum*
B216	Venezuela-heilabólga	Equine Venezuelan encephalomyelitis – *Alphaviridae*

Cattle		
B112	Fósturlát í kúm	Trichomonosis – *Trichomonas foetus*
B114	Illkynja slímhúðarbólga	Malignant catarrhal fever (AHV-1) – *Herpesviridae*
C652	Smitandi slímhúðarpest	Bovine viral diarrhea/Mucosal disease (MD/BVD) – *Flaviviridae*
I201	Smitandi öndunarfærabólga	Bovine respiratory syncytial virus (BRSV) – *Paramyxoviridae*
I202	Veiruskita	Viral diarrhea – *Coronaviridae*
B106	Vöðvasullur	Bovine cysticercosis – *Taenia saginata*

Sheep and goats:		
I302	Fellilús	Sheep biting louse – Damalinia ovis
I303	Fjárkláði	Sheep scab – Psoroptes ovis
C706	Fótakláði	Sheep mange – Chorioptes ovis
I304	Færilús	Sheep keds – Melophagus ovinus
B151	Lyppudrep	Ovine epididymitis – Brucella ovis
I305	Vöðvasullur	Ovine cysticercosis – Taenia ovis

Pigs		
I402	Illkynja lungnabólga	Pleuropneumonia – *Actinobacillus pleuropneumonia*
B257	PRRS-veiki	Porcine respiratory and reproductive syndrome (PRRS)
I403	Smitandi veiruskita	Porcine epidemic diarrhea (PED) – *Coronaviridae*
B252	Svínabandormur	Porcine cysticercosis – *Taenia solium*
I404	Svínainflúensa	Swine influenza – Hog flue – *Orthomyxoviridae*
B256	Ælu- og vanþrifapest	Vomiting & wasting disease – Hemagglutinating encephalomyelitis virus (HEV) – *Coronaviridae*

Dogs, cats and fur animals		
I505	Hundafár	Canine distemper – *Paramyxoviridae*
B501	Leishmaníu-veiki	Canine leishmaniosis – *Leishmania* spp.
I506	Lungnafár í mink	Hemorrhagic pneumonia – *Pseudomonas aeruginosa*
I507	Refavanki	Nosematosis – *Encephalitozoon cuniculi*
I508	Veiruskita í mink	Mink viral enteritis – *Parvoviridae*

Poultry		
B303	Fuglaberklar	Avian tuberculosis – *Mycobacterium avium*
B307	Fuglabólusótt	Fowl pox – *Poxviridae*
B306	Fuglakólera	Fowl cholera – *Pasteurella multocida*
B311	Fuglakregða	Avian mycoplasmosis – *M. gallisepticum/M. meleagridis*
B309	Gumboro-veiki	Gumboro disease – Infectious bursal disease (IBD) – *Birnaviridae*
B310	Hænsnalömun	Marek's disease – *Herpesviridae*
C853	Mænubólga	Avian encephalomyelitis (AE) – *Picornaviridae*
I602	Paramyxóveirusýkingar	Avian paramyxovirus (other than Newcastle disease) – *Paramyxoviridae*
B312	Páfagaukaveiki	Avian chlamydiosis – Psittacosis – Ornithosis – *Chlamydia psittaci* – (annað en fósturlát í ám)
B301	Smitandi berkjubólga	Infectious bronchitis (IB) – *Coronaviridae*
I603	Varpröskun	Egg drop syndrome (EDS) – *Adenoviridae*

Fish		
I705	Blóðfrumuveirusótt	Erythrocitic inclusion body syndrome (EIBS) – *Togaviridae*
I706	Hindberjaveiki	Proliferative kidney disease (PKD)
I707	Hitraveiki	Coldwater vibriosis – *Vibrio salmonicida*
I708	Hvirfilveiki	Whirling disease – *Myxobolus cerebralis*
I709	Kýlaveiki	Furunculosis – *Aeromonas salm.* spp. *salmonicida*
I710	Laxalús/Fiskilús	Salmon louse infection – *Lepeophtheirus salmonis*
		Marine louse infection – *Caligus elongatus*
I711	Nýrnaveiki	Bacterial kidney disease (BKD) – *Renibacterium salmoninarum*
I712	PD-veiki/Brisveiki	Pancreas disease (PD) – *Togaviridae*
I713	Piskirikketsíuveiki	Piscirickettsiosis – *Piscirickettsia salmonis*
I714	Rauðmunnaveiki	Enteric red mouth (ERM) – Yersiniosis – *Yersinia ruckeri*
I715	Spírónúkleusveiki	Systemic spironucleosis – *Spironucleus barkhanus*
I716	Sundmagasótt	Swimbladder nematode of eel – *Anguillicola crassus*

Molluscs		
I802	Sæeyrnaskelormur	Sabellid polychaete – *Terebrasabella heterouncinata*

Crustaceans		
I903	Postulínsveiki	Porselenssyke – *Thelohania contejeani*
I904	Sveppablettaveiki	Brannflekksyke – *Ramularia astaci*

Bees		
B453	Evrópsk býflugnapest	European foulbrood – *Streptococcus pluton*
B452	Illkynja býflugnapest	American foulbrood – *Bacillus larvae*
B451	Loftsekkjaveiki	Acariosis of bees – *Acarapis woodii*
B454	Þarmaveiki	Nosemosis of bees – *Nosema apis*
B455	Varróaveiki	Varroosis – *Varroa jakobsonii*

Appendix 2 (C-diseases)

Diseases subject to compulsory registration

Multiple species		
C612	Bogfrymlasótt	Toxoplasmosis – *Toxoplasma gondii*
I003	Bólusótt	Pox disease – *Poxviridae*
C615	Bótulismi	Botulism – *Clostridium botulinum*
C616	Clostridíasýkingar	Clostridiosis – *Clostridium* ssp. (Other than *Clostridium chauvoei, Cl. perfringens* type C og *Cl. botulinum*)
C620	Hníslasótt	Coccidiosis – *Eimeria* spp./*Isospora* spp.
C611	Hvanneyrarveiki	Listeriosis – *Listeria monocytogenes*
C613	Ígerðarsótt	Melioidosis – *Burkholderia pseudomallei*
C618	Kjálkabris	Actinomycosis – *Actinomyces* ssp.
C705/C752	Kýlapest	Caseous lymphadenitis – Ulcerative lymphangitis – *Actinobacillus lignieresii/Corynebacterium pseudotuberculosis*
I004	Lungnapest	Pasteurellosis – *Pasteurella multocida/P. haemolytica*
C617	Lungnadrep	Other pasteurellosis – *Pasteurella* ssp. (Other than *Pasteurella multocida*)
C614	Pestbjúgur	Blackleg – *Clostridium chauvoei*
C621	Ögðuveiki	Liver fluke disease – Distomatosis – *Fascicola hepatica*

Horses		
I101	Herpeskvef	Equine herpesvirus 2 (EHV-2) – *Herpesviridae*
C751	Herpesútbrot	Equine coital exhanthema (EHV-3) – *Herpesviridae*
I102	Húðsveppur	*Trichophyton equinum/T. mentagrophytes*

Sheep and goats		
C701	Smitandi munnangur	Orf – Contagious echtyma (CE) – *Poxviridae*
I306	Tannlos	Broken mouth

Pigs		
I405	Bjúgveiki	Edema disease – *E. coli* O138/O139/O140/O141
I406	Blóðskita	Swine dysentery – *Brachyspira hyodysenteriae*
I407	Garnadrep	Necrotic enteritis – *Clostridium perfringens* type C
I408	Gothiti	Mastitis-metritis-agalactia syndrome (MMA)
C801	Rauðsýki	Swine erysipelas – *Erysipelothrix rhusiopathiae*
I409	Smitandi fósturdauði	Porcine parvovirus (PPV) – *Parvoviridae*
B251	Snúðtrýni	Atrophic rhinitis of swine – *Pasteurella multocida* tox +
I410	Svínakláði	Sarcoptes mange – *Sarcoptes scabiei* var. *suis*
I411	Svínakregða	Endemic pneumonia (EP) – *Mycoplasma pneumonia*
I412	Þarmabólga	Porcine intestinal adenomatosis (PIA) – *Lawsonia intracellularis*

Dogs, cats and fur animals:		
I509	Eyrnamaur	Ear mites – *Otodectes cynotis*
I510	Kattafár	Feline leukemia virus – *Retroviridae*
I511	Kattamaur	Cheyletiellosis – *Cheyletiella parasitovorax*
I512	Smáveirusótt	Canine parvovirus – *Parvoviridae*
I513	Smitandi heila- og lifrarbólga	Hepatitis contagiosa canis (HCC)/Fox encephalitis – (CAV-1) – *Adenoviridae*

Poultry:		
I604	Blávængjaveiki	Chicken infectious anemia (CIA) – *Parvoviridae*
C856	Hvítblæði	Avian leucosis – *Retroviridae*
I605	Fuglakregða	Avian mycoplasmosis – (Other than *M. gallisepticum* and *M. meleagridis*)

Fish		
I718	Fiskaberklar	Mycobacteriosis – *Mycobacterium marinum*
I719	Kýlaveikibróður	Ulcer disease – *Aeromonas salm.* spp. *achromogenes*
I720	Klamydíuveiki	Epitheliocystis – *Chlamydia* spp.
I721	Roðdrep í klaklaxi	Ulcerative dermatic necrosis (UDN)
I722	VEN-veiki	Viral erythrocytic necrosis – *Iridoviridae*
I723	Vetrarsár	Winter ulcers – *Moritella viscosa*
I724	Víbríuveiki	Vibriosis – *Vibrio anguillarum*
I725	Vörtuveiki	Papillomatosis – *Herpesviridae*

Animal disease surveillance

Infections which can be latent and diseases which do not have clear clinical symptoms are monitored by routine sampling. Farms are selected at random with the limitation that samples must be taken on all farms within a certain time interval. The aim of the surveillance is to detect with 95% confidence at least one positive unit (animal or farm) if the infection is present at a maximum of 5% prevalence. The expected prevalence may vary based on the nature of the disease. The within-herd sample size is determined by the number of animals available for blood sampling. The following sections contain information about sampling and results of analyses for the active surveillance.

Cattle disease

Enzootic bovine leucosis

Enzootic bovine leucosis has never been detected. It is a notifiable disease, according to Act No 25/1993. At slaughterhouses, all tumours, suspected to be lymphosarcoma, are reported and sent for diagnosis at the official laboratory at Keldur. In 1993 a serological survey was carried out. Systematic surveillance has been carried out since 2007. See table below.

Table 17 Number of samples analysed for enzootic bovine leucosis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1993	51	21	51	0
2001	35	-	35	0
2007	-	97	97	0
2008	-	75	75	0
2009	-	79	79	0
2010	-	87	87	0
2011	-	80	80	0
2012	-	80	80	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Infectious bovine rhinotracheitis/ Infectious pustular vulvovaginitis

Infectious bovine rhinotracheitis/infectious pustular vulvovaginitis is a notifiable disease, according to Act No 25/1993. It was detected for the first time in Iceland in September 2012 in a bulk tank sample from one farm, taken according to the annual surveillance programme; no clinical symptoms were detected at the farm. Immediate notification was sent to OIE. Decision was made to cull all infected animals. In 1993 a serological survey was conducted and a systematic surveillance has been carried out since 2007. See table below.

Table 18 Number of samples analysed for IBR/IPV

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1993	51	21	51	0
2000	10	1	10	0
2001	39	-	39	0
2007	-	97	97	0
2008	-	76	76	0
2009	-	79	79	0
2010	-	87	87	0
2011	-	80	80	0
2012	-	80	79	1

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Bovine virus diarrhoea

Bovine virus diarrhoea has never been detected. It is a notifiable disease, according to Act No 25/1993. In 1992 and 1994 serological surveys were conducted. Systematic surveillance has been carried out since 2007. See table below.

Table 19 Number of samples analysed for bovine virus diarrhoea

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1992	-	120	120	0
1994	-	167	167	0
2000	10	1	10	0
2001	39	-	39	0
2007	-	97	97	0
2008	-	75	75	0
2009	-	79	79	0
2010	-	87	87	0
2011	-	80	80	0
2012	-	80	80	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Salmonella Dublin

Salmonella Dublin has never been detected. It is a notifiable disease according to Act No 25/1993. Serological surveillance was initiated in 2012, see table below.

Table 20 Number of samples analysed for Salmonella Dublin

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2012	-	80	80	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Q-fever

Coxiella burnetti has never been detected in animals. It is a notifiable disease, according to Act No 25/1993. Serological surveillance was initiated in 2012, see table below.

Table 21 Number of samples analysed for Coxiella burnetti

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2012	-	80	80	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Bovine brucellosis

Bovine brucellosis has never been detected in Iceland. It is a notifiable disease, according to Act N025/1993. In 1993 a serological survey was carried out. Systematic surveillance has been carried out since 2007. See table below.

Table 22 Number of samples analysed for bovine brucellosis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1993	51	21	51	0
2008	80	16	80	0
2009	75	15	75	0
2010	90	18	90	0
2011	80	16	80	0
2012	45	9	45	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Bovine spongiform encephalopathy

Bovine spongiform encephalopathy has never been detected. It is a notifiable disease, according to Act No 25/1993. Since 1968, it has been prohibited to import meat- and bone meal and greaves for use in feeding stuffs for livestock, and there has been a ban on feeding meat- and bone meal to ruminants since 1978 and all food producing animals since 2001. In 2004, Iceland was recognized as a negligible BSE risk country, by the OIE International Committee. Since 2000 samples have been taken systematically every year, see table below. Until 2009 samples were taken from cattle displaying behavioural or clinical signs consistent with BSE and cattle more than 24 months of age within the categories of fallen stock, casualty slaughter and routine slaughter. Since 2010 the age criteria has been 30 months for fallen stock and casualty slaughter and 36 months for the category routine slaughter. Only in 1999, 2000, 2006, 2009 and 2010 cattle was tested due to clinical symptoms, one each year.

Table 23 Number of samples analysed for BSE

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2000	28	-	28	0
2001	422	-	422	0
2002	64	-	64	0
2003	73	-	73	0
2004	120	-	120	0
2005	191	-	191	0
2006	65	-	65	0
2007	91	-	91	0
2008	148	-	148	0
2009	99	-	99	0
2010	101	-	101	0
2011	120	-	120	0
2012	99	-	99	0

Diagnostic method: TeSeE™ - detection kit and TeSeE™ - Western Blot kit (Bio-Rad).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Paratuberculosis

In cattle, paratuberculosis was first diagnosed in 1945. Samples are taken from cattle when suspicion of the disease arises and in connection with movement of cattle between surveillance zones. See table below.

Table 24 Number of cattle samples analysed for paratuberculosis

Year	Number of samples from ileum	Number of blood samples	Number of positive farms
2000	1356	945	1
2001	1705	427	3
2002	450	349	2
2003	1940	455	0
2004	32	649	0
2005	450	684	1
2006	52	430	0
2007	?	231	0
2008	10	0	0
2009	2	23	0
2010	14	111	1
2011	1	40	0
2012	0	43	0

Diagnostic method: Organ material: Histopathology. Blood: ELISA (enzyme-linked immunosorbent assay).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Sheep diseases

Scrapie

Scrapie has been endemic since 1878. A decision was made in 1986 to start an eradication programme. On farms where scrapie is detected, all sheep are culled. Areas where scrapie has been detected are kept under special surveillance for 10 years. Samples are taken annually from sheep at slaughter and sheep displaying clinical signs compatible with scrapie. See table below.

Table 25 Number of samples analysed for scrapie

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples	Number of positive farms
2000	7826	-	7822	4	3
2001	7647	-	7638	9	1
2002	5621	-	5609	12	2
2003	7208	-	7189	19	5
2004	9590	-	9569	19 + 2 NOR98	7 + 1 NOR98
2005	3551	-	3542	9	4
2006	3815	-	3794	21	2
2007	5057	-	5041	15 + 1 NOR98	3 + 1 NOR98
2008	3087	-	3029	57 + 1 NOR98	1 + 1 NOR98
2009	1717	123	1710	7	2
2010	3666	353	3661	5	1
2011	3527	197	3526	0 + 1 NOR98	0 + 1 NOR98
2012	2732	-	2732	0	0

Diagnostic method: TeSeE™ - detection kit and TeSeE™ - Western Blot kit (Bio-Rad).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Paratuberculosis

In sheep, paratuberculosis was first diagnosed in 1933. In 1966 a vaccination programme was established. Blood samples are taken if suspicion arises in live animals. At the slaughterhouses, ileum of all adult sheep is inspected and if considered necessary samples are submitted to the official laboratory at Keldur. See table below.

Table 26 Number of sheep samples analysed for paratuberculosis

Year	Number of samples from ileum	Number of blood samples	Number of positive farms
2000	15482	138	5
2001	21417	846	12
2002	8353	161	10
2003	11681	231	11
2004	2922	118	7
2005	20400	262	7
2006	10575	205	13
2007	14821	90	5
2008	8609	?	10
2009	387	5	0
2010	22	170 + 13 goats	3
2011	741	735	6
2012	34	0	0

Diagnostic method: Organ material: Histopathology. Blood: ELISA (enzyme-linked immunosorbent assay).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Ovine Brucellosis

Ovine Brucellosis (*Brucella melitensis*) has never been detected. It is a notifiable disease, according to Act No 25/1993. In 2010 a serological survey was carried out. See table below.

Table 27 Number of sheep samples analysed for paratuberculosis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2010	100	19	100	0

Swine diseases

Aujezky's disease

Aujeszky's disease has never been detected. It is a notifiable disease, according to Act No25/1993. Samples have been taken occasionally since 1994. See table below.

Table 28 Number of samples analysed for Aujezky's disease

Year	Number of Individuals sampled	Number of farms	Number of negative samples	Number of positive samples	Number of positive farms
1994	-	20	-	0	0
1995	-	1	-	0	0
1997	-	1	-	0	0
1998	-	1	-	0	0
2007	240	8	240	0	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, Lindholm, DK-4771 Kalvehave, Denmark.

Transmissible gastroenteritis and porcine respiratory corona virus

TGE and PRCV have never been detected. They are notifiable diseases, according to Act No 25/1993. Samples have been taken occasionally since 1994. See table below.

Table 29 Number of samples analysed for TGE and PRCV

Year	Number of individuals sampled	Number of farms	Number of negative samples	Number of positive samples	Number of positive farms
1994	-	20	-	0	0
1998	-	1	-	0	0
2007	240	8	240	0	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, Lindholm, DK-4771 Kalvehave, Denmark.

Porcine respiratory and reproductive syndrome

PRRS has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1994. See **Error! Reference source not found.**.

Table 30 Number of samples analysed for PRRS

Year	Number of individuals sampled	Number of farms	Number of negative samples	Number of positive samples	Number of positive farms
1994	-	20	-	0	0
1995	-	1	-	0	0
1997	-	1	-	0	0
1998	-	1	-	0	0
1999	-	3	-	0	0
2007	240	8	240	0	0
2009	119	-	119	0	0
2010	210	-	210	0	0
2011	240	9	240	0	0
2012	225	8	225	0	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, Lindholm, DK-4771 Kalvehave, Denmark.

Swine influenza

Clinical signs of swine influenza have only been detected in connection with an outbreak of the subtype H1N1 in people. It is a notifiable disease, according to Act No25/1993. Samples have been taken occasionally since 1994. See tables below.

Table 31 Number of samples analysed for swine influenza subtype H3N2

Year	Number of individuals sampled	Number of farms	Number of negative samples	Number of positive samples	Number of positive farms
1994	-	20	-	0	0
1997	-	1	-	0	0
1998	-	3	-	1*[1]	0
1999	-	3	-	5*[1]	0
2007	240	8	240	0	0
2009	239	8	239	0	0
2010	210	8	210	0	0
2011	240	9	207	33*[2]	9*[2]
2012	225	8	225	0	0

***1** Positive serology. No clinical signs. Repeated sampling negative. Considered false positive.
*2 Positive serology. No clinical signs.
Diagnostic method: HI (haemagglutionation inhibition).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Table 32 Number of samples analysed for swine influenza subtype H1N1

Year	Number of individuals sampled	Number of farms	Number of negative samples	Number of positive samples	Number of positive farms
1999	-	3	-	5*[1]	0
2009	370	8	345	25*[2]	2
2010	210	8	171	39*[2]	3
2011	240	9	240	0	0
2012	225	8	225	0	0

***1** Positive serology. No clinical signs.
*2 Considered H1N1 pan2009.
Diagnostic method: HI (haemagglutionation inhibition).
Laboratory: National Veterinary Institute, DK-1790 Copenhagen, Denmark.

Horse diseases

Equine infectious anemia

Equine infectious anaemia has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples were taken from horses intended for export in the period from 1990-2002. A total of 13.082 samples were analysed and all turned out to be negative. Systematic surveillance has been carried out since 2008. See table below.

Table 33 Number of samples analysed for equine infectious anaemia

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
<2003	13.082	-	13.082	0
2008	30	-	30	0
2009	60	-	60	0
2010	50	-	50	0
2011	50	-	50	0
2012	50	50	50	0

Diagnostic method: Coggins test.
Laboratory: Institute for Experimental Pathology, Keldur v/Vesturlandsveg, 112 Reykjavík, Iceland.

Equine influenza

Equine influenza has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1990. Systematic surveillance has been carried out since 2008. See table below. Samples are taken from stallions which have had a close contact with at least 100 horses for the past three months prior to sampling and horses with clinical symptoms, if any.

Table 34 Number of samples analysed for equine influenza

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1990	18	-	18	0
1995	4	-	4	0
1998	7	-	7	0
2000	15	-	15	0
2004	5	-	5	0
2008	30	-	30	0
2009	60	-	60	0
2010	50	-	50	0
2011	50	-	50	0
2012	50	50	50	0

Diagnostic method: HI (haemagglutination inhibition)
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Equine rhinopneumonitis

Equine rhinopneumonitis has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1990. Systematic surveillance has been carried out since 2008. See table below. Samples are taken from stallions which have had a close contact with at least 100 horses for the past three months prior to sampling and horses with clinical symptoms, if any.

Table 35 Number of samples analysed for equine rhinopneumonitis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1990	18	-	13	5*
1994	4	-	1	3*
1998	29	-	29	0
2000	11	-	11	0
2004	5	-	5	0
2008	35	-	35	0
2009	60	-	60	0
2010	50	-	50	0
2011	50	-	50	0
2012	50	50	49	1*[1]

* No clinical signs. Considered a cross-reaction to EHV-4
Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Poultry diseases

Newcastle disease

Newcastle disease has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1993. Systematic surveillance has been carried out since 2008. See table below.

Table 36 Number of samples analysed for Newcastle disease

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1993	100	-	100	0
1994	100	-	100	0
1995	100	-	100	0
1996	100	-	99	1*[1]
1997	100	-	100	0
1998	100	-	100	0
2000	100	-	100	0
2002	100	-	91	9*[1]
2007	200	5	199	1*[1]
2008	120	6	120	0
2009	238	6	238	0
2010	180	6	180	0
2011	190*[2]	8*[3]	190*[2]	0
2012	120*[2]	6*[4]	120	0

*1 No clinical symptoms. Repeated sampling negative. Probably not APMV-1.
*2 100 samples from back-yard flocks.
*3 Five back-yard flocks.
*4 Three back-yard flocks.
Diagnostic method: ELISA (enzyme-linked immunosorbent assay). (National Veterinary Institute, SE-751 89 Uppsala, Sweden.)
Diagnostic method: rRT-PCR. (Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.)

Avian infectious laryngotracheitis

Avian infectious laryngotracheitis has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1995. See table below.

Table 37 Number of samples analysed for avian infectious laryngotracheitis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1995	100	-	99	1*
1998	100	-	100	0
2000	100	-	99	1*
2002	100	-	88	12*
2007	200	5	193	7*
2008	120	6	120	0
2009	238	6	238	0
2012	58	3	58	0

* No clinical signs. Repeated sampling negative.
Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian rhinotracheitis

Avian rhinotracheitis has never been detected. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1998. See table below.

Table 38 Number of samples analysed for avian rhinotracheitis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1998	100	-	100	0
2000	100	-	100	0
2002	100	-	100	0
2007	200	5	200	0
2008	120	6	120	0
2009	20	1	20	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian encephalomyelitis

Avian encephalomyelitis is a notifiable disease, according to Act No 25/1993. Clinical disease has never been detected. Samples have been taken occasionally since 1993. See table below

Table 39 Number of samples analysed for avian encephalomyelitis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1993	100	-	100	0
1994	100	-	100	0
1995	100	-	100	0
1996	102	-	101	1*[1]
1997	100	-	100	0
1998	100	-	100	0
2000	100	-	98	2*[1]
2002	100	-	83	17*[1]
2008	120	6	120	0
2009	238	6	236	2*[2]

* 1 No clinical signs. Repeated sampling negative.
*2 No clinical signs. Considered false positive.
Diagnostic method: Indirect ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian mycoplasmosis (Mycoplasma synoviae)

Large proportion of poultry parent flocks was infected by *Mycoplasma synoviae* during the period from 1995 to 2003 when vaccination was started. Now the infection is considered eradicated. Infections due to *Mycoplasma synoviae* are subject to compulsory registration. Samples have been taken occasionally since 1995. See table below.

Table 40 Number of samples analysed for Mycoplasma synoviae

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1995	110	-	51	59
1996	102	-	81	21
1997	100	-	42	58
1998	100	-	52	48
2000	100	-	100	0
2002/3	100	-	60	40
2009	238	6	238	0
2010	180	6	180	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian mycoplasmosis (Mycoplasma gallisepticum)

Mycoplasma gallisepticum has never been detected. Infections due to *Mycoplasma gallisepticum* are notifiable, according to Act No 25/1993. Samples have been taken occasionally since 1995. See **Error! Reference source not ound.**.

Table 41 Number of samples analysed for Mycoplasma gallisepticum

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1995	110	-	110	0
1996	102	-	102	0
1997	100	-	42	0
1998	100	-	52	0
2000	100	-	100	0
2002/3	100	-	60	0
2007	207	14	207	0
2008	120	6	120	0
2009	238	6	238	0
2011	200	2	200	0

Diagnostic method: Blocking ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian mycoplasmosis (Mycoplasma meleagridis)

Mycoplasma meleagridis has never been detected. Infections due to *Mycoplasma meleagridis* are notifiable, according to Act No 25/1993. Systematic surveillance started in 2011. See table below.

Table 42 Number of samples analysed for Mycoplasma meleagridis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2011	100	1	100	0

Diagnostic method: Quick agglutination.
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Infectious bronchitis

Infectious bronchitis was frequently detected during the period from 1995 to 2002 but for the last few years it has not been detected in routine surveillance. It is a notifiable disease, according to Act No 25/1993. Samples have been taken occasionally since 1995. See table below

Table 43 Number of samples analysed for infectious bronchitis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1995	110	-	16	84
1996	102	-	60	40
1997	100	-	73	27
1998	100	-	13	87
2000	100	-	30	70
2002	100	-	93	7*
2010	180	6	180	0
2011	180	6	180	0
2012	58	3	58	0

* No clinical symptoms. Repeated sampling negative.
Diagnostic method: Blocking ELISA (enzyme-linked immunosorbent assay).
Laboratory: National Veterinary Institute, SE-751 89 Uppsala, Sweden.

Avian influenza

Avian influenza is a notifiable disease, according to Act No 25/1993. Clinical disease has never occurred. Samples have been taken occasionally since 1995. Systematic surveillance has been carried out since 2006. See tables below.

Table 44 Number of samples from poultry analysed for avian influenza

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1994	100		100	0
1995	100	-	100	0
1998	100	-	100	0
2000	100	-	100	0
2002	100	-	100	0
2006	352		348	4*[1]
2007	200	5	200	0
2008	120	6	120	0
2009	238	6	238	0
2010	180	6	180	0
2011	284*[2]	6	284	0
2012	120*[3]	5	116	4*[4]

*1 H5 positive. No clinical signs.
*2 104 samples from back-yard flocks.
*3 60 samples from back-yard flocks.
*4 InfA CT>40, H5 negative.
Diagnostic method: Hemagglutination inhibition (HI) or blocking ELISA (National Veterinary Institute, SE-751 89 Uppsala, Sweden.)
Diagnostic method: rRT-PCR (Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.)

Table 45 Number of fecal samples from wild birds analysed for AI

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2006	1093*[a]	-	1092	1*[1]
2007	465*[a]	-	465	0
2008	375*[a]	-	373	2*[2]
2009	411*[b]	-	410	1*[3]
2010	205*[b]	-	201	4*[3]

*1 LPH5 positive.
*2 H5 and H7 negative.
*3 H5 negative.
Diagnostic method: rRT-PCR Matrix.
Laboratory: *a National Veterinary Institute, SE-751 89 Uppsala, Sweden, *b Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Fish diseases

All Icelandic fish farms have been included in the official national health control programme since 1985. The surveillance also includes farms dealing with wild salmonids. The sampling and diagnostic methods regarding viral examination have been along the lines given in Commission Decision 2001/183/EC, including relevant amendments. Screening of important virus agents causing serious infectious diseases, like *Infectious salmon anaemia* (ISA), *Pancreas disease* (PD), *Infectious pancreatic necrosis* (IPN), *Viral haemorrhagic septicaemia* (VHS) and *Infectious haematopoietic necrosis* (IHN), has been a big part of the surveillance program. Until spring 2009, the diagnostic methods were mainly based on EPC, BF-2 and CHSE-214 cell-lines in the routine screening, in addition to clinical signs, gross pathology and histopathological examination of vital organs. In the first years of screening, 150 samples were taken from all farms four times a year. After achieving a "disease-free status", the sample size was decreased down to 30 samples per brood stock farm each year. However, exporting brood fish, farms must deliver at least 60 samples from every year-class of fish with 9 months interval. This frequency of sampling will be unchanged in the future regarding virus screening in general. In the beginning of May 2009 we started up with examination of ISA and PD (and to a large extent also of IPN) by Real-time RT-PCR technique. All stripped males and females in exporting farms have been tested for those diseases since then. Bacterial examination is in general based on the use of blood agar (with or without 2% NaCl, and 5% horse blood). An ELISA method has been used for the detection of BKD (*Renibacterium salmoninarum*) since 1991, with indirect fluorescent antibody test (IFAT) and/or RT-PCR methodology for confirmation.

Viral haemorrhagic septicaemia (VHS)

Viral haemorrhagic septicemia has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 1985. See tables below.

Infectious haematopoietic necrosis (IHN)

Infectious haematopoietic necrosis has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 1985. See table below.

Infectious pancreatic necrosis (IPN)

Infectious pancreatic necrosis has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 1985. See **Error! Reference source not found.**. In 2010, samples were nalysed for IPN partly on cell lines and partly by Real-time RT-PCR but since 2011 entirely by Real-time RT-PCR. See table below.

Table 46 Number of samples analysed for VHS, IHN and IPN

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
1985	1.214	-	1.214	0
1986	5.591	-	5.591	0
1987	9.121	-	9.121	0
1988	10.503	-	10.503	0
1989	4.854	-	4.854	0
1990	6.831	-	6.831	0
1991	5.603	-	5.603	0
1992	2.763	-	2.763	0
1993	949	-	949	0
1994	610	16	610	0
1995	775	18	775	0
1996	601	17	601	0
1997	945	21	945	0
1998	806	19	806	0
1999	860	17	860	0
2000	696	15	696	0
2001	706	15	706	0
2002	533	12	533	0
2003	885	13	885	0
2004	1.109	16	1.109	0
2005	725	13	725	0
2006	524	13	524	0
2007	669	16	669	0
2008	812	15	812	0
2009	963	15	963	0
2010	1.220	13	1.220	0
2011	310	12	310	0
2012	335	12	335	0

Diagnostic method: EPC, BF-2 and CHSE-214 cell lines are used routinely.
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Table 47 Number of samples analysed for IPN

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2010	928	4	928	0
2011	3.450	4	3.450	0
2012	1.988	3	1.988	0

Diagnostic method: Real-time RT-PCR.
Laboratory: Food and Veterinary Agency, Department of Fish and Animal Diseases, FO-100 Torshavn, Faroe Islands.

Viral nervous necrosis/ viral encephalopathy and retinopathy (VNN/VER)

Viral nervous necrosis has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 2000. See table below.

Table 48 Number of samples analysed for VNN/VER

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2000	45	1	45	0
2001	140	1	140	0
2002	75	1	75	0
2003	90	1	90	0
2004	90	1	90	0
2005	30	1	30	0
2006	30	1	30	0
2007	30	1	30	0
2008	30	1	30	0
2009	30	1	30	0
2010	32	1	32	0

* Halibut farming ceased in 2011.
Diagnostic method: Real-time RT-PCR.
Laboratory: National Veterinary Institute, Ullevålsveien 68, Pb 750 Sentrum, N-0106 Oslo, Norway.

Infectious salmon anaemia (ISA)

Infectious salmon anaemia has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 2009. See table below.

Table 49 Number of samples analysed for ISA

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2009	2.764	2	2.716	48*
2010	4.644	4	4.588	56*
2011	8.206	3	8.139	67*
2012	8.230	2	8.183	47*

*Low/non pathogenic ISAv (HPRo).
Diagnostic method: Real-time RT-PCR.
Laboratory: Food and Veterinary Agency, Department of Fish and Animal Diseases, FO-100 Torshavn, Faroe Islands, Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland and to some extent also PatoGen Analyse A/S, NO-6009 Aalesund, Norway.

Pancreas disease (PD/SAV)

Pancreas disease has never been detected. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 2009. See table below.

Table 50 Number of samples analysed for PD/SAV

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Number of positive samples
2009	1.908	2	1.908	0
2010	4.504	2	4.504	0
2011	8.206	3	8.206	0
2012	8.230	2	8.230	0

Diagnostic method: Real-time RT-PCR.
Laboratory: Food and Veterinary Agency, Department of Fish and Animal Diseases, FO-100 Torshavn, Faroe Islands, Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland and to some extent also PatoGen Analyse A/S, NO-6009 Aalesund, Norway.

Bacterial kidney disease (BKD)

Bacterial kidney disease occurs sporadically. It is a notifiable disease, according to Act No 25/1993. Routine sampling has been performed since 1985. See tables below.

Table 51 Number of samples from farmed salmon analysed for BKD

Year	Number of individuals sampled	Number of farms sampled	Number of positive farms
1991	435	12	0
1992	558	13	1
1993	453	14	1
1994	522	12	4
1995	431	8	1
1996	594	8	0
1997	337	10	0
1998	362	8	1
1999	316	7	0
2000	361	6	0
2001	312	6	0
2002	357	7	1
2003	713	6	1
2004	1.306	8	3
2005	2.052	16	3
2006	3.048	19	4
2007	3.169	16	1
2008	3.134	11	0
2009	3.930	19	0
2010	2.839	12	1
2011	1.006	11	2
2012	1.399	12	0

Diagnostic method: ELISA (enzyme-linked immunosorbent assay) and Real-time RT-PCR.
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland, Food and Veterinary Agency, Department of Fish and Animal Diseases, FO-100 Torshavn, Faroe Islands and PatoGen Analyse A/S, NO-6009 Aalesund, Norway.

Table 52 Number of samples from wild salmon analysed for BKD

Year	Number of individuals sampled	Number of farms sampled	Number of positive samples	Number of positive rivers
1991	569	49	8	5
1992	470	55	13	8
1993	403	50	3	3
1994	333	38	2	2
1995	349	38	4	2
1996	253	38	1	1
1997	407	45	0	0
1998	291	37	0	0
1999	240	40	0	0
2000	242	38	1	1
2001	602	38	1	1
2002	530	49	3	2
2003	827	50	4	2
2004	1.279	51	35	6
2005	1.160	48	7	1
2006	1.359	52	157	26
2007	1.757	54	174	32
2008	1.775	48	463	35
2009	1.370	44	340	33
2010	905	38	87	15
2011	929	33	97	20
2012	620	25	38	10

Diagnostic method: ELISA (enzyme-linked immunosorbent assay).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Fur animals

Plasmacytosis

Plasmacytosis has been detected a few times in farmed mink, last time in 2008. It is a notifiable disease, according to Act No 25/1993. Routine sampling was performed voluntarily by farmers for many years but it was made mandatory in 2007. See table below.

Table 53 Number of samples from farmed mink analysed for plasmacytosis

Year	Number of individuals sampled	Number of farms sampled	Number of negative samples	Year
2006	2.731	21	2.647	0
2007	3.220	22	3.220	0
2008	3.153	21	3.150	3
2009	3.201	21	3.201	0
2010	3.235	20	3.235	0
2011	3.999	22	3.999	0
2012	3.822	22	3.822	0

Diagnostic method: Counter-current immune-electrophoresis.
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik.

Scrapie eradication programme

Scrapie was apparently brought to Iceland with imported sheep in 1878. During the following 75 years the disease became prevalent within a limited area in Northern Iceland and was not found in other parts of the country until 1953. In the years 1968-1978 scrapie had spread to most sheep raising districts of the country. The losses became very high. The incidence culminated in 1986 with 104 scrapie farms. In 1978 a plan with the final aim to eradicate scrapie from Iceland was adopted in cooperation with farmers. The program was enhanced in 1986 and 1993, and has been effective. The incidence has decreased considerably during the last decade; table II. Areas where no cases of scrapie have occurred the last 20 years are considered scrapie free.

Table 54 Scrapie eradication in Iceland in the years 2002-2011

	No. of sheep flocks culled			No. of adult sheep culled		
	a	b	Total	a	b	Total
2002	2	0	**2**	224	0	**224**
2003	5	29	**34**	1.016	1.860	**2.876**
2004	8	26	**34**	1.388	2.118	**3.506**
2005	4	4	**8**	1.129	230	**1.359**
2006	2	3	**5**	153	42	**195**
2007	4	0	**4**	979	0	**979**
2008	2	0	**2**	918	0	**918**
2009	2	0	**2**	182	0	**182**
2010	1	0	**1**	133	0	**133**
2011	0	0	**0**	0	0	**0**

a: Sheep flocks where scrapie was confirmed and subsequent culling of all sheep took place.
b: Sheep flocks where stamping out was performed because of vicinity to scrapie afflicted flocks.

Scrapie is a notifiable disease, the owner (or finder) of a scrapie suspected animal is obliged to report the suspicion to the District Veterinary Officer (DVO) or to the police. The DVO inspects the animal, reports to the Chief Veterinary Officer (CVO), sends samples for diagnosis, instructs the owner and is responsible for all control measures in his/her area.

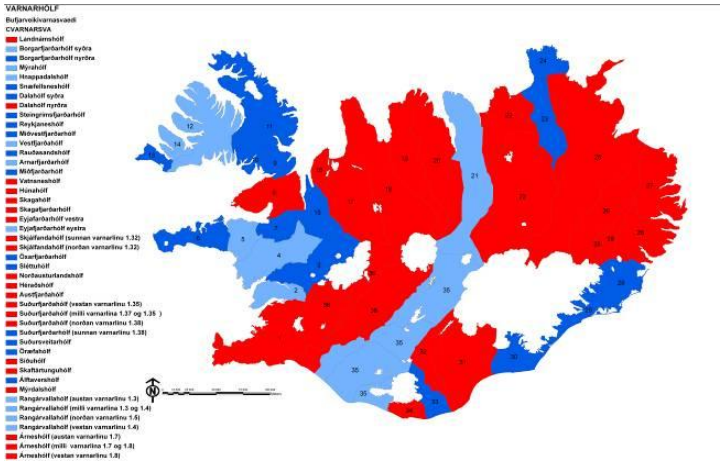


Figure 8 Distribution of scrapie according to ristriction zones

In dark blue areas, scrapie has never been detected, in light blue areas scrapie has not been detected for the last 20 years or more, in red areas scrapie has been detected within the last 20 years.

Paratuberculosis eradication programme

Paratuberculosis was apparently brought to Iceland with imported sheep in 1933, along with jaagziekte and maedi-visna. In 1937 the country was divided into surveillance/quarantine zones demarcated by natural barriers and fences. The purpose of the division was to limit dispersion of the three new diseases. In addition, strict rules were set regarding movement of animals between the zones. Sheep in infected zones were culled and replaced by sheep from uninfected zones. Jaagziekte was eradicated in 1952 and maedi-visna in 1965, but paratuberculosis is still endemic in many areas. Around 1960 a vaccine which proved to be effective against paratuberculosis was developed. In 1966 vaccination was made compulsory. This led to a considerable reduction in the incidence of the disease and it seems that it has been eradicated in some areas.

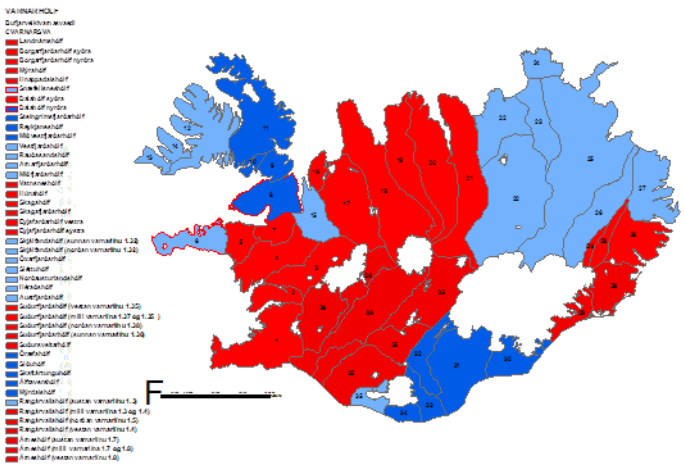


Figure 9 Distribution of paratuberculosis according to restriction zones

In dark blue areas, paratuberculosis has never been detected, in light blue areas paratuberculosis is considered eradicated, in red areas paratuberculosis has been detected and vaccination is compulsory, in areas with red outlines paratuberculosis has not been detected but vaccination is conducted as a precaution.

The tables below show the number of samples analysed for paratuberculosis from 2000 – 2011, from sheep and cattle respectively, and number of farms where paratuberculosis was detected. Only the sheep strain of *Mycobacterium paratuberculosis* has been detected in cattle and as the prevalence of paratuberculosis in cattle is very low, it is not anticipated that the cattle strain is present in cattle in the country.

Table 55 Number of samples from sheep analysed for paratuberculosis

Year	Number of samples from ileum	Number of blood samples	Number of positive farms
2000	15.482	138	5
2001	21.417	846	12
2002	8.353	161	10
2003	11.681	231	11
2004	2.922	118	7
2005	20.400	262	7
2006	10.575	205	13
2007	14.821	90	5
2008	8.609	?	10
2009	387	5	0
2010	22	170 + 13 goats	3
2011	741	735	6

Diagnostic method: Ileum: Histopathology. Blood: ELISA (enzyme-linked immunosorbent assay).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Table 56 Number of samples from cattle analysed for paratuberculosis

Year	Number of samples from ileum	Number of blood samples	Number of positive farms
2000	1.356	945	1
2001	1.705	427	3
2002	450	349	2
2003	1.940	455	0
2004	32	649	0
2005	450	684	1
2006	52	430	0
2007	?	231	0
2008	10	0	0
2009	2	23	0
2010	14	111	1
2011	1	40	0

Diagnostic method: Ileum: Histopathology. Blood: ELISA (enzyme-linked immunosorbent assay).
Laboratory: Institute for Experimental Pathology at Keldur, v/Vesturlandsveg, 112 Reykjavik, Iceland.

Chapter 6 Comparisons of the animal disease status in Iceland with those in selected countries

Selection of animal species eligible for comparison

The selection of animal species was implicit in the assumed import scenarios as outlined by the Icelandic expert opinions cited in Appendix 1. They concerned cattle, sheep and horses only.

Historically these are the traditional domestic animal species in Iceland, each with an indigenous breed with unique characteristics, adapted to the particular Icelandic environment and farm management systems. On one hand, keeping these animal populations free from major disease outbreaks caused by infectious agents exotic to Iceland is both economically and a culturally significant, as these populations are also naïve and therefore susceptible with regards to most foreign pathogens; on the other hand, they may not have the same production potentials as specialized breeds in other countries, and some Icelandic farmers may have an interest in improving their production economy through import of such breeds from other countries.

Pig and poultry production is based on genetic stock originating more recently from overseas. Thanks to the isolated geographical location of Iceland and due to the stringent import policy implemented by the Icelandic government for many years, they have also been spared from diseases and infections common to other countries. Risk assessments for these species are therefore also relevant, but probably not as apparent as for the Icelandic cattle, sheep and horses.

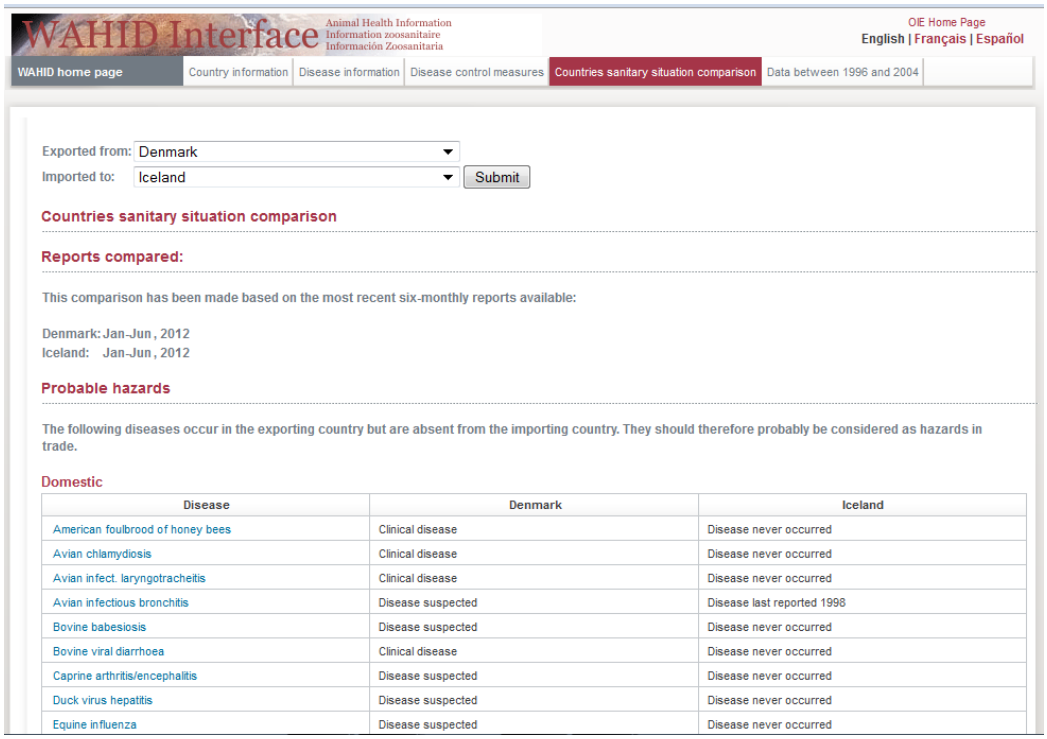
Selection of countries eligible for comparison

The following countries, all except Norway being EU member states, were selected based on their presumed reputation among Icelandic farmers as likely potential countries of origin for import of cattle, sheep, goats and horses. However, import from any other EU member states can not be excluded.

Denmark
Norway
Sweden
Finland
Netherlands
United Kingdom
Germany

Diseases and infections identified as potential hazards

Each of these countries was compared to Iceland in the OIE "Countries sanitary situation comparison" on-line tool (http://www.oie.int/wahis_2/public/wahid.php/Sanitarycomparision/Tradestatus). An example is shown in Figure 10. Diseases and infections on the OIE notifiable diseases list in domestic animals as well as in wild animals are included in the list by default. The domestic animals part of the list from a recent execution of the on-line comparison is included as Appendix 2.



Disease	Denmark	Iceland
American foulbrood of honey bees	Clinical disease	Disease never occurred
Avian chlamydiosis	Clinical disease	Disease never occurred
Avian infect. laryngotracheitis	Clinical disease	Disease never occurred
Avian infectious bronchitis	Disease suspected	Disease last reported 1998
Bovine babesiosis	Disease suspected	Disease never occurred
Bovine viral diarrhoea	Clinical disease	Disease never occurred
Caprine arthritis/encephalitis	Disease suspected	Disease never occurred
Duck virus hepatitis	Disease suspected	Disease never occurred
Equine influenza	Disease suspected	Disease never occurred

Figure 10 Screen-shot from the first part of the OIE on-line country comparison tool comparing Denmark and Iceland; see Appendix 2 for a complete listing of domestic animal diseases and infections

Following execution of this tool for each of the six selected countries versus Iceland, Table 57 shows a comparison of the OIE status for diseases and infections in cattle, sheep and horses listed as probable hazards in at least one of the selected countries relative to Iceland, which is free from these diseases and infections.

Table 57 Comparison of the OIE status for diseases and infections listed as probable hazards in at least one of the selected countries relative to Iceland

Disease	Denmark	Norway	Sweden	Finland	Netherlands	United Kingdom	Germany
Bovine babesiosis	Disease suspected	Last occurred in 2008	Last occurred in 2008	Clinical disease	Last occurred in 2008	Clinical disease	Last occurred in 2007
Bovine viral diarrhoea	Clinical disease	Last occurred in 2005	Clinical disease	Last occurred 06/2010	Clinical disease	Clinical disease	Unknown status
Caprine arthritis/encephalitis	Disease suspected	Clinical disease	Clinical disease	Never reported	Clinical disease	Clinical disease	Last occurred 01/2008
Equine influenza	Disease suspected	Last occurred in 2008	Clinical disease	Last occurred 04/2010	Disease suspected	Clinical disease	No information available
Equine rhinopneumonitis	Disease suspected	Last occurred in 2006	Clinical disease	Clinical disease	Demonstrated infection	Clinical disease	No information available
Equine viral arteritis	Clinical disease	No information available	Clinical disease	Clinical disease	Suspected, no clinical disease	No information available	Clinical disease
Maedi-visna	Disease suspected	Last occurred 06/2009	Clinical disease	Last occurred in 2006	Clinical disease	Clinical disease	Clinical disease
Q fever	Disease suspected	Never reported	Disease suspected	Disease suspected	Demonstrated infection	Clinical disease	Clinical disease
Bov. genital campylobacteriosis	Last occurred in 1995	Last occurred in 1966	Last occurred in 1976	Unknown status	Demonstrated infection	No information available	Clinical disease
Contagious equine metritis	Last occurred 03/2009	No information available	Confirmed infection	Last occurred 06/2009	Demonstrated infection	No information available	Clinical disease
Enzootic abortion (chlamydiosis)	Never reported	No information available	Last occurred in 2003	Never reported	Clinical disease	No information available	Clinical disease
Inf.bov.rhinotracheit. (IBR/IPV)	Last occurred 09/2005	Last occurred in 1992	Last occurred in 1995	Last occurred in 1994	Clinical disease	Clinical disease	Clinical disease
Bovine tuberculosis	Last occurred in 1994	Last occurred in 1986	Last occurred 01/2005	Last occurred in 1982	Confirmed infection	Clinical disease	Confirmed infection
Brucellosis (Brucella abortus)	Last occurred in 1962	Last occurred in 1953	Last occurred in 1957	Last occurred in 1960	Last occurred in 1996	Clinical disease	Last occurred in 2004

Selection of Denmark as the country of origin

Denmark will be used as the country of origin in the RA scenarios presented in Chapter 8 for a number of reasons:

Historically, Denmark and Iceland have had strong ties, e.g. in cultural, trade and economic matters.
Icelandic farmers would likely be inclined to choose a Scandinavian partner for animal imports, due to a somewhat similar animal husbandry, environment and climate than more southerly European countries.

The information in Table 57 shows, that the animal health situation in Denmark is somewhere in between the situations for the other Scandinavian countries and those for the Netherlands, the UK and Germany. As such, Denmark does not represent an extreme situation in either direction from those existing in EU member states nearby, which would be likely candidates for exporting live animals to Icelandic farmers.

As the other Scandinavian countries, Denmark has a relatively favourable animal health situation as far as many infectious animal diseases are concerned, but Denmark can also be considered a bridge to the rest of Europe for other infections to enter.

Denmark is very transparent about its disease situation, and current or recent field data on the prevalence of the most important animal infections, especially for dairy cattle, are readily available and have been published extensively in scientific journals with peer review. Evidence on disease occurrence or absence is therefore considered to be generally reliable.

Limitations of the methodology

The outcome of OIE country comparisons should be considered as indications only, with more detailed evaluations being made during the hazard identification and entry assessments, to be found in Chapter 8.

Some limitations of the output from the OIE country comparison tool are described in the following points:

The standard designations used by the OIE comparison tool may cover different situations as far as the reporting country is concerned. E.g. the designation "disease suspected" is used in Table 57 for bovine babesiosis, Q-fever, Maedi-Visna, CAE, EHV-1 and EIV infections in Denmark. The official report by the Danish authorities for the animal health situation in 2011 indicates for bovine babesiosis, EHV-1 and EIV:"Suspected, but not confirmed"; for Maedi-Visna and CAE: "a few instances/sero-reactors were found" ***(1).*** The OIE comparisons in Table 57 and Appendix 2 refer to the Danish OIE report from the first half of 2012, which states for both sheep infections: "suspected, but not confirmed". It is unlikely, however, that a change from "disease present/clinical disease" (at a low frequency) in one half-year to "suspected, but not confirmed" in the following half-year is an accurate description of a true change of status, as random variation might well explain the observed difference in outcome between a few and no cases reported. Bovine babesiosis is not going to be included for risk assessment in Chapter 8 due to a scarcity of information on the current Danish prevalence ***(2)***. For Q-fever in cattle the seroprevalence has been demonstrated to be quite high in Denmark at the herd- and within-herd levels, so random fluctuations between subsequent half-years are less likely to be important. The variation in Q-fever reporting may be due to differences in available and current surveillance data between the half-year periods in question or to the biology of Q-fever which facilitates detection during lambing/kidding.

The diseases and infections being listed are limited to the ones that the OIE has placed on its list of notifiable diseases and infections. Some diseases and infections that are notifiable within individual countries are therefore not covered by the comparison. E.g. *Salmonella* is a notifiable infection in Iceland, and *Salmonella* Dublin in cattle is being under official control in Denmark; *Salmonella* Dublin will therefore be considered in Chapter 7 for potential inclusion among the risk assessments in this report. This is in agreement with the recommendation in the OIE Handbook ***(3)***, which reads: "...., hazard identification begins with the development of a list of pathogenic agents that are appropriate to the species being imported... The OIE list of diseases should be used as a starting point when developing these lists, but pathogens not included in the OIE list should also be considered, where appropriate".

Sometimes infections and/or diseases are caused by an agent, which includes several strains with different pathogenicity or species affinity. The two countries being compared may have different strains present with different

pathogenicity and/or species affinity, which would also be a situation to consider during the hazard identification process. E.g., paratuberculosis in sheep in Iceland is caused by the S-strain of *Mycobacterium avium*, subspecies *paratuberculosis* (MAP), which occasionally also affects Icelandic cattle. In Denmark, however, the C-strain is the cause of paratuberculosis in Danish cattle, which is widespread and has considerable economic impact in affected animals and herds. C-strain MAP infections are therefore a legitimate concern for Iceland in connection with imports of Danish cattle. Also this situation is covered by the OIE Handbook ***(3)***, which states:

> "For a pathogenic agent reported in both the exporting and the importing country, IF:
> - It is subject to an official control program in the importing country, OR
> - there are zones or compartments of different health status, OR
> - local strains are likely to be less virulent than those reported internationally or in the exporting country,
>
> THEN the pathogenic agent might be classified as a hazard".

As a matter of fact, all three bullet points above apply to the situation in Iceland regarding paratuberculosis in cattle caused by the C-strain of MAP. This infection will therefore also be considered in Chapter 7 for inclusion among the risk assessments presented in Chapter 8 of this report.

The fact that a disease or infection occurs in the country of origin and not in the receiving country and therefore has a certain probability of being introduced with a live animal being transferred is in and by itself not enough to cause concern. Bovine babesiosis is transmitted by a vector (the tick *Ixodes ricinus*) which may not be permanently present in Iceland ***(4)***, so even if bovine babesiosis is listed in Table 57 and Appendix 2 it may not be possible to estimate the exposure of Icelandic cattle to bovine babesiosis.

In conclusion, using Denmark as the country of origin for the live cattle, sheep and horses to be transferred to Iceland, the following diseases and infections have been identified as potential hazards according to Table 57, and each will be evaluated further in Chapter 8:

Cattle
- Bovine viral diarrhoea (BVD)
- Q fever (caused by *Coxiella burnetii* infections)

Sheep
- Maedi-Visna and Caprine arthritis/encephalitis (small ruminant lenti-virus (SRLV) infections)

Horses
- Equine influenza
- Equine viral arteritis
- Equine rhinopneumonitis (caused by Equine herpes virus type 1 (EHV-1) infections)

For reasons mentioned above, a comprehensive evaluation will be made in Chapter 7 to make up for some of the limitations of the methodology used in this chapter and, if considered relevant, to supplement the diseases and infections shortlisted above.

References

1. Danish Veterinary and Food Administration (2012). Animal Health in Denmark 2011. Available at: http://www.foedevarestyrelsen.dk/Publikationer/Alle%20publikationer/2012095.pdf
2. Enemark HL, Kristoffersen JKM, Marcussen TR, Agerholm JS, Baptiste KE (2010). Bovine babesiosis in Denmark: seroconversion and clinical signs in susceptible animals introduced into an endemic area. Proceedings of the XIIth International Congress of Parasitology, Melbourne, Australia, 15-20 August 2010.
3. World Organisation for Animal Health (OIE). Handbook on Import Risk Analysis for Animals and Animal Products, vol.1 (2010) & vol.2 (2004).
4. Bjarnadottir, L. (2007). A seroepidemiological survey for antibodies to *Borrelia burgdorferi* sensu lato in dogs in Iceland. Hovedopgave, Fagdyrlægeuddannelsen vedr. hund og kat. Available at: https://www.ddd.dk/organisatorisk/fagdyrlaeger/hundogkat/hovedopgaver/Sider/default.aspx

Appendix 1 Expert opinions on the species and number of consignments and animals to be imported

The following expert opinions of likely scenarios for imports to Iceland were kindly provided by Dr. Halldor Runolfsson on January 28, 2013:

Cattle

a) Individual farmers might want to import single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.

b) A farmer might want to start a pure bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 examples of this kind of imports.

Sheep

According to the expert opinion of Dr. Halldor Runolfsson , around 5 imports of approximately 100 sheep each might be carried out annually, e.g. for the purpose of starting a purebred flock of an alternative breed to the Icelandic sheep breed.

Horses

The following opinion was obtained from an Icelandic equine expert, Dr. Sigridur Björnsdottir:

"According to the discussion at the annual general meeting of the Icelandic Horse Breeding Association (Dec 2012) there is an increasing interest of import of semen from some few very good Icelandic stallions that are localized and/or bred abroad. There might also be interest of importing some few stallions for breeding and even for Icelandic breeders to hire out some stallions for breeding abroad and take them back.

Re-import of competition horses, especially in connection with the World Championship every second year might also become actual.

As the transport cost will always be high due to the geographic isolation of the country it's most likely that only few valuable breeding horses will be imported to the country.

It can, however, not be excluded that some people will have interest of importing small or big herds to the country, and specially horses that suffer from summer eczema (seasonal insect-bite hypersensitivity)".

Appendix 2 Country sanitary situation for domestic animals: comparison between Denmark and Iceland

Page 1

OIE World Animal Health Information System

WAHID Interface — Animal Health Information / Information zoosanitaire / Información Zoosanitaria

OIE Home Page

English | Français | Español

WAHID home page | Country information | Disease information | Disease control measures | Countries sanitary situation comparison | Data between 1996 and 2004

Exported from: Denmark

Imported to: Iceland Submit

Countries sanitary situation comparison

Reports compared:

This comparison has been made based on the most recent six-monthly reports available:

Denmark: Jan-Jun , 2012
Iceland: Jul-Dec , 2012

Probable hazards

The following diseases occur in the exporting country but are absent from the importing country. They should therefore probably be considered as hazards in trade.

Domestic

Disease	Denmark	Iceland
American foulbrood of honey bees	Clinical disease	Disease never occurred
Avian chlamydiosis	Clinical disease	Disease never occurred
Avian infect. laryngotracheitis	Clinical disease	Disease never occurred
Avian infectious bronchitis	Disease suspected	Disease last reported 1998
Bovine babesiosis	Disease suspected	Disease never occurred
Bovine viral diarrhoea	Clinical disease	Disease never occurred
Caprine arthritis/encephalitis	Disease suspected	Disease never occurred
Duck virus hepatitis	Disease suspected	Disease never occurred
Equine influenza	Disease suspected	Disease never occurred
Equine rhinopneumonitis	Disease suspected	Disease never occurred
Equine viral arteritis	Clinical disease	Disease never occurred
Maedi-visna	Disease suspected	Disease last reported 1965
Porcine reproductive/respiratory syndr.	Clinical disease	Disease never occurred
Q fever	Disease suspected	Disease never occurred
Varroosis of honey bees	Clinical disease	Disease never occurred

Wild

Bovine babesiosis	Disease suspected	Disease never occurred
Echinococcosis/hydatidosis	Demonstrated infection (no clinical disease)	Disease last reported 1979

Possible hazards

No information is available for the following diseases, either in the exporting country, the importing country or both. More information is required to determine if these diseases may be considered as a hazard.

Domestic

Disease	Denmark	Iceland
Leishmaniosis	No information available	Disease never occurred

Wild

Leishmaniosis	No information available	Disease never occurred
Newcastle disease	No information available	Disease never occurred

Unlikely to be hazards

The following diseases are either absent from both countries, or present in the importing country, and are therefore unlikely to be trade hazards. However, some diseases may still be considered a hazard, particularly if there is a disease control program in place in the importing country

http://www.oie.int/wahis_2/public/wahid.php/Sanitarycomparision/Tradestatus[24-Feb-13 1:08:10 PM]

Page 2

OIE World Animal Health Information System

Domestic

Disease	Denmark	Iceland
Acarapisosis of honey bees	Disease last reported 04/2008	Disease never occurred
African horse sickness	Disease never occurred	Disease never occurred
African swine fever	Disease never occurred	Disease never occurred
Anthrax	Disease last reported 1988	Disease last reported 2004
Aujeszky's disease	Disease last reported 1991	Disease never occurred
Avian mycoplasmosis (M.synoviae)	Disease not currently present	Disease never occurred
Bluetongue	Disease last reported 01/2009	Disease never occurred
Bov. genital campylobacteriosis	Disease last reported 1995	Disease never occurred
Bovine anaplasmosis	Disease never occurred	Disease never occurred
Bovine spongiform encephalopathy	Disease last reported 19/11/2009	Disease never occurred
Bovine tuberculosis	Disease last reported 1994	Disease last reported 1959
Brucellosis (Brucella abortus)	Disease last reported 1962	Disease never occurred
Brucellosis (Brucella melitensis)	Disease never occurred	Disease never occurred
Brucellosis (Brucella suis)	Disease last reported 1999	Disease never occurred
Camelpox	Disease never occurred	Disease never occurred
Classical swine fever	Disease last reported 1933	Disease last reported 1953
Contagious agalactia	Disease never occurred	Disease never occurred
Contagious bov. pleuropneumonia	Disease last reported 1886	Disease never occurred
Contagious cap. pleuropneumonia	Disease never occurred	Disease never occurred
Contagious equine metritis	Disease last reported 03/2009	Disease never occurred
Crimean Congo haemorrhagic fever	Disease never occurred	Disease never occurred
Dourine	Disease never occurred	Disease never occurred
Echinococcosis/hydatidosis	Disease last reported 1996	Disease last reported 1979
Encephalomyelitis (West.)	Disease never occurred	Disease never occurred
Enzootic abortion (chlamydiosis)	Disease never occurred	Disease never occurred
Enzootic bovine leukosis	Disease last reported 1990	Disease never occurred
Epizootic haemorrhagic disease	Disease never occurred	Disease never occurred
Equine encephalomyelitis (Eastern)	Disease never occurred	Disease never occurred
Equine infectious anaemia	Disease last reported 1928	Disease never occurred
Equine piroplasmosis	Disease not currently present	Disease never occurred
European foulbrood of honey bees	Disease last reported 05/2005	Disease never occurred
Foot and mouth disease	Disease last reported 1983	Disease never occurred
Fowl typhoid	Disease last reported 2002	Disease last reported 1953
Glanders	Disease last reported 1928	Disease never occurred
Haemorrhagic septicaemia	Disease never occurred	Disease never occurred
Heartwater	Disease never occurred	Disease never occurred
Highly path. avian influenza	Disease last reported 05/2006	Disease never occurred
Inf.bov.rhinotracheit. (IBR/IPV)	Disease last reported 09/2005	Demonstrated infection (no clinical disease)
Infec bursal disease (Gumboro)	Disease last reported 2005	Disease last reported 1998
Japanese encephalitis	Disease never occurred	Disease never occurred
Low pathogenic avian influenza (poultry)	Disease last reported 03/2010	Disease never occurred
Lumpy skin disease	Disease never occurred	Disease never occurred
Mycoplasmosis (M. gallisepticum)	Disease last reported 1967	Disease last reported 1994
Myxomatosis	Disease last reported 10/2008	Disease never occurred
N. w. screwworm (C. hominivorax)	Disease never occurred	Disease never occurred
Nairobi sheep disease	Disease never occurred	Disease never occurred
Newcastle disease	Disease last reported 10/2005	Disease never occurred
Nipah virus encephalitis	Disease never occurred	Disease never occurred
O. w. screwworm (C. bezziana)	Disease never occurred	Disease never occurred
Ovine epididymitis (B. ovis)	Disease never occurred	Disease never occurred
Paratuberculosis	Clinical disease	Clinical disease

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Peste des petits ruminants	Disease never occurred	Disease never occurred
Porcine cysticercosis	Disease not currently present	Disease never occurred
Pullorum disease	Disease last reported 03/2010	Disease last reported 1958
Rabbit haemorrhagic disease	Disease last reported 04/2011	Disease last reported 2002
Rabies	Disease last reported 04/2002	Disease never occurred
Rift Valley fever	Disease never occurred	Disease never occurred
Rinderpest	Disease last reported 1782	Disease never occurred
Salmonellosis (S. abortusovis)	Disease never occurred	Disease never occurred
Scrapie	Disease never occurred	Disease last reported 01/2012
Sheep pox and goat pox	Disease last reported 1879	Disease never occurred
Small hive beetle infestation	Disease never occurred	Disease never occurred
Surra (Trypanosoma evansi)	Disease never occurred	Disease never occurred
Swine vesicular disease	Disease never occurred	Disease never occurred
Theileriosis	Disease never occurred	Disease never occurred
Transmissible gastroenteritis	Disease never occurred	Disease never occurred
Trichinellosis	Disease last reported 1930	Disease never occurred
Trichomonosis	Disease last reported 1990	Disease never occurred
Tropilaelaps infestation of honey bees	Disease never occurred	Disease never occurred
Trypanosomosis	Disease never occurred	Disease never occurred
Tularemia	Disease never occurred	Disease never occurred
Turkey rhinotracheitis	Disease last reported 2007	Disease never occurred
Venezuelan equ.encephalomyelitis	Disease never occurred	Disease never occurred
Vesicular stomatitis	Disease never occurred	Disease never occurred
West Nile Fever	Disease never occurred	Disease never occurred

Chapter 7 A comprehensive list of potentially hazardous diseases and infections

Chapter 6 contains a comparison of the Danish and Icelandic status as far as diseases and infections that are on the OIE list of notifiable diseases and infections. As also mentioned in Chapter 6, there are certain recognized shortcomings and limitations in the methodology applied in that chapter and the present chapter presents complementary activities to partly compensate for those limitations.

To identify and include any potentially hazardous diseases and infections for cattle, sheep and horses not on the OIE list, the notifiable cattle, sheep and horse diseases on the Icelandic A and B lists were compared to the status for those diseases and infections in Denmark. Prevalent diseases and infections being actively controlled in Denmark would be considered as prime RA candidates, since an active control program for a disease/infection is taken as an indication of its importance in terms of estimated consequences and impact, as well as an indication of the likely existence of current information on its prevalence in the country. The Icelandic list A and B diseases and infections in multiple species, cattle, sheep and horses as described in Chapter 5 are presented in Appendix 1 with information about the comparable Danish status and the information source. Table 58 summarizes the Icelandic listed diseases and infections for which the Danish status indicates their presence. Due to overlap between the OIE listed and the Icelandic listed disease, the table includes the probable hazards identified by the OIE comparison tool, which were shortlisted for detailed RAs in Chapter 6.

As already indicated in Chapter 6, there are objective reasons for adding two infections in cattle to the shortlist, namely paratuberculosis caused by MAP strain C and *Salmonella* Dublin (Table 58). Both are currently being controlled in Denmark, although neither is on the Danish lists of notifiable diseases. Both control programs are organized by the Danish Cattle Federation, but only *Salmonella* Dublin is covered by official Danish regulations ***(1-3).*** Table 58 summarizes all the selected diseases and infections that will be evaluated in detail in Chapter 8.

Table 58 The final list of diseases and infections selected for detailed risk assessments

Disease/ agent	*OIE listed*	*Iceland listed*	*OIE status Iceland*	*Icelandic surveillance*	*DK listed*	*OIE Status DK*[1]	*Danish surveillance*
Cattle							
Q-fever	+	B	Disease never occurred	Neg. samples	+	Clinical disease	Dairy herd prevalence: 60 - 70% (2008 - 2009)
BVD/mucosal disease	+	B	Disease never occurred	Neg. samples	+	Clinical disease	2 herds found positive in 2012
Paratuberculosis (strain C)[1]	+	B	Disease last reported 12/2010 in cattle	Sporadic pos. samples (strain S)		Clinical disease (strain C)[1]	Herd level prevalence: 80% Within-herd prevalence: < 20 %
Salmonella Dublin[1]		B	Disease never occurred[1]	Neg. samples		Clinical disease[1]	Herd level prevalence: 8% Within-herd prevalence: < 20 %
Sheep							
Maedi-visna	+	A	Disease last reported 1965	No laboratory surveillance	+	Clinical disease	Low prevalence
Caprine arthritis/ encephalitis	+	A	Disease never occurred	No laboratory surveillance	+	Clinical disease	Low prevalence
Horses							
Equine influenza	+	B	Disease never occurred	Neg. samples		Disease suspected	Endemic, unknown prevalence
Equine rhino-pneumonitis	+	B	Disease never occurred	Neg. samples		Disease suspected	Endemic, unknown prevalence
Equine viral arteritis	+	B	Disease never occurred	No laboratory surveillance	+	Clinical disease	Endemic, unknown prevalence

[1]Information from the Danish Cattle Association ***(1, 2)***

Table 59 contains the additional diseases and infections notifiable in Iceland, which might have been chosen for RA. Only one infection, leptospirosis, is notifible in Denmark, but it is rare, especially in cattle, where it's current prevalence is characterized as "negligible"***(4)***.The remaining diseases and infections in the table are, however, neither notifiable nor covered by active control programs in Denmark, and less accurate information is therefore available about their current prevalence and consequences. If risk assessments were to be carried out for these diseases and infections, the results and conclusions would be less substantiated than those for the nine diseases and infections selected for detailed risk assessments and listed in table 58.

Table 59 Iceland list A and B diseases not listed by the OIE, with comments on the Danish situation

Iceland list A	
Sheep and goats	
Border disease – Hairy shaker disease – Flaviviridae	Low sporadic occurrence
Jaagsiekte – Ovine pulmonary adenomatosis – Retroviridae	Present, but rare
Iceland List B	
Multiple species	
Parafilariosis – Parafilaria spp.	Not detected for several years
Footrot – Fusobacterium necrophorum	Endemic - prevalence unknown
Paratuberculosis – Mycobacterium avium paratuberculosis[1]	Strain differences by species (sheep/cattle) - to be covered by risk assessment
Ringworm – Microsporum spp./Trichophyton spp.	Endemic - prevalence unknown
Dermatophilosis – Dermatophilus congolensis	Endemic - prevalence unknown
Leptospirosis – Leptospira spp.	DK List 2 - Serological examination of bovine and porcine sera indicates a low incidence of leptospirosis in pigs and a negligible incidence in cattle.
Neosporosis – Neospora caninum	Endemic - prevalence unknown
Intestinal salmonella infections – Salmonella spp. (Other than Salmonella gallinarum/S. pullorum)	S. Dublin in cattle to be covered by risk assessment
Horses	
Horse pox – Poxviridae	Unknown, no surveillance
Sarcoptic mange – Sarcoptes scabiei var equi	Endemic - prevalence unknown
Strangles – Streptococcus equi equi	Endemic - prevalence unknown
Epizootic lymphangitis – Histoplasma farciminosum	DK free
Cattle	
Malignant catarrhal fever (AHV-1) – Herpesviridae	Low sporadic occurrence
ovine respiratory syncytial virus (BRSV) – Paramyxoviridae	Endemic - prevalence unknown
Viral diarrhea – Coronaviridae	Endemic - prevalence unknown
Bovine cysticercosis – Taenia saginata	Low sporadic occurrence - slaughter prevalence estimated at 0.06% (2004 - 2011)
Sheep and goats	
Sheep biting louse – Damalinia ovis	Endemic - prevalence unknown
Sheep scab – Psoroptes ovis	Endemic - prevalence unknown
Sheep mange – Chorioptes ovis	Endemic - prevalence unknown
Sheep keds – Melophagus ovinus	Endemic - prevalence unknown
Ovine epididymitis – Brucella ovis	DK free
Ovine cysticercosis – Taenia ovis	Unknown, no surveillance

[1]Paratuberculosis is listed by the OIE, but not with strain-specific information

To be included in RA's (Chapter 8) | Not to be included in RAs | DK free

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Appendix 1. Icelandic list A and B diseases and infections, with information about the comparable Danish status according to the OIE WAHID system and supplementary Danish sources[1]

Iceland List A	**Comparison status**
Multiple species	
Aujeszky´s disease – Pseudorabies – Herpesviridae	Unlikely to be a hazard (OIE)
Bluetongue – Reoviridae	Unlikely to be a hazard (OIE)
Foot and Mouth Disease – Picornaviridae	Unlikely to be a hazard (OIE)
Tularemia – Francisella tularensis	Unlikely to be a hazard (OIE)
Rabies – Rhabdoviridae	Unlikely to be a hazard (OIE)
Anthrax – Bacillus anthracis	Unlikely to be a hazard (OIE)
Vesicular stomatitis – Rhabdoviridae	Unlikely to be a hazard (OIE)
Rift Valley fever – Bunyaviridae	Unlikely to be a hazard (OIE)
Brucellosis – Brucella-abortus/B. suis/B. melitensis	Unlikely to be a hazard (OIE)
Horses	
African horse sickness – Reoviridae	Unlikely to be a hazard (OIE)
Dourine - Trypanosoma equiperdum	Unlikely to be a hazard (OIE)
Equine infectious anemia (EIA) – Retroviridae	Unlikely to be a hazard (OIE)
Glanders – Pseudomonas mallei	Unlikely to be a hazard (OIE)
Cattle	
Tuberculosis – Mycobacterium bovis/tuberculosis	Unlikely to be a hazard (OIE)
Lumpy skin disease – Poxviridae	Unlikely to be a hazard (OIE)
Contagious bovine pleuropneumonia – Mycoplasma mycoides mycoides	Unlikely to be a hazard (OIE)
Bovine spongiform encephalopati (BSE) – Prion	Unlikely to be a hazard (OIE)
Rinderpest – Kvegpest – Pestis bovum – Paramyxoviridae	Unlikely to be a hazard (OIE)
IBR/IPV – Herpesviridae	Unlikely to be a hazard (OIE)
Enzootic bovine leucosis (EBL) – Retroviridae	Unlikely to be a hazard (OIE)
Sheep and goats	
Border disease – Hairy shaker disease – Flaviviridae	Low sporadic occurrence
Sheep pox and goat pox – Poxviridae	Unlikely to be a hazard (OIE)
Peste des petits ruminants (PPR) – Paramyxoviridae	Unlikely to be a hazard (OIE)
Enzootic abortion of ewes (EAE) – Chlamydia psittaci	Unlikely to be a hazard (OIE)
Contagious caprine pleuropneumonia – Mycoplasma F38	Unlikely to be a hazard (OIE)
Contagious agalactia – Mycoplasma ssp.	Unlikely to be a hazard (OIE)
Maedi/Visna – Retroviridae	Probable hazard (OIE)
Scrapie – Prion	Unlikely to be a hazard (OIE)
Salmonellosis – Salmonella abortus ovis	Unlikely to be a hazard (OIE)
Caprine arthritis and encephalitis (CAE) – Retroviridae	Probable hazard (OIE)
Jaagsiekte – Ovine pulmonary adenomatosis – Retroviridae	Present, but rare in DK

Iceland List B	Comparison status:
Multiple species	
Parafilariosis – Parafilaria spp.	Not detected for several years
Footrot – Fusobacterium necrophorum	Endemic - prevalence unknown
Paratuberculosis – Mycobacterium avium paratuberculosis	To be covered by risk assessment
Ringworm – Microsporum spp./Trichophyton spp.	Endemic - prevalence unknown
Dermatophilosis – Dermatophilus congolensis	Endemic - prevalence unknown
Leptospirosis – Leptospira spp.	List 2 disease - low sporadic occurrence
Neosporosis – Neospora caninum	Endemic - prevalence unknown
Q-fever – Coxiella burnetii	Probable hazard (OIE)
Intestinal salmonella infections – Salmonella spp. (Other than Salmonella gallinarum/S. pullorum)	S. Dublin to be covered by risk assessment
Bovine genital campylobacteriosis – Campylobacter fetus fetus	Unlikely to be a hazard (OIE)
Echinococcosis – Hydatidosis – Echinococcus granulosus	Unlikely to be a hazard (OIE)
Trichinosis – Trichinella spiralis	Unlikely to be a hazard (OIE)
Horses	
Equine influenza – Orthomyxoviridae	Probable hazard (OIE)
Horse pox – Poxviridae	Unknown, no surveillance
Sarcoptic mange – Sarcoptes scabiei var equi	Endemic - prevalence unknown
Strangles – Streptococcus equi equi	Endemic - prevalence unknown
Equine viral rhinopneumonitis/Equine abortion virus (EHV-1/EHV-4) – Herpesviridae	Probable hazard (OIE)
Eastern & Western equine encephalomyelitis – Alphaviridae	Unlikely to be a hazard (OIE)
Contagious equine metritis (CEM) – Taylorella equigenitalis	Unlikely to be a hazard (OIE)
Equine viral arteritis (EVA) – Arteriviridae	Probable hazard (OIE)
Epizootic lymhangitis – Histoplasma farciminosum	DK free
Equine Venezuelan encephalomyelitis – Alphaviridae	Unlikely to be a hazard (OIE)
Cattle	
Trichomonosis – Trichomonas foetus	Unlikely to be a hazard (OIE)
Malignant catarrhal fever (AHV-1) – Herpesviridae	Low sporadic occurrence
Bovine viral diarrhea/Mucosal disease (MD/BVD) – Flaviviridae	Probable hazard (OIE)
Bovine respiratory syncytial virus (BRSV) – Paramyxoviridae	Endemic - prevalence unknown
Viral diarrhea – Coronaviridae	Endemic - prevalence unknown
Bovine cysticercosis – Taenia saginata	Low sporadic occurrence - slaughter prevalence estimated at 0.06% (2004 - 2011)
Sheep and goats	
Sheep biting louse – Damalinia ovis	Endemic - prevalence unknown
Sheep scab – Psoroptes ovis	Endemic - prevalence unknown
Sheep mange – Chorioptes ovis	Endemic - prevalence unknown
Sheep keds – Melophagus ovinus	Endemic - prevalence unknown
Ovine epididymitis – Brucella ovis	DK free
Ovine cysticercosis – Taenia ovis	Unknown, no surveillance

[1]Information obtained at The Danish Veterinary and Food Administration English language web-site: http://www.foedevarestyrelsen.dk/english/Animal/AnimalHealth/Pages/default.aspx or by personal communication from Dr. S. E. Jorsal, National Veterinary Institute, Technical University of Denmark, 2013.

To be included in RA's (Chapter 8) Not to be included in RAs DK free

Chapter 8 Import Risk Assessments

Section 1 Background and methodology

Introduction

Permanent transfer of live animals from one EU member state to another is a process covered under the label of "intra-community trade", which is a different official concept than "export" and "import", being reserved for transfer of animals to and from, respectively, a third country, i.e. a non-EU country.

In this document the terms of "export" and "import" will be used, as Iceland is currently a non-EU country, but the specific IRAs assume a situation where the rules of the EU internal market would apply to the transfer of animals from a current EU member state, e.g. Denmark, to Iceland as a potential future EU member state.

Denmark was chosen as the example of a likely exporting country to Iceland for a number of reasons:

Historically, Denmark and Iceland have had strong ties, e.g. in cultural, trade and economic matters.
Icelandic farmers would likely be inclined to choose a Scandinavian partner for animal imports, due to a somewhat similar animal husbandry, environment and climate than more southerly European countries.

As the other Scandinavian countries, Denmark has a relatively favorable animal health situation as far as many infectious animal diseases are concerned, but Denmark can also be considered a bridge to the rest of Europe for other infections to enter.

In representing one of the EU member states as the country of origin, Denmark could not be considered a worst case scenario as far as the present animal health situation. As demonstrated in Chapter 6, Denmark has a middle animal health position when compared to other potentially likely countries of origin for live animals being exported to Iceland.

Denmark is very transparent about its disease situation, and current or recent field data on the prevalence of existing animal infections, especially for dairy cattle, are readily available and have been published extensively in scientific journals with peer review. Evidence on disease occurrence or absence is therefore considered to be reliable.

Implemented types of import risk assessments

The import risk assessments (IRAs) contained in this chapter were carried out according the "Handbook for Import Risk Analysis for Animals and Animal Products" published by the OIE ***(1).*** IRAs can either be qualitative or quantitative, both types being equally valid. The quantitative methods, however, require more specific input details, in the form of field data, that may not always be available, or as assumptions, which may not always be complete, appropriate and fully defendable.

The series of IRAs contained in the chapter are a mixture of the two types: quantitative and qualitative, depending on data availability (see below).

Four of the eight subsequently described disease-specific RAs are purely qualitative (Maedi-Visna and CAE in sheep and the equine infections EHV-1, EI and EVA), because quantitative estimates of neither the probabilities of entry and exposure, nor of the consequences and their impact, appear to be available.

For the other four diseases (Paratuberculosis, Q-fever, Salmonella Dublin and BVD, all in cattle), enough recent Danish surveillance data could be made available to quantitatively estimate the entry probabilities, when combined with the Icelandic expert opinions about the annual size of the expected imports.

Not enough information, however, has been identified to quantitatively estimate neither the probability of exposure nor consequences of these cattle infections, so qualitative assessments have been made. The chosen IRA methodology might be considered a type of semi-quantitative IRA. In order to complete the IRAs, the quantitative entry probability estimates had to be converted to a qualitative scale for them to be combined with the qualitative estimates of the exposure probability and the consequence impact, as described in the following sections.

A quantitative entry/release pathway

Figure 11 depicts the steps in composing each of the estimated number of consignments of Danish cattle for transfer to Iceland per year, to illustrate how the associated herd- and animal-level disease/infection status determine the entry prevalence of infected consignments.

For simplicity, the model assumes that each consignment is made up of cattle originating from only one herd. In reality, if the same consignment contained animals from two or more herds, each with a herd-level probability p_h of being infected, the probability P_c that the consignment contains infected cattle would be:

$P_c = 1 - (1 - p_h)^n$,

where n is 2 or more. The larger the n, the larger the P_c becomes. So the assumption of one herd only to supply cattle for each consignment leads to an underestimation of the entry probability, if in reality several herds supply animals to the consignments, especially if the herd-level prevalence is high.

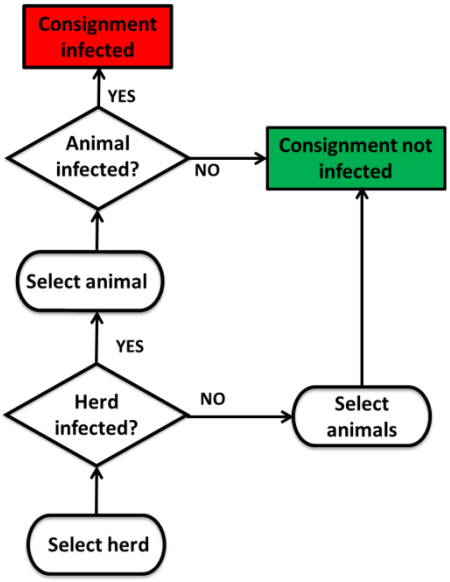

Figure 11 Flowchart showing how the herd- and the within-herd infection status influence the entry probability of infection for one year's consignments

A quantitative entry/release simulation model

A simulation model was constructed using Excel (Micosoft ®) with @Risk (Palisade®) to model the probability of the selected diseases and infections entering Iceland with cattle consignments arriving from Denmark over a period of 1 to 20 years. The model implemented the appropriate probability estimation formulas included in the OIE Handbook ***(1)***. The following steps were included in executing the model:

1. Based on the in Chapter 6 Appendix 1 specified opinions of the Icelandic experts, enter the expected number of consignments exported per year: minimum, mode and maximum values, which define a PERT distribution for use in the model
2. Based on the in Chapter 6 Appendix 1 specified opinions of the Icelandic experts, enter the expected number of animals per consignment: minimum, mode and maximum values, which define yet another PERT distribution for use in the model
3. Specify beta distributions for both the herd- and the within-herd apparent prevalence based on Danish surveillance data that were either published or made available through personal communications with Danish experts. Parameters for a Beta probability distribution can be calculated using estimates of the mode and a percentile of the prevalence distribution. The mean or median was used to estimate the mode in some situations, where modal values were not available, as described in ***(2)***. The conversion of the prevalence estimates to beta distribution parameters was achieved using the BetaBuster tool. Beta distributions are specified by two parameters, a and b and presented as beta (a; b) ***(3).***
4. If prevalence estimates from several different data sets were available, they were used to allow for sensitivity analysis by repeating points 3 – 6 for each beta parameter set. Comparing the model outcomes gives an impression of the importance of possible differences in the input parameters based on different data sets. Examples of this will appear in the subsequent sections.
5. Run 1000 @Risk model iterations
6. By visual inspection of the graphical model output, verify that the distributions of model input data for steps 1 to 3 fit with the shapes of the defined beta- and PERT-distributions
7. The probability of at least one infected animal entering Iceland with the consignments received from Denmark over a given period of time (between 1 and 20 years) is the end result of the estimation. The results have been summarized in the @Risk probability distribution graphs and from tables with mean entry probability values by selected numbers of cumulative years, as well as for different sets of beta-distributions, when available

It should be noted, that 20 years may be a long time horizon for any entry assessment, implicitly assuming constant conditions as far as the estimated levels and distributions of herd- and with-herd prevalence, the estimated size of the annual transfer of consignments and animals, disease and management situations in both countries, etc. Careful application of the results would dictate, that limited confidence be placed on the validity of risk estimates based on an extended number of years into the future.

Before combining the resulting entry probability with estimates of the likelihood of exposure and of the impact of the consequence, the quantitative entry estimates were converted to the qualitative scale using a probability conversion table (table 60) ***(4).***

Table 60 Probability/likelihood conversion table (modified from 4)

Qualitative interpretation		**Quantitative interpretation**	
Likelihood	**Description**	**Proportion**	**Percentage**
Very low	Event very unlikely to occur	< 0.05	< 5%
Low	Event unlikely to occur	0.05 - 0.3	5 - 30%
Moderate	Event likely to occur	0.3 - 0.7	30 - 70%
High	Event very likely to occur	0.7 – 1.0	70 - 100%

Qualitative risk assessments

As previously mentioned, for some diseases and infections qualitative risk assessments had to be the used, according to the procedures described in the OIE Handbook ***(1).*** To enable a proper combination of qualitative likelihood estimates, e.g. from the entry and the exposure assessments, table 61 was used ***(5, 6).***

Table 61 Combination matrix used to evaluate two likelihood estimates based on the assumption that the second event is conditioned on the first event and/or an increase of likelihood is not meaningful (modified from 6)

Previous event	Following event				
	Very low	Low	Moderate	High	Unknown
Very low	Very low	Very low	Very low	Very low	Very low
Low	Very low	Low	Low	Low	Low
Moderate	Very low	Low	Moderate	Moderate	Moderate
High	Very low	Low	Moderate	High	High
Unknown	Very low	Low	Moderate	High	Unknown

The impact categories of direct and indirect consequences of introduction of an infection and/or disease to Icelandic animal populations are presented in table 62.

Table 62 Impact of direct and indirect consequences

Impact of consequences[1]	Direct consequences				Indirect consequences
	Infection	Disease	Production loss	Public health	Control costs
Very low	Few cases asymptomatic	Few cases, short duration	Temporary, slight decrease	Few cases, short duration	None
Low	Low incidence, asymptomatic	Low incidence, short duration, no mortality	Temporary decrease, short duration	Few cases, temporary illness	Low
Moderate	Moderate incidence, symptoms	Moderate incidence, moderate duration, low mortality	Moderate decrease, moderate duration	Moderate case numbers, moderate illness, moderate duration	Moderate
High	High incidence and/or rapid spread, carriers, latent infections	High incidence, treatment required, long duration, mortality, poor welfare	Severe decrease, long duration, treatment costs, mortality/culling	High incidence, long duration, hospital treatment, mortality	High
Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

[1]The highest impact score among the five columns determines the overall impact level

Combining the joint likelihood estimate from table 61 with the consequence impact from table 62 was done using the matrix in table 63 ***(4).*** This determines the overall risk estimate.

Table 63 Risk estimation matrix combining the likelihood of entry and exposure with the consequence impacts (modified from 4)

Combined, conditional likelihood	**Consequence impacts**				
	Very low	Low	Moderate	High	Unknown
Very low	Very low risk	Very low risk	Very low risk	Very low risk	Very low risk
Low	Very low risk	Low risk	Low risk	Low risk	Low risk
Moderate	Very low risk	Low risk	Moderate risk	Moderate risk	Moderate risk
High	Very low risk	Low risk	Moderate risk	High risk	High risk
Unknown	Very low risk	Low risk	Moderate risk	High risk	Unknown risk

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Section 2 Paratuberculosis in cattle caused by *Mycobacterium paratuberculosis* strain C

Scope and purpose of the import risk assessment

This risk analysis identifies and assesses the likelihood of paratuberculosis in cattle caused by *Mycobacterium avium* subsp. p*aratuberculosis (MAP or Mycobacterium paratuberculosis)* strain C being introduced, becoming established and spreading among Icelandic cattle farms, together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing cattle (*Bos taurus*) from Denmark.

According to the opinion of an Icelandic expert as described in Chapter 6 Appendix 1, the following two scenarios are likely to occur for cattle imports to Iceland:

a) Individual farmers might want to import single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.
b) A farmer might want to start a pure-bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 occasions of such imports (per year).

A short introduction to the infection and the disease

Paratuberculosis is a chronic, inflammatory intestinal disease of cattle and other ruminants, caused by the bacteria *Mycobacterium avium* subsp. p*aratuberculosis* (hereafter *M. paratuberculosis or MAP*). In the dairy industry, losses due to paratuberculosis can be substantial in infected herds, and several countries have implemented national programs based on herd-classification to manage the disease. Under natural conditions, the disease in cattle spreads by ingestion of *M. paratuberculosis* from the contaminated environment. The disease persists after the introduction of infected animals.Young animals are most susceptible to the infection, which is caused by intake of milk from the contaminated udder of the cow. The infection has a very long incubation period, and cattle can be infected and shed bacteria for years before any symptoms are recognized. Furthermore, it has been suggested that *M. paratuberculosis* could be a co-factor in the human intestinal disorder Crohn's disease ***(1 -4).***

Sheep and cattle strains of *M. paratuberculosis*

Distinct strains of *M. paratuberculosis* with a tendency to segregate in either sheep, or cattle and other ruminants have been described and are known as S and C strains, respectively. Use of the terms type C or type S does not imply absolute host specificity, as both types have been isolated, at least occasionally, from all common ruminant hosts, but the designation has epidemiological usefulness in many situations. C strains are relatively easy to culture from tissues and faeces of animals with paratuberculosis, but S strains are difficult to culture. S strains were identified in archival tissues from paratuberculous sheep and cattle in Iceland, confirming epidemiological and microbiological evidence that paratuberculosis in Iceland was due to S strain following importation of infected sheep from Europe. In each bovine case in Iceland there had been direct or indirect contact with paratuberculous sheep, and husbandry practices appear to have favoured transmission of S strains to cattle ***(5 - 6).***

Fecal shedding

To transmit paratuberculosis, the bacterium *M. paratuberculosis* must be shed from an infected animal and transmitted to a susceptible animal directly or indirectly. Testing for the presence of *M. paratuberculosis* in fecal samples from infected animals, however, has a low sensitivity (10 – 15%) and is a tedious and slow process. Therefore, indirect test methods such as serology on blood or milk samples are most often used to indicate exposure to the pathogen and, therefore, the presence of the infection in herds and individuals. Serological methods have a higher sensitivity, but do not necessarily indicate a current infection. Therefore, one should expect prevalence measured by fecal isolation to be lower than serological prevalence estimates. Adjustment of apparent prevalence to true prevalence has sometimes been attempted in published studies, but apparently with limited success, so that only general "guesstimates" could be provided ***(1, 7)***.

In an observational prospective study conducted to identify risk factors associated with faecal shedding of MAP in naturally exposed dairy heifers, it was found that 36 out of 1,842 faecal samples (2%) cultured positive for MAP. Heifers shedding MAP were more likely to occur in herds with adult-cow MAP ELISA prevalence >10% (odds ratio= 4.7; 95% conf. interval: 2.0 – 11.1) ***(8).***

Hazard identification

Paratuberculosis is not on the OIE list of notifiable diseases and infections. There is, however, a Chapter 2.1.11 in the OIE Manual dealing with testing and vaccination aspects of paratuberculosis ***(4).***

Paratuberculosis is a notifiable disease in Iceland (list B, multiple species), as described in Chapter 5. Paratuberculosis in cattle is rare and only caused by the sheep (S) strain, which causes paratuberculosis in Icelandic sheep ***(5).*** As described in Chapter 5, the sheep strain infection is the subject of an on-going eradication program, and some geographical zones are now free from paratuberculosis. The cattle (C) strain of *Mycobacterium paratuberculosis* has never been detected in Icelandic cattle.

Paratuberculosis is not a notifiable disease in Denmark, but the Danish Cattle Association has organised many research and surveillance projects to acknowledge its importance and prevalence, and in 2006 a voluntary control program among Danish dairy herds was implemented ***(9).*** Strain C is the only type found in Denmark ***(10).***

Within the EU, Article 8.1 and Annex B III in Council Directive 91/68 on animal health conditions governing intra-Community trade in ovine and caprine animals specifies that paratuberculosis is one of the diseases to which sheep and goats are susceptible, which may be the basis for considerations of additional guaranties when a Member State considers that its territory or part of its territory is free from this disease. No such EU provision exists for paratuberculosis in cattle.

In conclusion, infection with the cattle-adapted C strain of *M. paratuberculosis* is prevalent and being controlled in Danish cattle, while the sporadic cases of paratuberculosis in cattle in Iceland are caused by the sheep-adapted S strain which is under eradication. Paratuberculosis caused by the C strain should be considered a potential hazard when importing cattle to Iceland from Denmark.

Risk assessment

Entry (Release) assessment

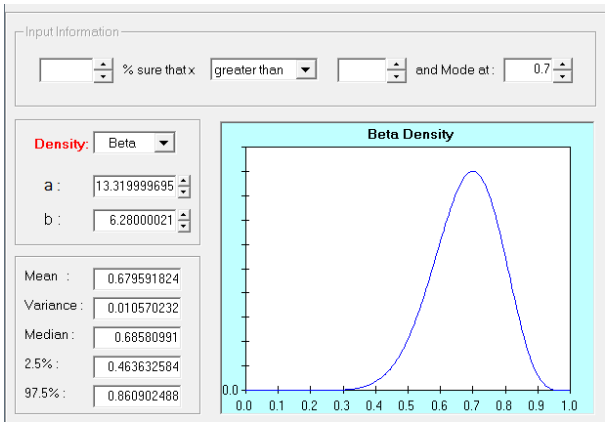
Status in European cattle

European data on prevalences of MAP in all farmed animal species have been evaluated based on a review of the literature**.** A critical review of the included studies indicated, that although a wide range of studies have been conducted, likely and comparable true prevalence estimates could rarely be calculated. Based on a few studies where the prevalences appeared to be plausible, it was concluded that prevalences of MAP would have to be "guesstimates" based on available data. The true prevalence among cattle appeared to be approximately 20% and was at least 3 – 5 % in several countries. Between-herd prevalence appeared to be >50%. No country had published sufficient data to claim freedom from MAP or a near-zero prevalence of MAP infections. No within-flock prevalence estimates were available for goats and sheep. The between-flock prevalence was assumed to be >20%, based only on estimates from Switzerland and Spain ***(7)***.

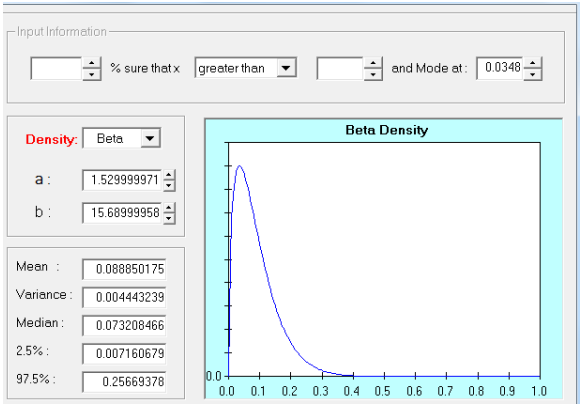
A later study from two provinces in Italy showed that the herd-level apparent prevalences were 48 and 65%, respectively, while the median within-herd apparent prevalences were 2.6% and 4%, respectively.

A model to determine the test characteristics and the true ELISA prevalences used the following parameters:

Herd level TP: Mode: 0.7; 95 percentile: >0.5; beta distribution: (13.32; 6.28)
Within-herd TP: Mode 0.035; 95 percentile: 0.22; beta distribution: (1.53; 15.69) ***(11).***



Herd-level beta distribution



Within-herd level beta distribution

Figure 12 BetaBuster output for MAP prevalence estimates from two Italian provinces (11)

These distributions are similar to the ones derived for the Danish prevalences (see Appendix 2) and if used in the simulation model would produce comparable estimates for entry probability.

Status in Danish herds

Para-tuberculosis has likely been present in Denmark since the 1880s. However, reliable historical prevalence estimates are not available, partly because of poor diagnostic tests, reporting has been based on clinical disease rather than infection, and in the past farmers have been unwilling to disclose the true infection status of herds and animals

During the 1990s, limited efforts were made to control paratuberculosis. However, research projects from 1999 and onwards led to an increased awareness of infection status in many herds, along with novel ways of testing and management of MAP infections. During this period of time, stigmatisation associated with MAP infections appeared to decrease significantly in the country. Consequently, farmers demanded the initiation of a voluntary programme, which

was implemented in 2006. By mid-2011 participation in this programme was 29% of Danish dairy herds and 40% of dairy cows.

Early control efforts were based on culture-based testing and, to some extent, use of vaccination. Vaccination could only be used if permission had been obtained from the veterinary authorities. To achieve permission, a farmer had to supplement vaccination with management changes to reduce transmission of MAP. Vaccination, however, was banned in 2008 ***(9).***

The prevalence of MAP strain C in Denmark has been estimated in several studies. For example, in 1998, 19 out of 22 herds (86%) had at least one test-positive cow, and a total of 102 of the 1,155 cows (8.8%) were test-positive. The median within-herd prevalence among the 22 herds was 5.4%, ranging from 0 – 28.6% ***(3).*** It is currently estimated that approximately 80 – 85 % of Danish herds are infected with MAP and that the average apparent within-herd prevalence of infected animals is around 5.5% (range 0 – 25%). Data from the voluntary Danish control program indicate that among the participating herds, 91% are infected with a median within-herd prevalence of 3.4% ***(9).***

Purchase of animals as a herd risk factor

A cross-sectional study on milk samples from 1,155 cows from 22 Danish dairy herds used ELISA to detect antibodies against MAP. Of the 1,155 samples, 102 (8.8%) were test-positive, and 19 out of the 22 herds had 1 or more test-positive cows. In five of the 19 seropositive herds, the only affected animals at the time of testing were purchased individuals ***(3).***

In a study of the effect of management practices on paratuberculosis prevalence in Danish dairy herds, it was found that a large proportion of purchased animals in the herds negatively affected the progress over time ***(12).***

Within the Danish voluntary control program for paratuberculosis, a certification scheme was implemented in 2011 and more than 100 herds are currently recognized as being “free of MAP infection”. To obtain a certification status, a minimum of 75% of the animals have to be tested negative (?) within the last 12 months. Herds are classified based on their own test-prevalence and the prevalence in herds from which they have purchased livestock. To be classified as “potentially free of infection” the herd should include no purchased animals and have a probability of being “free of MAP infection” > 0.95 and an estimated true prevalence of <0.5% ***(9).***

Also, in the USA, it is recommended that considerations be given to the critical role of transmission from farm to farm through the introduction of purchased cattle. A key preventive measure for MAP is the careful evaluation of purchased cattle through screening of the herd of origin to avoid introduction of the infection. Evaluating the prevalence of infection in purchased cattle is one important way to reduce the risk of introducing disease on the farm ***(13).***

Simulation of the MAP infection status of Danish cattle consignments to Iceland

A simulation model was developed to estimate the probability of the presence of at least one infected animal in a series of annual exports from Denmark. The model was applied to MAP in live cattle exports to Iceland.

Two import scenarios were outlined by an Icelandic expert opinion as described in Appendix 1.

Parameters describing the apparent prevalence of MAP strain C infections in Danish cattle at the herd and within-herd levels determined by bulk tank milk-ELISA and individual animal milk-ELISA, respectively, were assembled from the scientific literature and by personal communications with Danish experts ***(1, 10, 14, 15)***. Parameters were combined into two sets (I and II) by combining the herd- and within-herd estimates from the same source into Set 1 ***(10, 14)***, and the remaining estimates into Set II ***(1, 15)***. To estimate beta-distributions for use in the simulations, the software BetaBuster ***(16)*** was applied to the Danish MAP prevalence estimates, as explained in Section 1 of this chapter.

Table 64 Parameters for Danish MAP prevalence estimates

Population level	No. of herds	Mode[1]	Percentile[1]	Beta (a, b)	Figure	Reference
Herd	-	-	-	(6.2; 1.9)	1	(10)
Herd	-	0.75	<5%: 0.50	(9.64;3.88)	2	(1)
Within-herd	1034	0.026	<75%: 0.05	(3;75)	3	(15)
Within-herd	92	0.043	<95%: 0.138	(2.7; 38.3)	4	(14)

[1]These two prevalence parameters need to be specified to enable estimation of the beta distribution, as explained in Section 1 of this chapter

These four beta-distributions are presented as graphs in Appendix 2.

Appendix 3 shows the output distributions from 1000 model simulations as a verification of the input parts of the model (parameter set I).

Appendix 4 – 6 describe in more details the simulation inputs and results for scenarios a and b, respectively (parameter set I).

Appendix 7 compares the results from using two parameter sets I and II based on the four different beta distributions. There are only minor differences between the results for the two parameter sets.

Finally, Appendix 8 shows the resulting probabilities for the combined effect of the simultaneous occurrence of import scenarios a and b (i.e. introduction of MAP by one or both of the two pathways), thus presenting the final estimates of the cumulative probabilities of the release of MAP in Iceland with imported Danish cattle across selected spans of cumulated years.

The conclusions from the model simulations can be summarized as follows:

Assuming an annual import pattern of Danish cattle consisting of the joint numbers of animals and consignments as defined in scenarios a and b in Appendix 1 and for both parameter sets available, there is more than 80% probability of MAP strain C being released in Iceland already during the first year and 100% probability after five years of importation; see tables below:

Table 65 Simulated mean cumulated probabilities of entry in scenarios a, b and their combination

Parameter set I

Year	Scenario a	Scenario b	Scenario a or b
1	37.8%	88.9%	93.1%
5	90.0%	100%	100%
10	98.8%	100%	100%
20	100%	100%	100%

Parameter set II

Year	Scenario a	Scenario b	Scenario a or b
1	22.9%	77.8%	82.9%
5	72.0%	99.9%	100%
10	91.8%	100%	100%
20	99.2%	100%	100%

In conclusion, the annual entry probability of paratuberculosis strain C infection arriving to Iceland in at least one consignment with Danish cattle under the two import scenarios is **high.**

Exposure assessment

History of paratuberculosis of sheep in Iceland

The history of paratuberculosis in Iceland has been reviewed in Chapter 1**.** Briefly, 20 Karakul sheep were imported from Germany in 1933, and at least five of these sheep were subclinical carriers of paratuberculosis. Within 16 years, paratuberculosis and the other Karakul diseases (Maedi-Visna and Jaagsiekte) almost ruined sheep farming, the main agricultural industry in Iceland. The first clinical case of paratuberculosis in sheep was confirmed in 1938 and in cattle in 1944. The first cattle cases of paratuberculosis appeared on farms where the disease had been prevalent in sheep for years. Extensive measures were used to control the spread of paratuberculosis in sheep. Hundreds of kilometres of fences were put up and used together with natural geographic borders to restrict the movement of sheep from infected areas. Serological tests were used to detect and dispose of infected individuals, but the measures proved inadequate and the disease could not be eradicated. Culling and restocking of uninfected sheep in endemic areas eradicated Maedi-Visna and Jaagsiekte, but not paratuberculosis ***(17).***

Spread of MAP in Europe

In Norway, paratuberculosis in cattle was initially described in 1908 and was endemic in certain regions and farms until the 1950s, but died out and disappeared in the late 1970s. In 1994 paratuberculosis was diagnosed in a group of cattle in a quarantine imported from Denmark; the animals were destroyed. In 1997 paratuberculosis was found in two cattle herds in Norway. The animals were imported from Finland and Denmark in 1992 and 1994, and the infection has spread from these herds to other herds before the condition was detected. All detected herds have been destroyed ***(2).***

After decades of no cases observed in Sweden, MAP was detected in an imported beef cow in 1993. During the following years with several extensive surveillance activities including dairy as well as beef cattle, 53 infected herds were revealed. All cases have been in beef cattle and all cases have been linked to imported cattle. A national chain of infection in the Limousine breed could be traced back to a cow imported in 1975. The fact that all detected Swedish cases have been linked to imported animals clearly indicates that the major risk of introduction in Sweden is via imported animals. The risk of introduction decreases if the number of imported animals can be kept low. Each imported animal poses a risk of introducing MAP because paratuberculosis is a frequently occurring disease in most other countries and because the incubation period is long and there is no reliable method to detect MAP in an incubating animal. It is important to control this risk of introduction in a free country or a country with a low prevalence. The Swedish Animal Health Service contacts all farmers that plan to import animals, providing information about risks and supplying recommendations on sampling in addition to the mandatory requirements. The close and constructive cooperation in actions taken between Swedish authorities and the Swedish Animal Health Service is of vital importance in keeping Sweden free from MAP. This is particularly important when legislation does not allow the authorities to require sampling of imported animals or their herds of origin to exclude carriers of MAP ***(18).***

These and other previous investigations suggest that the prevalence of MAP in Swedish cattle is low and all recent cases have been linked to imported animals. The last case of MAP in Sweden was in 2004 in an imported bull, which was sampled and detected through surveillance by necropsy of fallen stock. At a design prevalence of one animal in 0.5% of the herds the estimated probability of freedom is >95%, which indicates that the prevalence of MAP in Swedish cattle is below this level or absent. Because MAP is present in most other countries, the Swedish animal health experts on both the government and the industry side agree that absence of testing requirements inevitably leads to the introduction of MAP ***(19).***

Furthermore, an Irish study of paratuberculosis in dairy herds indicated that although this disease was present in Irish cattle herds for decades, only since the introduction of the Single European Market in 1992 has it become more widespread ***(20).***

In conclusion, the probability of exposure and spreading of paratuberculosis caused by strain C in Icelandic cattle is **high.**

Consequence assessment

As described in Chapter 1 and in the literature ***(17),*** Iceland has in the past suffered serious consequences in sheep and to a lesser degree in cattle from importing sheep affected by paratuberculosis caused by strain S.

The first clinical case of paratuberculosis in sheep was diagnosed in 1938, 5 years after the arrival of the imported sheep. Gradually, the infection spread from the five original case herds to surrounding farms, and over the next 18 years, 440 farms or 20 – 30 % of the farms in the main sheep breeding area were infected. Farms in the infected area held about 25% of the total sheep population in Iceland. The annual mortality of sheep during the epidemic averaged 8 – 9 % in these areas and could approach 40% on individual farms. It is estimated that the total losses during the epidemic were around 100,000 sheep.

In spite of draconian conrol measures including areal fencing and movement control, testing and culling infected sheep and slaughter and restocking of sheep in infected areas, the infection was not eradicated, although the spread of the infection was delayed. Mortality was still high on some farms.

Vaccination of breeding sheep at the age of 4 – 6 months in infected areas has been compulsory since 1966, using a locally produced vaccine based on S strain isolates. The vaccine reduces mortality in infected herds ***(17).***

Paratuberculosis also leads to serious losses in cattle herds in other EU member states. A case study describes the economic impact of MAP in an Irish dairy herd. An epidemiological investigation concluded that the purchase of 20 heifers from the Netherlands in 1993 introduced MAP to the herd. The practice of feeding pooled colostrum/milk was considered to have disseminated MAP widely within the herd. Farm performance between 1993 and 2003 declined substantially as a result of reduced milk yields, increasing culling and reduced cull cow values. There was a significant negative association between clinical MAP infection status and milk yield, somatic cell count and culling price in the study herd. These direct effects, in combination with increased culling for infertility and increasing replacement rates, had a negative impact on the economic performance of the herd ***(20, 21).*** Similar observations have been made in the USA, even in herds with subclinical infections ***(22).***

In Iceland, for sheep and cattle with strain S infections there is still an active paratuberculosis eradication program in effect, which operates at great costs to farmers and the government. In spite of the extensive control measures, such as herd culling, compulsory vaccination and physical separation of infected from non-infected geographical regions, paratuberculosis is still endemic in many areas accounting for about half of the size of Iceland (see map in Chapter 5).

Paratuberculosis in Iceland caused by strain S is clearly associated with serious consequences in terms of clinical disease and associated production losses, as well as with continued control and eradication activities as required in the present legislation.

In conclusion, the consequences of MAP strain C infection in Icelandic cattle would have a **high** impact for the Icelandic farmers and the government.

Risk estimation

The probability of entry (release) of MAP strain C through import of live cattle to Iceland from Denmark was estimated to be high and approaching certainty after only a few years of importation. A similar introduction among sheep of strain S took place in Iceland in the 1930s, as described in Chapter 1.

The scientific literature is rich on examples of exposure to paratuberculosis caused by introduction with purchased animals, both among herds within affected countries and from infected to free or low-prevalent countries, including Norway and Sweden. The introduction and spread of paratuberculosis takes place due to direct as well as indirect contact through environmental contamination of housing and grazing areas with the highly resistant bacteria. The traditional housing and grazing systems in Iceland do not lend themselves easily to biosecurity measures useful in limiting the spread of such infections within and between sheep and cattle herds. The probability of exposure and spread would be high after animals infected with MAP strain C are brought into Icelandic cattle herds. The Icelandic

cattle are likely to be fully susceptible to the C strain of MAP, because they have been exposed only to a limited extent to the circulating but sheep adapted S strain.

According to the Icelandic experience with their long lasting strain S epidemic in sheep and based on the economic estimates of losses from strain C infected EU member states, the consequences of such introduction and spread are likely to have a serious impact on Icelandic dairy farming.

In conclusion, the risk associated with paratuberculosis strain C from import of Danish cattle to Iceland is estimated to be **high**.

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Appendix 1 Definition of scenarios a and b

The following description of likely scenarios for imports of cattle to Iceland was kindly provided by Dr. Halldor Runolfsson on January 28, 2013:

a) "Individual farmers would be importing single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year".
b) "A farmer wants to start a pure bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 examples of this kind of imports".

This information was taken into account in the simulation model by defining PERT distributions with the following parameters to be used in the respective simulations:

Scenario a:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).		
	# lots/year	# animals/lot
min.	0	1
mean	10	1
max.	20	1

Scenario b:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).		
	# lots/year	# animals/lot
min.	0	1
mean	5	20
max.	10	30

Appendix 2 Beta distributions used in the scenarios

Population level	No. of herds	Mode	Percentile	Beta (a, b)	Figure	Reference
Herd	-	-	-	(6.2; 1.9)	1	*(10)*
Herd	-	0.75	<5%: 0.50	(9.64;3.88)	2	*(1)*
Within-herd	1034	0.026	<75%: 0.05	(3;75)	3	*(11)*
Within-herd	92	0.043	<95%: 0.138	(2.7; 38.3)	4	*(12)*

Herd level distributions:

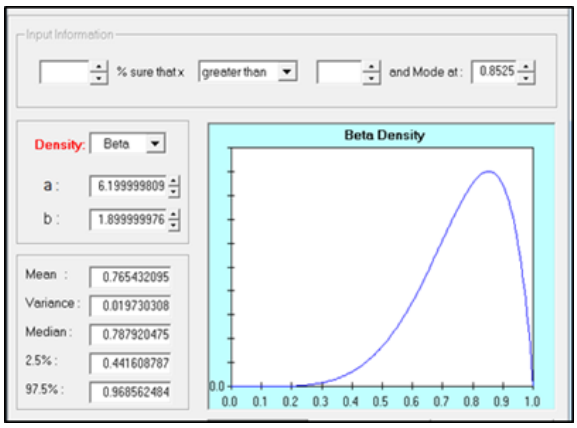


Figure 1

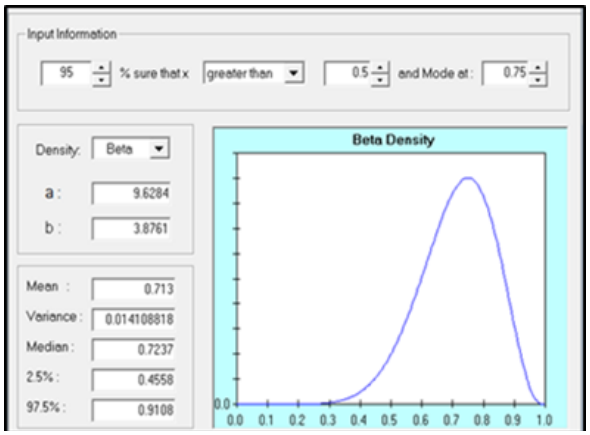


Figure 2

Parameter set I: Figure 1 and Figure 4

Within-herd level distributions:

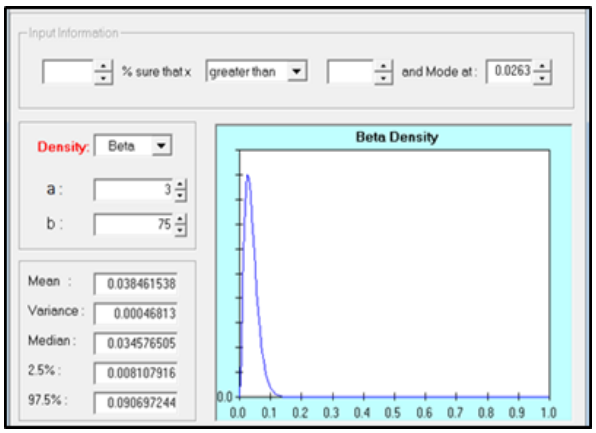


Figure 3

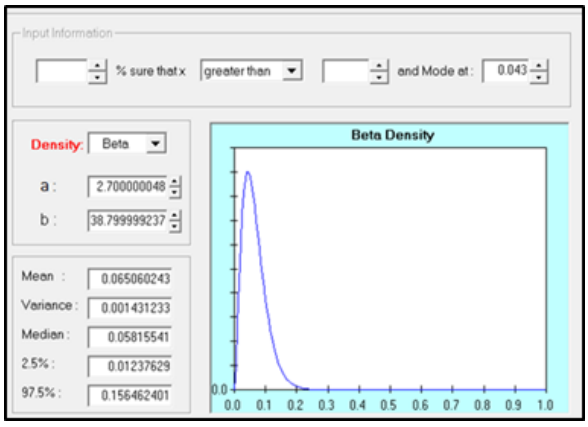


Figure 4

Parameter set II: Figure 2 and 3

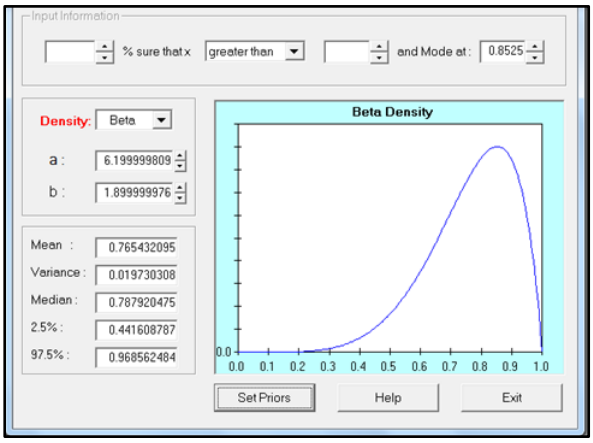
Appendix 3 Verifying model input distributions

Specifying the beta distribution used in the model:

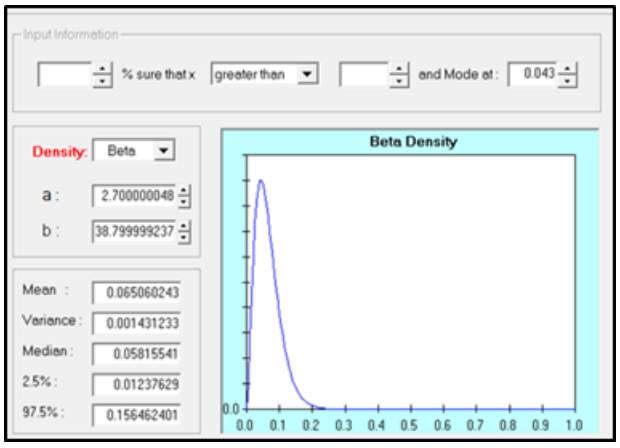
Parameter set I

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3

Beta distributions as presented in BetaBuster:

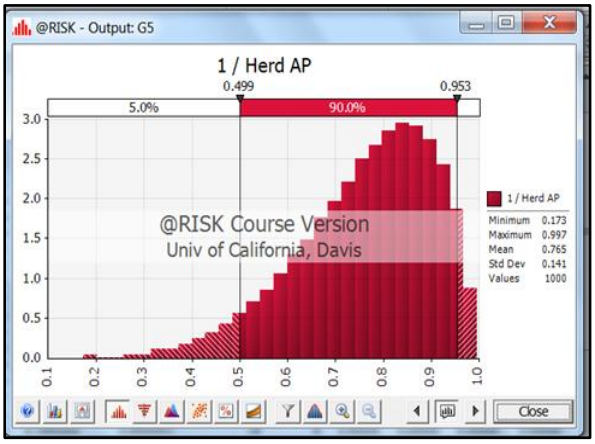


Herd-level prevalence distribution

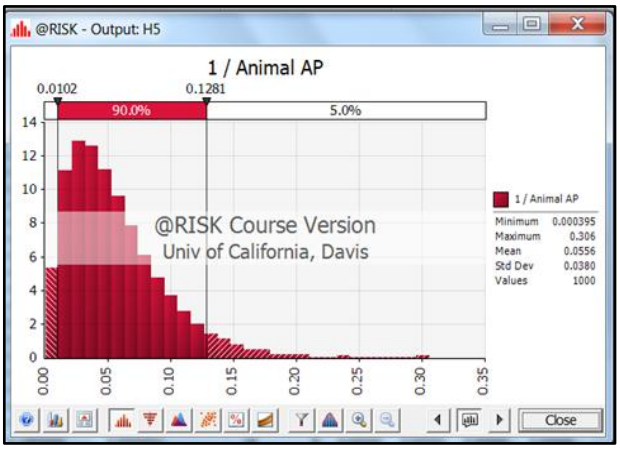


With-in herd prevalence distribution

Distributions from 1000 simulations:



Herd-level prevalence input



With-in herd prevalence input

Appendix 4 Scenario a input distributions and results

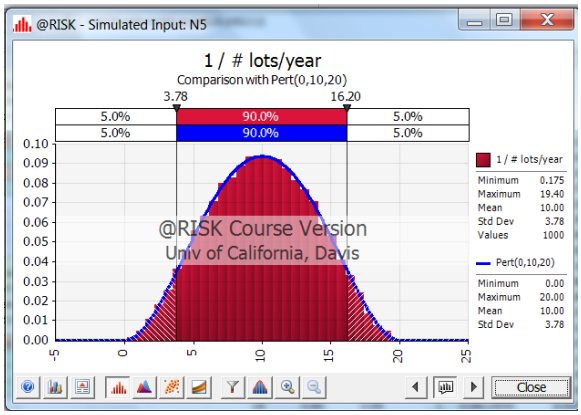
Parameter set I:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

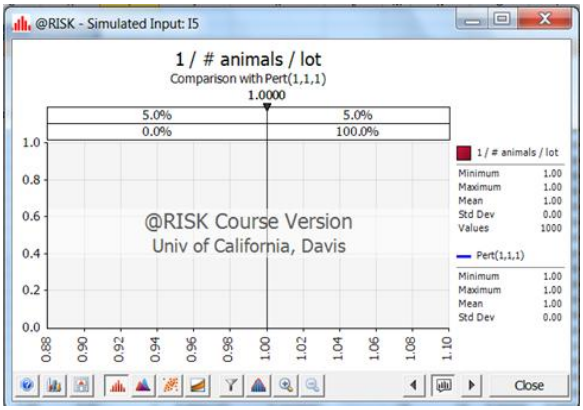
	# lots/year	# animals/lot
min.	0	1
mean	10	1
max.	20	1

Define the beta distributions for the herd-level apparent prevalence and the within-herd level apparent prevalence of MAP

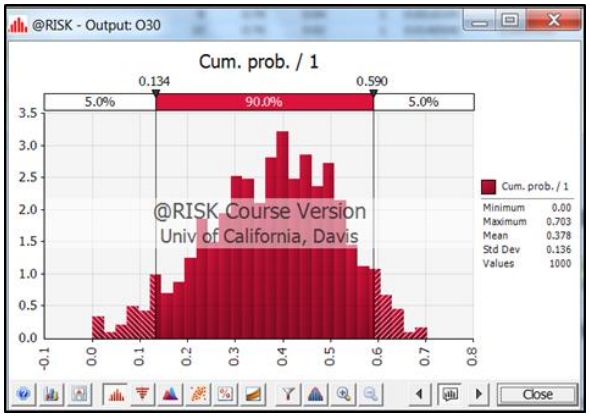
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3



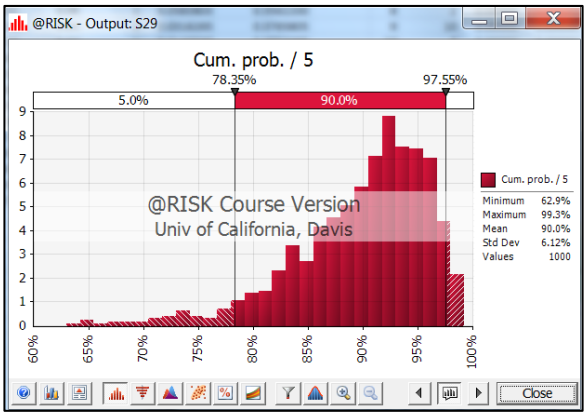
Input: Number of consignments per year



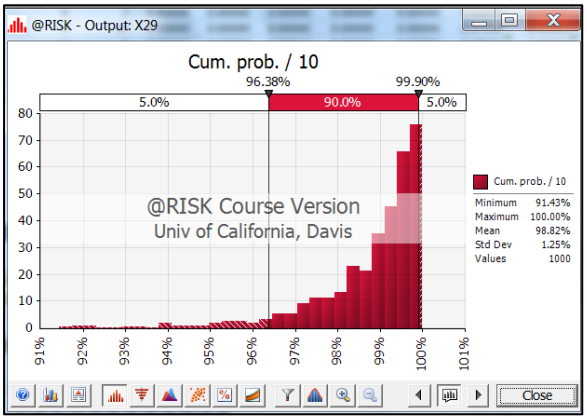
Number of animals per consignment; here always 1



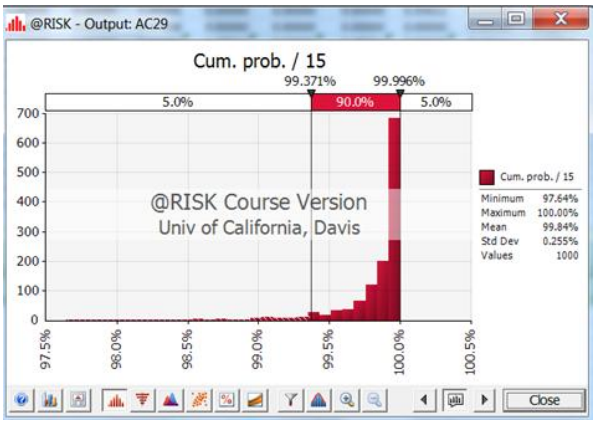
Entry probability after 1 year



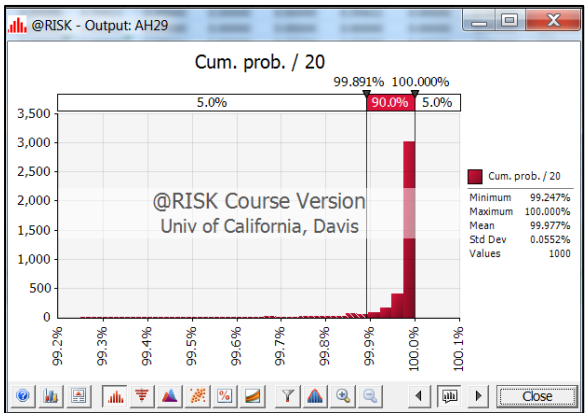
Entry probability after 5 years



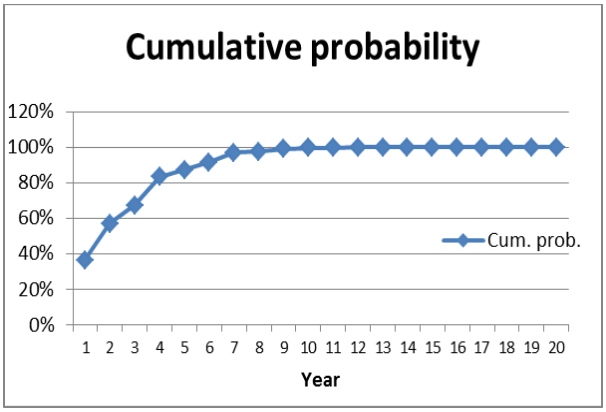
Entry probability after 10 years



Entry probability after 15 years



Entry probability after 20 years



Cumulative entry probability, single simulation

Appendix 5 Scenario b input

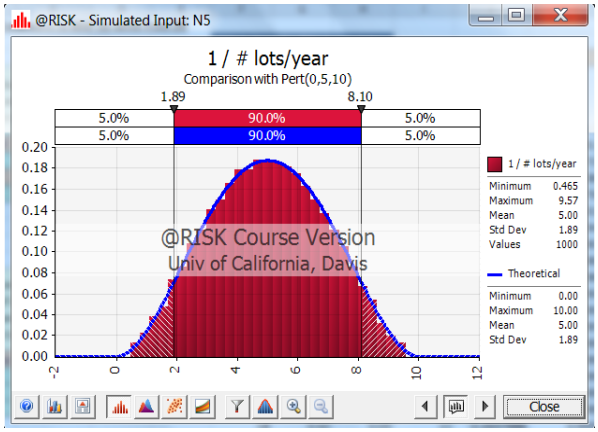
Parameter set I:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

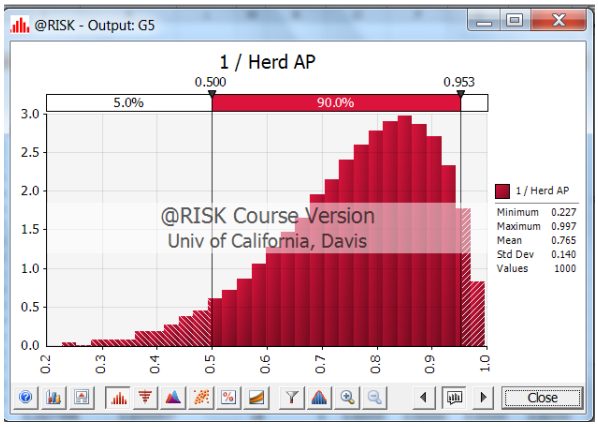
	# lots/year	# animals/lot
min.	0	1
mean	5	20
max.	10	30

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of MAP

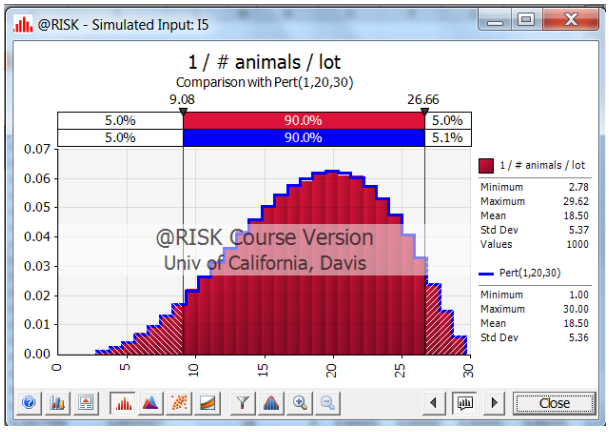
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3



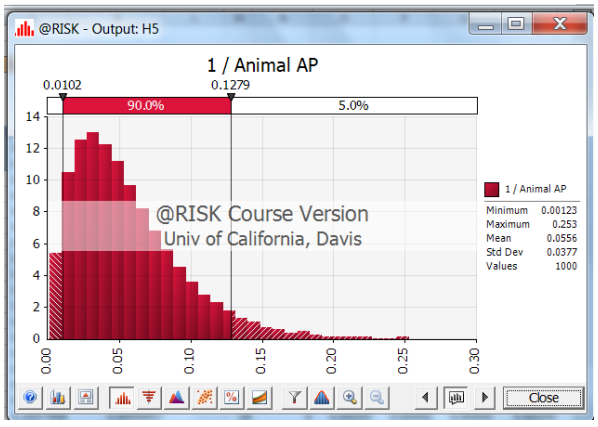
Input: Number of consignments per year



Input: Herd level prevalence, cf. Figure 1



Input: Number of animals per consignments

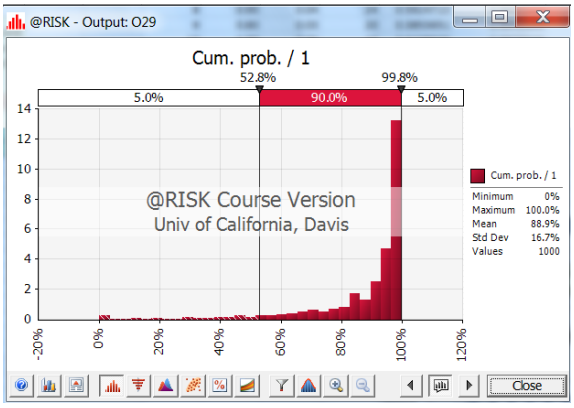


Input: Within-herd prevalence, cf. Figure 4

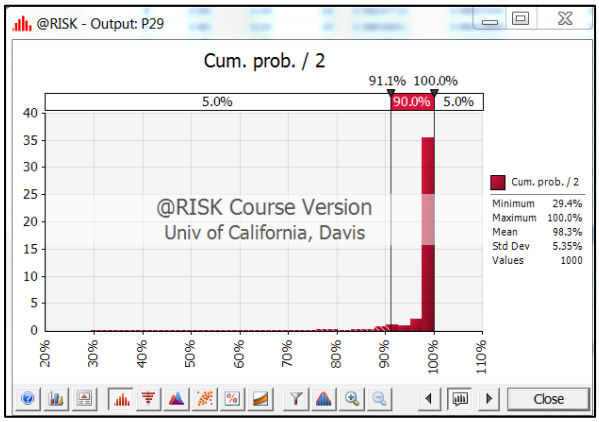
Appendix 6 Scenario b results

Parameter set I

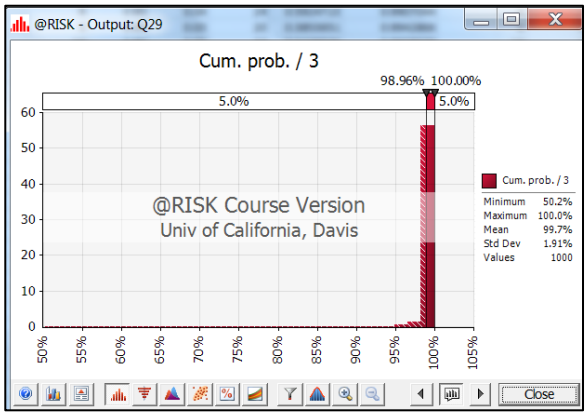
Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3



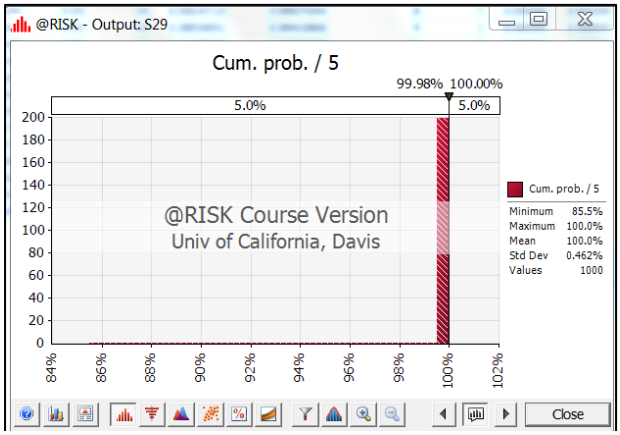
Entry probability after 1 year



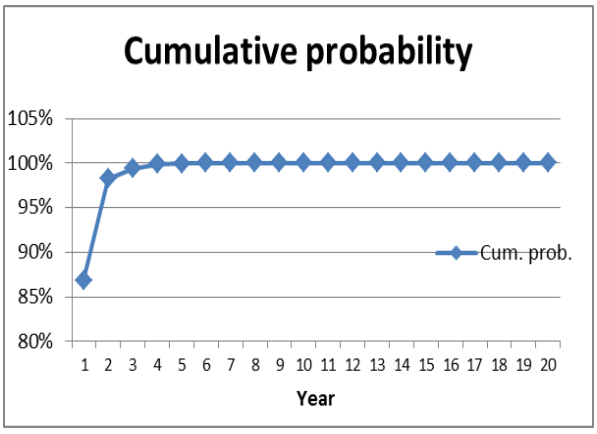
Entry probability after 2 years



Entry probability after 3 years



Entry probability after 5 years



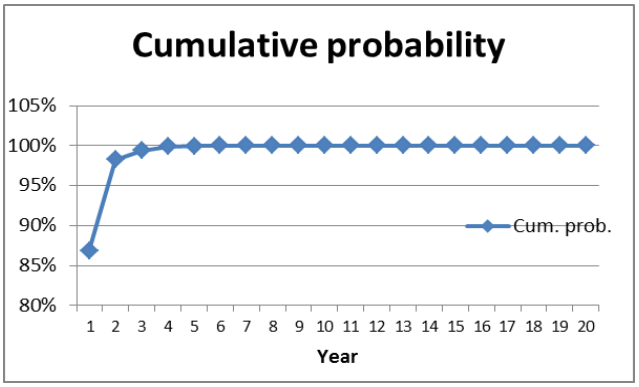
Cumulative entry probability, single simulation

Appendix 7 Effect of different parameter sets on the cumulative probability of MAP infection in Danish cattle exported to Iceland

Parameters used in Scenario b

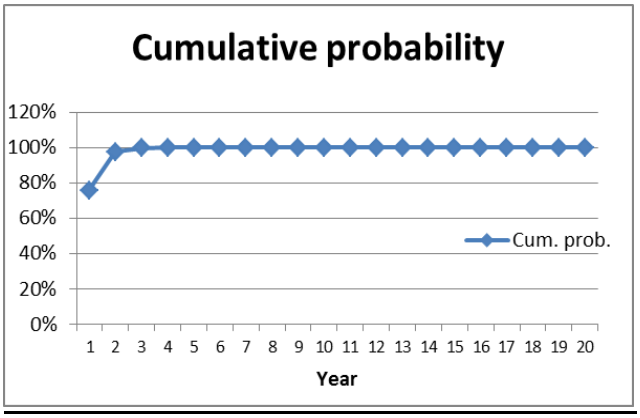
Parameter set I

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3



Parameter set II

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	9.64	3
b	3.88	75



Appendix 8 Combining the results of scenarios a and b

Since the two import scenarios would occur simultaneously within a given year, their respective probability of entry should be combined to give the overall probability of entry of paratuberculosis from the imports of Danish cattle to Iceland:

p(a OR b) = 1-(1-p(a))*(1-p(b))

Parameter set I

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	6.2	2.7
b	1.9	38.3

Simulated mean probabilities of entry in Scenarios a, b and the combined a or b

Year	Scenario a	Scenario b	Scenario a or b
1	37.8%	88.9%	93.1%
5	90.0%	100%	100%
10	98.8%	100%	100%
20	100%	100%	100%

Parameter set II

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of MAP		
Beta	Herd AP	Animal AP
a	9.64	3
b	3.88	75

Simulated mean probabilities of entry in Scenarios a, b and the combined a or b

Year	Scenario a	Scenario b	Scenario a or b
1	22.9%	77.8%	82.9%
5	72.0%	99.9%	100%
10	91.8%	100%	100%
20	99.2%	100%	100%

Section 3 Bovine virus diarrhea (BVD) in cattle

Scope and purpose of the import risk assessment

This risk analysis identifies and assesses the likelihood of bovine virus diarrhea virus (BVDV) being introduced, becoming established and spreading among Icelandic cattle farms, together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing cattle (*Bos taurus*) from Denmark.

According to the opinion of an Icelandic expert as described in Chapter 6 Appendix 1, the following two scenarios are likely to occur for cattle imports to Iceland:

a) Individual farmers might want to import single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.

b) A farmer might want to start a pure-bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 occasions of such imports per year.

A short introduction to the infection and the disease

Cattle of all ages are susceptible to infection with bovine viral diarrhoea virus. The clinical signs range from subclinical to the fulminating fatal condition called mucosal disease. Acute infections may result in transient diarrhoea or pneumonia, usually in the form of group outbreaks. Acute forms of the disease associated with high mortality have also been described, often, but not always, associated with a haemorrhagic syndrome. However, most infections in the young calf are mild and go unrecognised clinically. The virus spreads mainly by direct contact between cattle. Vertical transmission plays an important role in its epidemiology and pathogenesis. Infections of the bovine fetus may result in abortions, stillbirths, teratogenic effects or persistent infection in the neonatal calf. Persistently infected (PI) viraemic animals may be born as weak, unthrifty calves or may appear as normal healthy calves and be unrecognised clinically. Some of these PI animals may later develop mucosal disease with anorexia, gastrointestinal erosions, and profuse diarrhoea, leading invariably to death. Mucosal disease can arise only in persistently infected animals ***(1).***

Hazard identification

BVDV is a *pestivirus* in the family *Flaviviridae* and is closely related to classical swine fever and ovine Border disease viruses ***(1).***

Bovine viral diarrhoea (BVD) is an OIE listed disease ***(3)***, but there is no chapter in the Terrestrial Animal Health Code with recommendations for BVD in relation to trade of live animals. However, Chapter 2.4.8. of the OIE Manual covers the diagnostic techniques and vaccines and biologicals relevant for BVDV **(1).**

BVDV infections have never been diagnosed in Iceland, neither clinically nor serologically, the latter documented by the active surveillance data in Chapter 5. The disease is a notifiable List B disease, which, if occurring, would lead to governmental control measures.

In Denmark, BVD is a notifiable disease on lists 2 and 4. The disease has been controlled by a successful official program since 1993 – 94, see below.

Risk assessment

Entry (Release) assessment

Distribution of the BVDV is world-wide. Although the reported prevalence of infection varies among surveys, the infection tends to be endemic in many populations, reaching a maximum level of 1 – 2% of cattle being persistently infected (PI) and 60 – 85 % of the cattle being antibody positive. Persistently infected animals are the main source for transmission of the virus. Transmission is most efficient by direct contact. Acutely infected cattle as well as other ruminants, either acutely or persistently infected, may transmit the virus. However, as infections have been observed in closed, non-pasturing herds, other transmission routes seem likely to have some practical importance ***(2).***

It is important to avoid the trade of viraemic animals. It is generally considered that serologically positive, but nonviraemic cattle are 'safe', providing that they are not pregnant. Antibody-positive pregnant cattle carrying persistently infected fetuses are important transmitters of the virus between herds ***(1).***

Status of cattle in Europe

Infections with bovine viral diarrhoea virus (BVDV) are endemic in most cattle-producing countries throughout the world, causing significant economic losses to the cattle industry. A review of prevalence surveys performed in Europe from the late 1970s and into the 21st Century showed that BVDV was endemic in all countries where no systematic control has been initiated. Under such conditions, approximately 50% of all herds have PI animals, and 90% of all cattle become exposed during their lifetime ***(4).***

The prevalence and incidence of BVDV infection have been investigated in several epidemiological studies. In many European countries, the infection seems to have occurred endemically with about half the herds having PI animals and most herds having antibody carriers. The overall prevalence of PI animals is often in the range of 1–2% and the overall prevalence of antibody carriers in the range of 40–70%. It has been estimated that in an endemic area the maximum possible number of PI animals will be around 2%. However, in a few regions, the infection is present at a much lower prevalence. Studies from the US indicate that BVD virus is present in relatively few herds, but occasionally in high numbers in these herds. A screening of 18,931 calves in 128 beef herds (76 randomly selected and 52 with suspected infection) in the US revealed a total of 56 BVDV positive calves (0.3%) in 13 herds (10%). Among the 76 randomly selected herds BVDV positive animals were detected in 3 (4%) of the herds. This study also revealed several herds with multiple BVDV positive animals. Thus, there seems to be a difference in epidemiology between regions. In several regions, the infection is endemic with high prevalence. The PI animals occur in several herds but with low number in each herd. In other regions the prevalence is lower. Here PI animals occur in fewer herds but in higher number in those herds ***(5).***

BVDV eradication programs have worked reasonably well in countries where vaccination was banned and strict control measures were implemented, i.e. in the Nordic countries ***(6).*** It should be noted that some additional countries, e.g. Switzerland have comparable eradication programs ***(7).***

Status in Danish herds

A BVDV eradication program was started by the Danish dairy industry in 1993 – 94. The program has been supported by official regulation of BVDV infections as a List 2 notifiable disease, and has been very successful. Table 66 shows the number of non-dairy and dairy herds placed under regulatory quarantine and official restrictions in Denmark by month during the last two years ***(8).***

Table 66 Official monthly BVD status with number of suspected and infected Danish non-dairy and dairy cattle herds, 2011 – 2013

Dato (Seneste dato er øverst)	Ikke-mælkeleverende		Mælkeleverende	
	Mistanke	Smittet	Mistanke	Smittet
05-02-2013	2	1	0	1
01-02-2013	2	1	0	1
01-01-2013	3	3	1	6
03-12-2012	2	1	0	1
01-11-2012	2	2	0	2
01-10-2012	2	2	0	2
03-09-2012	1	2	0	2
01-08-2012	1	1	0	2
02-07-2012	5	5	0	3
01-06-2012	0	4	0	2
01-05-2012	0	4	0	3
02-04-2012	0	4	0	2
01-03-2012	0	4	0	3
01-02-2012	0	4	0	3
02-01-2012	0	4	0	3
01-12-2011	1	4	0	3
01-11-2011	0	2	0	2
03-10-2011	0	1	0	1
01-09-2011	0	1	0	1
01-08-2011	0	1	0	1
01-07-2011	0	1	0	1
01-06-2011	0	1	0	1
02-05-2011	0	2	0	1
01-04-2011	0	2	0	1

At any time during 2012 – 2013, on average 2 -3 herds have been under twelve month quarantine with additional restrictions, as required by the regulation. The maximum number observed was 6 herds at one time being quarantined. The prevalence throughout the two years can be estimated at a median value of 2 herds among the around 3,900 Danish dairy herds (approximately 0.05%).

With the quarterly BMT testing two negative tests several months apart should be required to classify a herd as BVDV negative ***(2).*** This translates into that on average one herd might be positive for 3 – 6 months before being detected as infected, which would be around a herd prevalence of 0.025% at any time. The maximum prevalence would be 3 undetected herds at any time, or 0.08%.

In conclusion, thanks to the active surveillance program with quarterly testing of BTM samples from all Danish dairy herds and the rigorous restrictions placed on the few detected herds, the probability of a dairy herd being infected and remaining undetected and free to export animals is estimated at 0.025% on average or very low.

Simulation of the BVDV infection status of Danish cattle consignments determined for export to Iceland

A simulation model has been established to estimate the probability of the presence of at least one BVDV infected animal in a series of export consignments of live cattle from Denmark to Iceland over a span of calendar years (1 – 20).

Two import scenarios a and b which were estimated by an Icelandic expert to be realistic are described in the beginning of this section and in Appendix 1.

As mentioned earlier, the current average probability of Danish dairy herds being infected, but not yet detected and quarantined, was estimated at 0.025%. In infected herds, a within-herd prevalence of 60 – 85% should be expected ***(2)***. These two parameters were used to estimate the probability of bovine virus diarrhea infections in Danish dairy cattle at the herd and within-herd levels, respectively, for simulating the entry probability with Danish dairy cattle exported to Iceland.

As explained in Section 1 of this chapter, the software BetaBuster ***(9)*** was applied to the set of Danish BVD prevalence parameters to obtain the beta distribution parameters a and b shown in table 67 for use in the simulations.

Table 67 BVD prevalence estimates used to provide beta-distribution for the simulation model

Population level	No. of herds	Mode	Percentile	Beta (a, b)	Reference
Herd	3900	0.00025	95% <0.0008	(2.94; 7748)	*(8)*
Within-herd	-	0.7	95% < 0.85	(10.5; 6.1)	*(2)*

Appendix 2 shows the input distributions and resulting cumulative probabilities for scenario a. Appendix 3 describes the simulation inputs and results for scenario b, as well as results for the combined scenarios a and b across selected spans of cumulated years, as summarized in table 68

Table 68 Simulated mean cumulative probabilities of entry under scenarios a, b and their combination

Year	Scenario a	Scenario b	Scenario a or b
1	0.242%	0.171%	0.41%
10	2.39%	1.69%	4.04%
20	4.72%	3.36%	7.92%

In conclusion, the estimated probability of entry of BVDV into Iceland with import of Danish cattle is **very low**, even when accumulated over a 10 year period and **low** when accumulated over 20 years. This is predicted when applying the current level of BVD infections throughout and the current level of risk management related to animal exports, i.e. only apparently healthy animals are accepted. If the Danish BVD control program continues to improve the situation, the entry probability is likely to be further reduced in the longer run (10 and 20 year scenarios).

Exposure assessment

Differences in BVDV prevalence among regions or introduction of virus into herds previously free of BVDV are often associated with particular epidemiological determinants such as cattle population density, animal trade and pasturing practices ***(2).***

In a Danish study of 67 newly infected herds that had previously been found test negative showed, that nineteen herds (28%) were found infected because of purchase of pregnant cows or heifers which delivered persistently infected (PI) calves, and 24 (36%) and two (3%) because of PI animals on neighbouring pastures or in neighbouring farm houses, respectively. In five herds (7%) pregnant heifers had become infected on one and the same common pasture, while in 17 herds (25%) no immediate cause of infection could be demonstrated. Yet, airborne spread from PI herds as a source of infection was suspected in some of these cases ***(10).***

In conclusion, if infected Danish dairy cattle were to enter Icelandic dairy farms, BVDV has a **high** likelihood of spreading within the receiving herds and further to other dairy herds before detection of the initial introduction.

Consequence assessment

Despite eradication efforts, BVDV infections remain a source of significant economic loss for producers worldwide. It is important to provide for biosecurity aimed at the development of management practices that prevent BVDV from being introduced into a herd ***(11).***

Estimates of economic losses due to BVDV infection vary depending on the immune status of the population and the pathogenicity of the infecting virus strains. Introduction of the infection into a totally susceptible population invariably causes extensive losses until a state of equilibrium is reached. Infection with highly virulent BVDV strains causing severe clinical signs and death after acute infection gives rise to substantial economic losses. In 1992, Denmark had an estimated annual incidence of acute infections of 34%, and the total annual national losses were estimated to be US$ 20 million ***(2).***

Calculations of the herd level losses due to so-called 'classical' outbreaks of BVDV, where most transient infections go unnoticed, and where most losses are associated with reproductive disorders and PI animals, have fallen within the range of 21 euros to 135 euros per cow in the outbreak herd. In contrast, losses from outbreaks due to BVDV occurring simultaneously with other infections, or to highly virulent strains causing severe disease and high mortality (also among transiently infected animals), have been estimated to be more than 340 euros per cow in the outbreak herd ***(4).***

As an alternative to calculating losses observed in real cases, mathematical modelling can be used to estimate the mean losses over several years. For beef herds, an estimated mean loss of 54 euros per cow per annum was calculated. Calculations at the national level performed to date have been based on estimated parameters of incidence risks and probabilities of losses due to different types of outcomes of BVDV infection. Based on estimations from the UK, Norway and Denmark, the national losses at the population level, under endemic conditions, have been estimated to be in the range of 8.5 euros to 34 euros per calving. The losses due to the occurrence of a highly virulent strain in a population have been estimated as 48 euros per calving. It is clear that BVDV infections have a significant impact on the competitiveness of European cattle industries. It should be noted that many of the economic estimates mentioned above were based on publications older than ten years. It is therefore reasonable to assume that the figures would be considerably higher today ***(4).***

As part of an evaluation of alternative mitigation programs for Switzerland, the baseline disease costs were estimated using epidemiological modelling predictions at 16 million CHF for 2008 and 15 million CHF for 2009 ***(7).***

Although the economic impact of BVDV is largely due to the effects of acute infections, PI animals are the most common sources of virus and the most frequent vectors for introduction of virus into naive herds ***(11).***

Due to their naïve immune status, if Icelandic dairy herds were becoming infected they would be expected to suffer severe economic losses due to clinical disease, calf abortions and mortality, as well as other production losses. In addition, when diagnosed, according to Icelandic regulations, BVD positive herds would be the subjects to restrictions and other measures, and the government would be investing funds in the control and eradication of the infection. Diagnostic screening of in-contact and neighbouring herds would also be required.

In conclusion, the overall impact of these consequences is considered to be **high.**

Risk estimation

As the probability of entry into Iceland with imported Danish cattle is very low to low depending on the time horizon applied (10 or 20 years), the conditional probability of subsequent exposure of Icelandic dairy cattle is also very low to low despite the fact that the potential for spread is high. Once the very low or low probability of exposure is combined with the high impact of the consequences, the over-all risk is estimated to be **very low to low,** depending on the time horizon (10 or 20 years).

References

1. World Organisation for Animal Health (OIE) (2012). Chapter 2.4.8. Bovine Viral Diarrhoea. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, Vol 1, 7. ed. Available at: http://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.04.08_BVD.pdf
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Appendix 1 Definition of scenarios a and b

The following description of likely scenarios for imports of cattle to Iceland was kindly provided by Dr. Halldor Runolfsson on January 28, 2013:

a) "Individual farmers would be importing single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year".

b) "A farmer wants to start a pure bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 examples of this kind of imports".

This information was taken into account in the simulation model by defining PERT distributions with the following parameters to be used in the respective simulations:

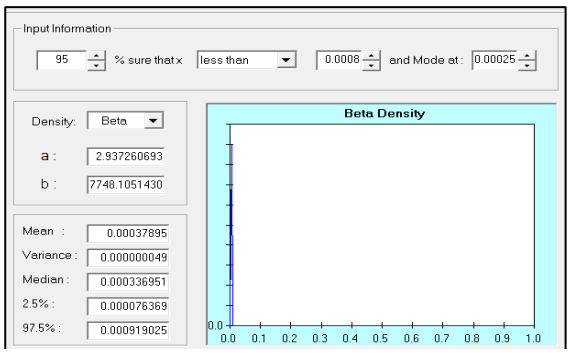
Scenario a:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).		
	# lots/year	# animals/lot
min.	0	1
mean	10	1
max.	20	1

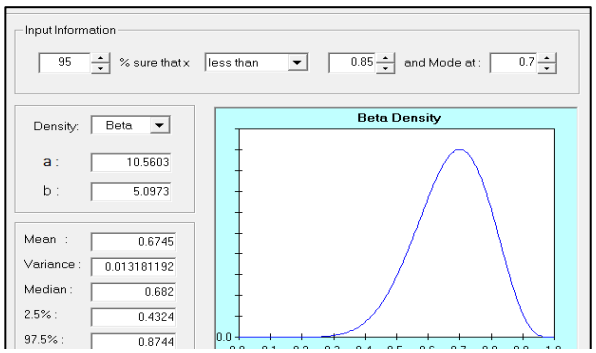
Scenario b:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).		
	# lots/year	# animals/lot
min.	0	1
mean	5	20
max.	10	30

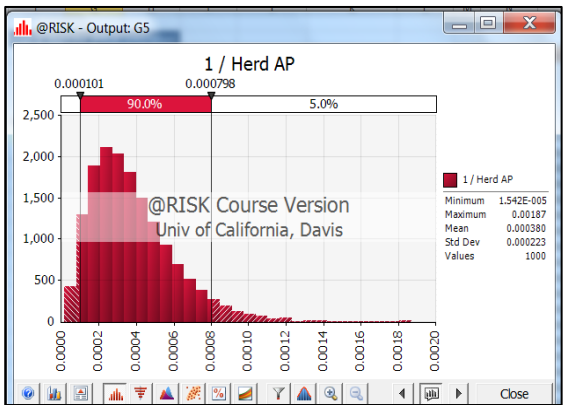
Appendix 2 BVD scenario a



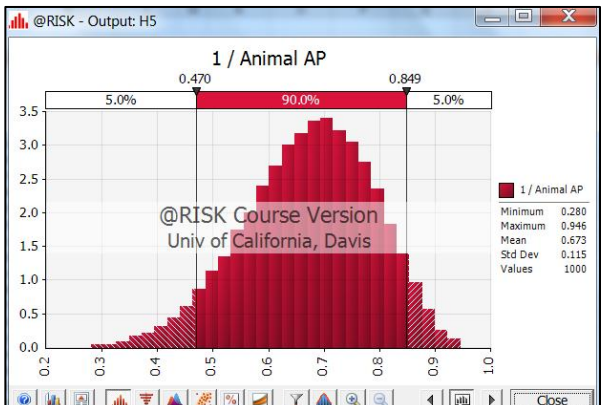
Herd prevalence beta-distribution



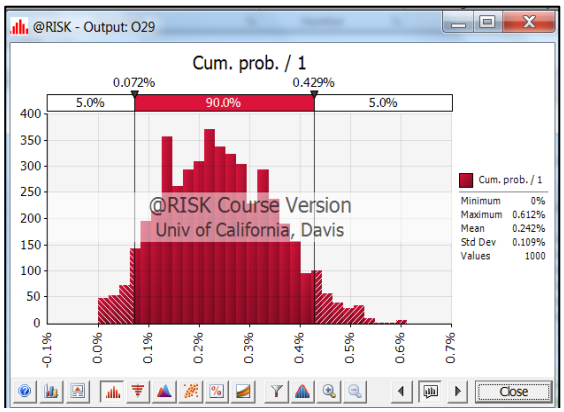
Within-herd prevalence beta-distibution



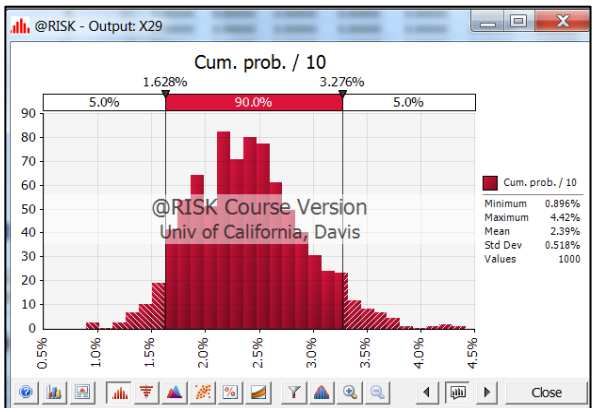
Herd prevalence input values, 1000 simulations



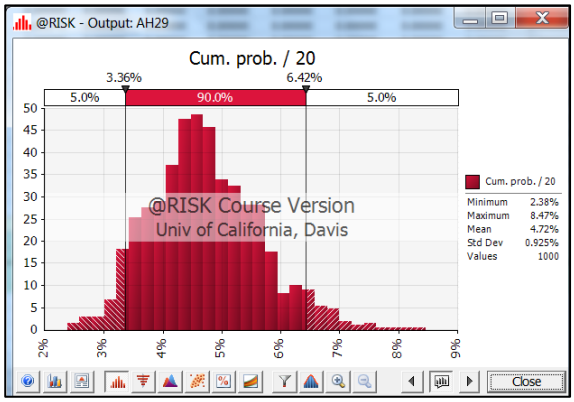
Within-herd prevalence input, 1000 simulations



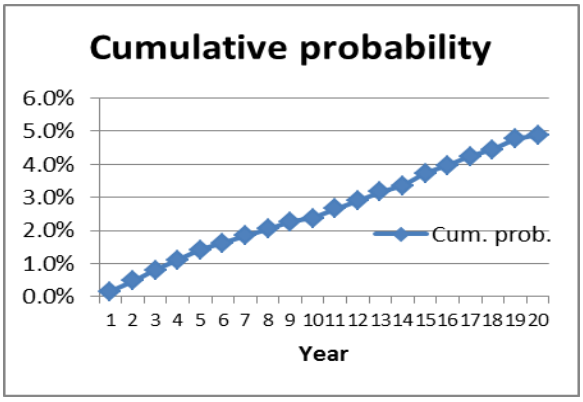
Entry probability during 1 year



Entry probability during 10 years

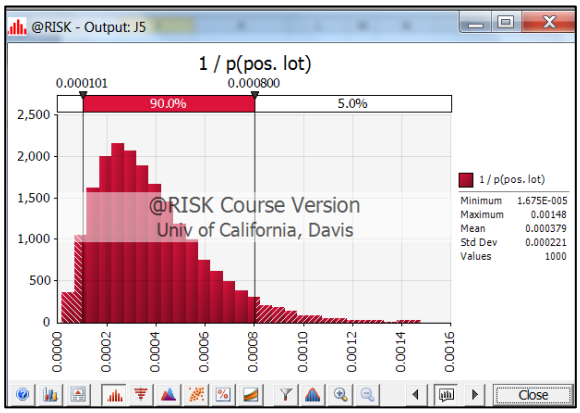


Entry probability during 20 years

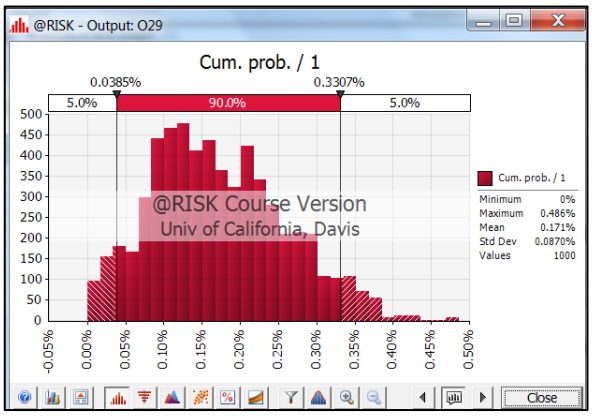


Cumulative entry probability, single simulation

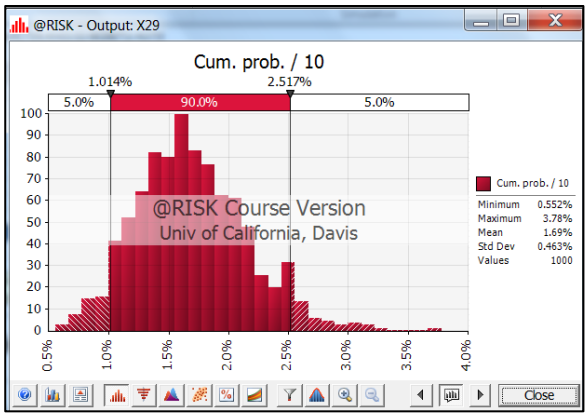
Appendix 3 BVD scenarios b and the combined a or b



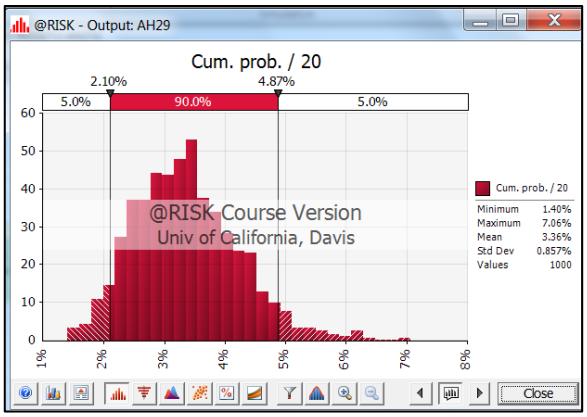
Entry probability for a single consignment



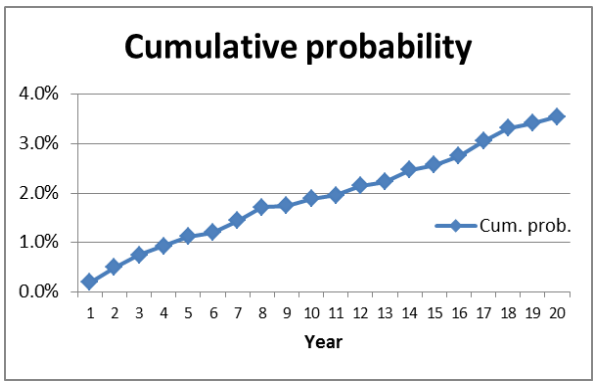
Entry probability in 1 year



Entry probability in 10 years



Entry probability in 20 years



Entry probability plot, single simulation

Mean simulated cumulative entry probabilities for Scenarios a, b and the combined a or b

Year	Scenario a	Scenario b	Scenario a or b
1	0.242%	0.171%	0.41%
10	2.39%	1.69%	4.04%
20	4.72%	3.36%	7.92%

Section 4 *Coxiella burnetii* infections and Q fever in cattle

Scope and purpose of the import risk assessment

This risk assessment identifies and estimates the likelihood of *Coxiella burnetii*, the agent causing Q fever, being introduced, becoming established and spreading among Icelandic cattle farms, together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing cattle (*Bos taurus*) from Denmark.

According to the opinion of an Icelandic expert as described in Chapter 6 Appendix 1, the following two scenarios are likely to occur for cattle imports to Iceland:

a) Individual farmers might want to import single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.

b) A farmer might want to start a pure-bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 occasions of such imports per year.

A short introduction to the infection and disease

Q fever is a zoonosis caused by *Coxiella burnetii* that is prevalent throughout the world, except in New Zealand and Iceland. Goats, sheep and cattle are the livestock species most frequently infected. Infection in these species is usually subclinical, but abortions do occur in naïve goats, sheep and occasionally cattle. Abortion storms due to Q fever that affect several herds over a large geographical area are unusual. Infection in humans usually follows exposure to infected livestock that are shedding the organisms during parturition or abortion or inhalation of contaminated aerosols. Frequently the human infections are mild with influenza-like symptoms. However, this illness is associated with a wide clinical spectrum, from asymptomatic or mildly symptomatic seroconversion to fatal disease ***(1, 2).***

Hazard identification

Coxiella burnetii is a small obligate intracellular gram-negative bacterium, which has been reclassified from the order *Rickettsiales* to *Legionellales*, and falls in the gamma group of *Proteobacteria* ***(1).***

Q fever is included among the OIE listed diseases and infections, but there is no chapter on the disease in the Terrestrial Animal Health Code. However, the OIE Manual's Chapter 12.1.12 includes an extended review of the infection together with the technical descriptions of diagnostic procedures, etc***. (3).***

Q fever is a notifiable disease in Iceland on list B. *Coxiella burnetii* and Q fever have never been found in Iceland in cattle, sheep or goats. Surveillance was initiated in 2012..

In Denmark, Q fever is notifiable on lists 2 and 4 for cattle, and on lists 1 and 3 for small ruminants.

Risk assessment

Entry (Release) assessment

Status in ruminants in European countries

Infection is endemic in domestic ruminants in most, if not all, EU member states, however, disease is rare and impact is limited. A recent EFSA opinion on Q fever also included a review of available surveillance data from Europe. However, because of the lack of harmonization of the monitoring program and tests being used in the various EU MS, a comparison of the occurrence of *C. burnetii* infection in animal populations between different EU MS is subject to considerable bias and therefore associated with considerable uncertainty ***(4).***

A recent comprehensive literature review covered published apparent prevalences of Q fever in cattle, sheep and goats at the animal, herd and within-herd levels. The overall median values for cattle were 19.9%, 37.7% and 26.3%, respectively, but with considerable variation among the different studies. Slightly lower values were found for sheep and goats, but with similar variations as among cattle ***(5).***

In a recent Dutch study, the herd prevalence was 78.6% for ELISA and 56,6% for PCR in cattle BTM samples collected in 2007, but the animal-level prevalence in blood samples was just 16% in cows and 1% in young animals in 2008. The median within-herd prevalence by ELISA was 11.4% and by PCR it was 6.7%. There was a relatively strong correlation (0.68) between within-herd ELISA and within-herd PCR ***(6).*** The Dutch situation for small ruminants in 2008 was investigated in another study. In sheep 2.4% were sero-positive and in goats 7.8% were positive in ELISA. In 14.5% of the sheep flocks and 17.9% of goat herds there was at least one positive animal. In positive sheep flocks the within-herd prevalence was 14.8% and in goat herds it was 29% ***(7).***

A study from Ireland found 37.9% of BMT samples and 1.8% of sera to be antibody positive ***(8).*** From Northern Ireland using serum ELISA a study found 6.2% of cattle from 48.4 % of herds to be positive. In sheep the sero-prevalence was 12.3% in animals and 62.1% in herds, while in goats the sero-prevalence was 9.3% of animals and 42.9% of flocks ***(9).***

In Spain, a study in sheep found antibodies against *C. burnetii* in 40% of BTM samples from 154 flocks with a mean flock sero-prevalence of 34.4%. The PCR- and ELISA-values were significantly correlated ***(10).***

Status in Danish cattle

Antibodies to the infection are commonly found in Danish cattle (milk and serum) and subclinical infections are frequent. Sporadic clinical cases in ruminants are not uncommon and associated with abortion and other reproductive problems ***(11).***

In Denmark, 57% of 742 non-randomly selected dairy herds were found to be ELISA positive in bulk tank milk samples ***(12),*** whereas in a more recent study 59% of 100 randomly selected herds were found to be antibody positive ***(13).*** At the individual animal level, a study found that on average across three sampling rounds in 12 herds, 10 of which were bulk tank milk (BTM)-positive, 25% of the individual milk tests were sero-positive and 32% were positive for *C. burnetii* DNA. There was a considerable variation among the herd prevalences for both test methods: 2% - 87%, and 2% - 93%, respectively. However, a significant statistical association was found between the antibody titer and the simultaneous DNA shedding level ***(14).*** A more recent study reported 20 – 25% animal level sero-prevalence ***(15).***

Simulation of the Coxiella burnetii infection status of Danish cattle consignments determined for export to Iceland

A simulation model was developed to estimate the probability of the presence of at least one infected animal in a series of exports from Denmark. The model was applied to *Coxiella burnetii* infections in exports of live cattle to Iceland.

Two import scenarios were assumed by an Icelandic expert to be realistic are described earlier in this section and in Appendix 1.

A set of different parameters describing the probability of *Coxiella burnetii* infections in Danish cattle at the herd and within-herd or animal levels was assembled from the scientific literature and by personal communications with Danish experts. To estimate beta-distributions for use in the simulations, the software BetaBuster ***(16)*** was applied to the set of Danish *Coxiella burnetii* prevalence data, as shown in Appendix 2. Appendix 3 and 4 describe in more details the simulation inputs and results for scenarios a and b, respectively. Appendix 5 summarizes the results, including the estimates of the probabilities of the release of *C. burnetii* in Iceland with imported Danish cattle across selected spans of cumulated years, as also shown in the table below for the two of the four possible sets of parameter estimates used in the simulation modeling (see Appendix 2). Very similar entry probabilities were found for both sets of parameters, showing that the entry probabilities are high, approaching certainty within 1 to 5 years of importing.

Table 69 Simulated mean cumulated probabilities of entry in scenarios a, b and their combination

Parameter Set I:

Year	Scenario a	Scenario b	Scenario a or b
1	80%	82%	96%
5	100%	100%	100%
10	100%	100%	100%
20	100%	100%	100%

Parameter Set II:

Year	Scenario a	Scenario b	Scenario a or b
1	89%	99%	100%
5	100%	100%	100%
10	100%	100%	100%
20	100%	100%	100%

In conclusion, the entry probability for Q fever is **high** with imported Danish cattle to Iceland.

Exposure assessment

It has been reported, that goats that live in close contact can become infected with *C. burnetii*, e.g. trough abortions ***(2).*** Also, 40% of uninfected cows that were imported into an area of endemic infection became infected within 6 months ***(1).*** Animals remain infected for years, and probably for life ***(3).***

A serological reaction does not necessarily indicate an active infection, but the newer PCR methods detect bacterial DNA and are therefore believed to give a better estimate of the shedding potential of the animals tested. When investigating the potential sources of bacteria being shed, samples of milk, faeces and vaginal mucus were all found to contribute, and no single source would provide a good relative sensitivity of detection ***(17).***

There is therefore a high probability that if *Coxiella burnetii* enters Icelandic cattle herds, it will spread to other cattle and sheep, as these are often reared and housed together on the same farms. Direct and indirect contacts in the traditional Icelandic housing, grazing and management systems will promote spreading to other herds. The Icelandic ruminant populations are naïve with respect to this infection, and the degree of susceptibility of the indigenous breeds is unknown.

In conclusion, the probability that *Coxiella burnetii* will become established in and spreading among Icelandic cattle herds, as well as sheep and goat flocks, is **high**.

Consequence assessment

Subclinical infections will most likely dominate among the occurrence of *Coxiella burnetii* infections in ruminants in Iceland, but sporadic clinical cases of abortions or births of weak or dead calves, lamb or kids may occur. In some herds the abortion rate may be quite high causing "abortion storms", which not only is an economical problem for the farmers, but it also increases the risk of spreading the infection to humans in the area ***(18 - 21).***

Breed differences in susceptibility to *Coxiella*-infections have been reported ***(8, 9, 15),*** and it is not known if the indigenous Icelandic cattle and sheep breeds may possess more or less resistance to infection and disease than found with other breeds.

Most frequently, human infections are mild with influenza-like symptoms. However, this illness is associated with a wide clinical spectrum, from asymptomatic or mildly symptomatic seroconversion to fatal disease ***(1).***

In 2007 – 2009, there was a serious human epidemic in the Netherlands affecting more than 3500 people and being a contributing factor to the deaths of at least 6 people within an area, where there had been a high number of clinical cases with abortions in goat flocks. More than 50,000 goats were subsequently slaughtered to help in the control of the outbreak ***(18 - 20).*** It seems that the infection had become endemic in the human population in the Netherlands between 1953 and 1983, and sporadic human cases have been recorded since the infection became notifiable in 1975 ***(19).***

In 2010 EFSA concluded, that *Coxiella burnetii* infection is endemic in domestic ruminants in most, if not all, EU member states, however, disease is rare in ruminants and the impact is limited. In the EU, Q fever is a zoonotic disease with limited public health impact, except under certain epidemiological circumstances and for particular risk groups. Human cases are often associated with proximity to small ruminants, particularly at parturition or during abortions ***(4).***

Within the EU MS, infections with *Coxiella burnetii* are common both in ruminants and humans, but clinical disease is rare with few exceptions, e.g. veterinarians and farmers assisting with ruminant parturition. If the infection is brought to Iceland, the naïve populations of indigenous dairy and sheep breeds might develop more severe clinical disease and larger outbreaks, with higher public health risk than seen elsewhere in Europe, where the overall impact of the infection is considered to be limited.

In conclusion, the impact of the animal and public health consequences of *Coxiella burnetii* infections and associated disease is estimated to be **low**. However, due to the significant uncertainty about the consequences under the specific Icelandic conditions, a **moderate** impact cannot be excluded.

Risk estimation

There is a **high** probability of introducing *Coxiella burnetii* to Iceland with import of Danish cattle according to the Icelandic expectations during a one year period, which over a few years results in almost certainty of entry (see Appendix 5).

The probability of Icelandic cattle and sheep herds being exposed to *Coxiella burnetii* through imported Danish cattle is **high** due to the traditional housing and grazing system and the shedding of the bacteria from persistently infected animals through several pathways.

Q fever is a notifiable disease in Iceland and there would be economic consequences of any outbreaks occurring, both for the farmers and for the government. The economic losses and potential public health threats may in some, rare instances be serious, but would in most cases be considered as **low.** There is,

however, uncertainty about how the infection would behave in the indigenous Icelandic cattle and sheep breeds under Icelandic conditions.

In conclusion, by importing cattle from Denmark, the likelihood *of Coxiella burnetii* being released is high, as is the probability that the Icelandic cattle and sheep populations become exposed and the infection spreading among Icelandic farms. This may lead to moderate losses to dairy and sheep farmers and to the government, as well as to sporadic human cases, but it is unlikely to become a serious threat to animal and public health. The risk associated with *Coxiella burnetii* infections and Q fever in Icelandic cattle and sheep populations is estimated to be **low.** However, due to a significant uncertainty about the impact under Icelandic conditions, a **moderate** risk cannot be excluded.

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Appendix 1 Definition of scenarios a and b

The following description of likely scenarios for imports of cattle to Iceland was kindly provided by Dr. Halldor Runolfsson on January 28, 2013:

a) Individual farmers would be importing single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.
b) A farmer wants to start a pure bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 examples of these occassions (per year).

This information was taken into account in the simulation model by defining PERT distributions with the following parameters to be used as input to the simulations:

Scenario a:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

	# lots/year	# animals/lot
min.	0	1
mean	10	1
max.	20	1

Scenario b

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

	# lots/year	# animals/lot
min.	0	1
mean	5	20
max.	10	30

Appendix 2 Beta distributions for *Coxiella burnetii* prevalences

Population level	No. of herds	Mode	Percentile	Beta (a, b)	Figure	Reference
Herd		0.59	95%<0.80	(7;5)	1	***(13)***
Herd		0.38	95%<0.80	(1.9;2.5)	2	***(11)***
Within-herd		0.25	95%<0.85	(1.2;1.7)	3	***(14)***
Within-herd		0.41	90%<0.66	(3.4;4.4)	4	***(22)***

Herd-level prevalences

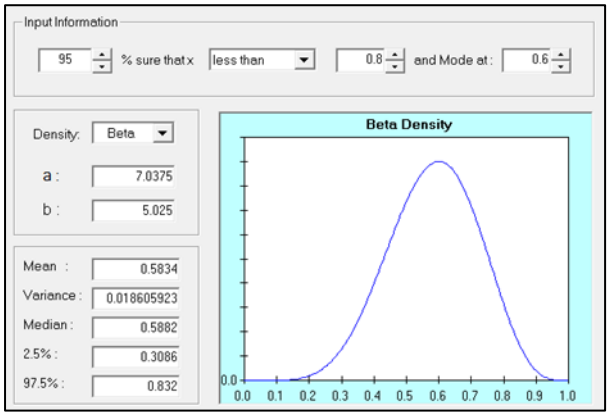


Figure 1

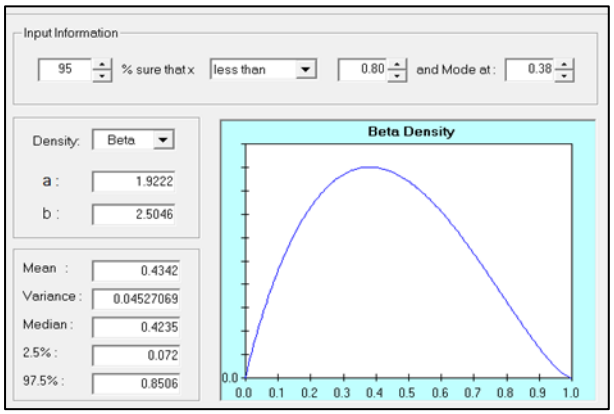


Figure 2

Parameter Set I: Figure 1 and Figure 4

Within-herd prevalences

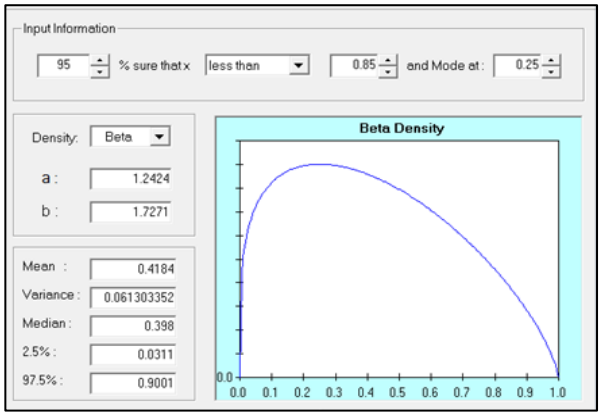


Figure 3

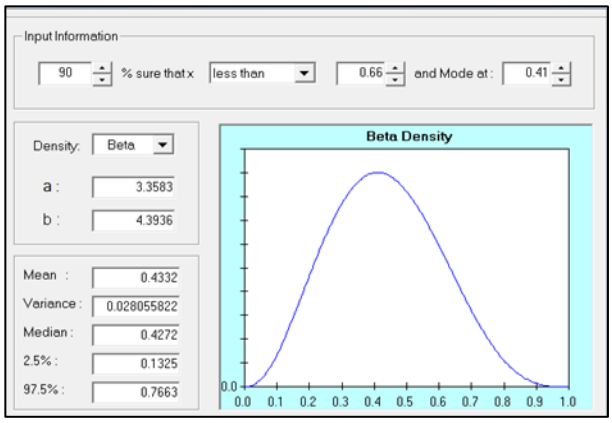
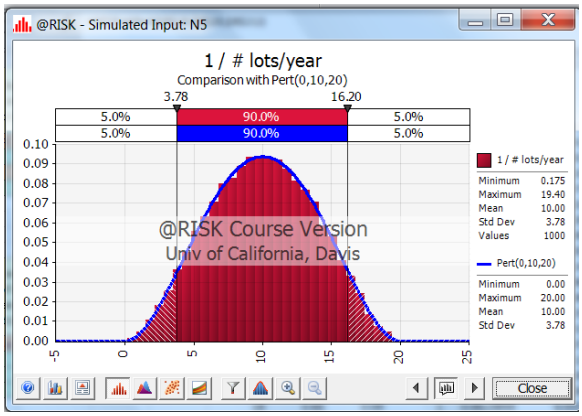


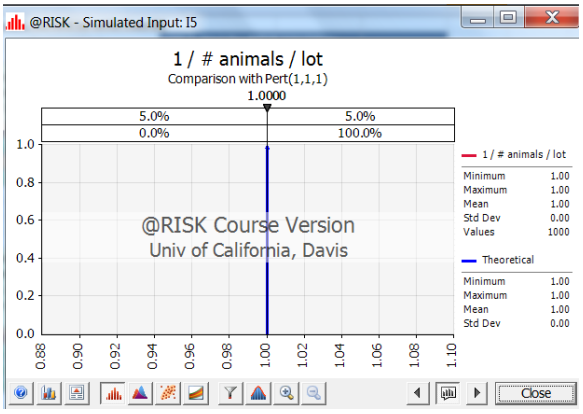
Figure 4

Parameter Set II: Figure 2 and Figure 3

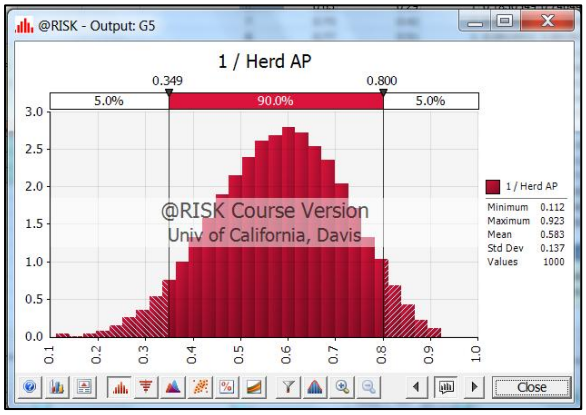
Appendix 3 Scenario a - Input distributions and results



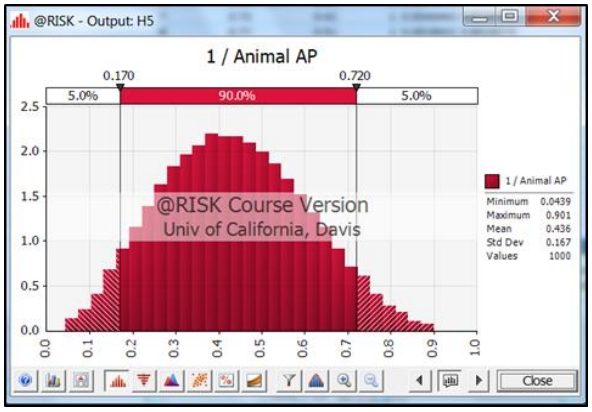
Input: Number of consignments per year



Number of animals per consignment; here always 1



Herd prevalence input 1000 simulations, Fig. 1

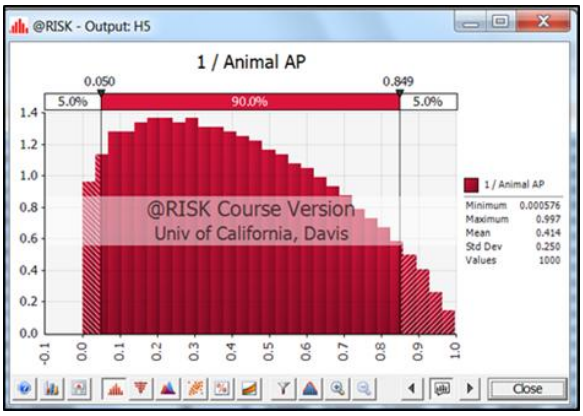


Within-herd prevalence input, cf. Fig. 4

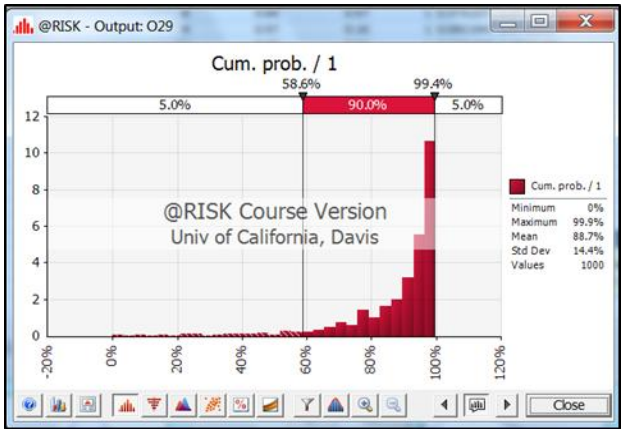
Parameter Set I

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	7	3.4
b	5	4.4

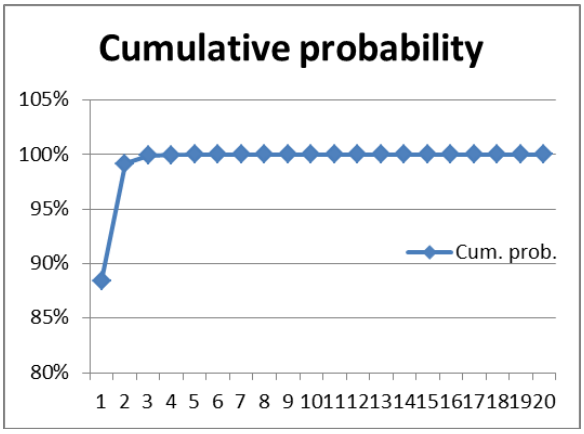
Parameters for: Fig. 1 Fig. 4



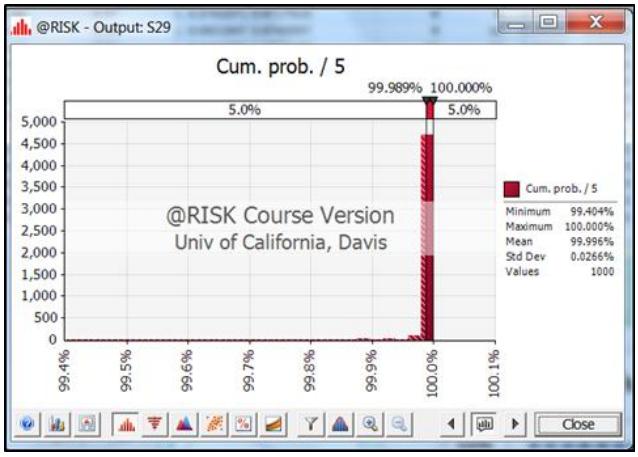
Within-herd prevalence, cf. Figure 3



Entry probability after 1 year, 1000 simulations



Cumulative entry probability, single simulation

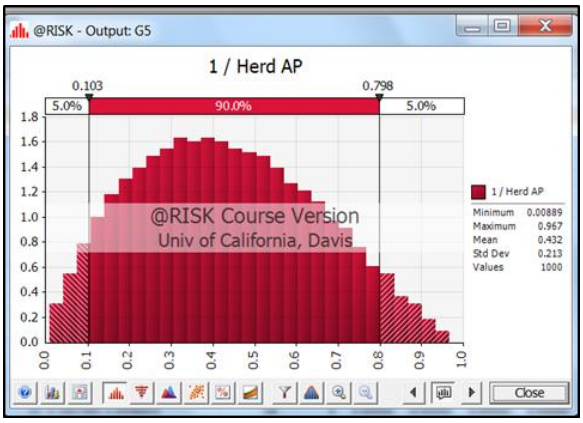


Entry probability after 5 years, 1000 simulations

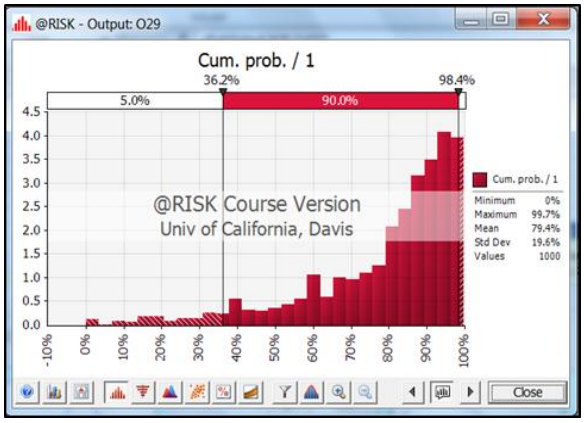
Parameter Set II

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	1.9	1.2
b	2.5	1.7

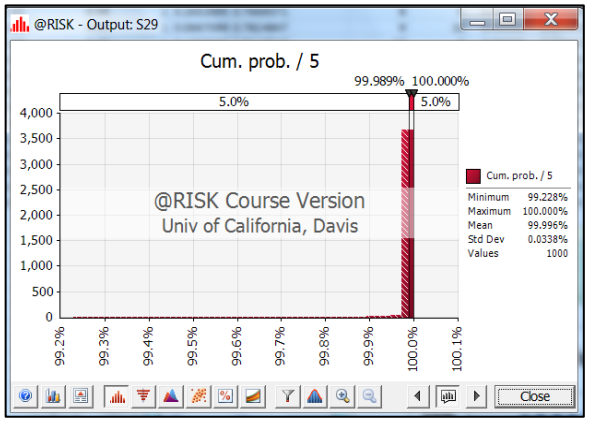
Parameters for: Fig. 2 Fig. 3



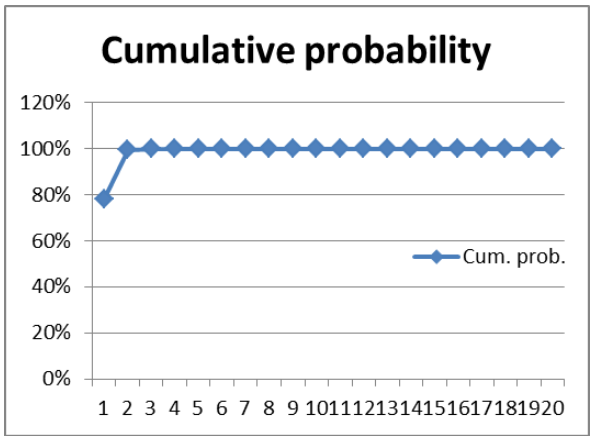
Herd-level prevalence input, cf. Fig. 2



Entry probability after 1 year

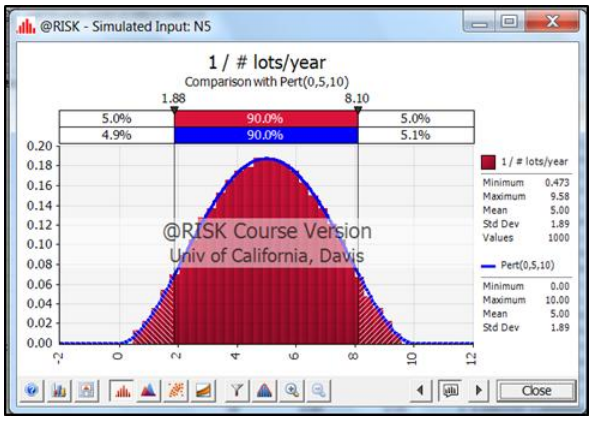


Entry probability after 5 years

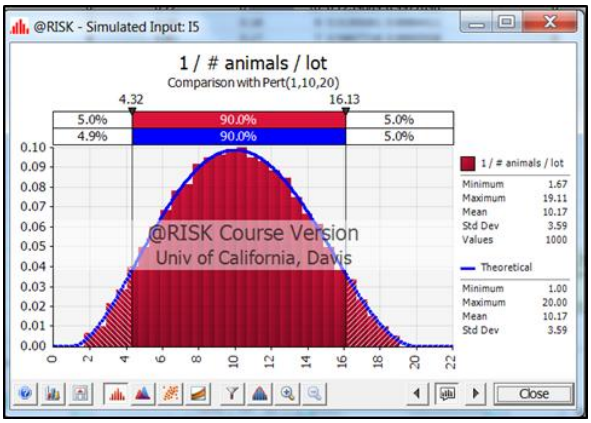


Cumulative entry probability, single simulation

Appendix 4 Scenario b input distributions and results



Number of consignments per year

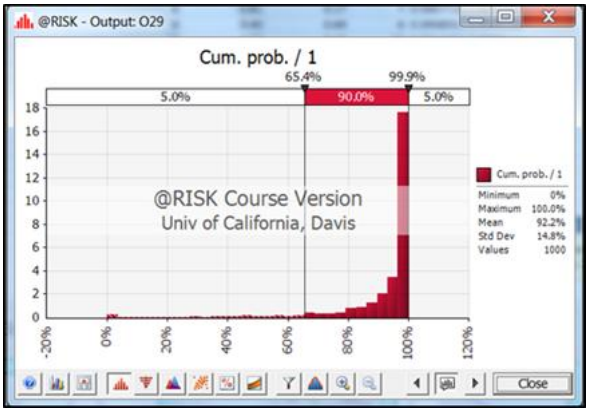


Number of animals per consignment

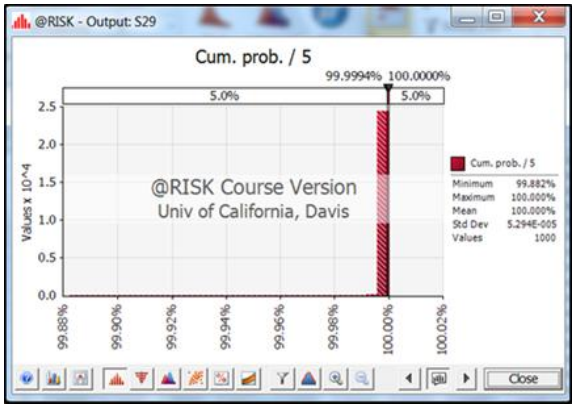
Parameter Set I

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	7	3.4
b	5	4.4

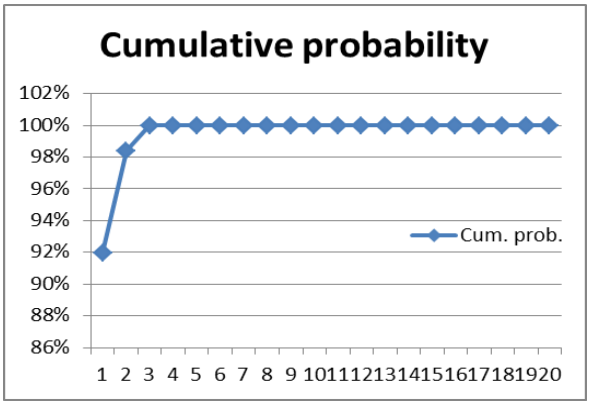
Parameters for: Fig. 1 Fig. 4



Entry probability after 1 year



Entry probability after 5 years

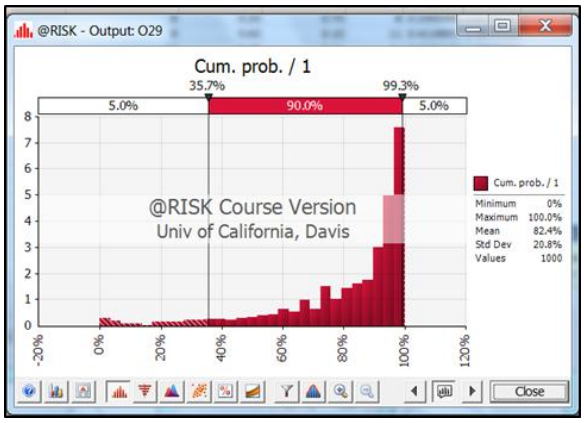


Cumulative entry probability, single simulation

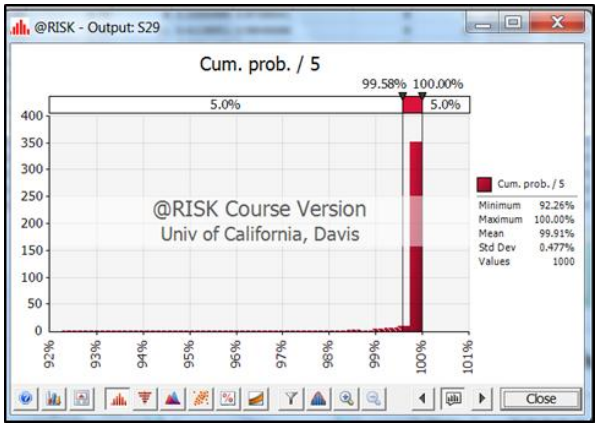
Parameter Set II

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	1.9	1.2
b	2.5	1.7

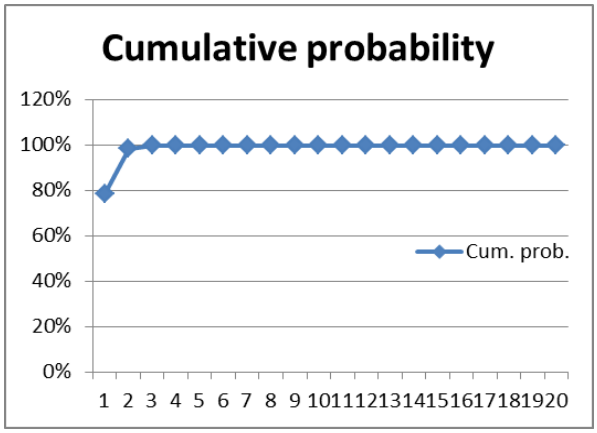
Parameters for: Fig. 2 Fig. 3



Entry probability after 1 year



Entry probability after 5 years



Cumulative entry probability, single simulation

Appendix 5 Combining the results of scenarios a and b

Since the two import scenarios most likely would occur simultaneously within a given year, their respective probability of entry should be combined to give the overall probability of entry of Q fever from the import of Danish cattle to Iceland:

p(a & b) = 1-(1-p(a))*(1-p(b))

Simulated mean cumulative probabilities of entry in Scenarios a, b and the combined a or b

Parameter set I

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	7	3.4
b	5	4.4

Year	Scenario a	Scenario b	Scenario a or b
1	80%	82%	96%
5	100%	100%	100%
10	100%	100%	100%
20	100%	100%	100%

Parameter set II

Define the beta distributions for the herd-level apparent prevalence and the within-herd-level apparent prevalence of C.b.		
Beta	Herd AP	Animal AP
a	1.9	1.2
b	2.5	1.7

Year	Scenario a	Scenario b	Scenario a or b
1	89%	99%	100%
5	100%	100%	100%
10	100%	100%	100%
20	100%	100%	100%

Section 5 *Salmonella* Dublin infections in cattle

Scope and purpose of the import risk assessment

This risk assessment identifies and estimates the likelihood of *Salmonella enterica* subspecies *enterica* serovar Dublin (*Salmonella* Dublin*)* infections in cattle being introduced, becoming established and spreading among Icelandic cattle farms, together with the likely magnitude of potential consequences for animal health and production, as a result of importing cattle (*Bos taurus*) from Denmark.

According to the opinion of an Icelandic expertas described in Chapter6 Appendix 1, the following two scenarios are likely to occur for cattle imports to Iceland:

a) Individual farmers might want to import single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year.
b) A farmer might want to start a pure-bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 occasions of such imports (per year).

A short introduction to the infection and the disease

Salmonella enterica subspecies *enterica* serovar Dublin (*Salmonella* Dublin) receives much attention in the cattle industry for several reasons. *Salmonella* Dublin causes economic losses and welfare consequences from disease and death among calves and young stock, decreased milk yield, as well as abortions and reproductive disorders among adult cattle, all of which contribute to extra labour and increased veterinary expenses ***(1-5).***

Salmonella Dublin is also a foodborne zoonotic bacterium that can cause severe invasive infections in humans, usually after consumption of contaminated milk products that have not been pasteurized properly or of insufficiently cooked beef. The infection can lead to higher fatality rates than other serotypes found in hospitalized patients, as high as 28.3% ***(3).***

Hazard identification

Salmonella Dublin is not on the OIE list of notifiable diseases and infections, and the chapter on salmonellosis in the OIE Manual has no specific information about S. Dublin, except that it is a cattle adapted serotype, which has been shown to cause serious disease in humans ***(6).***

All intestinal salmonella infections in domestic animals are notifiable in Iceland, see Chapter 5.

In Denmark, *S*. Dublin is not on the lists of notifiable diseases and infections, but there is a special regulation on salmonella in cattle describing the surveillance and control of *S*. Dublin ***(7).***

In conclusion, *Salmonella* Dublin infection is a potential hazard with respect to import of Danish cattle to Iceland.

Salmonella Dublin infections in cattle and humans

Salmonella Dublin is the serotype most frequently isolated from Danish cattle. In 2003 the herd sero-prevalence was approximately 26%. It was therefore deemed desirable to be able to control the infection in Danish cattle herds. In 2007 the Danish Cattle Federation initiated a campaign to eradicate *S*. Dublin from the Danish cattle population by the end of 2014. Since 2010 the control program has been regulated by the Danish Veterinary and Food Administration ***(4, 7).*** In Denmark the yearly incidence of human cases has been in the range of 10 – 50 cases ***(3).***

Carriers and shedding

A special feature of *S*. Dublin is its tendency to lead to persistent infections in some infected animals without clinical manifestations. Such long-term *Salmonella* Dublin carrier animals harbor the pathogen in lymph nodes and internal organs and can periodically shed bacteria through feces or milk, and contribute to transmission of the pathogen within and among infected herds. Even when the within-herd prevalence is low, carriers still appear. However, the sensitivity of the fecal culture test for detection of *S.* Dublin is poor: 6 – 14%. The superior sensitivity and negative predictive value for serum ELISA makes this test preferable to fecal culture as an initial screening test and for certification of herds not infected with *S.* Dublin ***(3, 5).***

Risk assessment

Entry (Release) assessment

Status in Danish herds

The Danish control program for *S*. Dublin has resulted in many scientific publications on risk factors and prevalence. The program has been successful and the overall prevalence of infected herds has been brought down from 26% in 2003 to 8.3% in 2013 (fig 13).

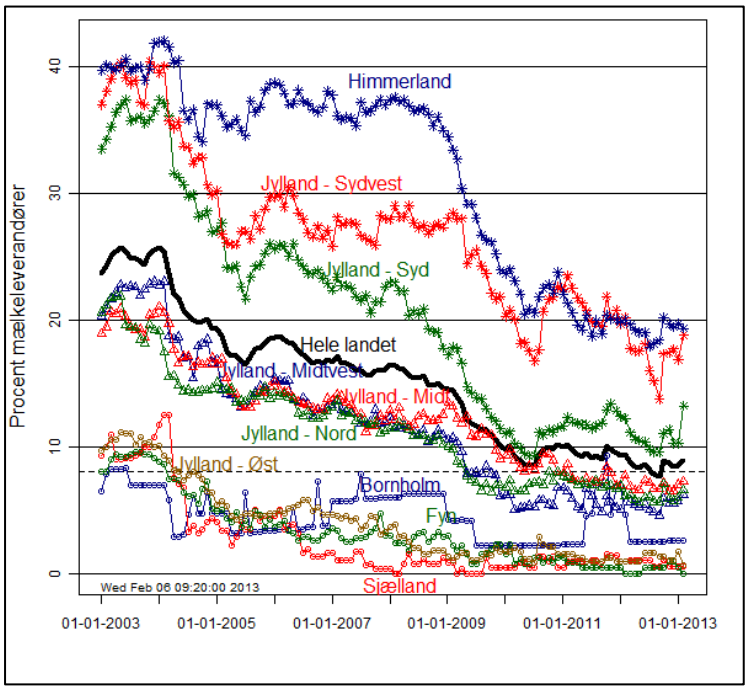


Figure 13 Percentage of S. Dublin positive dairy herds in Denmark by regions and overall ("Hele landet"), 2003 – 2013 (8).

Several published studies include detailed data on herd level and with-in herd prevalences, as described in the following. In a study based on data from 2000 - 2002, 12 bulk-tank-milk (BTM)-positive herds were intensively tested with fecal samples for culturing and serum and milk samples for ELISA testing. Herd-level estimates of apparent and true within-herd prevalence (Ap and Tp, respectively) based on the combined information from culture and ELISA tests showed that the Ap values ranged from 11% - 55%, the Tp values from 5 % – 76% ***(5)***. In another study it was found, that few herds had within-herd prevalence of > 5% without also having positive fecal sample. Also, there were no individual positive fecal samples or environmental samples from herds with < 5% within-herd prevalence ***(9).***

In another study using the data sampled during 2000 - 2002, within-herd prevalence of *Salmonella* Dublin was investigated during five herd visits at 3-month intervals of 14 endemically infected dairy herds. A total of 10,162 paired fecal cultures and antibody measurements were used to calculate the age and temporal dynamics of sero-prevalence and prevalence of positive fecal cultures. Fecal culture-positive prevalence was generally low. It was highest (5.4%) in calves during December to February. Sero- prevalence varied from 0% to 70% between herds and over time, but was generally more stable in young stock and adult cows than in calves. Sero-prevalence was associated with the bacteriological status in calves and cows, but not in young stock ***(10).***

In a modelling study of the Danish program, an empirical distribution of the fecal culture test results from 2000 -2002 was established. The distribution shows, that the median within herd prevalence was around 3% and the 95% percentile at around 10 % ***(11).***

Simulation of the Salmonella Dublin infection status of Danish cattle consignments determined for export to Iceland

A simulation model was developed to estimate the probability of the presence of at least one infected animal in a series of exports from Denmark over 1 – 20 calendar years. The model was parameterized for *Salmonella* Dublin infections in exports of live cattle to Iceland.

The two import scenarios a and b, which were provided by an Icelandic expert, are described above and in Appendix 1.

Two different sets of parameters describing the probability of *Salmonella* Dublin infections in Danish cattle at the herd and within-herd or animal levels were assembled from the scientific literature and by personal communications with Danish experts. To estimate beta-distributions for use in the simulations, the software BetaBuster ***(12)*** was applied to the set of Danish *Salmonella* Dublin prevalence data as shown in Appendix 2. Appendix 3 and 4 describe in more details the simulation inputs and results for scenarios a and b, respectively, using the different diagnostic test results available in authoritative reports from Denmark. Appendix 5 summarizes the results, including the estimates of the cumulative probabilities of the entry of *S.* Dublin in Iceland with imported Danish cattle across selected spans of cumulated years, as summarized in the tables below.

It should be noted, that the fecal-only testing is known to have a very low sensitivity (6 – 14 %), which explains the low apparent prevalence values recorded and estimated for this test ***(3).*** The difference when comparing fecal culture results to an antibody test prevalence estimate is partly due to the fact that the latter will include past as well as current infections, partly that the former test may be negative in some truly infected animals due to intermittent shedding. The cited and estimated fecal prevalences, therefore, should be considered as low estimates for the proportions of animals able to shed *S*.Dublin, which would be the ones able to spread the infection after arriving in Iceland.

Simulated mean cumulative probabilities of entry for import scenarios a, b and their combination, by diagnostic method used:

Ap fecal + ELISA

Year	Scenario a	Scenario b	Scenario a or b
1	31.4%	38.4%	57.7%
5	84.0%	89.8%	98.4%
10	97.2%	98.6%	100%
15	99.5%	99.8%	100%
20	99.9%	100%	100%

Tp fecal + ELISA

Year	Scenario a	Scenario b	Scenario a or b
1	37.7%	39.1%	62.1%
5	89.8%	90.4%	99.0%
10	98.7%	98.8%	100%
15	99.8%	99.8%	100%
20	100%	100%	100%

Fecal only[1]

Year	Scenario a	Scenario b	Scenario a or b
1	5.0%	16.1 %	20.3%
5	22.3%	56.8%	66.4%
10	39.4%	79.9%	87.8%
15	52.6%	90.1%	95.3%
20	62.8%	94.8%	98.1%

[1]Fecal only testing has a very low sensitivity (6-14%), see text above

ELISA only

Year	Scenario a	Scenario b	Scenario a or b
1	31.0%	38.1%	57.3%
5	83.5%	89.5%	98.3%
10	96.9%	98.5%	100%
15	99.3%	99.8%	100%
20	99.9%	100%	100%

In conclusion, the entry probability for the combined import scenario and using the results from ELISA only is **moderate** for a 1 year period and **high** for a period of 5 years or more.

The ELISA diagnostic method is the most commonly used both in practice and in epidemiological and economical studies of *S*. Dublin infections, and it yields intermediate probability estimates between the true prevalence estimates and the fecal culture estimates. The latter methods are likely biased in opposite

directions due to low specificity (due to past infections producing positive results) and low sensitivity (due to intermittent or low fecal shedding), respectively.

Exposure assessment

Purchase of animals as a risk factor for dairy herd infection

Analyses have identified that increased probability of successful Salmonella control was strongly associated with avoiding purchase of cattle from test-positive herds ***(2, 13).*** Similarly, purchase from test-positive cattle herds within the previous 6 months was associated with higher hazard of herds becoming test-positive compared to no purchase and purchase from test-negative herds ***(4).***

In a modeling study, the effects of introducing one infectious heifer on the risk of spread of S. Dublin within the herd and on the duration of infection were estimated through 1,000 simulation iterations for a number of scenarios. Overall, more than 60% of herds that were exposed to an infectious heifer had within-herd spread of infection ***(14).*** The risk of changing from test-negative to positive was also statistically significantly higher if a herd had purchased animals from test-positive herds in the previous quarter than if it had only purchased animals from test-negative herds or not purchased animals at all. Using the number of positive source herds instead of the number of purchased animals from test-positive herds also showed significant effect on the probability of changing the herd status from negative to positive ***(13).*** Also, restricting cattle movement between regions provided a strong benefit to those regions initially with a low prevalence of infection. The various measures used in the model to mimic enhanced biosecurity, i.e. less frequent trade of cattle, smaller consignments of cattle during trading, and less high-risk trading, were predicted to have a strong impact on the control of *S*. Dublin in Danish dairy herds ***(11).***

Introduction of cattle from a *S*. Dublin infected herd is recognized as being one of the most important risk factors for the infection to spread from an infected to a non-infected herd The traditional Icelandic dairy management system does not protect against this type of introduction of pathogens due to relatively low levels of within- and between herd biosecurity.

In conclusion, the probability of exposure and further spreading of *S.* Dublin to Icelandic dairy herds with imported Danish cattle is **high**, at least in the initial phase of unrestricted spread**.**

Consequence assessment

S. Dublin is a food-borne zoonotic bacterium that causes severe invasive infections in humans, usually after consumption of contaminated milk products which have not been pasteurized properly or of insufficiently cooked beef. The infection can lead to higher fatality rates than other serotypes found in hospitalized patients **(3).**

In cattle, *Salmonella* Dublin causes economic losses and welfare consequences from disease and death among calves and young stock, decreased milk yield, as well as abortions and reproductive disorders among adult cattle, all of which contribute to extra labour and increased veterinary expenses ***(1-5).***

In a recent Danish PhD-project, the economic consequences of *S*. Dublin in Danish dairy herds were investigated. *S.* Dublin's effects on calf mortality and milk yield as well as control elements for the infection were investigated. Results showed that there was an effect of *S*. Dublin infection in many dairy herds. It was found that *S*. Dublin BTM antibody positive herds had higher calf mortality than BTM negative herds, milk yield decreased after *S.* Dublin herd infection and high losses in gross margin (GM) were estimated per stall after introduction and within-spread of *S.* Dublin. Estimated GM losses were highest in the first year after infection, and increased with poorer management and herd size. GM losses were estimated at on average 57 Euros per individual stall for the first year after infection, and to 9 Euros per stall averaged over 10 years after herd infection for a 200 cow stall herd with very good management. In contrast, a 200 cow stall herd with poor

management would lose on average 315 Euros per stall in the first year, and 196 Euros per stall per year averaged over the 10-year period following infection. Specific management practices, especially avoiding purchasing animals from *S.* Dublin antibody positive herds were found to be associated with preventing exposure of calves to *S*. Dublin ***(15).***

In conclusion: *Salmonella* Dublin infections in cattle have great impact on the economy of dairy farmers because they cause disease and production losses in infected cattle herds. Since such infections are notifiable in Iceland, the animal health authorities would have to establish a surveillance and eradication program. For consumers and for public health authorities, probably rare, but serious and sometimes life-threatening foodborne infections in humans would be a consequence. The combined animal and public health consequences are therefore considered to be **high.**

Risk estimation

Salmonella Dublin infections in cattle have a **moderate to high** likelihood of entering Iceland with imported Danish cattle, although the on-going official Danish control program has effectively limited the spread, so that the prevalence among the Danish dairy herds has decreased to 8.3% of all herds.

Introduction of cattle is recognized as being one of the most important risk factors for the spread of the infection from an infected to a non-infected herd. The traditional Icelandic dairy management system does not protect against introduction and further spread of this type of pathogen due to relatively low levels of within- and between herd biosecurity. However, all salmonella infections are notifiable in Iceland and will be controlled by measures to limit the losses and the spread, but due to the occurrence of carriers, *S*. Dublin introduction would not always lead to obvious clinical problems in time to detect and control further spread. The exposure probability is **high** within and among Icelandic cattle herds**.**

Salmonella Dublin infections in cattle are of great concern to dairy farmers and to consumers, because they cause disease and production losses in infected cattle herds, and they can cause relatively rare, but serious and sometimes life-threatening foodborne infections in humans. The impact of these consequences is estimated as **high.**

In conclusion, by importing cattle from Denmark the annual probability of *Salmonella* Dublin entering into Iceland is moderate to high, and the probability that the Icelandic cattle population becomes exposed after an incursion and that the infection will spread among Icelandic cattle herds is high. The consequences are significant losses to dairy farmers and to the government, and consumers of Icelandic dairy and meat products will potentially experience fatal food borne infections. The impact of these consequences is estimated as **high**. The result is, that the annual risk is **moderate to high,** and the risk in the mid to long term is **high**.

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Appendix 1 Definition of scenarios a and b

The following description of likely scenarios for imports of cattle to Iceland was kindly provided by Dr. Halldor Runolfsson on January 28, 2013:

a) "Individual farmers would be importing single bulls for improving their herd by cross breeding. This could be ca. 10 animals per year".
b) "A farmer wants to start a pure bred herd and would import ca. 20 cows and a bull and then regularly import semen to improve the herd. There could maybe be ca. 5 examples of this kind of imports" (per year).

This information was taken into account in the simulation model by defining PERT distributions with the following parameters to be used in the respective simulations:

Scenario a:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

	# lots/year	# animals/lot
min.	0	1
mean	10	1
max.	20	1

Scenario b:

Enter the expected minimum, mean and maximum number of lots per year (min. 0 & max. 20) and number of animals per lot (min. 1).

	# lots/year	# animals/lot
min.	0	1
mean	5	20
max.	10	30

Appendix 2 Beta distributions for *Salmonella* Dublin prevalences

Population level	No. of herds	Median / mode	Percentile	Beta (a, b)	Test	Figure	Reference
Herd	3776	8.3%	90% <0.20	(3; 23)	BTM ELISA	1	***(6)***
Within-herd	12	32.5%	95% < 57	(4.7; 8.8)	Fecal+ELISA, Ap	2	***(5)***
Within-herd	12	42%	95% < 75	(2.9; 3.7)	Fecal+ELISA, Tp	3	***(5)***
Within-herd	31	3%	95% <0.10	(2.6; 53.6)	Fecal only	4	***(9)***
Within-herd	14	30%	95% < 0.60	(3.3; 6.3)	ELISA only	5	***(8)***

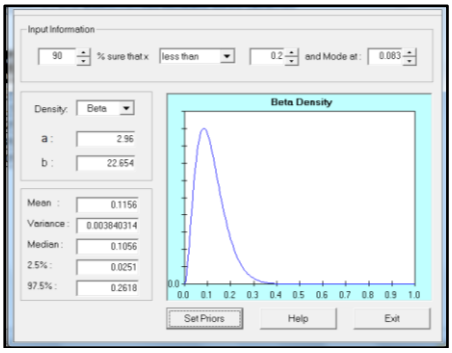


Figure 1 Herd-level apparent prevalence, BMT ELISA

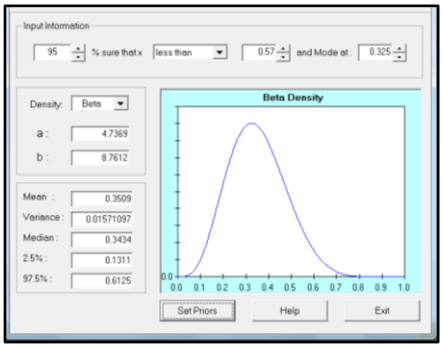


Figure 2 Within-herd apparent prevalence, fecal + ELISA

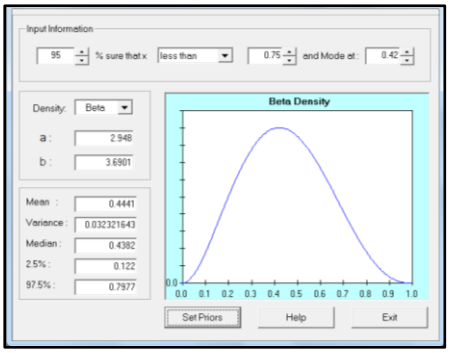


Figure 3 Within-herd true prevalence, fecal + ELISA

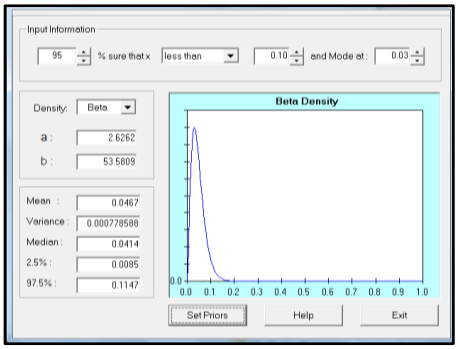


Figure 4 Within-herd apparent prevalence, fecal-only

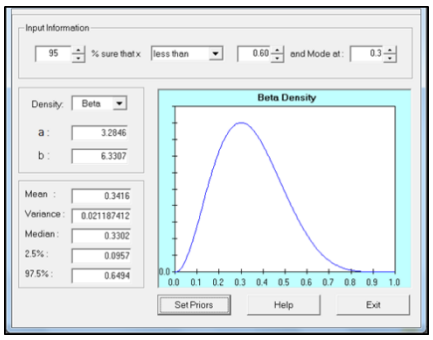
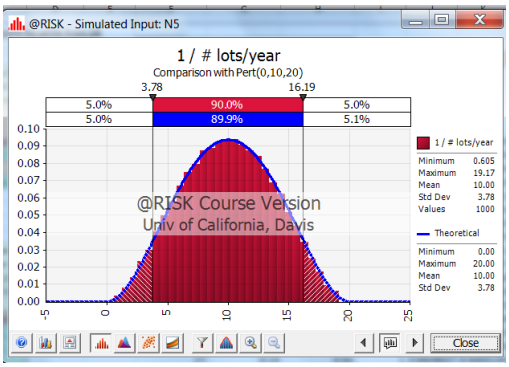


Figure 5 Within-herd apparent prevalence, ELISA-only

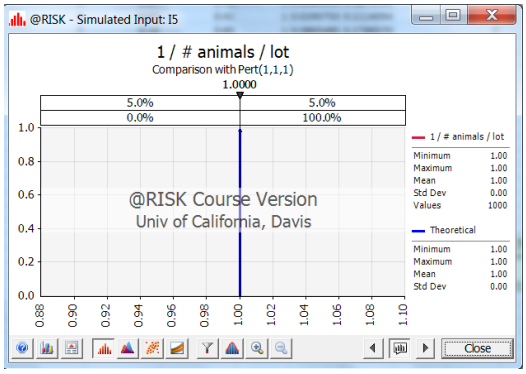
Appendix 3 Scenario a input distributions and results

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of S.D.		
Beta	Herd Ap	Animal Ap
a	3	4.7
b	23	8.8

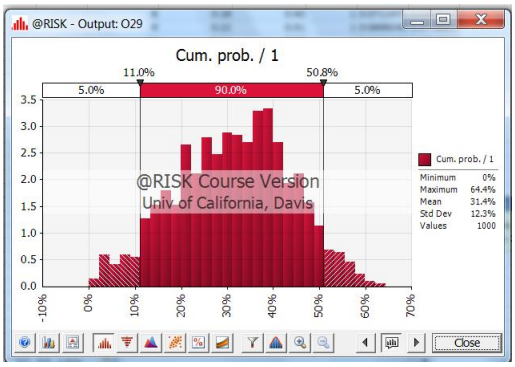
Ap: fecal + ELISA



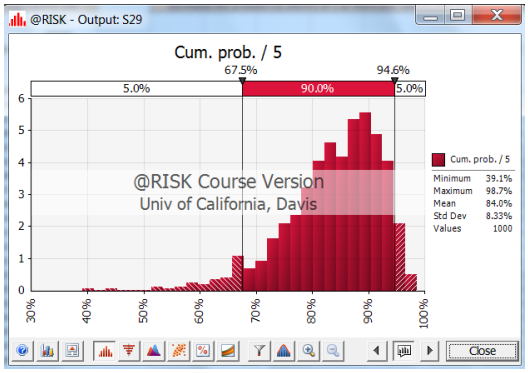
Number of consignments per year



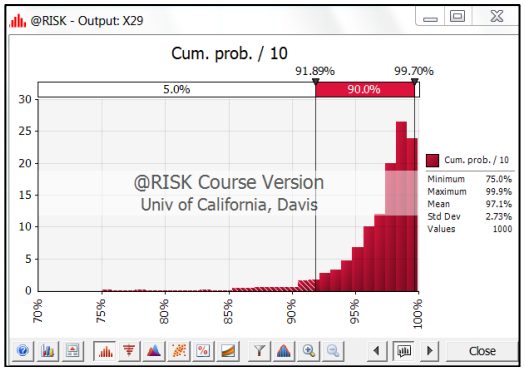
Number of animals per consignment, here 1



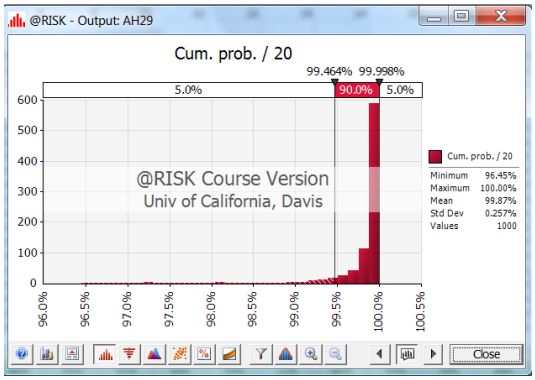
Entry probability after 1 year



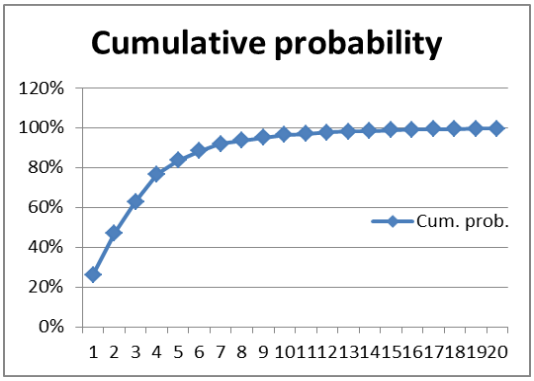
Entry probability after 5 years



Entry probability after 10 years

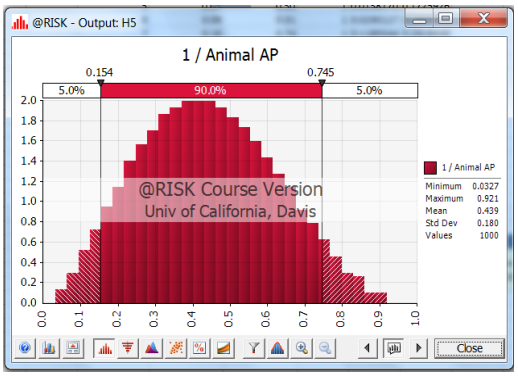


Entry probability after 20 years



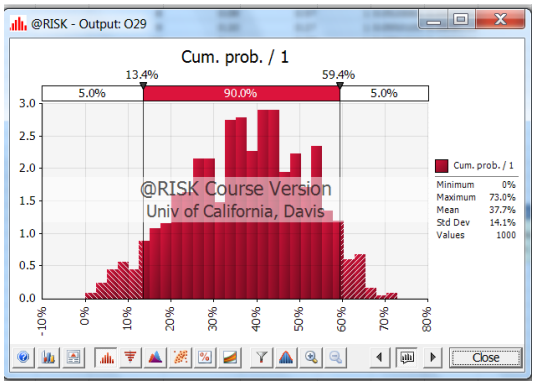
Cumulative entry probability, single simulation

Define the beta distributions for the herd-level apparent prevalence and the animal-level true prevalence of S.D		
	Herd Ap	Animal Tp
Beta 1	3	2.9
Beta 2	23	3.7

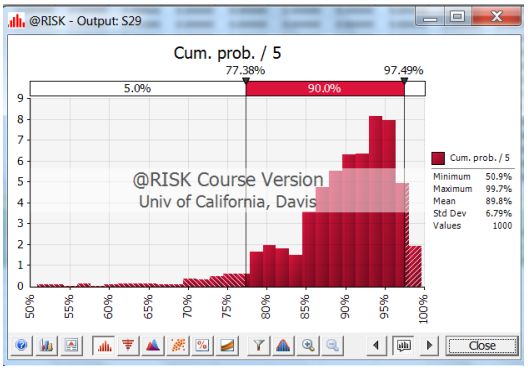


Tp: fecal + ELISA

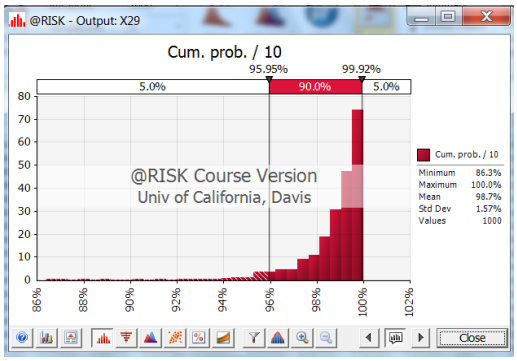
Within-herd prevalence distribution, input



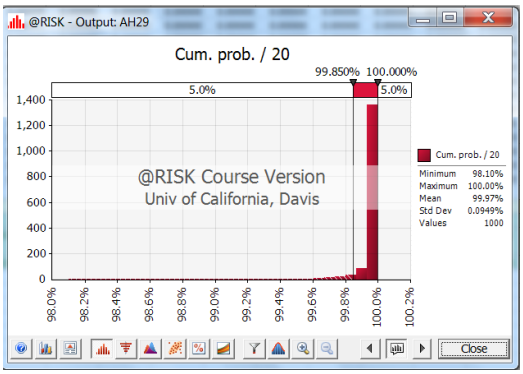
Entry probability after 1 year



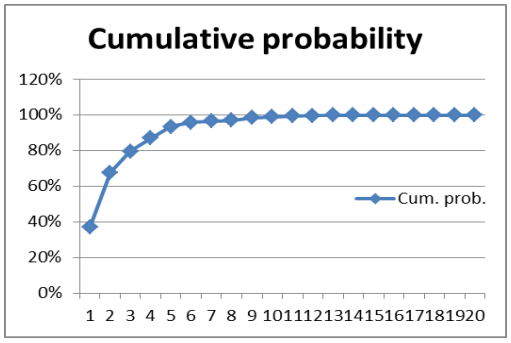
Entry probability after 5 years



Entry probability after 10 years



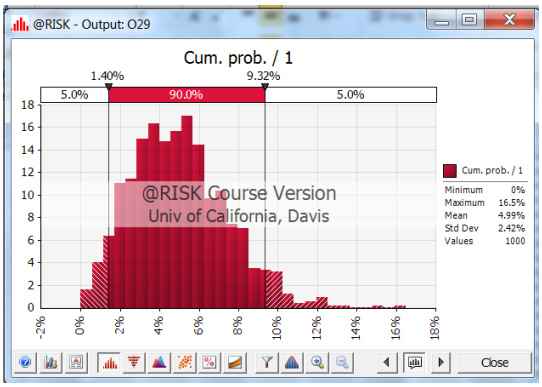
Entry probability after 20 years



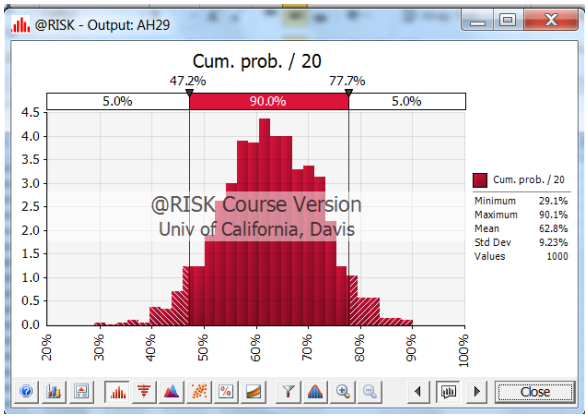
Cumulative entry probability, single simulation

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of S.D		
Beta	Herd Ap	Animal Ap
a	3	2.6
b	23	53.6

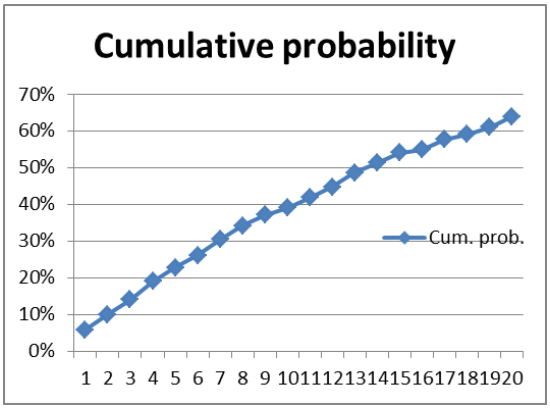
Fecal only



Entry probability after 1 year



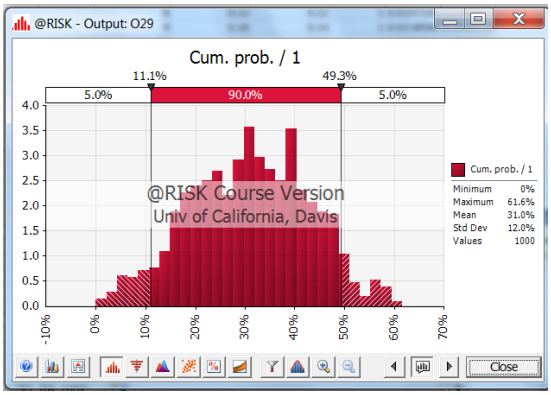
Entry probability after 20 years



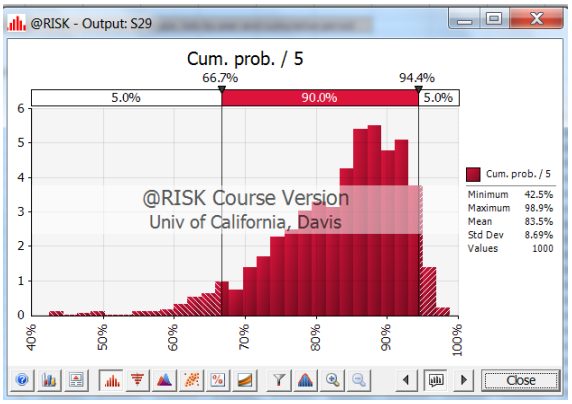
Cumulative entry probability, single simulation

Define the beta distributions for the herd-level prevalence and the animal-level prevalence of S.D.		
Beta	Herd Ap	Animal Ap
a	3	3.3
b	23	6.3

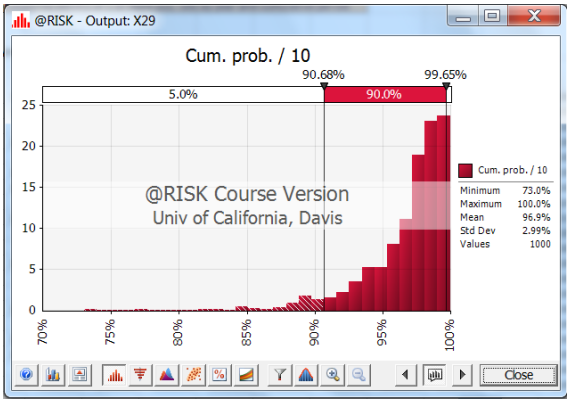
ELISA only



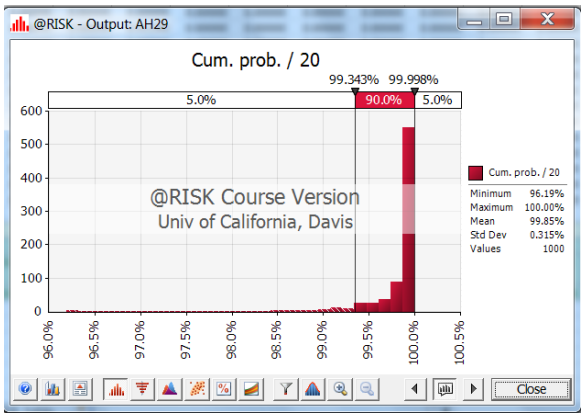
Entry probability after 1 year



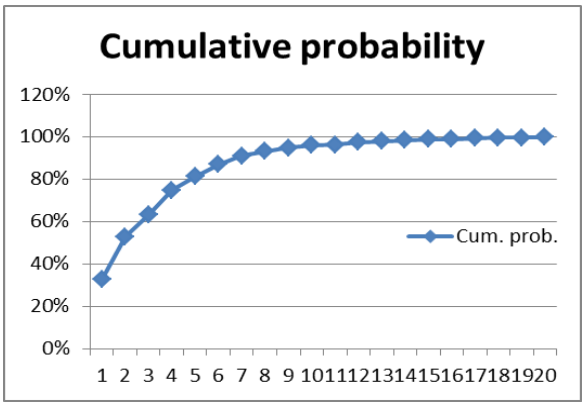
Entry probability after 5 years



Entry probability after 10 years



Entry probability after 20 years



Cumulative entry probability, single simulation

Cumulative probabilities (%) for entry of *S.* Dublin for scenario a using the within-herd prevalence distributions from different diagnostic test procedures

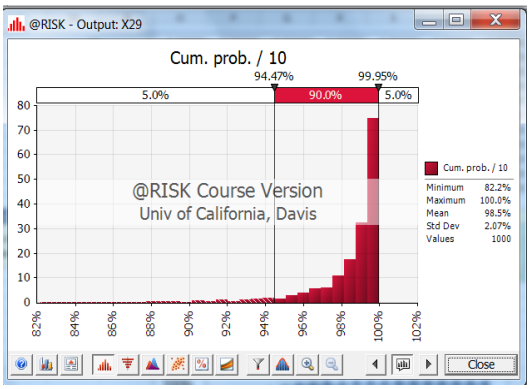
Cum. years	Ap fecal+ELISA (%)	Tp fecal+ELISA (%)	Fecal only[1] (%)	ELISA only (%)
1	31.4	37.7	5.0	31.0
5	84.0	89.8	22.3	83.5
10	97.2	98.7	39.4	96.9
15	99.5	99.8	52.6	99.3
20	99.9	100.0	62.8	99.9

[1] **Fecal only testing has a very low sensitivity of 6-14% *(3)***

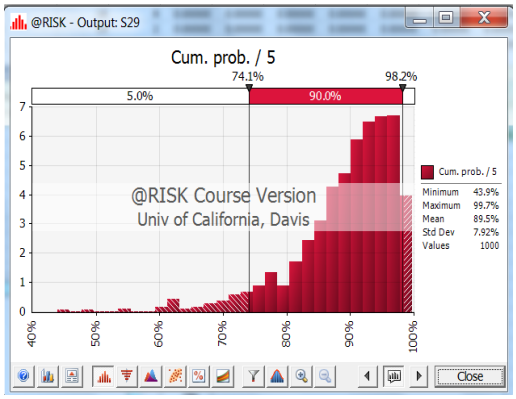
Appendix 4 Scenario b input distributions and results

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of S.D		
Beta	Herd Ap	Animal Ap
a	3	3.3
b	23	6.3

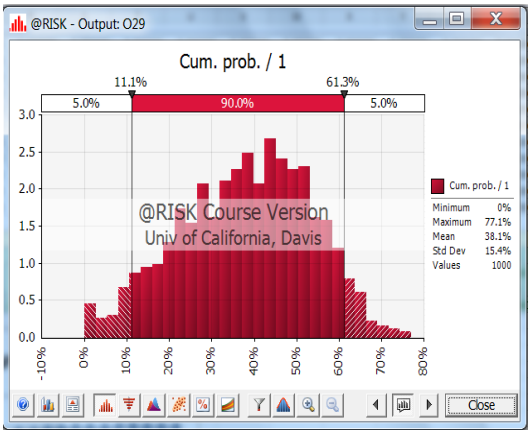
ELISA only



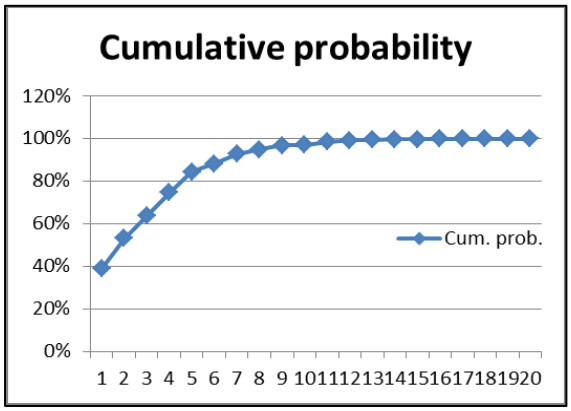
Entry probability after 10 years



Entry probability after 5 years



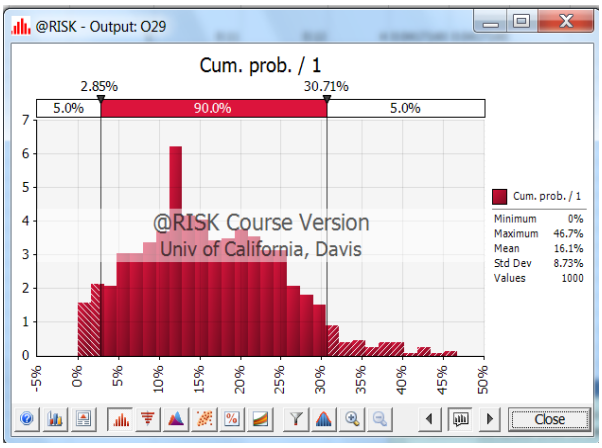
Entry probability after 1 year



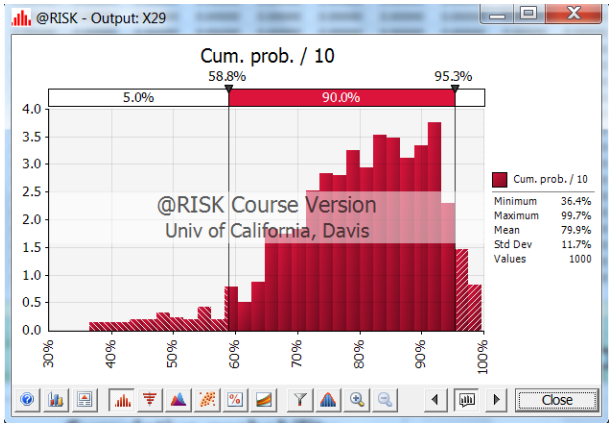
Cumulative entry probability, single simulation

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of S.D		
Beta	Herd Ap	Animal Ap
a	3	2.6
b	23	53.6

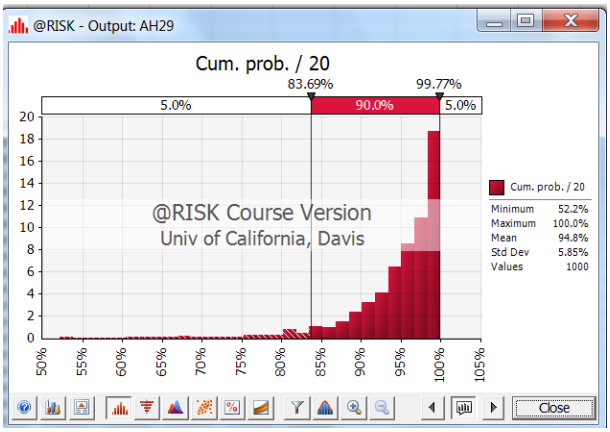
Fecal only



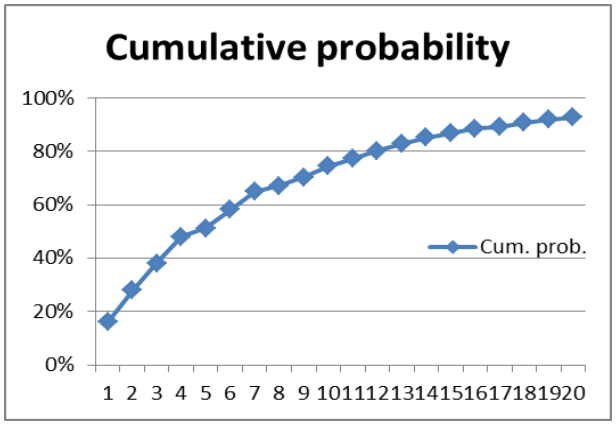
Entry probability after 1 year



Entry probability after 10 years

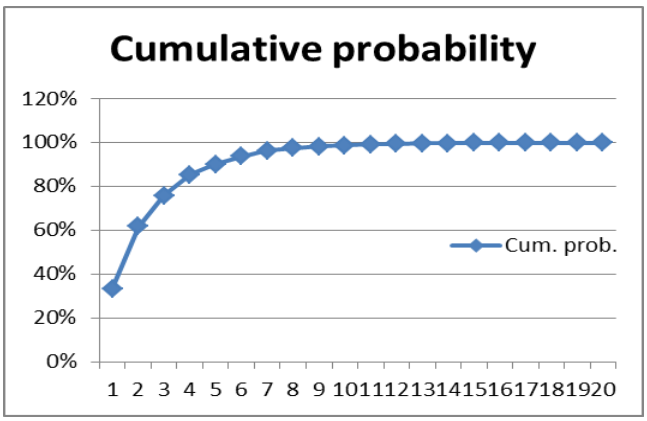


Entry probability after 20 years



Cumulative entry probability, single simulation

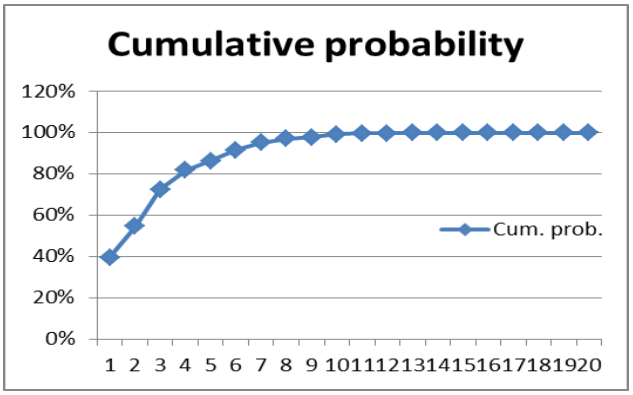
Define the beta distributions for the herd-level apparent prevalence and the animal-level true prevalence of S.D		
Beta	Herd Ap	Animal Tp
a	3	2.9
b	23	3.7



Tp fecal + ELISA

Cumulative entry probability, single simulation

Define the beta distributions for the herd-level apparent prevalence and the animal-level apparent prevalence of S.D		
	Herd Ap	Animal Ap
Beta 1	3	4.7
Beta 2	23	8.8



Ap fecal + ELISA

Cumulative entry probability, single simulation

Cumulative probabilities (%) for entry of *S*. Dublin for scenario b using the within-herd prevalence distributions from different diagnostic procedures

Cum. years	Ap fecal+ELISA (%)	Tp fecal+ELISA (%)	Fecal only[1] (%)	ELISA only (%)
1	38.4	39.1	16.1	38.1
5	89.8	90.4	56.8	89.5
10	98.6	98.8	79.9	98.5
15	99.8	99.8	90.1	99.8
20	100.0	100.0	94.8	100.0

[1]**Fecal only testing has a very low sensitivity of 6-14% *(3)***

Appendix 5 Combining the results of scenarios a and b

Since the two scenarios most likely would occur simultaneously within a given year, their respective probability of entry should be combined to give the overall probability of entry of *S*. Dublin from the import of Danish cattle to Iceland:

p(a & b) = 1-(1-p(a))*(1-p(b))

Simulated mean cumulative probabilities of entry in Scenarios a, b and their combination:

Ap fecal + ELISA

Year	Scenario a	Scenario b	Scenario a or b
1	31.4%	38.4%	57.7%
5	84.0%	89.8%	98.4%
10	97.2%	98.6%	100%
15	99.5%	99.8%	100%
20	99.9%	100%	100%

Tp fecal + ELISA

Year	Scenario a	Scenario b	Scenario a or b
1	37.7%	39.1%	62.1%
5	89.8%	90.4%	99.0%
10	98.7%	98.8%	100%
15	99.8%	99.8%	100%
20	100%	100%	100%

Fecal-only[1]

Year	Scenario a	Scenario b	Scenario a or b
1	5.0%	16.1 %	20.3%
5	22.3%	56.8%	66.4%
10	39.4%	79.9%	87.8%
15	52.6%	90.1%	95.3%
20	62.8%	94.8%	98.1%

[1]Fecal-only testing has a very low sensitivity of 6-14% (3).

ELISA only

Year	Scenario a	Scenario b	Scenario a or b
1	31.0%	38.1%	57.3%
5	83.5%	89.5%	98.3%
10	96.9%	98.5%	100%
15	99.3%	99.8%	100%
20	99.9%	100%	100%

Section 6 Maedi-Visna and Caprine Arthritis and Encephalitis infections in sheep

Scope and purpose of the import risk analysis

This risk assessment identifies and assesses the likelihood of Maedi-Visna virus or Caprine Arthritis and Encephalitis virus being introduced, becoming established and spreading among Icelandic sheep farms, together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing sheep (*Ovis aries*) intended for breeding purposes from Denmark.

According to the opinion of an Icelandic expert as described in Chapter 6 Appendix 1, around 5 consignments of approximately 100 sheep each might be imported annually, e.g. for the purpose of starting a purebred flock of an alternative breed to the Icelandic sheep breed.

A short introduction to the infections and diseases

Maedi-Visna (MV) of sheep and caprine arthritis/encephalitis (CAE) of goats and sheep are lifelong persistent virus infections caused by closely related lentiviruses, belonging to a sub-family of *Retroviridae*, and often referred to as "the small ruminant lentiviruses" (SRLVs). The two virus infections (MVV and CAEV) are not species-specific, but can infect both sheep and goats, especially in mixed herds. Most infected animals do not exhibit clinical signs, but remain capable of transmitting virus**.** Infected herds often show high within-herd prevalences due to several routes of transmission and persistent infections. Clinical signs are developing slowly in infected animals and may eventually lead to high levels of within-herd mortality and production losses in sheep flocks ***(1 - 3).***

Hazard identification

As mentioned in Chapter 2, Maedi-Visna was originally detected and described as a disease entity in Iceland in 1939, after having been imported with sheep from Germany in 1933. The infection was eradicated in 1965 after an intensive control program, which included fenced-off regional quarantine zones, depopulation of infected farms, restocking of lambs from disease-free zones and compensation to affected farmers.

The sheep population of Iceland is currently close to 500,000 individuals of the indigenous breed kept in approximately 2,600 farms, while there are less than 1,000 goats in the country. Sheep production is traditionally the main agricultural sector in Iceland.

Maedi-Visna and CAE are both notifiable List A diseases in Iceland. CAE has never been found in Iceland. No active surveillance activities for these infections have been conducted recently.

In Denmark, both diseases are notifiable and included in Lists 2 and 4. Both Maedi-Visna and CAE are endemic infections in the Danish sheep and goat populations. A voluntary control program for SRLV infections has been established by the agricultural organizations.

Both infections are among the OIE listed diseases and infections. Chapters 14.2 and 14.6 of the Terrestrial Animal Health Code contain recommendations for the import of sheep and goats to minimize the likelihood of introducing CAE and Maedi-Visna, respectively ***(4).***

Within the EU, Article 8.1 and Annex B III in Council Directive 91/68 on animal health conditions governing intra-Community trade in ovine and caprine animals specifies that both Maedi-Visna and CAE are among the diseases to which sheep and goats are susceptible, which may be the basis for considerations of additional guaranties when a Member State considers that its territory or part of its territory is free from this disease.

Risk assessment

Entry (Release) assessment

Status of small ruminants in European countries

SRLV infections are particularly prevalent throughout Europe, with the notable exception of Iceland, as they are also wide-spread worldwide, except for Maedi-Visna in New Zealand and Australia ***(1, 5).*** In Norway, Maedi-Visna was officially reported for the first time in 1972, after an introduction with sheep from Denmark during 1962 – 70 ***(6).*** Results from a Norwegian surveillance and control program for Maedi, including data from November 2003 through 2006, show a preliminary prevalence of less than 0.2 % positive flocks. During 2006 – 2008, no new positive flocks were detected ***(7).*** In Finland, where CAE has never been reported, Maedi-Visna was apparently eradicated after having been introduced from Sweden in 1981, resulting in a limited spread to 14 herds ***(8, 9).***

Status in Danish small ruminants

In Denmark MV was first described in the 1960'es, and by 1972 – 1978 the herd level prevalence was estimated at around 31%, while the animal level prevalence was 11% ***(10).***

In 2011, the National Veterinary Laboratory in Denmark tested 2,443 blood samples for MV in sheep and 644 blood samples for CAE in goats as part of the voluntary control program, and they found 3 and 1 positive tests, respectively ***(11).*** Although the samples were from herds participating in the voluntary Danish MV/CAE program, and therefore not representative for the entire populations of Danish sheep and goats, the results confirm that both infections are endemic in Denmark, apparently now at low within-herd prevalence in these self-selected herds. The prevalence is probably considerably higher among sheep and goats from non-participating flocks. There are, however, no recent representative prevalence estimates available from the Danish sheep and goat populations.

In conclusion, both Maedi-Visna and CAE infections are known to be endemic in Denmark; their current prevalences are, however, unknown. This means that the entry probabilities of SRLV infections with shipments of sheep from Denmark to Iceland are currently **unknown,** but likely to be of epidemiological importance as potential hazards.

Exposure assessment

Live animal trading is considered a major risk factor in the spread of SRLV infection between herds ***(5).*** As mentioned above, MVV has moved with imported sheep from Germany to Iceland in 1933, from Sweden to Finland in 1981 ***(8),*** and from Denmark to Norway during 1962 - 70 **(6).** A recent study showed that there was a statistically significantly higher seroprevalence in herds that had purchased many sheep during the last 5 years than in herd with fewer introductions ***(3).*** Live animal trade is also responsible for dispersion of CAEV among

geographical regions. The infection has been documented to have moved from France to Spain and Poland, and from the USA to Mexico with imported goats ***(12).***

Housing and direct close contact have long been recognized as major risk factors for within-herd spread of infection once introduced into a susceptible herd. Management conditions, such as long housing seasons, high stocking densities and poor building ventilation may also facilitate virus exposure ***(13, 14).***

It has also been suggested, that the spread of the infection within a herd is more rapid in temperate geographical regions of the world, where the winter housing seasons take up the larger part of the year ***(14).***

After the importation of the infected German sheep in 1933, Icelandic scientists suggested that the native Icelandic sheep breed were extremely susceptible to MV, since the imported animals and the flock of origin in Germany never showed any clinical signs, while the native sheep on the same farm were severely affected by the infection. Only certain breeds develop clinical signs after an infection with MVV. It appears that coarse wool type sheep are more susceptible than fine wool type sheep ***(14).***

Serological testing and segregation or culling of seropositive animals is necessary to minimize horizontal transmission of SRLV, and is recommended as an important element in control and eradication programs ***(13).***

In conclusion, history has demonstrated that the indigenous Icelandic sheep breed, when housed and grazed under traditional Icelandic sheep farm management systems, is very susceptible enabling the establishment and spread of Maedi-Visna. The likelihood of establishment and spreading in the Icelandic sheep population subsequent to the entry of SRLV infection is **high**.

Consequence assessment

The consequences of SRLV infections are significant economic losses as well as animal welfare issues.

The economic losses come from decreased milk production and mastitis, which is often a feature of SRLV infection. Low birth weight, slow weight gain, low fertility and up to 20 - 30% mortality in affected animals have also been reported ***(5),*** as well as a shortened lifespan and increased culling ***(3).***

CAE adversely affects the health of goats and the quality of life in clinically affected animals due to pain and disability, most commonly affecting the joints ***(5, 12).***

Many countries have initiated voluntary control programs for SRLV infections in sheep and goats to help their farmers to avoid or limit these consequences ***(13).***

Due to the historical experience of Iceland with a long-lasting and extensive eradication of Maedi-Visna, which had been imported to the country with infected sheep, due to the apparent susceptibility of the indigenous Icelandic breed and due to the common housing and grazing systems for sheep in Iceland, the consequences of a new introduction of an SRLV infection would be disastrous for the Icelandic society.

In conclusion, the consequences of SRLV infections being introduced, established and spreading among the Icelandic sheep farms are estimated to have a **high** economic impact. Clinical disease would also have a considerable impact on the welfare of the sheep.

Risk estimation

Both Maedi-Visna and CAE occur endemically in Denmark, but the current prevalence is unknown. The probability of releasing SRLV with import of Danish sheep is unknown, but not zero.

Once introduced into the Icelandic sheep population, the establishment and spreading of SRLV infections would likely be extensive, since clinical disease might not be apparent until years later. Serological monitoring or screening would be necessary for detection of occurrence and spread of these notifiable diseases.

In terms of economic losses for the farmers and the governmental expenses for surveillance, control and eradication efforts, the consequences would be very high for an extended period of time.

In conclusion, the risk to the Icelandic sheep industry and the government from Maedi-Visna and CAE infections is estimated as **high**.

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Section 7 Equine Herpes Virus - 1 (EHV-1) infections in horses

Scope and purpose of the import risk analysis

This risk assessment identifies and assesses the likelihood of Equine herpesvirus -1 (EHV-1) being introduced, becoming established and spreading among Icelandic horses (*Equus caballus*), together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing horses from Denmark. These horses may be intended for a variety of purposes, as described in Chapter6 Appendix 1 by an Icelandic equine expert:

"According to the discussion at the annual general meeting of the Icelandic Horse Breeding Association (Dec 2012) there is an increasing interest of import of semen from some few very good Icelandic stallions that are localized and/or bred abroad. There might also be interest of importing some few stallions for breeding and even for Icelandic breeders to hire out some stallions for breeding abroad and take them back.

Re-import of competition horses, especially in connection with the World Championship every second year might also become actual.

As the transport cost will always be high due to the geographic isolation of the country it's most likely that only few valuable breeding horses will be imported to the country.

It can, however, not be excluded that some people will have interest of importing small or big herds to the country, and specially horses that suffer from summer eczema (seasonal insect-bite hypersensitivity)".

A short introduction to the infection and the disease

Five different herpes virus are known to infect horses, three belong to the sub-family *alpha herpesviridinae*: EHV-types 1, 3 and 4; and two belong to the sub-family *gamma herpesviridinae*: EHV-types 2 and 5. EHV-1 and 4 are clinically, economically and epidemiologically the most relevant pathogens causing the syndrome known as Equine rhinopneumonitis (ER) ***(1)***.These viruses are endemic in most horse populations world-wide, and the majority of horses show serologic evidence of exposure to them. EHV-4 is recognized for its primary association with upper respiratory disease in horses ***(2)***. Also EHV-1 is commonly associated with respiratory disease in young horses. EHV-1 can, however, also cause late-gestation abortion, perinatal mortality and myeloencephalitis, the latter also called EHV-1 myeloencephalopathy (EHM) ***(3).*** EHM is most likely caused by mutant or neuropathogenic strains of EHV-1 ***(4)***, and also differences in abortigenic potential may be related to different strains ***(1)***. As with other herpes virus, the ability of EHV-1 to infect horses and establish long-term latent-carrier state in the face of the host's immune response assures indefinite endemic EHV-1 infection in the equine population. Resistance to re-infection resulting from recovery from field infection with EHV-1 is short-lived, lasting only a few weeks to a few months ***(3).***

Hazard identification

EHV-1 infections are included in the OIE listed diseases under Equine rhinopneumonitis. Recommendations for the importation of equines to minimize the probability of entry of EHV-1 infections are specified in Chapter 12.8 of the Terrestrial Animal Health Code ***(5).***

Equine rhinopneumonitis/EHV-1 is notifiable on List B in Iceland. EHV-1 has never been identified in horses in Iceland, as opposed to the other four EHV types ***(6).*** The absence of the infection has been substantiated by the results of the active surveillance data as presented in Chapter 5.

Equine rhinopneumonitis/EHV-1 is not notifiable in Denmark. EHV-1 infections are officially "suspected, but not confirmed" in Denmark ***(7)***. The Infection is most likely endemic, but the prevalence is unknown, as detailed below.

Risk assessment

Entry (Release) assessment

Status in Danish horses

EHV-1 and EHV-4 are reported worldwide as etiological agents in viral respiratory infections of horses ***(2)***. Several scientific papers describing Danish field isolates of EHV-1 have been published ***(8 - 10)***, as well as an early paper reporting an outbreak of "enzootic paresis" and abortion following infections with "rhinopneumonitis virus" **(11).**

Laboratory testing for EHV-1 and other equine pathogens is no longer carried out at the National Veterinary Institute in Denmark, so all test samples have to be submitted to laboratories in neighbouring countries, e.g. Sweden and Germany, resulting in lack of information about occurrence of some non-notifiable equine diseases and infections, such as EHV-1.

According to the Danish veterinary authorities, the current official status for EHV-1 is, that the presence of the infection is "suspected, but not confirmed" ***(7).***

In conclusion, the assessment of EHV-1 occurrence in Denmark is that the infection at present is most likely endemic, although the prevalence is unknown. The entry probability to Iceland with Danish horses would be **high**.

Exposure assessment

The management of horses in Iceland is traditionally extensive where most of the horses, including the breeding mares, foals and young horses up to 3-4 years, are free roaming and fed outside during the winter. The horses are often kept in large fields, in flocks of 10 – 100 individuals. Good health is a prerequisite for this method of management, as weather conditions can vary.

Housing is almost exclusively restricted to horses in training. Up to 10.000 horses are housed during the period January – May. The legislation allows rather dense stabling (4.0 m^2 for each horse in a box) and small pens. The stables are often built in clusters, in specifically designated areas in outskirts of towns, resulting in high density of horses on small areas.

During recent years, the population has been exposed to infectious agents that apparently were new in the country. It resulted in two epidemics, which caused considerable economic losses for the horse industry, as described in Chapter 1 and in the following according to ***(12)***.

In February 1998, a mild infection of the digestive system (Infectious pyrexia), characterized with elevated body temperature, a reduced appetite and an increased risk of secondary complications started near Reykjavik. It gradually developed into an epidemic, which lasted for a year involving the entire horse population and with high morbidity, but low mortality. The infectious agent was considered to belong to the picornavirus family. It had not previously been described as a possible pathogen for horses.

In 2010, a "new" strain of the bacterium *Streptococcus equi* subsp. *zooepidemicus* (ST2309) was introduced to the horse population resulting in an epidemic of a mild respiratory tract infection resulting in 100% morbidity, but with a very low mortality. Coughing and muco-purulent discharge could persist up to 10 weeks. No records have been found on a comparable epidemic caused by this bacterium.

The total absence of specific immunity was the most important presumption for both of the epidemics. The Icelandic horse management method appeared, however, to have a great effect on the infectious load and thereby on the severity of the clinical signs and their duration. The dense stabling, sometimes with poor ventilation and limited outdoor facilities appeared to be advantageous for the infective agents and intensified the contagion. Collecting the free roaming horses onto smaller fields/paddocks or housing them, for better supervision and care, clearly resulted in more stress, increased infectious load and risk of complications ***(12).***

It has been concluded, that the isolation of the Icelandic horse population together with the density of horses stabled in the Reykjavík area give new infectious agents an opportunity to magnify and to become epidemic. Therefore even low pathogenic agents, let alone highly neuropathogenic EHV-1 strains, may cause extended epidemics and related losses for the horse industry in Iceland ***(12 - 14)***.

Active surveillance for EHV-1 antibodies in Iceland has been carried out systemattically since 2008 and sporadically before that, and EHV-1 antibodies have never been detected (see Chapter 5).

Animal movements appear to be associated with several of the recent outbreaks in the USA. An outbreak in 2006 involved a group of 15 horses shipped from Germany to 8 states. Five of the horses went to Florida, which resulted in 13 horses identified as infected, with neurological signs in 7 cases and in 6 associated deaths. One horse from the original group from Germany died shortly after arrival in California ***(15).***

In conclusion, introduction of EHV-1 into the Icelandic horse population is likely to result in rapid spread of the infection due to the traditional horse management, the density of horses in local areas around cities and the large herds of horses on pasture. The exposure probability of Icelandic horses after import of Danish horses would be **high**.

Consequence assessment

Epidemic outbreaks of respiratory disease and abortions are likely to appear. EHM may occur depending on the virus strains present. Although EHM is a sporadic and relatively uncommon manifestation, it can cause devastating losses and have severe consequences for the equine industry, as can be seen from outbreaks in horse establishments throughout North America and Europe. Prevention is difficult because many horses are latently infected, allowing the virus to circulate silently in horse populations, and currently available vaccines do not confer protection against neurological manifestations of infection ***(3).*** In some EHM outbreaks, a high fatality rate around 40% of the clinical EHM cases has been observed ***(4).***

In conclusion, the economic losses caused by any extended epidemic among horses affecting their health status and thereby their value for riding or meat production will be high. In addition, the risk of EHM as an invalidating and life-threatening condition is by itself a serious risk for the welfare of the affected horses. The consequences of an EHV-1 epidemic infection among Icelandic horses would be **high**.

Risk estimation

The prevalence of EHV-1 infections in Denmark is likely endemic, but the prevalence is unknown. If released into the Icelandic horse population the infection would no doubt be established and spread throughout the country, with potentially serious consequences for and high impact on the farmers economy and the welfare of the horses, partly depending on the strains of virus and their ability to cause abortions and myeloencephalopathy.

In conclusion, the risk to the Icelandic horse population from EHV-1 infections is estimated as **high**.

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Section 8 Equine Viral Arteritis in horses

Scope and purpose of the risk assessment

This risk assessment identifies and assesses the likelihood of Equine Viral Arteritis (EVA) being introduced, becoming established and spreading among Icelandic horses (*Equus caballus*), together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing horses from Denmark. These horses are presumably intended for a variety of purposes, as described in Chapter 6 Appendix 1 by an Icelandic equine expert:

"According to the discussion at the annual general meeting of the Icelandic Horse Breeding Association (Dec 2012) there is an increasing interest of import of semen from some few very good Icelandic stallions that are localized and/or bred abroad. There might also be interest of importing some few stallions for breeding and even for Icelandic breeders to hire out some stallions for breeding abroad and take them back.

Re-import of competition horses, especially in connection with the World Championship every second year might also become actual.

As the transport cost will always be high due to the geographic isolation of the country it's most likely that only few valuable breeding horses will be imported to the country.

It can, however, not be excluded that some people will have interest of importing small or big herds to the country, and specially horses that suffer from summer eczema (seasonal insect hypersensitivity)".

A short introduction to the infection and the disease

Equine arteritis virus (EAV) is an RNA virus of the family *Arteriviridae* (genus *Arterivirus*, order *Nidovirales*), which a. o. also includes porcine respiratory and reproductive syndrome virus (PRRSV) ***(1).***

EAV is the cause of equine viral arteritis (EVA), a contagious disease restricted to the family *Equidae* characterized by systemic "influenza-like" illness in foals and adult horses, abortion in mares, and the establishment of a carrier state in persistently infected stallions in which they constantly shed infectious virus in their semen. The disease is named for the characteristic inflammatory lesions of small blood vessels, especially arterioles that occur in affected horses. Although EVA is rarely, if ever, fatal to healthy adult horses, it is listed as a disease notifiable to the Office International des Epizooties (OIE) which indicates that it is considered to have significant potential for transmission internationally and within naïve populations ***(2).***

Hazard identification

Equine Viral Arteritis is on the OIE list of notifiable diseases and infections, and Chapter 12.9 of the Terrestrial Animal Health Code recommends measures to limit the spread of EVA through importation of live equids and semen ***(3).***

Equine viral arteritis is a notifiable disease in Iceland on List B. It has never been found in Icelandic horses. No active surveillance has been documented.

Equine viral arteritis is also a notifiable disease in Denmark on Lists 2 and 4 and it is known to be present in Denmark ***(4).*** Most likely the infection is endemic, but the prevalence is unknown, as described in the following.

Within the EU, no shedding stallions can be present on a stud which engages in the intercommunity trade of semen. In addition, semen and stallions imported to the EU must be certified as seronegative for EAV or if seropositive, have a negative virus isolation result from semen. The importation of semen from stallions shedding EAV is also prohibited ***(5, 6).***

Risk assessment

Entry (Release) assessment

Status in horses from European and other countries

EAV is widespread in most countries with dense horse populations, including Sweden. Although no abortions had been attributed to EVA in Sweden, EAV was isolated from fresh and frozen semen samples in year 2000 ***(7).***

Serological surveys have shown that EAV infection occurs among horses in North and South America, Europe, Australasia, Africa, and Asia with considerable variation in seroprevalence of EAV infections among countries and within equine populations in some countries. In that regard, Iceland and Japan are apparently free of the virus, whereas EAV infection is relatively common in horses in several European countries. The seroprevalence of EAV infection was estimated at 11.3% in Swiss horses, and 2.3% in English horses, in studies conducted in 1973. Similarly, in 1963 and 1975 approximately 14% of Dutch horses were seropositive to EAV, whereas 1.8% of German horses were seropositive in 1987, increasing to 20% in a subsequent survey in 1994. In the USA, the National Animal Health Monitoring System's Equine 1998 Study revealed that only 2.0% of unvaccinated horses in the U.S. were seropositive to EAV. Similarly, resident unvaccinated California horses had a seroprevalence to EAV of only 1.9%, whereas 18.6% of horses imported into California, most commonly European Warmbloods, were seropositive ***(1, 8).***

Status in Danish horses

A scientific paper published by researchers from the National Veterinary Laboratory in 2001 describes investigations on the phylogenetic relationship between isolates of equine arteritis virus (EAV) from semen of asymptomatic stallions and from fatal cases (three dead foals and an aborted foetus) from outbreaks of EVA in Denmark in 1997 and 1999 in three separate herds. The paper also mentions that the EAV seroprevalence was in the range of 15 – 30% in samples submitted to the laboratory, and that a minor survey of 25 stallions in 1997 revealed that nine stallions had neutralizing antibodies against EAV, and that the virus was detected in semen from three of these stallions. Information on EAVs previously isolated in Denmark was also provided, which documents that many of these isolates were from stallions or mares imported from other European countries and from the USA. The paper concludes that the presence of virus-shedding asymptomatic stallions in Denmark represents a potential source of severe EVA ***(9).***

Laboratory testing for EAV and other equine pathogens is no longer carried out at the National Veterinary Institute in Denmark, so all test samples have to be submitted to laboratories in neighbouring countries, e.g. Sweden and Germany, resulting in loss of information about recent occurrence of equine infections, such as EAV.

According to the Danish veterinary authorities, the current official status is that EVA infection is "known to be present" ***(4).*** This is confirmed by the OIE WAHID information, where EVA in Denmark for most years between 2005 and 2012 is marked with the designation "Clinical disease".

In conclusion, the assessment of EVA occurrence in Denmark is that at present the infection is most likely endemic, although the prevalence is unknown. The probability of entry with Danish horses imported to Iceland is estimated to be **high.**

Exposure assessment

The apparent global dissemination of EAV and rising incidence of EVA likely reflect the extensive national and international movement of horses for competition and breeding, as well as increased recognition of the importance of EAV infection ***(10).***

In 1992, it was proposed that changes in regulations as part of the European Community single market economy could adversely affect the disease free status of the UK with regard to viral arteritis; seropositive animals from continental Europe could introduce this disease into Britain. Serosurvey and virus isolation data had shown that equine viral arteritis existed within the EC. Since the disease can be passaged from seropositive stallions to mares it was unreasonable to expect that, with changes in importation requirements, the UK would remain free of this disease. Consequently UK veterinarians needed to be informed on all aspects of EAV disease, diagnosis and management ***(11).***

It was also argued, however, that undoubtedly forthcoming changes governing animal movement between EC member states would increase the risk of introducing not only for EVA but also other infectious diseases into the British horse population. In the case of EVA, however, the threat can be minimized through implementation of a more selective and less restrictive program of serological and virological testing for EAV infection. Prophylactic vaccination of breeding stallions ought to be considered a necessary adjunct to any control program if the risk of EVA becoming endemic in the country is to be avoided. Such measures if adopted internationally would do a great deal to facilitate movement of horses and re-establish the true significance of EAV as an equine pathogen ***(12).***

In 1993, EVA was diagnosed for the first time in the United Kingdom. The first mare to be covered by a recently imported stallion from Eastern Europe was the first animal to be affected. Although the outbreak was contained, the free movement of animals within the European Union would increase the possibility of infected stallions being introduced into the UK ***(13).***

Since then, the results of a study showed that 18 of 50 seropositive stallions that were identified in the UK in 1994 and 1995, and five of nine stallions that were confirmed to be shedding the virus, originated from countries in the EU. As there had been no statutory requirements since 1993 to demonstrate that stallions moving between EU countries are free of EAV, these results highlighted the potential risks posed to the largely susceptible UK horse population by the importation from within the EU of stallions which are shedding the virus. "If stallions continue to be imported from the EU without such voluntary screening it is probably only a matter of time before further clinical outbreaks of EVA occur in the UK" ***(14).***

Information on EAVs previously isolated in Denmark documents that many of these isolates were from stallions or mares imported from other European countries and from the USA. EVA viruses introduced by an imported horse may become endemic in the new country ***(7).***

In conclusion, if equine viral arteritis were to be introduced into the Icelandic horse population, the exposure probability will be **high**.

Consequence assessment

A diagnosis of EVA can have profound economic consequences for both the breeding and performance sectors of the horse industry, which is an important economic sector in Iceland. Direct financial losses resulting from outbreaks of the disease on breeding farms include: losses due to abortion and/or disease and death in very young foals; decreased commercial value of persistently infected stallions; reduced demand to breed to carrier stallions, due to the added expense and inconvenience involved in vaccinating and isolating mares before and after breeding; and denied export markets for carrier stallions and infected semen.

An outbreak of EVA at a racetrack, equestrian event, or horse show can have considerable impact, due to the widespread potential for further dissemination of the virus when horses return to their farm or premises of origin. This impact may include direct financial losses such as abortion, pneumonia in newborn foals, infected stallions, and disruption of training schedules, reduced competition entries, and event cancellations.

The impact at the international level will affect the trade of horses and semen, due to denied export opportunities for carrier stallions and EVA-infective semen. In fact, in the case of some countries, all categories of horses that have antibodies to the virus are affected ***(1).***

In conclusion, the experiences from many countries about the economic burdens associated with outbreaks of equine viral arteritis demonstrate the serious impact of the consequences to be expected from such outbreaks. For the economically important Icelandic horse industry the consequences are likely to be even bigger, since the Icelandic horse population would be totally naïve and susceptible to the infection, which is much different from equine populations in endemic countries, where also vaccination may play a role in limiting the spread and impact of EVA infections. The consequences of EAV infections in Iceland are estimated as having a **high** impact**.**

Risk estimation

Imported horses from Denmark will be able and likely to carry equine viral arteritis virus to Iceland over the course of relatively short time, although the current prevalence of EVA infections in Denmark is unknown. The literature review shows that similar introductions have frequently occurred in other countries over the years. Due to the naïve and susceptible Icelandic horse population and the traditional management of horses, exposure, spread and epidemic situations are likely to follow, with serious economic consequences for the horse industry in Iceland.

In conclusion, the risk to Iceland from importing horses from Denmark as concerns equine viral arteritis is estimated to be **high**.

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Section 9 Equine Influenza Virus (EIV) infections in horses

Scope and purpose of the risk assessment

This risk assessment identifies and assesses the likelihood of Equine influenza being introduced, becoming established and spreading among Icelandic horses (*Equus caballus*), together with the likelihood of and the likely magnitude of potential consequences for animal health and production, as a result of importing horses from Denmark intended for a variety of purposes, as described in Chapter 6 Appendix 1 by an Icelandic equine expert:

"According to the discussion at the annual general meeting of the Icelandic Horse Breeding Association (Dec 2012) there is an increasing interest of import of semen from some few very good Icelandic stallions that are localized and/or bred abroad. There might also be interest of importing some few stallions for breeding and even for Icelandic breeders to hire out some stallions for breeding abroad and take them back.

Re-import of competition horses, especially in connection with the World Championship every second year might also become actual.

As the transport cost will always be high due to the geographic isolation of the country it's most likely that only few valuable breeding horses will be imported to the country.

It can, however, not be excluded that some people will have interest of importing small or big herds to the country, and specially horses that suffer from summer eczema (seasonal insect hypersensitivity)".

A short introduction to the infection and the disease

Equine Influenza (EI) is a highly contagious though rarely fatal respiratory disease of horses, donkeys and mules and other equidae. The disease has been recorded throughout history, and when horses were the main draft animals, outbreaks of EI crippled the economy. Nowadays outbreaks still have a severe impact on the horse industry ***(1).***

Equine influenza is caused by two virus subtypes: H7N7 (formerly subtype 1) and H3N8 (formerly subtype 2) of influenza A viruses (genus *Influenzavirus A* of the family *Orthomyxoviridae*); viruses of the H7N7 subtype have not been isolated since the late 1970s ***(2).*** Equine influenza H3N8 viruses continue to cause widespread problems in horses despite control measures including quarantine and vaccination, and international spread of the virus occurs as horses travel for racing and breeding purposes ***(3).***

Typical outbreaks of EI are characterised by pyrexia, coughing and nasal discharge. The virus is spread by the respiratory route, by personnel, vehicles contaminated with virus, and by fomites. Large outbreaks are often associated with high density stabling, the congregation of horses at equestrian events and their dispersal over a wide geographic area after the event.

Vaccination is practiced in most countries. However, due to the variability of the strains of virus in circulation, and the difficulty in matching the vaccine strain to the strains of virus in circulation, vaccination does not always prevent infection although it can reduce the severity of the disease and speed recovery times.

Since the disease is most often introduced by an infected animal, isolation of new entries to a farm or stable is paramount to preventing the introduction of disease to a premise. When the disease appears, efforts are placed on movement control and isolation of infected horses. While the disease is rarely fatal, complications

such as pneumonia are common, causing long term debility of horses, and death can occur due to pneumonia, especially in foals ***(1).***

Hazard identification

Equine influenza is on the OIE list of notifiable diseases and infections, and Chapter 12.6 of the Terrestrial Animal Health Code recommends measures to limit the spread of equine influenza through importation of live equids and fresh meat from equids ***(4).***

Equine influenza is a notifiable disease in Iceland on List B. It has never been found in Icelandic horses, and its absence is substantiated by the surveillance data found in Chapter 5

Equine influenza is not a notifiable disease in Denmark, but the official opinion is, that presence of the infection is "suspected, but not confirmed" in Denmark ***(5).***The Infection is most likely endemic, but the current prevalence is unknown, as described in the following.

Risk assessment

Entry (Release) assessment

Status of horses from European and other countries

Influenza A virus infection of equids has been reported world-wide with the exception of a small number of island countries, including New Zealand and Iceland. Equine influenza (EI) is endemic in Europe and America. Other parts of the world such as Japan, South Africa, India and Hong Kong suffer occasional incursions but the disease is not endemic ***(6).*** Based on the results of epidemiological and virological studies, there is no definitive evidence that strains of the A/equine-1 (H7N7) have been active in horse populations throughout the world since 1980. Strains of A/equine-2 (H3N8) on the other hand, continue to circulate and are of increased significance in many countries in western Europe and the United States, in which they appear to have become endemic ***(7).***

The increase in international travel of horses has resulted in both European and American lineages being spread to most countries in which outbreaks have occurred. An equine influenza outbreak that included vaccinated horses occurred in Sweden in 1991/1992. Another epidemic occurred in China during 1993 to 1994 in an unvaccinated rural horse population and was caused by a strain related to the H3N8 virus circulating in Europe. Two H3N8 Europe-like strains were isolated from an outbreak in the Netherlands in 1995, prompting the development of a surveillance program named Benelux in that country by 2001, to facilitate the production of vaccines that contained more relevant strains of virus. Many outbreaks have occurred in recent years, including Tunisia in 1998, Egypt in 2000, the United Kingdom and South Africa in 2003, and Argentina, Canada, Croatia, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Sweden, the United Kingdom, and the USA during 2004. The American lineage of virus has been responsible for all of the 2004 outbreaks ***(8).*** Since then, regular outbreaks continue to occur in European countries and the United States, despite extensive use of vaccines in some horse populations ***(3).*** During 2011, outbreaks/cases of equine influenza were reported by France, Germany, Ireland, Mongolia, Sweden, United Kingdom (UK), and United States of America (USA). Equine influenza A (H3N8) viruses were isolated and/or characterized from outbreaks in France, Germany, Ireland, the UK and the USA ***(9).***

Status in Danish horses

An EI outbreak at the Danish Warmblood Stallion Show in 2004 has been described, in which many premises were infected by the returning stallions ***(10).***

Laboratory testing for EI and other equine pathogens is no longer carried out at the National Veterinary Institute in Denmark, so all test samples have to be submitted to laboratories in neighbouring countries, e.g. Sweden and Germany, resulting in lack of information about occurrence of non-notifiable equine diseases and infections, such as EI.

According to the Danish veterinary authorities, the current official status for EI is, that presence of the infection is "suspected, but not confirmed" ***(5).***

In conclusion, the assessment of EI occurrence in Denmark is that the current prevalence is **unknown,** but the infection is most likely endemic. The likelihood of entry into Iceland with Danish horses is therefore estimated a **high**.

Exposure assessment

Although the mortality rate associated with equine influenza virus (EIV) infection is very low it is considered the most important respiratory virus of horses. The equine population is highly mobile and horses travel long distances by road and air for competition and breeding purposes. When an infected horse is introduced into a susceptible population virus spread can be explosive. The incubation period can be less than 24 hours in naïve horses and the continuous coughing which is a major feature of the disease, serves to release large quantities of virus into the environment ***(6).***

In many cases, the inadvertent introduction of the EI virus into countries previously free of this infection has been linked directly to the international shipment of horses for competition or breeding purposes. Confirmed instances where this has taken place include the epidemics of equine influenza in Singapore in 1977, Republic of South Africa in 1986, India in 1987 and Hong Kong in 1992. Known occurrences of influenza associated with the international movement of horses since 1963 have been summarized ***(7).***

Once introduced into an area with a susceptible population, the disease, with an incubation period of only one to three days, spreads quickly and is capable of causing explosive outbreaks. Most outbreaks of influenza originate from the introduction of a subclinically infected animal that is shedding virus. The virus is spread by the respiratory route, and indirectly by mechanical transmission of the virus on clothing, equipment, brushes etc. carried by people working with horses. In partially immune vaccinated animals the incubation period may be extended, one or more clinical signs may be absent and spread of the disease may be limited. Crowding and transportation are factors that favour the spread of EI ***(1, 7)***.

Non-endemic countries rely heavily on vaccination of imported horses to help prevent an incursion. Many countries, however, have experienced EI epidemics related to the importation of such horses ***(6).*** Vaccination does not produce sterile immunity; vaccinated horses may shed virus and contribute silently to the spread of EI. Appropriate risk management strategies to deal with this possibility should be developed ***(2).***

The Icelandic horse population is immunologically naïve to almost all equine pathogens, and history shows that even relatively low pathogenic agents can cause major outbreaks throughout the country in a short time (see Chapter 1 and the section on EHV-1 infections).

Icelandic housing and grazing conditions are far from ideal for isolating imported horses, new introductions, and EI suspected horses. All animal vaccinations are currently prohibited by law in Iceland, so the Icelandic horse population has no vaccination history. Also, the management of flocks in the open is impractical even in

the winter, and regular revaccinations as required for EI will be prohibitively expensive for the professional horse farmers.

In conclusion, if the infection were to be introduced to the Icelandic horse population, the probability of exposure and the likelihood of spreading of EI would be **high**.

Consequence assessment

Influenza is considered the most economically important respiratory disease of horses in many of the major horse breeding and racing countries of the world ***(7).*** This is because it is highly contagious and has the potential to cause significant economic losses due to the disruption of major equestrian events and possible movement restrictions ***(6).***

In 1987, an equine influenza epidemic in India affected more than 27,000 animals and killing several hundred **(3)**. Major epidemics caused by two distinctly different strains of A/equine-2 influenza virus have occurred in the People's Republic of China in 1989/90 and again in 1993/94. Economic losses associated with these epidemics were considerable, with an approximate 20,000 horses affected and at least 400 deaths in the 1989/90 epidemic and an estimated 2,245,000 clinical cases and a mortality rate of around 1% (24,600 deaths) in the more devastating 1993/94 occurrence ***(7).***

Australia, a country previously free of equine influenza, suffered a large EI outbreak in 2007, when the virus was apparently brought in with imported horses from Japan. Since EI was recognized in Australia as one of the major disease risks associated with live horse imports, import quarantine protocols were principally designed to manage this risk ***(11*)**.

Despite a rapid and effective eradication campaign and the imposition of movement controls that limited the spread to just two states, the outbreak in Australia infected horses on 10,651 premises in three months. The disease was eradicated, but the cost of treatments and cancellation of events was about 1 billion dollars Australian ***(3).*** The outbreak demonstrates that the regular international movement of live horses means that with current risk management measures, it is impossible to guarantee prevention of entry of a widespread and highly contagious disease in the presence of significant animal movements **(11).**

The global transportation of horses has been responsible for numerous outbreaks of EIV through introduction of the virus or novel strains of the virus into previously unexposed horse populations. Geographically isolated countries, such as New Zealand, Australia, and Iceland, are the only nations to have remained free of equine influenza; however, global transport of horses places the highly susceptible populations of horses in these countries at risk for widespread outbreaks if quarantine measures fail. Adherence to strict quarantine and vaccination protocols and vigilant monitoring are required to avoid the introduction and spread of equine influenza virus among all horse populations. The clinical signs of fever, lethargy, and cough prevent affected horses from performing at their usual level, which holds importance to both the individual horse owner and the large-scale equine industries. Infection is generally self-limiting and the majority of horses recover uneventfully; however, the recovery period may take several weeks to months. Infected horses may suffer life-threatening complications such as bacterial pneumonia, particularly when they are not provided with an adequate period of rest to promote recovery. Outbreaks affecting performance horses exert a significant economic impact on the equine industry due to loss of performance and time out of work. Vaccination and careful management can limit the spread and severity of disease among groups of horses, but, in the past, vaccines have often failed to provide adequate protection. Vaccine failure has been attributed to genetic and antigenic drift of the influenza A/equine/2 virus from vaccine strains, as well as failure of some vaccines to stimulate the appropriate array of immune responses ***(9).***

In conclusion, the experiences from many countries about the economic burdens associated with outbreaks of equine viral arteritis demonstrate the serious impact of the consequences to be expected from such

outbreaks. Furthermore, the Icelandic horse population would be totally naïve and susceptible to the infection, which is much different from equine populations in endemic countries, i.e. most of the world, where also vaccination may play a role in limiting the spread and impact of EI infections. For the economically important Icelandic horse industry the consequences of an EIV epidemic are likely to have a **high** impact**.**

Risk estimation

Imported horses from Denmark will be able and likely to bring equine influenza virus to Iceland over the course of a relatively short time, although the prevalence of EI infections and the entry probability cannot be quantitatively estimated. Importations of equine influenza have frequently happened in other countries over the years. Due to the naïve and susceptible Icelandic horse population and the traditional management of horses, exposure, spread and epidemic situations are likely to follow, with serious consequences for the economically important horse industry in Iceland.

In conclusion, the risk to Iceland from importing horses from Denmark as concerns equine influenza is estimated to be **high.**

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