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The control of notifiable zoonotic diseases in pet animals in Sweden

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1 Introduction

Zoonotic diseases are diseases that can be transmitted from animals to humans. There are multiple ways for humans to acquire a zoonotic disease. Zoonoses can spread either from direct contact with a carrier or sick animal, ingestion of contaminated feedstuff or have an indirect or environmental source (LAHUERTA, et al., 2011). Zoonotic diseases are caused by a great variety of agents or infections such as parasites, fungi, bacteria or viruses (RABINOWITZ, et al., 2007). The clinical symptoms in humans are of a wide range and depend on the disease. Some zoonotic infections are asymptomatic while other has clinical signs that vary from mild, chronic form to an acute life threatening disease (LAHUERTA, et al., 2011).

For the prevention and control of zoonotic diseases it is important to find the main animal host species or feedstuff that is the source for the spread of the specific infection (LAHUERTA, et al., 2011). The treatment carried out is infection-specific and the prevention often includes simple hygienic measures such as washing of hands, disposal of animal waste, cleaning of litter boxes, regular deworming and proper diagnosis and treatment of infected animals (RABINOWITZ, et al., 2007).

The close relationship and interaction between human and their companion animals in today's society have shown multiple beneficial effects on for example human mental and physical health as well as socialization (DEPLAZES, et al., 2011). Pet owners are healthier, with fewer visits to their doctors, taking fewer medications and even lower cholesterol and blood pressure have been noticed (ROBERTSON and THOMPSON, 2002). But this close relationship also presents a risk of transferring zoonosis from pets to their owners (MANI and MAGUIRE, 2009). Healthy individuals in the population might be infected, but more commonly small children, pregnant women, immune compromised and elderly are risk groups of acquiring severe zoonotic diseases due to behavioural or immunological reasons. Another group of the population with an increased risk are people working in close connection and during prolonged time with animals such as veterinarians, veterinary nurses and breeders.

As the inter-country trade with animals, animal products and movement of human population increases so does the risk of spreading zoonotic diseases. Zoonotic agents and infections might be

introduced or re-introduced across borders into different countries and areas (ROBERTSON, et al., 2000). Travelling with companion animals across borders both globally and within Europe provides a threat of introduction of severe zoonoses such as rabies and echinococcosis to places where it has not been found before (DAVIDSON and ROBERTSON, 2012).

Sweden has for a very long time had a much favourable situation regarding serious infectious diseases and zoonoses. Sweden is officially free from several diseases that occur frequently in other European countries. Many zoonoses have been eradicated through extensive actions and eradication programs. Trade of live animals is today the greatest risk for introduction of new diseases to Sweden (BENGTSSON, et al., 2011).

Sweden is a member of the European Union and therefore complies with EU directive concerning zoonosis monitoring and control since 2004. In addition to this Sweden has its own legislations concerning zoonoses and infectious diseases to maintain the low prevalence within the country.

The aim of this thesis is to get an overview of the legislations regulating the most important notifiable zoonotic pet animal diseases present in Sweden and also the possible threat of introduction of other zoonotic diseases still not present.

2 Legislations and control

2.1 European Union (EU)

The three basic types of legislations within the European Union (EU) are regulations, directives and decisions. Regulations are applicable in all Member States within EU and are comparable to the national laws in the different countries. Directives are obligatory general rules that each nation should transfer into their national legislation as seems appropriate to achieve the defined objectives. Decisions deals with a specific issue and the addressees are persons or organizations (EUROPEAN COMMISSION, 2012).

2.1.1 Directive 2003/99/EC of the European Parliament and of the Council

The monitoring and control of zoonoses and zoonotic agents within the European Union are covered in the Directive 2003/99/EC. This directive was set in force 17 November 2003 with the predominant importance of protecting human health against zoonotic diseases through monitoring zoonoses and zoonotic agents. The zoonoses directive defines the minimum requirements for each Member State concerning the measures to be reinforced in their monitoring systems.

Each Member State should have a functioning monitoring system in which data is collected and analysed for epidemiological investigations and outbreaks of zoonotic diseases. With a functioning monitoring system hazards can be identified and risks can be defined. The European Commission has the responsibility to evaluate the trends at European level from the information collected from each member state. The trends, sources of zoonoses, zoonotic agents and microbial resistance should be assessed by each member state and sent in a report to the European Commission each year. The reports are forwarded to the European Food Safety Authority (EFSA) which publishes a summary of the reports.

The 2003/99/EC directive is composed of eight chapters containing seventeen articles regarding monitoring and control of zoonosis in the Member States. Four annexes with zoonotic agents and specific requirements are also added. The legislation includes rules concerning live animals, food of animal origin, wild animals and pet animals which may all be sources for zoonoses. The zoonoses and zoonotic agents given in Annex 1a should be monitored by all the member states

while zoonoses and zoonotic agents given in Annex 1b should be monitored depending on the epidemiological situation in the country. Zoonoses and zoonotic agents listed in Annex 1a that affect pet animals are brucellosis, echinococcosis, salmonellosis and tuberculosis while in Annex 1b rabies and leptospirosis (EUR-LEX, 2003).

2.2 Swedish institutions responsible for zoonotic disease control and prevention

Questions concerning zoonotic diseases and possible outbreaks in Sweden includes many different governmental agencies both from the human and veterinary fields; each one with its own expertise and area of responsibility. A close relationship, communication and collaboration between these agencies are of outmost importance for the prevention of zoonotic disease. In case of a zoonotic outbreak fast exchange of information is vital to minimize the damages. In year 2006 the involved agencies formed a zoonosis coordination group coming up with strategies for the collaboration between the agencies in case of a zoonotic disease and in 2009 a national plan was also made (SJÖBERG, et al., 2009). The agencies and their roles are described briefly in the following text.

2.2.1 Zoonosis Centre

The zoonosis centre in Sweden was established in conjunction with the European zoonosis directive. One of the main objectives of the centre is to give an overview of the zoonotic situation in Sweden. The centre is in charge of sending the yearly Zoonotic Disease Surveillance report to the EU. The zoonotic centre is also involved with epidemiological and other scientific studies to widen the knowledge concerning zoonotic diseases. It participates in the group with StramaVL and the Swedish national veterinary institute to follow the antibiotic resistance situation within the country (SVA, 2011).

2.2.2 National Zoonotic Council

In Sweden there is also a zoonotic council that was formed in conjunction with the zoonotic centre in 1997 to optimize the different agencies cooperation and mutual understanding. The council helps to build a common base for the agencies that practice within the area of zoonosis. The zoonotic council is represented by the Swedish National Veterinary Institute, the Swedish Board of Agriculture, National Food Agency, National Board of Health and Welfare, Swedish

Institute for Communicable Disease Control, Swedish Society of Communicable Disease Prevention and Control, Swedish Society of State Veterinarians, Swedish Work Society Authority and Swedish Association Environmental Health Professionals (SVA, 2011).

2.2.3 Swedish National Board of Health and Welfare (SoS)

SoS is the governmental agency under the Ministry of Health and Social Affairs. SoS is in charge of coordination of the human communicable disease control in Sweden (SJÖBERG, et al., 2009). SoS also has the central responsibility for surveillance control guidance for other committee's concerning contagious diseases as stated in the environmental code (SOCIALSTYRELSEN, 2009).

2.2.4 Swedish Institute for Communicable Disease Control (SMI)

SMI has the responsibility to monitor the epidemiological situation for communicable diseases among humans in Sweden. SMI is in charge to promote protection against such diseases and with the received information trace, analyse and fight infectious diseases as the governmental expert agency in this field. SMI is also the institution which carries out the diagnostic analyses of the infectious agents (BENGTSSON, et al., 2011).

2.2.5 Swedish board of agriculture (SBA)

SBA is the expert authority in the field of agriculture and food policy, and is in charge of agriculture and horticulture in Sweden. SBA is the chief authority for Swedish district veterinarians and promotes animal health and welfare by strict requirements. SBA is responsible of prevention and control of the spread of contagious diseases among animals (BENGTSSON, et al., 2011). In case of a zoonoses SBA is the agency that makes decisions concerning road blocks, quarantine, animal sample-taking, euthanasia, sanitation etc. and the control of such work. SBA is in charge of reporting cases of zoonotic diseases to the European Commission and the World Organisation of Animal Health (OIE) (SJÖBERG, et al., 2009).

2.2.6 Swedish National Veterinary Institute (SVA)

SVA are experts specialized in the field of risk assessments, prevention, diagnosis and control of contagious and infectious diseases including zoonotic agents. In addition to this SVA is also responsible for monitoring and control of antimicrobial resistance in bacteria from animals and food of animal origin in coordination with other relevant authorities (BENGTSSON, et al., 2011).

2.2.7 County Administrative Board

Sweden is divided into 20 counties with their own councils and 290 municipalities with self-governing local authorities (LÖFGREN, 2009). Municipalities' committees for protection of the environment and health are the surveillance control agencies in charge of controlling the spreading of infectious diseases from companion animals in the holding of private persons. If there is a suspicion of a companion animal carrying or spreading a severe zoonotic disease these committee's should immediately take measures to trace the infection and prevent the spreading. The committee has the rights to perform necessary examinations, testing's, declare injunctions and bans and decide about euthanasia of companion animals if necessary. The committee is also in charge of controlling different infections which are spreading indirectly from animals to humans, for example through animal faeces in the environment (SOCIALSTYRELSEN, 2009).

2.3 Swedish acts and legislations concerning zoonotic diseases of pet animals

Legislations concerning object-transferred infections are covered in the Environmental code (1998:808) chapter 9, article 14 and 15. Zoonoses spread by animal or feedstuff of animal origin is regulated by several different legislations. Often multiple regulations are involved and duties of the different governmental agencies are interposed on each other. It is therefore important that the agencies described above cooperate. In addition to the Environmental code is the Zoonosis act (1999:658), Epizootic disease act (1999:657) and the law concerning sample-taking on animals (2006:806) also regulating zoonotic diseases (SOCIALSTYRELSEN, 2009).

2.3.1 Environmental code

Pet animals in the environmental code are animals kept by private persons in their homes or close to their homes. A pet animal is defined by how the animal is kept and not by species.

Chapter 9 deals with questions concerning special regulations regarding protection of health. It states that the municipalities should without delay notify to the communicable disease control doctor about observations that could be of importance to the communicable disease control of humans.

If suspicion concerns a pet animal which is kept by a private person or an object carrying a severe contagious disease which can be transmitted to humans, the municipalities should immediately

take the measures necessary to trace the infection and eliminate the risk of spreading the infection. If it is necessary to prevent spreading of the disease the municipalities has the right to destroy objects of person and decide about euthanasia of pet animals kept by private persons. The person who has been affected by decisions according to the first part has the right to reasonable compensation by the municipalities. The first and second part are not applicable if the decisions are made based on the Food Act (2006:804), Act (2006:806) concerning sample-taking on animals, Epizootic disease act (1999:657) or the Zoonosis act (1999:658) (GOVERNMENT OFFICES OF SWEDEN, 1998:808).

2.3.2 Zoonosis act

The act is divided into chapters which state the general regulations, preventive measures and control, different agencies responsibilities, injunctions and prohibitions, penalty and appeal. These chapters are covered in 14 articles.

The Zoonosis act is complementing the EC-directive which falls within the scope of the act. The act concerns zoonotic diseases which are not covered in the Epizootic disease act. It only concerns such zoonotic diseases in which there is sufficient knowledge and means for effective control. The list of zoonotic diseases covered is given by the government in the SJVFS 2002:16. In case of other zoonotic agents and diseases which are not covered by this act there is other regulations concerning control and preventive measures in the act (1992:1683) concerning sample-taking on animals.

If a veterinarian suspects the occurrence of a zoonotic case the veterinarian should immediately do an examination to identify the disease or zoonotic agent and take measures necessary to prevent spreading. The caretaker should submit to the necessary measures and give help necessary for the examination. The caretaker who is the subject for public control or measures according to this law should also provide the help needed to perform the control or measures needed for prevention of spreading. The veterinarian should notify SBA and the County Administrative Board right away. The County Administrative Board should in their turn immediately notify the communicable disease control doctor. To confirm the occurrence or the freedom of a zoonotic disease SBA has the right to decide about sample-taking, examination of animal, products of animal origin or objects that can carry the infection. SBA can submit the

responsibility of decision making to the County Administrative Board or other governmental agencies. If a case of zoonosis is confirmed the County Administrative Board should also notify SVA, SMI, SoS, Swedish National Food Agency, the Municipal Agency of Environment and Health and the district veterinarian. The same applies for the finding of zoonotic agents in the laboratories where zoonosis are confirmed.

To prevent or combat a zoonotic disease the national government or governmental authority SBA implements rules or in separate case measures to be taken. Measures such as slaughter or euthanasia of animal, decontamination of dead animals, sanitation, vaccination or other preventive measures, examination of animal and animal products due to preventive measures, isolating animals, limitations or other conditions concerning animal keeping or products, transport of animals and animal products, methods for sample-taking and analysis in the laboratories (GOVERNMENT OFFICES OF SWEDEN, 1999:658).

2.3.3 Zoonosis decree

This decree contains complementing regulations to the Zoonosis act. The main chapter concerns compensation for persons affected by measures taken in accordance to the Zoonosis act. Compensation is decided by SBA. The given costs which are covered by compensation from the government funds are listed in this constitution and it is concluded that for dogs and cats which have been euthanized compensation is only given in case of professional breeding (GOVERNMENT OFFICES OF SWEDEN,1999:660).

2.3.4 Epizootic disease act

This law concerns such public health hazard diseases which can spread as an infection among animals or from animals to humans, epizootic diseases. Public health hazard diseases are such diseases which can be a serious threat against humans or animals health or cause big economic losses for the society. The epizootic diseases concerned are listed in the SJVFS 2002:16.

This law complements such EC-legislations which fall within the scope of this act. If someone has reason to suspect an epizootic disease among animals in his care he should immediately notify the district veterinarian or other veterinarian. Until the veterinarian give a notice the care-

taker should do everything possible to prevent or limit the spread of the disease. The government or the agency declared by the government should notify what should be done in given case.

If a veterinarian has reason to suspect a case of epizootic disease, the veterinarian should instantly make an examination to confirm the disease and agent. The veterinarian should do everything possible to prevent and hinder the spread of the infection. The care-taker is obliged to give the information and help needed for the examination. A veterinarian or someone working with the animal suspected of an epizootic disease should notify it to the SBA and the County Administrative Board. The obligation to notify the disease is also applied for laboratories. The County Administrative Board should without delay notify SVA, district veterinarian and the municipality committee for environmental and health. The veterinarian has the right to order isolation. This should be controlled by SBA which is responsible for the further measures in confirmed cases. If necessary an animal can be euthanized without the consent of the owner.

To prevent or combat epizootic disease the government or the agency declared by the government are allowed to order measures or in specific case decide about: slaughter or euthanasia of animal which is suspected to be infected or able to spread the infection, decontamination of dead animals or waste products, sanitation, vaccination or other preventive measures of animals, examination of animals and products in control purpose, limitations or other measures concerning transport or other management of live or dead animals, products and waste materials etc., documentation and record keeping, methods for sample-taking and analysis (GOVERNMENT OFFICES OF SWEDEN, 1999:657).

2.3.5 Epizootic decree

The epizootic decree withholds complementing regulations to the Epizootic disease act. It concerns the compensation of people affected by the Epizootic disease act. The compensation is decided by SBA in each case (GOVERNMENT OFFICES OF SWEDEN, 1999:659).

2.3.6 National board of Agriculture statutes

SBA's regulations concerning notifiable animal diseases are based on legislations given in the Zoonosis act and Epizootic disease acts. The regulations concern the veterinarians and people working in laboratories that suspect or detect notifiable diseases. The statute, SJVFS 2002:16,

defines the list of notifiable diseases to which the regulations apply. The notifiable diseases are listed according to diseases which can affect multiple species such as echinococcosis, rabies, brucellosis and diseases which affect specific groups such as companion animals in which leishmaniosis is listed (JORDBRUKSVERKET, 2002).

2.3.7 The act concerning sample-taking on animals

This law is applied for the detection and control of contagious animal diseases, control of residues and other materials in animals and animal products, marking and registration of animals, measures to prevent and restrict the spreading of contagious animal diseases.

To map the incidence, confirm freedom from or control contagious animal diseases the government or agency entitled by the government should implement the measures and in the individual case decide about sample-taking and examination according to this law. The sample-taking or examination should be done by a veterinarian or other person authorized by the government. Sample-taking and examination can be done without consent from the owner. The government or the agency given by the government can order measures concerning what the veterinarian or the one in charge of a laboratory should do concerning notification and reporting in case of suspecting or confirming contagious animal diseases.

To prevent and hinder the spread of a contagious animal disease the government or the agency defined by the government can order measures or in specific case decide about euthanasia of animals, isolation of animals and limitations or other terms concerning handling of animals or animal products. For combating of epizootic and other zoonotic diseases the special regulations are given in the Epizootic disease act and Zoonotic act (GOVERNMENT OFFICES OF SWEDEN, 2006:806).

2.3.8 The act of communicable diseases

The act of communicable diseases is composed of nine chapters and two annexes. The chapters are divided into general regulations, preventive measures and notification of diseases, examination in case of illness, isolation, communicable disease control doctors, compensation, appeal and other regulations. In the annexes the list of diseases which are of public health hazards are listed.

It is stated that this law should meet the population's need of protection against spreading of communicable diseases. The law defines rules concerning preventive measures of spreading communicable diseases in humans. Regulations concerning preventive measures for animals or feedstuff or other objects are given in the Environmental code, Epizootic act, Zoonosis act etc.

The responsibilities for the control of communicable diseases are given in articles seven to ten of this law. SoS are responsible for the coordination of the communicable disease control at national level and should take the action needed to maintain an effective communicable disease control within the country. Every County Council is responsible for the necessary communicable disease control and measures needed, within each county. In each county there should be a communicable disease control doctor available. Agencies concerning the communicable disease control, other concerned agencies, doctors and health- and medical staff should cooperate to prevent and minimize the spreading of a communicable disease.

Doctors and other medical staff should be aware of the incidence of communicable diseases and take measures needed from a communicable disease control point of view. A doctor who suspects or confirms a case of a public hazard disease or other notifiable disease should without delay notify to the communicable disease control doctor in the County Council and to the Communicable Disease Control Institution (GOVERNMENT OFFICES OF SWEDEN, 2004:168).

2.3.9 The act concerning international threats against human health

The act includes regulations to fulfil World Health Organization's international regulations put in force in Genève 2005. The law act to protect against international threats against humans health. Diseases described as a threat to the society in the act of communicable diseases should always be considered as an international threat against human health.

This act states the regulations concerning measures to be taken to protect human health and procedures at arrival to Sweden, also including control of animal that might be carrier of infections (GOVERNMENT OFFICES OF SWEDEN, 2006:1570).

2.4 History of the legislation concerning transport of pet animals to Sweden

Until 1995 when Sweden joined the European Union, every dog that entered Sweden had to be quarantined except dogs coming from Norway. Dogs from Norway did not have to be quarantined since Sweden and Norway had the same epidemiological status for a very long time.

Between year 1995 and 2004 dogs from EU and EFTA countries were allowed into Sweden without quarantine if they had correct identity mark, rabies vaccinations, rabies antibody control, other prophylactic treatments and an import license.

Since 2004 the European pet regulation 998/2003 allows dogs to entry Sweden in combination with Sweden's national requirements to control the movements of pets in EU. Dogs from EU and EFTA countries only needed identity mark, rabies vaccination, antibody testing, deworming and a pet passport. It facilitate the travelling with dog between different European countries and Sweden but also presents a risk of transferring infections previously unknown to Sweden into new areas (STRÖM HOLST et al., 2012).

Today the regulations for importing a dog/cat or travelling from an EU or EFTA country to Sweden are the same as in all other EU countries. The pet only needs a passport and rabies vaccinations that are up to date. No rabies antibody titre is needed any more nor deworming since echinococcosis is nowadays present in Sweden (JORDBRUKSVERKET, 2012).

3 Notifiable zoonotic diseases in Sweden

3.1 Canine brucellosis

3.1.1 Aetiology

There are many different *Brucella* species affecting primary- and secondary host species (SVA, 2013a). Canine brucellosis is a contagious infection caused by a gram-negative coccobacillus, *Brucella canis*. *Brucella canis* can affect all dog breeds and occasionally also humans (WANKE, 2004). It is of special concern for breeding dogs as the main source is venereal transmission and it causes reproductive problems (STRÖM HOLST, et al., 2012). Dogs can be infected with other zoonotic *Brucella* species sporadically in which case the dog act as a secondary host species for *Brucella abortus* or *Brucella suis* infections. *Brucella abortus* and *Brucella suis* has both been isolated from dogs in conjunction with abortion (SVA, 2013a).

3.1.2 Transmission

Spreading of the *Brucella canis* infection occurs mainly by transmission through vaginal secretion from infected bitches. Transmission also occurs by excretion of bacteria within the semen in male dogs and urine in both sexes with a higher titre in male urine. The excretion with urine starts 4-8 weeks post infection. Cages, equipment and people which has been in contact with infected dogs can also be a source of infection (WANKE, 2004). The environmental infection spread mostly by places where the dogs often urinate (STRÖM HOLST, et al., 2012).

3.1.3 Pathogenesis

The entry route of the bacteria is via genital, oronasal or conjunctival mucosa (WANKE, 2004). After entry into the body the bacteria is phagocytized by macrophages and other phagocytic cells and transferred into lymphatic and genital organs through the blood, where the bacteria reproduce (STRÖM HOLST, et al., 2012). Bacteraemia occurs within 1-4 weeks and persists for a minimum of 6 months and continuous as an intermittent infection. As the bacteria reaches the target organs with the blood pathological changes typical for the disease occurs (WANKE, 2004).

3.1.4 Clinical symptoms

Most of the time canine brucellosis is not a generalized disease with general clinical signs but the symptoms vary according to the affected organs (WANKE, 2004). The most typical clinical signs

of canine brucellosis are abortion in the third trimester of pregnancy (STRÖM HOLST, et al., 2012). Symptom in the bitch is abortion with partly autolysis of puppies. The puppies' shows lesions characteristic of generalized bacteraemia. In the affected bitch a greenish-grey vaginal discharge is continuous for a long period of time, repeated abortions and puppies born healthy and developing disease later as a generalized lymphadenitis before puberty is also common. In male dogs the most typical clinical signs are severe epididymitis and prostatitis accompanied by pain, increased size and accumulation of fluid (WANKE, 2004). Brucellosis in male dogs can be seen in the acute phase as described above or chronic phase with decreased size and atrophy of the testis (STRÖM HOLST, et al., 2012). A few cases of brucellosis have been reported in humans generally after close contact with infected animals. Humans infected with brucellosis shows signs of prolonged fever, enlarged lymph nodes, joint pain and weight loss (WANKE, 2004).

3.1.5 Diagnosis

Definitive diagnosis can be made only by a bacteriological isolation but often serological diagnosis is made in the practice which might give false positive or negatives (WANKE, 2004). Blood culture can be used but it is better to use sample from the genital tract as the infection is localized in these parts (STRÖM HOLST, et al., 2012). Two negative tests should be taken four to six weeks apart to prove that a dog is free from brucellosis due to the long incubation time (HOLLETT, 2006). As the symptoms are quite unspecific in humans some cases might go undetected and often a history of close contact with dogs is needed to make the diagnosis (STRÖM HOLST, et al., 2012).

3.1.6 Treatment

Treatment of dogs infected with *Brucella canis* is complicated since it is an intracellular bacterium which makes it hard to reach by antibiotic treatments. So far no treatment plan is 100 % effective to eradicate the disease in dogs (WANKE, 2004). Since the infected dogs, even without clinical signs can transfer the infection to other dogs and humans euthanasia is often recommended (STRÖM HOLST, et al., 2012). Affected humans in comparison to animals, responds very well to antibiotic treatment (WANKE, 2004).

3.1.7 Prevention and control

Brucella canis is a notifiable disease for animals in Sweden according to SJVFS 2002:16 and in humans according to the Communicable disease act (SFS 2004:168). The surveillance in both pet animals and humans are passive (BENGTSSON, et al., 2011).

If any of the clinical symptoms of brucellosis occurs the dog should be tested and if diagnosed positive control measures should be taken. Quarantine should be enforced, serological testing of all dogs in a kennel should be done, identification of the source and removal of positive animal. To prevent brucellosis all female and males should be routinely tested before breeding. No positive animals should be used in breeding programs (WANKE, 2004).

Since the severe form of the disease SBA has the right to decide about proper measures. A huge effort is put on the contact tracing if dogs are suspected to be infected. Euthanasia of infected dogs is often the only effective way to eradicate the disease. Sanitation of the environment is also very important in the control (JORDBRUKVERKET, 2013a). The most important preventive measure is to have a strict control of breeding dogs especially if mated to dogs from other countries. Control of dogs imported from other countries can also play a role to minimize the risk of infection (SVA, 2013a).

3.1.8 Cases in Sweden

In December 2010 the first case of *Brucella canis* was suspected in Sweden. A three years old American Staffordshire terrier, imported from Poland was presented to an animal hospital in south of Sweden. The dog was 46 days pregnant, of good general condition but had green vaginal discharge. On the ultrasound it was shown that all pups were dead. The bitch had been mated in Poland as she been once before as well without conceiving. The dog was tested negative for *Brucella canis*.

In May 2011 the same dog was presented with bloody vaginal discharge. At this time she was 59 days pregnant after mating with the same dog. The ultrasound showed death and autolysis of the puppies. A caesarean section was made and the placenta and aborted foetuses was sent to SVA for bacteriological analysis. The test came back positive for *Brucella canis* and so did the serological test.

SBA made the decision to isolate the bitch and initiate contact tracing and contacted the county veterinarian and county medical officer. The definitive decision was made by SBA to euthanize the bitch as recommended by SVA. SVA recommended how and which dogs to be tested and SBA had the main responsibility for the contact tracing. Dogs in Sweden that had been mated to the infected bitch, had been in common housing or in close contact were all tested. The dogs were tested twice by both bacterial culture and serology. Possible sources of the infection were the dogs that was mated to the bitch and in total 15 dogs were tested, all negative. Since all other dogs tested negative the source of the infection could not be established. The government made the decision to eliminate the infected bitch since *Brucella canis* is a zoonotic agent and may cause disease in humans and the fact that there is no fast and reliable diagnosis (STRÖM HOLST, et al., 2012).

In August 2013 as I wrote this thesis one more case of *Brucella canis* was discovered in a Swedish kennel breeding Miniature Schnauzers. *Brucella canis* was diagnosed in a bitch that aborted her litter in the beginning of August and tests were carried out to find the reason. Samples were sent to SVA where they diagnosed the bitch with *Brucella canis*. SBA made the same the decision as in the first case to euthanize the bitch and start the contact tracing. One more bitch from the same kennel was also euthanized after showing similar clinical signs. The rest of the dogs in the kennel are now being tested (GUNNARSSON, 2013).

3.2 Echinococcosis

3.2.1 Aetiology

Echinococcosis also referred to as hydatid disease is caused by the tapeworms *Echinococcus granulosus* and *Echinococcus multilocularis* (RABINOWITZ, et al., 2007). The genus *Echinococcus* contains multiple species but only *E. multilocularis* and *E. granulosus* are found in Europe. *E. multilocularis* causes alveolar echinococcosis (WAHLSTRÖM, et al., 2012) while *E. granulosus* causes cystic echinococcosis (DEPLAZES, et al., 2011). The lifecycle of these two *Echinococcus* species vary greatly but both require a definitive and an intermediate host.

Humans may acquire the infection by accidentally ingestion of the *Echinococcus* eggs but are dead-end hosts (BENGTSSON, et al., 2011). Alveolar echinococcosis is one of the most serious

parasitic diseases in humans that can be found in Europe (WAHLSTRÖM, et al., 2012). It rarely affects humans but it is a public health concern due to its high mortality rate (BENGTSSON, et al., 2011).

3.2.2 Cystic echinococcosis transmission and pathogenesis

Cystic echinococcosis caused by *E. granulosus* frequently has domestic dogs and wild canids as its main hosts who excrete the eggs with their faeces. The excreted eggs serve as a source of infection to intermediate hosts such as cattle, horses and wild ruminants. In the intermediate hosts the egg develops into a hydatid cyst (the larval stage) which is mostly found in the liver and occasionally other organ such as lung, heart or brain tissue. The main host acquires the infection by ingestion of infected organs containing the hydatid cysts (BENGTSSON, et al., 2011). Humans may acquire the infection by ingestion of the eggs shed in dog faeces (RABINOWITZ, et al., 2007). In humans as well as the animals the main localization of the hydatid cysts are the liver but other organs might be infected as well.

3.2.3 Alveolar echinococcosis transmission and pathogenesis

E. multilocularis causes alveolar echinococcosis, an even more fatal form of echinococcosis of which dogs and cats might be definitive hosts (RABINOWITZ, et al., 2007). A significant source of the spreading of *E. multilocularis* in Europe is represented by foxes as definitive hosts. Rodents may serve as intermediate host and play a big role in spreading the infection to dogs and cats. The pet owners therefore have a risk of becoming infected (ROBERTSON, et al., 2000). The transmission of *Echinococcus* can occur from animals to humans when humans ingest infective eggs shed in dogs or other definitive hosts faeces but it can also be due to contact with contaminated soil (MANI and MAGUIRE, 2009).

3.2.4 Clinical signs of cystic echinococcosis

In animals the infection is present mostly asymptotically (BENGTSSON, et al., 2011). In humans the clinical sign of the infection depends on the cysts mostly found in the liver and lungs (MANI and MAGUIRE, 2009). The incubation period for developing hydatid cysts vary between months up to years and infected humans might therefore be asymptomatic for years. The clinical signs depend on the number, localization and pressure of the cysts on the surrounding tissues (BENGTSSON, et al., 2011).

3.2.5 Clinical signs of alveolar echinococcosis

Infection with *E. multilocularis* leads to clinical signs from invasion and destruction of the liver which is frequently fatal (MANI and MAGUIRE, 2009). In humans the infection may lead to serious, even fatal disease with cystic tumour-like lesions in the affected organ. The incubation time to develop the clinical signs in humans are very long, it is thought to be between 5-15 years (BENGTSSON, et al., 2011).

3.2.6 Diagnosis

Diagnosis of individual animal or mass screenings is possible. Diagnosis can be made based on different materials and methods. One method is based on finding the eggs in faecal samples but this has a low sensitivity. ELISA for detection of the antigen in the faeces or PCR used in faecal samples are possible as well (DEPLAZES, et al., 2011). In humans the diagnosis is based on CT and ultrasound (RABINOWITZ, et al., 2007).

3.2.7 Treatment

Alveolar echinococcosis is fatal within 10 - 15 years if left untreated (DEPLAZES, et al., 2011). As the disease has a very long incubation period the disease is often detected at a late stage and requires long-term or even life-long treatment or surgery (HÖJGÅRD, et al., 2012).

3.2.8 Prevention and control of cystic echinococcosis

E. granulosus is notifiable in all animals according to SJVFS 2002:16 as well as in humans according to Communicable disease act. The surveillance in animals is based on routine meat inspection and in human it is passive. *E. granulosus* has not been detected in Sweden since 1990's (BENGTSSON, et al., 2011).

3.2.9 Prevention and control of alveolar echinococcosis

Detection of *E. multilocularis* in animals is notifiable according to Swedish legislation SJVFS 2002:16. For humans the infection has been notifiable since 2004 as well according to Communicable disease act (SFS 2004:168). The surveillance among foxes is active in Sweden while for human it is passive (BENGTSSON, et al., 2011).

E. multilocularis was found in a red fox for the first time 11th February 2011 in Sweden. After this finding the surveillance among foxes in Sweden was increased and faecal samples was

collected from hunting dogs as well. A consulting group lead by the National Board of Health and Welfare was put together to take action. After some research it was concluded that *E. multilocularis* was not restricted to a single area and could not be eradicated.

As alveolar echinococcosis is a public health concern it is recommended to keep high hand hygiene after contact with free running pets in risk areas (WAHLSTRÖM, et al., 2012).

Until 2010 when Sweden was free from echinococcosis it was required to treat all dogs and cats with praziquantel before entering as a preventive purpose. EU regulation 998/2003 gave Sweden a transitional period for these rules until 31 December 2011. As *E. multilocularis* is now found in Sweden there is no longer any legal requirement to treat animals before entering but dog owners are still recommended to deworm their pets before entering as the prevalence of the parasite is still very low (BENGTSSON, et al., 2011). Deworming before entry to Sweden will reduce the risk for the individual dogs of becoming infected but it also helps to prevent further spread of alveolar echinococcosis to areas where it is still not present. It is not known when and exactly how *E. multilocularis* was introduced to Sweden but most likely it was through illegal admission of dogs from mainland Europe (WAHLSTRÖM, et al., 2012).

3.3 Leishmaniosis

3.3.1 Aetiology

Canine visceral leishmaniosis is a worldwide zoonosis caused by the protozoal parasite *Leishmania infantum* (PINTO, et al., 2011). *Leishmania* is rapidly becoming an emerging zoonotic disease worldwide (MORIELLO, 2003).

3.3.2 Transmission and pathogenesis

Leishmaniosis is a vector-borne intracellular protozoan disease with the blood-sucking phlebotomine sand-fly as the main vector and dogs as the primary reservoir host (IRWIN, 2002). Dogs as the primary reservoir play an important role in the transmission to humans and present a public health concern (PINTO, et al., 2011). Few cases of possible direct transmission with blood to human have been reported. Since the sand mosquitoes do not occur in Swedish climate the risk of spontaneous transmission is very low. Visceral leishmaniosis is a severe disease for humans but the risk that healthy people not living in an endemic area of becoming infected is very low

(SVA, 2013b). Tissue damage that appears in Leishmania infections is due to the granulomatous inflammation and immune complex deposition (MORIELLO, 2003).

3.3.3 Clinical signs

Leishmania has a very long incubation period from three months up to seven years. 90% of the infected dogs show cutaneous lesions like alopecia, scaling and ulcerations while some even show systemic signs. In humans Leishmania presents in two typical forms depending on the species responsible for the infection; cutaneous and mucocutaneous or visceral leishmaniasis.

Dogs serve as the main reservoir of the visceral leishmaniosis caused by *L. infantum* (MORIELLO, 2003). Leishmaniosis causes severe chronic illness in both dogs and humans (IRWIN, 2002). The visceral form of the disease also called Kala azar is the most severe form with high fatality (STRÖM HOLST, 2003/2004). The clinical signs presented by visceral leishmaniosis in humans ranges from lymphadenopathy, skin lesions, weight loss, hepatic- and splenomegaly, musculoskeletal abnormalities and atrophy, renal diseases and epistaxis (PINTO, et al., 2011).

3.3.4 Diagnosis

The diagnosis can be made based on cytological samples and/or histopathology. Serological investigation can also be made but the most accurate method is PCR (MORIELLO, 2003).

3.3.5 Treatment

Treatment is very difficult in infected dogs and cats and there is no treatment proved to be sufficient. Treatment of leishmaniosis seldom leads to total eradication of the parasite (MORIELLO, 2003).

3.3.6 Prevention and control

Leishmaniosis is notifiable in both dogs and cats in Sweden according to SJFV 2002:16 (SVA, 2013b).

The spreading of leishmaniosis from south to northern Europe is a concern caused by pet owners that brought their animals on vacation to endemic areas and after brings them back home. Leishmania has a long pre-patent period and it is possible that the animal is brought back to non-

endemic areas without any clinical signs (IRWIN, 2002). With the movement of pets all over Europe leishmaniosis is spreading to areas which have not been endemic before (ROBERTSON, et al., 2000). Leishmaniosis does not occur natively in Sweden but during the last years Leishmania have been diagnosed in several dogs, most of the dogs were imported street dogs or dogs that have been travelling to south Europe (SVA, 2013b).

To prevent the infection it is important to use mosquito repellents and vaccinate the dogs when travelling to endemic areas. Due to the very rare cases of suspected direct transmission for example by contaminated material used for treatment of an infected dog some preventive measures should be taken especially for immune-compromised individuals (SVA, 2013b).

3.4 Leptospirosis

3.4.1 Aetiology

Leptospirosis is a bacterial disease (MAELE, et al.). Leptospira species are highly motile, obligatory aerobic spirochetes. Canine species are carriers of *L. canicola*, *L. bataviae* and *L. icterohemorrhagiae* (MANI and MAGUIRE, 2009).

3.4.2 Transmission

Leptospirosis is one of the most common zoonotic diseases worldwide and can be carried both by wild and domestic animals. Among pet animals dogs seems to be infected more often than cats. The infection can be transmitted to humans through contact with urine, other body fluids from infected animals or indirectly by contaminated environment (RABINOWITZ, et al., 2007). Rodents act as maintenance hosts for several of the Leptospira serovars and therefore hunting dogs and dogs in regular contact with wildlife are in greater risk of becoming infected (MAELE, et al., 2008).

3.4.3 Pathogenesis

In the animal Leptospira colonize in the proximal renal tubules and is shed with the urine (MANI and MAGUIRE, 2009). Leptospira enter the host by direct way from contaminated urine or indirect from the environment contaminated soil, water or mud. Once inside the host the infection spreads rapidly. Leptospiraemia can last up to 10 days after the onset of clinical signs, after this

time the infection localizes in the proximal renal tubules and is shed in the urine (MAELE, et al., 2008).

3.4.4 Clinical symptoms

The infection in humans is often asymptomatic or present with clinical signs similar to mild influenza. In some cases more severe disease can be seen with high fever, headache, hepatitis, conjunctival suffusion, abdominal pain, diarrhoea and in worst cases renal failure, heart failure or even death (RABINOWITZ, et al., 2007). Cats usually do not develop clinical leptospirosis (MANI and MAGUIRE, 2009). Most common clinical signs in dogs are icterus, haemorrhagic diathesis and acute renal failure. The severity of the clinical signs is very variable. Leptospirosis in dogs varies from peracute, acute, subacute to chronic infections (MAELE, et al., 2008).

3.4.5 Diagnosis

Subacute leptospirosis is the most commonly clinical form diagnosed. To diagnose the infection complete blood count, biochemistry and urinalysis are made. Antibody detection is the most often used method, also serological methods such as microscopic agglutination test can be used (MAELE, et al., 2008). *Leptospira* is hard to culture and do not always give the right results. Often two blood samples are taken to control the antibody levels, two to four weeks apart (SVA, 2013c).

3.4.6 Treatment

To treat leptospirosis both supportive and specific treatment is important such as antimicrobial and fluid therapy (MAELE, et al., 2008).

3.4.7 Prevention and control

Leptospirosis is a notifiable disease in animals according to SJVFS 2007:90 as well as in humans according to the Communicable disease act (SFS 2004:168). Surveillance in pet animals and humans are passive (BENGTSSON, et al., 2011).

Leptospirosis is an unusual disease among dogs in Sweden, the disease occurs more often in climates warmer than Sweden. Vaccination against *L. canicola* and *L. icterohaemorrhagiae* is recommended for dogs that are travelling outside the Scandinavian countries and will stay in

close contact with wild animals. Gloves are recommended to use when handling infected dogs and their urine (SVA, 2013c).

3.5 Methicillin-resistant *Staphylococcus aureus* (MRSA) and Methicillin-resistant *Staphylococcus pseudointermedius* (MRSP)

Antimicrobial agents are often used in the small animal practice. Frequently broad-spectrum antibiotics such as aminopenicillins and clavulanic acid, cephalosporins and fluoroquinolones are used, preparations also commonly used in human medicine (GUARDABASSI, et al., 2004). Antimicrobial resistance involves a lot of different bacterial species, resistance mechanisms, reservoirs and transfer mechanisms and is therefore a very complex problem (WEGENER, et al., 1999).

Resistance to various antimicrobial agents have emerged in pet animals isolates of different bacteria including for example *Staphylococcus aureus*, a gram positive bacterium. Methicillin-resistance means that the *Staphylococcus* is changed genetically through the so called *mecA*-genes. The *Staphylococcus* becomes more resistant to beta-lactam antimicrobials which become ineffective (EFSA, 2009). Beta-lactam antimicrobials are a large and important group of antibiotics to which penicillin, amoxicillin and cephalosporins belong (SVA, 2013d). Methicillin-resistant *Staphylococcus aureus* (MRSA) has potential of zoonotic transmission and pet animals might serve as a reservoir of the infection for humans (GUARDABASSI, et al., 2004). There is still limited information of the zoonotic aspect of methicillin-resistant *Staphylococcus pseudointermedius* (MRSP) and more information is needed (SVARM REPORT, 2013).

Staphylococcus aureus is the most common agent in wound infections but can also cause more severe infections such as sepsis (SOCIALSTYRELSEN, 2011). Symptoms of MRSA can be mild, severe or in worst case even fatal (EFSA,2009). Most of the isolates of MRSP among companion animals in Sweden have been found in dogs but there were also a few cases in cats. The most common location of *Staphylococcus pseudointermedius* is skin, ear and wound infections (SVARM REPORT, 2013).

MRSA infection in companion animals is increasing and it has been shown that most of the cases of MRSA infections in companion animals are of the same type found in the human hospitals in

the same area (EFSA, 2009). As the use of antimicrobials increase in companion animals living in close connection to their owners they represent an important potential source of spreading antimicrobial resistance. In many cases bacterial identification and antimicrobial susceptibility testing is not carried out before antimicrobial treatment in companion animals, leading to inappropriate treatment. Dogs hospitalized in intensive care unit where broad-spectrum antibiotics are often used present a problem for the emergence of multi-resistant pathogens (GUARDABASSI, et al., 2004).

People working with animals infected with MRSA are a risk group of becoming infected, it is therefore very important to minimize the chance of transmission with good hospitalization hygiene (SOCIALSTYRELSEN, 2011). Companion animal which carries MRSA can be a threat of infection to the owners as well, especially if the owner is immune-compromised or is in closer contact to the pet such as children. It should also be emphasized that pet animals may become a reservoir of MRSA after infection transferred from human; transmission can also be human-to-pet. If companion animals and humans share the same household both direct and indirect transmission has favourable conditions (GUARDABASSI, et al., 2004). MRSA is mostly transmitted through direct contact but can also be transmitted indirectly thorough the environment (SVA, 2013d). In case of human-to-pet infection the dogs and cats still play an important role in the propagation of MRSA through shredding of the resistant bacteria in their faeces. It is more likely that MRSA is transferred from humans to pets than the other way around but pets still play an important role as reservoirs of the infection (GUARDABASSI, et al., 2004). Antimicrobial resistant bacteria only need a very low number to transmit from one host to another. Resistant bacteria selected by antimicrobial use in pet animal practice can reach humans and exchange their resistant genes with resistant bacteria in humans, and the other way around (GUARDABASSI, et al., 2004).

MRSA was noticed for the first time in a dog in Sweden 2006 and in a cat 2009 (SVA, 2013d). Treatment of dogs or cats with MRSA infections should not include antibiotics. It has been shown that traditional wound treatment is enough to make most of the wounds heal. MRSA is a notifiable disease in pet animals according to SBA's statutes 2002:16 (SVA, 2013d) and is regulated according to the Environmental code (SOCIALSTYRELSEN, 2011). In humans it is

notifiable as well according to the Communicable disease act (2004:168) (SVA, 2013d). MRSA has been classified as a communicable disease since 2000 and since 2008 all cases of MRSA is notifiable in all animal species in Sweden (SOCIALSTYRELSEN, 2011).

If a case of MRSA or MRSP is suspected, isolates should be sent to SVA for confirmation of the *mecA* genes (SVARM REPORT, 2013). The district veterinarian and the communicable disease doctor should be contacted if a case of MRSA is confirmed, it is important that the animal is isolated so no direct or indirect contact is possible with other patients (SVA, 2013d).

MRSP was noticed the first time in a Swedish dog 2006 and is a notifiable disease since 2008. It is also covered by the Communicable disease act for humans since 2000. To prevent the spread of MRSA and MRSP many clinics and hospitals have started infection control programs including keeping a very high hygiene (SVARM REPORT, 2013).

3.6 Rabies

3.6.1 Aetiology

Rabies is a fatal viral disease caused by rhabdovirus from the family of Lyssaviruses (BENGTSSON, et al., 2011). Rabies can present as the classical furious form or as paralytic rabies. It has a very long incubation time and is present in the infected animal or human long before clinical signs appears (HEMACHUDHA, et al., 2013). Rabies can infect all mammals including humans and is one of the most severe zoonotic diseases around the world (JORDBRUKSVERKET, 2013b).

3.6.2 Transmission and pathogenesis

Rabies is mainly transmitted by the saliva from dog bites in Europe compared to America where most infections are transmitted by bats (HEMACHUDHA, et al., 2013). Carnivores and stray dog serve as a reservoir of the infection in endemic areas of Europe. For more than 100 years Sweden has been free from rabies (BENGTSSON, et al., 2011).

The most efficient transmission rout of rabies is by bites from an infected animal carrying the virus in the saliva. Other routs of transmission include inhalation, organ and tissue transplants, handling and skinning of infected carcasses or contamination of wounds and scratches. The

incubation time vary from weeks up to years but the average is 1-2 months independent of the location of the bite. During the long incubation time the virus is found in the muscles with low replication. During the prodromal stage the non-specific clinical signs such as fever, flu-like symptoms, malaise or gastrointestinal problems appear and the virus is already spread throughout the central nervous system. From the infected muscles the virus spread through centripetal or centrifugal propagation (HEMACHUDHA, et al., 2013).

3.6.3 Clinical signs

The four stages of rabies are; incubation period, prodromal, acute neurological signs, coma and death (HEMACHUDHA, et al., 2013). Rabies affects the central nervous system of the infected animals, showing non-specific clinical signs during the prodromal stage and as the infection progress neurological symptoms such as hyper salivation, insomnia, paralysis, confusion and hallucinations appear (BENGTSSON, et al., 2011).

The clinical symptoms of infected dogs are changes in the mental state to a more aggressive state. Dogs also get a changed appetite and often eat un-normal particles such as stones. In the end the dogs suffers from convulsions, paralysis and dies. The disease is similar in cats and most often seen as the classical aggressive form (JORDBRUKSVERKET, 2013b). Most of the infected humans show the classical form of furious rabies with clinical signs such as changed mental status, fluctuating consciousness, spasms and autonomic stimulation signs. Around one third of the infected humans show paralytic form with signs similar to Guillian-Barré syndrome with progression to coma, bladder incontinence and myoedema (HEMACHUDHA, et al., 2013).

3.6.4 Diagnosis

The diagnosis of rabies is made post mortem in animals. The virus has to be localized on at least two places in the brain, preferably the cerebellum and brainstem. To diagnose the disease in humans ante-mortem is hard and requires several different tests. Tests are taken from saliva, serum, spinal fluid and biopsies. The samples are tested with PCR, for virus antibodies and antigen (CDC, 2011).

3.6.5 Treatment

The attempts to treat humans showing symptoms of rabies are mostly unsuccessful and very few cases survived. There is no standard treatment for rabies and as it is the most fatal viral

encephalitis more information and understanding of the disease is necessary (HEMACHUDHA, et al., 2013).

3.6.6 Prevention and control

Rabies is a notifiable disease in Sweden according to the Epizootic diseases act. Any suspicion or confirmation of rabies should be notified and measures taken for prevention and control of further spread (BENGTSSON, et al., 2011). Rabies in humans is also notifiable according to the Communicable disease act (SFS 2004:168). For both animals and humans the surveillance is passive in Sweden.

In Sweden rabies vaccinations are used to prevent rabies infections by building up pre-exposure immunity and there for prevent animals from getting infected by rabies and spreading to other animals or humans. As Sweden's obligatory quarantine system was removed in 1995 when joining EU the new European Committees' rules for non-commercial movement of pets was put in place. The rules state that all pet animals should be properly identified by microchip or tattoo and vaccinated against rabies with a 21 day waiting period from the primary vaccination before entering Sweden (BERNDTSSON, et al., 2011). As Sweden is free from rabies the EU regulation 998/2003 should be followed to prevent the introduction.

As the illegal importation of pet animals, especially dogs, to Sweden has been increasing during the last 10 years when the new EU regulations were put in force there is a greater chance of introduction of rabies. The illegal importation of pet animals is probably the biggest threat to the rabies free status of Sweden (BENGTSSON, et al., 2011).

3.7 Salmonellosis

3.7.1 Aetiology

Salmonellae are gram-negative, motile, non-spore forming facultative anaerobic bacilli. Salmonella consists of two species; Salmonella enterica and Salmonella bongori (MARKS, et al., 2011). Salmonella enterica are a strictly human pathogen while the other zoonotic serotypes have a wide variety of animal reservoirs (MANI and MAGUIRE, 2009). The prevalence of salmonella is similar in healthy dogs and cats as in animals presenting with diarrhoea. Salmonella is pathogenic to dogs and cats but many cases are subclinical and not all strains are equally capable

of causing disease. The virulence depends on multiple factors such as the infective organism and the host (MARKS, et al., 2011).

3.7.2 Transmission and pathogenesis

Transmission of salmonella is mainly through the faecal-oral route but also through direct contact or ingestion of contaminated meat or products of an infected animal. Cats can become infected with the serotype Typhimurium through hunting and catching infected birds. A potential way of dogs and cats becoming infected is through eating pig ear or raw food diets (MANI and MAGUIRE, 2009).

Salmonellosis has a major zoonotic importance all around the world as all salmonella species with the exception of the one causing human typhoid fever infects both humans and animals. Feeding the dog on a raw meat diet is the most common way of transmission of the infection to dogs and also a risk of transmission of salmonella to humans. There have also been salmonella infections in humans connected to contact with contaminated dry dog and cat food (MARKS, et al., 2011).

Salmonellosis is wide spread throughout the entire world except in Scandinavia with only a few cases each year. In most of the cases a high infection dose is needed to cause a disease (SVA, 2013e).

3.7.3 Clinical signs

Most animals infected with salmonella are asymptomatic while clinical disease can develop especially during stress or other illness (MANI and MAGUIRE, 2009). The clinical signs depend on the involved salmonella species, the infective dose and the animals' immune response. Not all the infections lead to disease (SVA, 2013e). Canine and feline salmonellosis is often an acute disease but should be suspected in any acute or chronic gastrointestinal disease among dogs and cats as the clinical signs are highly variable. The acute clinical signs occur about three to five days after the exposure but sometimes as early as 12 hours post exposure. The most common clinical signs are fever, malaise, anorexia followed by vomiting, abdominal pain and watery diarrhoea, bloody in severe cases (MARKS, et al., 2011). Humans can be asymptomatic or develop self-limiting disease with diarrhoea, fever and sometimes transient bacteraemia.

Prolonged bacteraemia or even sepsis might develop especially in immune-compromised beings, infants or older (MANI and MAGUIRE, 2009).

3.7.4 Diagnosis

The diagnosis of canine or feline salmonellosis are based on isolation of the agents in conjunction with clinical signs presented and assessment of risk factors such as hospitalization, age, environment or long time antibiotic treatment. The isolation can be made with a culture or by PCR (MARKS, et al., 2011). The culture is made from fresh faeces of the infected animal. The culture might show a false negative during the first week as the infection might be intermittent (SVA, 2013e). The isolation alone is not enough as a diagnosis of salmonella induced enteritis among dogs and cats as healthy animals might carry salmonella as well (MARKS, et al., 2011).

3.7.5 Treatment

Treatment depends on how severe the clinical signs are, in most cases of salmonellosis in dogs' and cats' only supportive treatment is recommended. In case of systemic disease or in immune-compressed animals antimicrobial treatment might be needed (MARKS, et al., 2011). It is important not to give antimicrobial treatment if not needed due to the increasing chance of resistant bacteria (SVA, 2013e).

3.7.6 Prevention and control

Salmonella irrespective of serovar is notifiable in all animal species according to the Zoonosis act (SFS 1999:658). Salmonellosis is notifiable in humans as well according to the Communicable disease act (SFS 2004:168).

Pet animals are tested for Salmonella if suspected or trace-back. In humans all reported cases of domestic salmonellosis are traced for the source of the infection. All the isolates taken are sent to Swedish Institute for Communicable Disease Control and analysed according to WHO's guidelines. In Sweden and the rest of the Scandinavian countries salmonellosis have a low proportion of domestic human infections compared to most other European countries. This reflects a good Salmonella situation in domestic animals and food (BENGTSSON, et al., 2011).

In year 1999 the first case of salmonella from outdoor cats was discovered in Sweden. At the same time a higher frequency of Salmonella Typhimurium was also discovered in small song-

birds and humans. It was concluded that that the spread was made through cats catching the birds (SVA, 2013f).

Preventive measures are based on heating the food and thorough hand hygiene especially while handling infected dogs or cats and their vomit or diarrhoea. The faeces should be collected to minimize the contamination of the environment. Children, older or immune-compromised individuals should avoid having infected animals sleeping in their bed. If possible tracing the original source of the infection should be carried out to avoid the dog to be re-infected or transfer the infection to humans (SVA, 2013e).

3.8 Tuberculosis

3.8.1 Aetiology

Tuberculosis is a bacterial infection caused by acid-fast, aerobic Mycobacteria (MANI and MAGUIRE, 2009). *M. bovis* causes bovine tuberculosis which can affect several other animal species than cattle including companion animals and humans. The most common cause of human tuberculosis is *M. tuberculosis* and can also be found in pet animals. Sweden has been officially free from bovine tuberculosis since 1958 and since then a few sporadic cases have occurred in cattle (BENGTSSON, et al., 2011). Tuberculosis is a very rare disease among dogs and cats in Sweden and has been eradicated from the livestock (SVA, 2013g).

3.8.2 Transmission and pathogenesis

Dogs and cats can get infected with *M. bovis* and *M. tuberculosis* through contact with infected cattle or humans. Dogs and cats are not typical reservoirs of Mycobacterium (MANI and MAGUIRE, 2009). Tuberculosis is transmitted through for example coughing, pus, inhalation or milk from infected individuals (SVA, 2013g).

3.8.3 Clinical signs

Clinical signs vary greatly in both animals and humans depending on the location of the infection. Tuberculosis has a long incubation period from weeks up to years. The slow progression of the disease leads to that clinical signs might not develop even in case of significant lesions. Clinical signs such as weight loss, cough, ascites or mastitis can occur depending on the affected organ groups (BENGTSSON, et al., 2011). The infection with *M. tuberculosis* most

often cause respiratory signs in infected dogs and cats while *M. bovis* mostly causes gastrointestinal signs (MANI and MAGUIRE, 2009).

3.8.4 Diagnosis

In case of suspicion of tuberculosis samples are taken from five different areas of lymph nodes and organs with macroscopic lesions. The samples are examined by histology, smears and cultures at SVA. In humans similar smears are made for the diagnosis (BENGTSSON, et al., 2011).

3.8.5 Treatment

When the infection is confirmed SBA decides about measures to be taken. Due to the severe form of the disease, bad prognosis and zoonotic risk, treatment of an infected animal is not an option. Decision to euthanize an infected animal can be made even without the agreement of the owner (SVA, 2013g).

3.8.6 Prevention and control

Infection with *M. bovis* or *M. tuberculosis* is notifiable in all animal species according to the Epizootic diseases act (SFS 1999:657). Tuberculosis is notifiable in humans according to the Communicable disease act (SFS 2004:168) and contact tracing is obligatory and the treatment for human is free of charge (BENGTSSON, et al., 2011).

Immediate notification should be made to SBA and the state veterinarian. SBA makes the decision concerning the infected animal. If the infected animal is a pet it is most common that SBA agrees with the owner regarding measures necessary to confirm the diagnosis and prevent spreading. *M. avium* is not included in the Epizootic disease act. The chance of pet animals getting infected from their owners should not be neglected since tuberculosis can be spread from humans to animals as well as a “reverse” zoonosis. To prevent the spreading from an infected human to pet animal no close contact should be made in a confirmed case. The “reverse” zoonotic risk should be considered as an animal with tuberculosis is always a risk of transmission of the disease back to humans (SVA, 2013g).

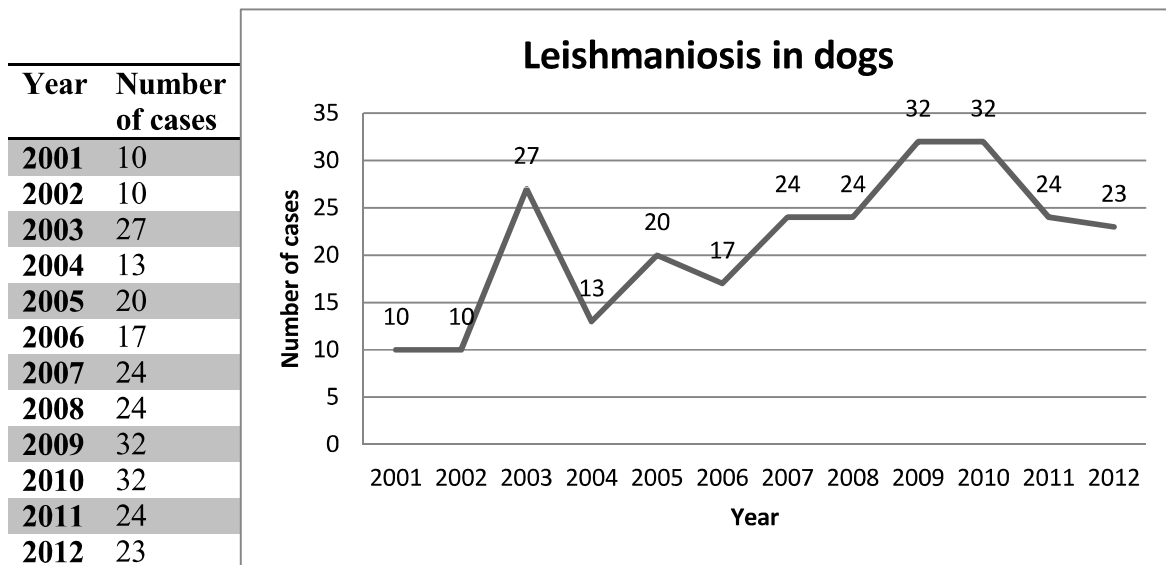
4 Non-notifiable zoonotic diseases

There are multiple other zoonotic diseases which can be transferred from pet animals to humans found in Sweden that is not presented in this thesis; these zoonotic diseases are non-notifiable. Non-notifiable zoonotic diseases are still important to keep in mind during the daily work as a veterinarian as well as a pet owner. Non-notifiable zoonotic diseases can still cause severe disease in pet animal and in humans and should therefore be diagnosed and treated correctly. Non-notifiable zoonotic agents occurring in both dogs and cats are for instance Anaplasma, Giardia, Sarcoptes and Trichopython. In dogs' borreliosis, tick-born encephalitis and neosporiosis and in cats chlamydiosis and toxoplasmosis are all important diseases transmissible to humans (SVA, 2013h).

5 Prevalence of notifiable zoonotic diseases in Sweden

The statistics shown in this part is based on information given from the Swedish Board of Agriculture in their summery of reported notifiable disease cases among animals in Sweden collected each year. Based on the numbers given in the tables I collected them and put them together to present it more easily on one chart for each disease. Some diseases have longer history of appearance in Sweden whilst other are based on cases reported during the last years only. Sweden is still free of rabies, tuberculosis and echinococcosis cases in pet animals and brucellosis only occurred once during 2011 and now in 2013. Salmonella is not included in the statistics from 2001 – 2008.

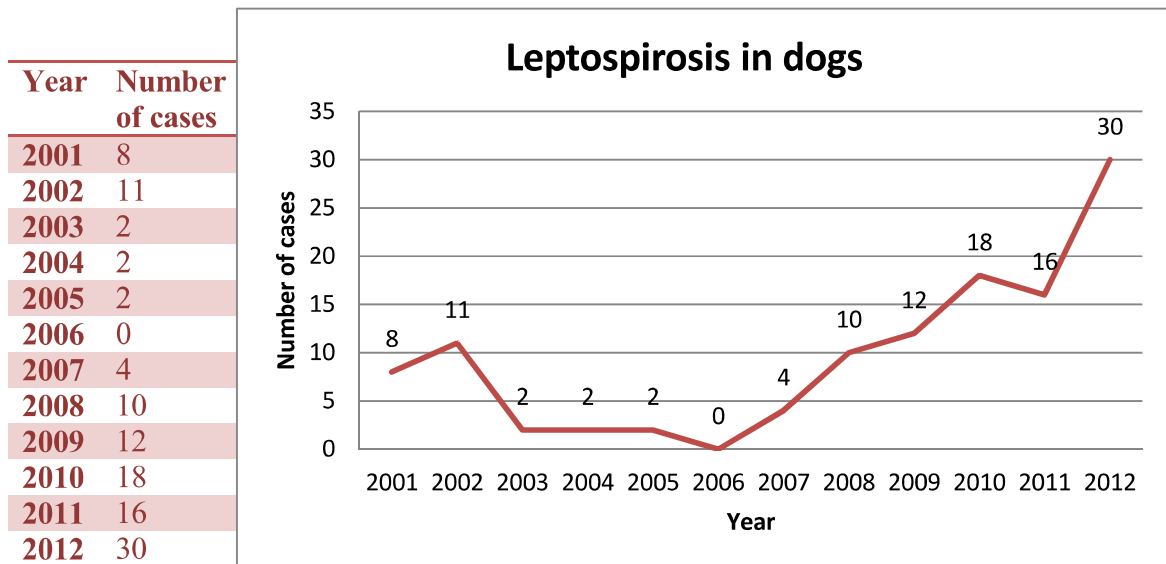
Figure 1: Leishmaniosis in dogs



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

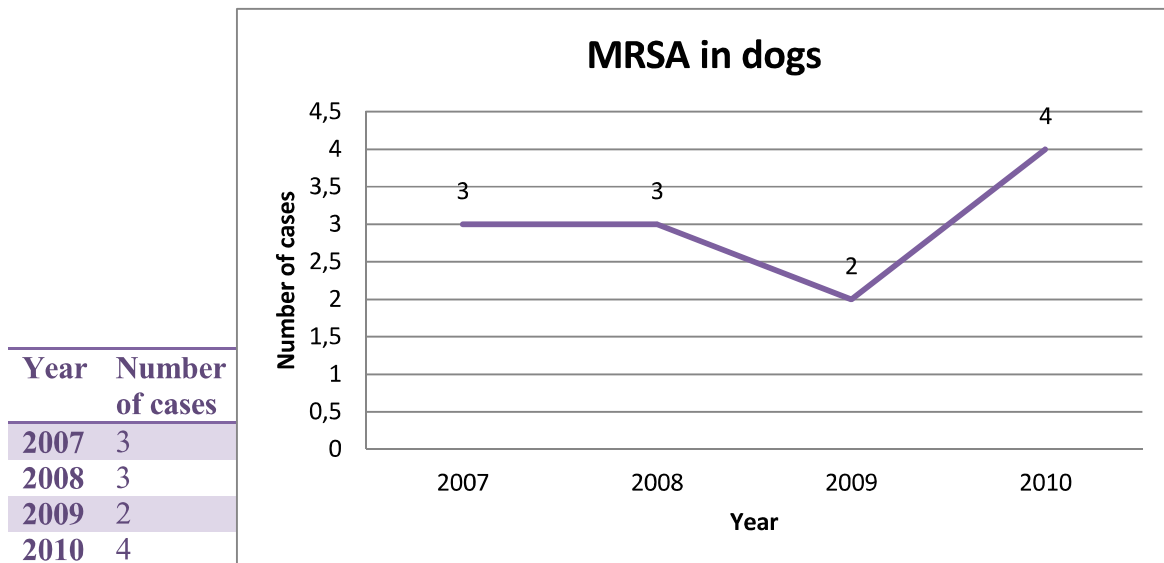
Figure 2: Leptospirosis in dogs



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

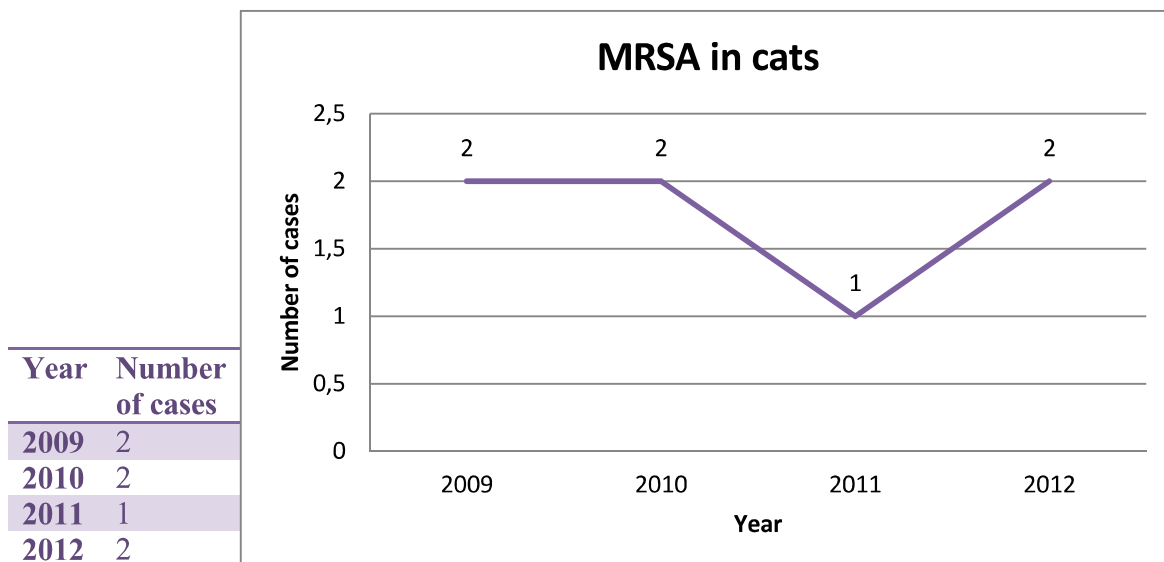
Figure 3: MRSA in dogs



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

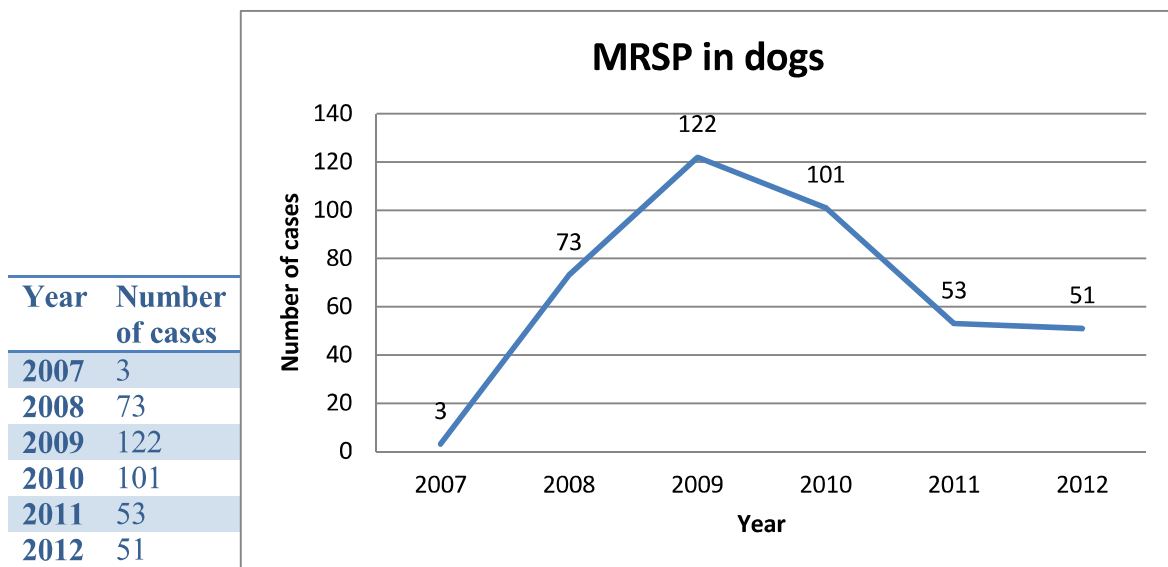
Figure 4: MRSA in cats



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

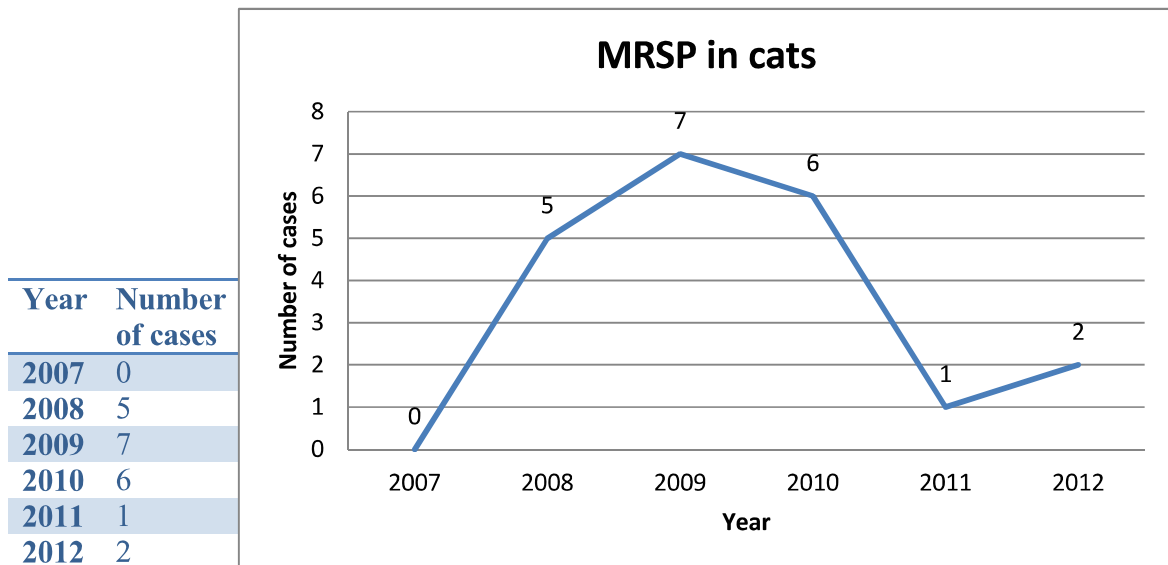
Figure 5: MRSP in dogs



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

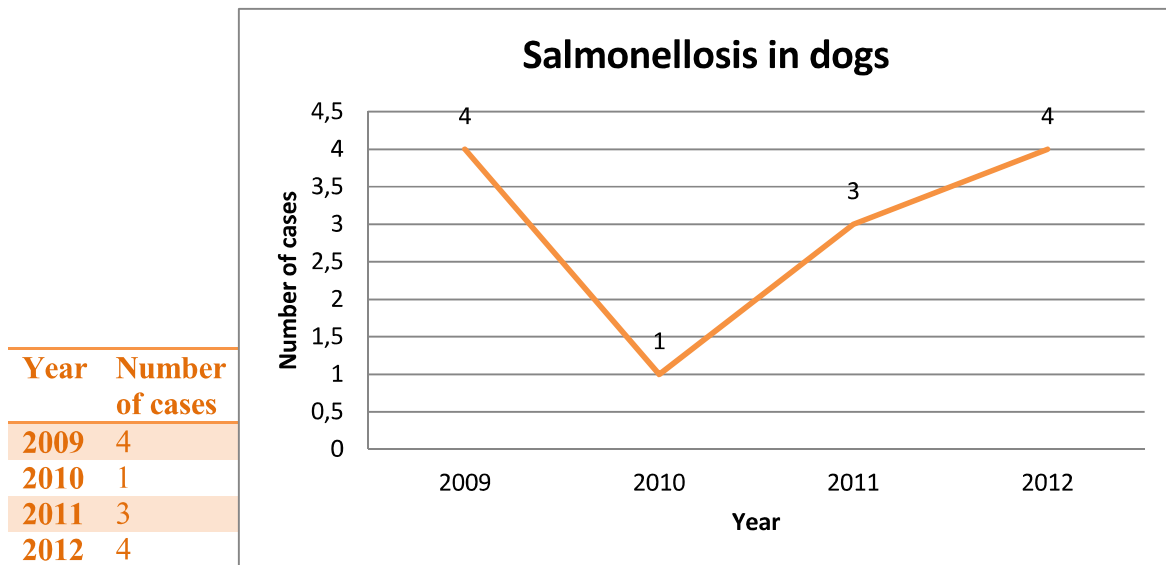
Figure 6: MRSP in cats



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

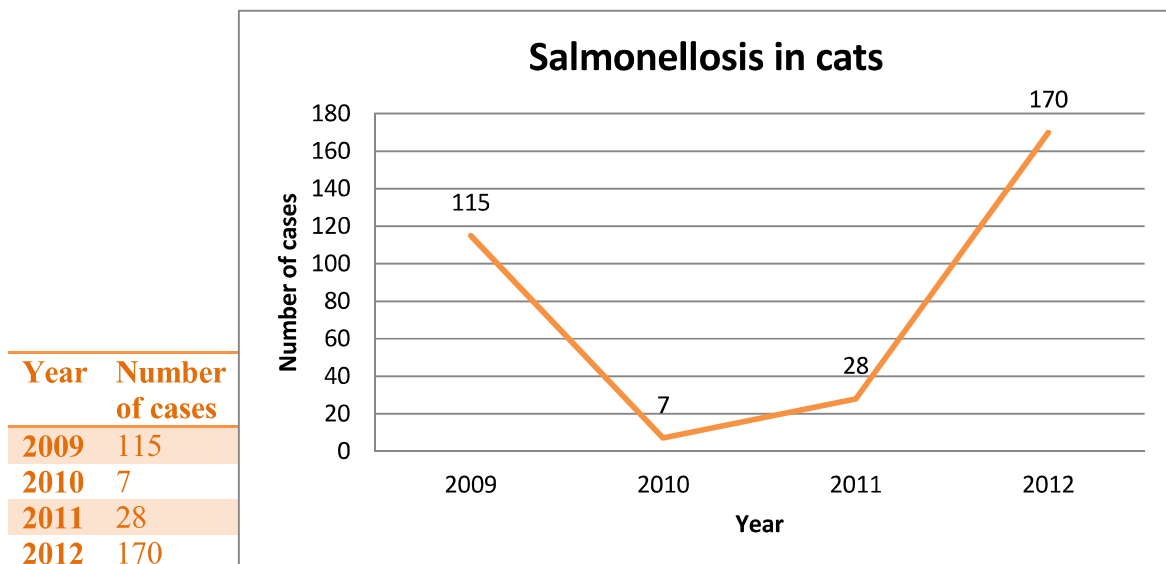
Figure 7: Salmonellosis in dogs



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

Figure 8: Salmonellosis in cats



Source: Statistics can be downloaded from:

<http://www.jordbruksverket.se/amnesomraden/djur/sjukdomarochsmittskydd/anmalningsplikt/sjukdomsstatistik.4.4ef62786124a59a20bf80001409.html>

6 Discussion

Zoonotic diseases affecting companion animals are an important matter of concern as zoonotic diseases do not affect only animals but are diseases that may cause diseases also in humans. Zoonotic diseases are therefore a great issue of public health in today's society.

One of the biggest threats of increasing numbers of zoonotic diseases in companion animals in Sweden is the fact that people travel more and more with their pets and companion animals are also illegally imported to the country. European legislation makes it easier for people to travel across country borders with their companion animals but it also increases the chance of diseases occurring in Sweden which has not been found before. Pets are becoming a part of the family and the close contact is a risk of spreading diseases from the pet to the owners. Sweden still has a favourable situation concerning zoonotic pet animal diseases but attention should be paid to the increasing number of travelling pets which may carry the infection. In the European Union opening and eliminating the borders and making the movement of animals between countries easier are of great importance for today's society but it also presents a risk. Sweden had stricter regulations concerning travelling or import of companion animals before joining the European Union, today Sweden complies with the European legislation in which only rabies vaccination is required before entering into Sweden. The legislative norms make the movement across Europe much easier but this might also lead to increasing number of zoonotic diseases during the coming years and therefore it is necessary to follow the statistics of zoonotic cases occurring in Sweden.

Sweden is a member of the European Union and complies with the legislations including the European Union's zoonosis directive. Sweden has many different institutions taking part in handling zoonotic diseases and it is therefore of utmost importance that each institution tries their best to cooperate with each other to keep the number of zoonotic cases at a minimum. The European Union states the basic directives concerning control of zoonotic diseases and Sweden has transposed these directives into the national legislations. Zoonotic diseases in pet animals are covered in many different acts to control the problem and take measures for prevention. Sweden has shown great interest to handle the zoonotic situation which can be seen in the Surveillance and SVARM reports for example.

In the prevalence part of this thesis it can be seen that Sweden still has a low number of notifiable zoonotic cases in companion animals. No clear trend can be established since some diseases such as MRSA and MRSP has not been found in Sweden before 2008 and salmonellosis is not included in the statistics until 2009. To see a clear trend on the evolution of zoonotic diseases the statistics needs to be monitored over a longer period. It can be seen in Table 1 concerning leishmaniosis and Table 2 concerning leptospirosis, both which has statistics collected for over 10 years that the trend is going up and it might be used as a warning concerning the zoonotic situation in companion animals in Sweden. Therefore preventive legislation and surveillance control is very important in which the Surveillance report and SVARM reports sent to EFSA each year is a great start.

Cases such as leishmaniosis and leptospirosis which are not naturally occurring infections in Sweden are increasing in number. MRSA and MRSP are also of huge concern to the welfare and even though the numbers are still low it should be monitored closely. Salmonellosis might be of bigger concern in other animal species than companion animals from the zoonotic aspect but it should still be mentioned as a rising concern in pet animals. Sweden is free from some severe zoonotic diseases such as rabies and it is important to follow the legislations and cooperation within the different units to maintain this favourable situation. In the last years two cases of *Brucella canis* have been found in kennels in Sweden and also *Echinococcus multilocularis* has been found on Swedish ground which shows that zoonotic diseases are an important matter of concern.

Sweden has a low occurrence rate of zoonotic diseases in companion animals and in humans but I think it is still important to increase the knowledge among pet owners concerning zoonotic diseases of their pets. Making the owners aware of the possibility that their animals may catch infections abroad that may be carried back home can help to minimize this risk of spreading. It is important to make owners aware of the clinical signs of zoonotic infections in their companion animals and also concerning infections which may be transmitted from humans to pets such as MRSA or tuberculosis. I also believe that it is important to keep educating the medical staff working at human and animal clinics and hospital concerning the matter. Keeping the zoonotic diseases at low level by simple means such as keeping hygiene at high level will minimize the

risk of spreading of certain zoonotic diseases. It is important that Sweden constantly maintain the monitoring programs and surveillance in both human and the animal sectors to prevent zoonotic infections. Even though the situation is favourable today it might easily change.

7 Summery

The aim of this thesis is to present an overview of the zoonotic situation among pet animals in Sweden and the legislations to control and prevent spreading of zoonoses to humans. This thesis gives an overview of the history and current situation of notifiable zoonotic diseases present in pet animals in Sweden. A summery is given of the aetiology, transmission, pathogenesis, clinical signs, diagnosis, treatment and legislations concerning the notifiable zoonotic diseases that occurs or may occur in Sweden. In the prevalence part the cases notified in pet animals are presented for each disease. Since 1994 Sweden is a member of the European Union and complies with the European Union's directive for zoonotic diseases. Sweden has transposed the directive into the national legislation. Both the European directive and the Swedish legislations concerning zoonotic diseases are presented and described briefly to get an overview on the present legislative structure in Sweden concerning zoonotic diseases in pet animals and also in humans. To understand the legislations an introduction to the different institutions found in Sweden which play important part in zoonosis control and prevention is also given.

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