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A Review Of *Neospora Caninum* And Neosporosis

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Abstract: *Neospora caninum* is a protozoan parasite of animals. Until 1988, it was misidentified as *Toxoplasma gondii*. Since its first recognition in dogs in 1984 and the description of the new genus and species *Neospora caninum* in 1988, neosporosis has emerged as a serious disease of cattle and dogs worldwide. Abortions and neonatal mortality are a major problem in livestock operations, and neosporosis is a major cause of abortion in cattle. Although antibodies to *Neospora caninum* have been reported, the parasite has not been detected in human tissues. Thus, the zoonotic potential is uncertain. This review is focused mainly on the epidemiology and control of neosporosis in cattle. The role of wildlife in the life cycle of *Neospora caninum* and strategies for the control of neosporosis in cattle is discussed. *Neospora caninum* infection have been reported in the United States, Australia, Europe, America china, Costa Rica, Czech republic, Denmark, France, Germany, Korea, Mexico, Portugal, Sweden, United Kingdom, Vietnam, Uruguay, Tanzania, South Africa and Ethiopia. Major economic loss due to neosporosis is reproductive failure in cattle in many countries. There are also some indirect losses associated with professional help and expenses for establishing a diagnosis, rebreeding, possible loss of milk yield, and replacement costs. Control strategies focus on reducing exposure and preventing transmission of the parasite. These may include improving farm biosecurity, reproductive management, testing and culling and vaccination.

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US	United States
UK	United Kingdom
USA	United States of America
IgG	Immunoglobulin G
DNA	Dioxy ribonucleic acid
PO	Per Os
CNS	Central Nervous System
HE	Hematoxylin and Eosin
IgM	Immunoglobulin M
CSF	Cerebro Spinal Fluid
IM	Intra Muscular
BVD	Bovine Viral Diarrhea
ELISAs	Enzyme Linked Immuno Sorbent Assays
NAT	Neospora Agglutination Test
IFAT	Immuno Florescent Antibody Test
IFA	Immuno Florescent Antibody
PCR	Polymerase Chain Reaction
IgG –HRP	Immunoglobulin G Horseradish Peroxidase-Conjugate

1. INTRODUCTION

Neospora caninum is a coccidian parasite that was identified as a species in 1988. Prior to this, it was misclassified as *Toxoplasma gondii* due to structural similarities. *Neospora caninum* is an obligate intracellular protozoan parasite that infects a wide variety of mammals and causes the disease neosporosis. Under microscopic examination the *Neospora caninum* sporozoite (the body of the parasite) closely resembles the *Toxoplasma gondii* sporozoite, and the two diseases share many of the same symptoms However, the *Neospora caninum* infection has a more severe impact on a dog's neurological and muscular system than *T. gondii* does. This infection naturally leads to the development of neosporosis, the medical term for a diseased state that has been caused by the death of cells and living tissue (an incident known as necrosis) in response to the invasion of *Neospora caninum* (Dubey, 1999). It is associated with tissue damage from the rupture of a cyst and subsequent invasion of tachyzoite microorganisms the stage at which the sporozoite organism multiplies rapidly in the tissues throughout the body. *Neospora caninum* is a microscopic protozoan parasite with worldwide distribution. Many domestic (e.g. dogs, cattle, sheep, goats, horses, chickens) and wild animals (deer, rodents, rabbits, coyotes, wolves, and foxes) can be infected. Neosporosis is one of the most common causes of bovine abortion, especially in intensively farmed cows. Neosporosis abortion also occurs in sheep, goats, water buffalo and South American camelids, although they may be less susceptible than cattle. The dog is the definitive host, cattle are the intermediate host and other mammalian species may act as incidental hosts. The sexual phase of replication takes place in the gastrointestinal tract of dogs, oocysts are passed in the feces which then develop into sporozoites and are infective to dogs and cattle (Dubey *et al*., 2003).

Transplacental infection results in congenital infection of puppies which is the most typical presentation of the disease. More than one puppy in a litter may be affected, although this may not occur simultaneously. Successive litters can be affected; therefore a dam whelping infected litter should not be allowed to breed again. Other methods of infection include ingestion of sporulated oocysts from dog fecal matter and ingestion of tissue cysts in the tissues of intermediate or incidental hosts, for example bovine placenta. The clinical syndrome associated with infection is primarily neuromuscular and is a result of the organism replicating in tissues. Other organ systems may also be affected which may result in pneumonia, ulcerative dermatitis and hepatitis. In some animals with a chronic or subclinical infection, administration of glucocorticoids results in activation of neospora in tissue cysts and clinical disease (Dubey, 1999).

Therefore, the **objective** of this seminar is to review literature about the disease, diagnosis, clinical signs, epidemiology, economic impact and control and prevention measures of neosporosis in dog and cattle.

2. DESCRIPTION OF THE ETIOLOGY

2.1. Etiology

Neosporosis is caused by the protozoan *Neospora caninum*, which invades mostly tissue of the host animal. Dogs and coyotes are definitive hosts of *Neospora caninum* and cattle's are intermediate hosts (*http://www.petmd.com, 2014*).

2.2. Species

Neosporosis is an important neuromuscular disease of domestic dogs world-wide. The causative parasite, *Neospora caninum*, cycles between canine definitive hosts and herbivore intermediate hosts, most notably cattle (Dubey and Schares, 2011).

Table 1. Species specification of *Neospora caninum* (Alvarez-Garcia, 2013)

Specifications	
Method	Indirect ELISA
Species	Multiple species, including ruminants and dogs
Specimens	Serum, plasma or milk
Coated antigen	Purified *Neospora caninum* extract
Conjugate	Anti-multi-species IgG –HRP conjugate (concentrated 10X)

2.3. Stages of the Parasites

Three stages of *Neospora caninum* identified:

- Oocysts (environmental stages formed in canine intestinal epithelium and passed with the feces).
- Tachyzoites (rapidly dividing stages that actively invade tissues).
- Bradyzoites (slowly dividing stages that encyst within tissues) (Lyon, 2010).

Figure 1 Oocyst of *N. caninum* in tissue under light microscopy

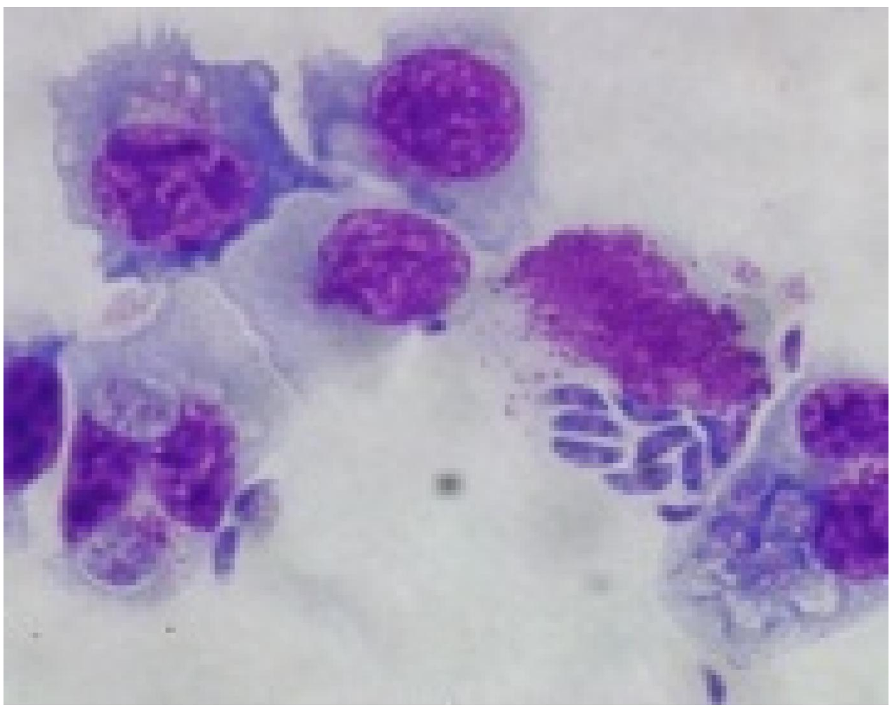

Figure.2 Tachyzoite of *N. caninum in* tissue under light microscopy
Source*:* *(http://www.vetbook.org, 2014)*

2.4. Life Cycle

N. caninum is a coccidian parasite with a wide host range. In general, it is very similar in structure and life cycle to *T. gondii*, with two important differences: (i) neosporosis is primarily a disease of cattle, and dogs and related canids are definitive hosts of *N. caninum*, whereas (ii) toxoplasmosis is primarily a disease of humans, sheep, and goats, and canids are the only definitive hosts of *T. gondii*. The life cycle is typified by the three known infectious stages: tachyzoites, tissue cysts, and oocysts (Fig1&2). Tachyzoites and tissue cysts are the stages found in intermediate hosts, and they occur intracellularly (Dubey *et al., 2002)*.

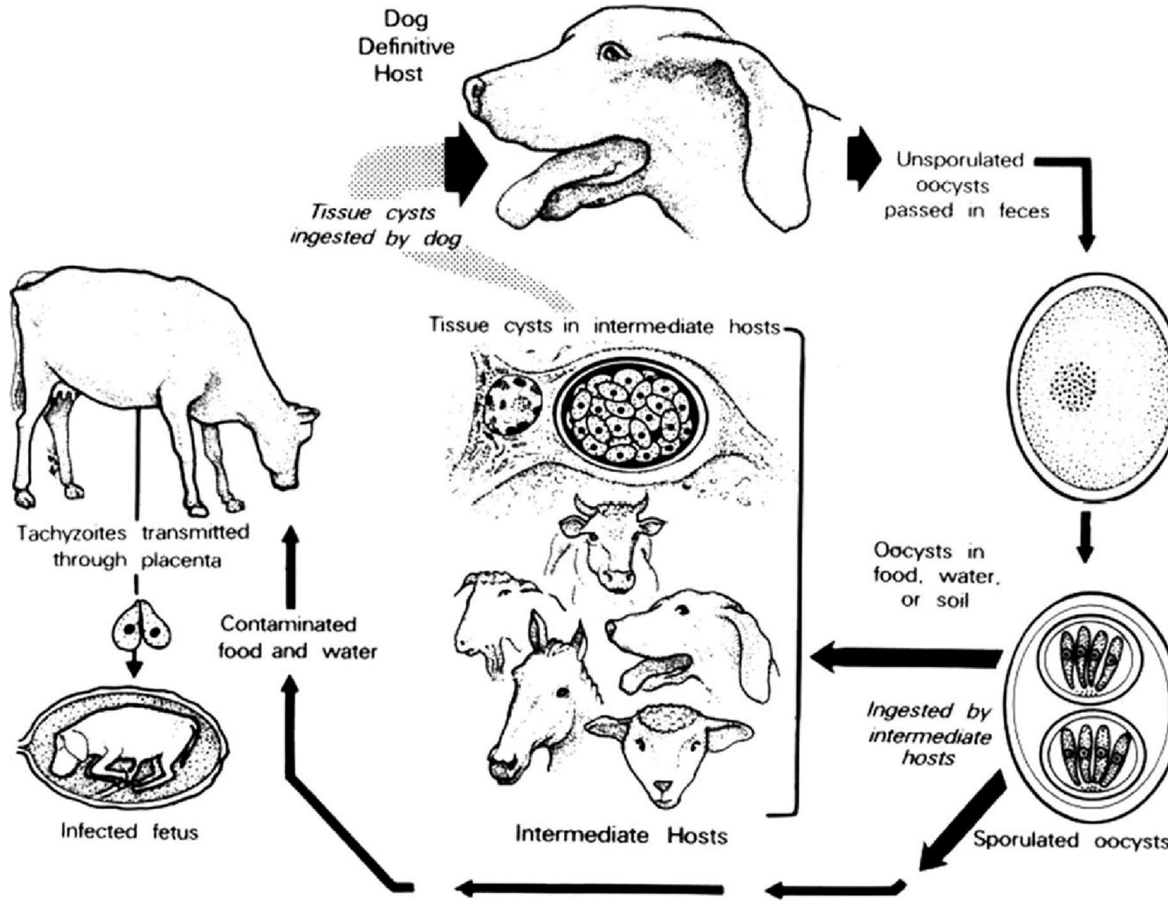

Figure.3 Life cycle of *Neospora caninum* (Dubey*, 1999)*

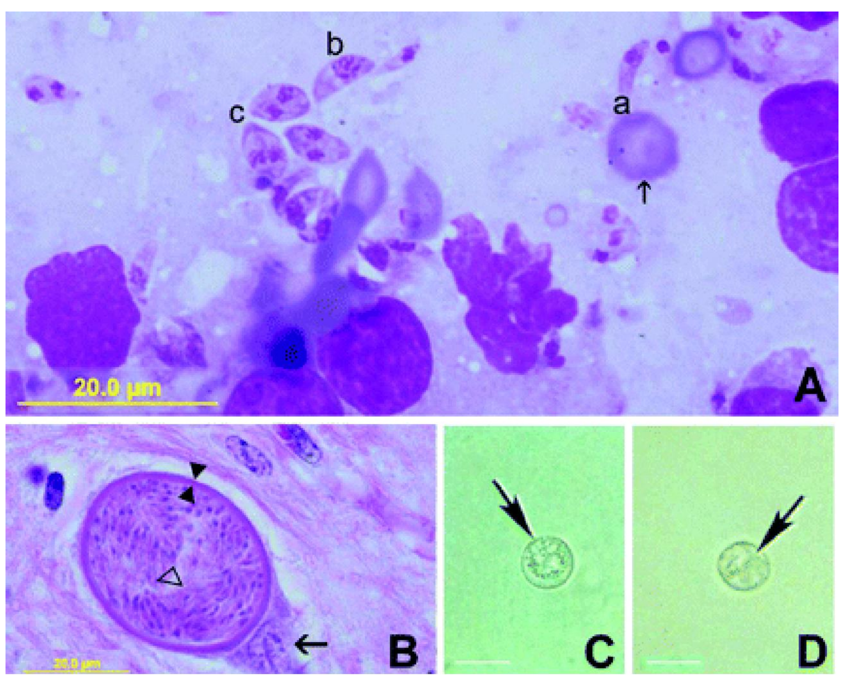

Figure.4 Life cycle stages of *Neospora caninum (*Dubey*,* 1999)

Life cycle stages of *Neospora caninum* (Fig. 4) (A) experimentally infected mouse depicting numerous tachyzoites (Giemsa stain). (a) a slender tachyzoite, (b) a tachyzoite before division, and (c) three dividing tachyzoites compared with the size of a red blood cell (arrow). (B) Histological section of a tissue cyst inside a neuron in the spinal cord of a congenitally infected calf (hematoxylin and eosin stain). (C) Unsporulated oocyst (arrow) with a central undivided mass in the feces of a dog (unstained). Bar 10 µm. (D) Sporulated oocyst (arrow) with two internal sporocysts (unstained). Bar 10 µm.

All three infectious stages of *N. caninum* (tachyzoites, bradyzoites, and oocysts) are involved in the transmission of the parasite. Carnivores probably become infected by ingesting tissues containing bradyzoites, and herbivores probably become infected by the ingestion of food or drinking water contaminated by *N. caninum* sporulated oocysts. Transplacental infection can occur when tachyzoites are transmitted from an infected dam to her fetus during pregnancy (Lindsay *et al*., *1999).*

2.5. Mode of Transmission

The parasite can be transmitted transplacentally in several hosts and vertical route is the major mode of its transmission in cattle. Carnivores can acquire infection by ingestion of infected tissues (Lindsay *et al*., 1999).

Transplacental transmission in experimentally infected dogs has been demonstrated. These data suggest that *N. caninum* is transmitted from the dam to the neonates toward the terminal stages of gestation or postnatally via milk. Vertical transmission of *N. caninum* in dogs is considered highly variable and not likely to persist in the absence of horizontal infection. The consumption of bovine fetal membranes may be a source of *N. caninum* for dogs. The parasite has been found in naturally infected placentas and dogs fed placentas from freshly calved seropositive cows may shed *N. caninum* locusts (Dubey and Lindsay, 1996).

N. caninum is one of the most efficiently transplacentally transmitted parasites in cattle. In certain herds, virtually all calves are born infected but asymptomatic (Frössling *et al*., 2005). The ingestion of sporulated *N. caninum* locusts from the environment is the only demonstrated natural mode of infection in cattle after birth (Gondim *et al*., 2004). At present there is no evidence that live *N. caninum* is present in excretions or secretions of adult asymptomatic cows. Neonatal calves may become infected after ingestion of milk contaminated with tachyzoites (Davison *et al*., 2001).

3. EPIDEMIOLOGY OF *NEOSPORA CANINUM*

3.1. Prevalence

Neosporosis is found world-wide; serologic prevalence in domestic dogs ranges from 0 – 100% depending on the country. In the United States, 7% of pet dogs tested from 35 states (n=1,077) were seropositive in a 2007 study. Overall, serologic prevalence of *N. caninum* infections in clinically healthy dogs is greater than the prevalence of clinically presented dogs; sub-clinical infections are suspected (Dubey, 2007). Neosporosis-associated bovine abortion and neonatal mortality has been reported from Argentina, Australia, Belgium, Brazil, Canada, Costa Rica, Denmark, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Poland, Portugal, Spain, South Africa, Sweden, United Kingdom, USA, Tanzania, South Africa and Zimbabwe.

i. Seroprevalence of *Neospora caninum* and associated risk factors in intensive or semi-intensively managed dairy and breeding cattle of Ethiopia:

A cross-sectional study of *Neospora caninum* infection was conducted in major milk sheds of Ethiopia. Cattle ($n = 2334$) from 273 farms were bled and the sera screened for antibodies against *N. caninum* using a commercial ELISA kit. Herd and individual animal level data were collected from farm records and a semi-structured questionnaire format. The overall animal level seroprevalence was 13.3%, while the prevalence at farm level was 39.6%. Crossbred cattle (Holstein-Friesian crossed with indigenous zebu) were associated with lower risk than pure breeds. *Neospora caninum* infection is highly prevalent, widely distributed and clinically important in dairy and breeding cattle of Ethiopia (Asmare *et al*., 2013).

Table 2 Report on the occurrence of bovine neosporosis in different parts of the world (Dubey, 2007).

Country	No. of animals examined	% positive
Argentina	189	64.5
Australia	266	24
Belgium	711	52
Costa Rica	2,743	43.3
France	575	26
Italy	864	30.8
Korea	895	48.7
Mexico	187	59
New Zealand	77	46.7
Portugal	119	49
Spain	889	43
Sweden	70	63
Taiwan	613	44.9
UK	95	60
USA	176	34
Ethiopia	2334	39.6
Tanzania	49	22

3.2. Isolation and Geographic Distribution

In order to understand the epidemiology of *N. caninum*, it is important to identify its host range and geographic distribution. Unlike *T. gondii*, viable *N. caninum* is difficult to isolate (Marsh *et al*., 1998).

Viable *N. caninum* has been isolated from cattle, sheep, dogs, white-tailed deer, and water buffaloes. Most of these isolates were from clinically affected animals and from neonatally infected animals, except for the isolates from buffaloes, sheep, and deer, which were from adult asymptomatic animals. Isolation of viable *N. caninum* has been achieved with a variety of cell cultures and by bioassays of immunosuppressed mice, gerbils, and dogs. Isolation in cell culture is limited by the necessity of having materials not contaminated with other microbes, and not all isolates can be adapted to grow in cell culture (Dubey *et al*., 2006).

3.3. Risk Factors for Bovine Neosporosis

Neospora caninum-associated abortion in bovine herds may have an epidemic or an endemic pattern. There are reports that in the years after an epidemic abortion outbreak, the affected herd may experience endemic abortion. Abortion outbreaks have been defined as epidemic if the abortion outbreak is temporary and if 15% of the cows at risk abort within 4 weeks, 12.5% of the cows abort within 8 weeks, and 10% of the cows abort within 6 weeks. In contrast, an abortion problem is regarded as endemic if it persists in the herd for several months or years (Fig. 5) (Trees and Williams, 2005).

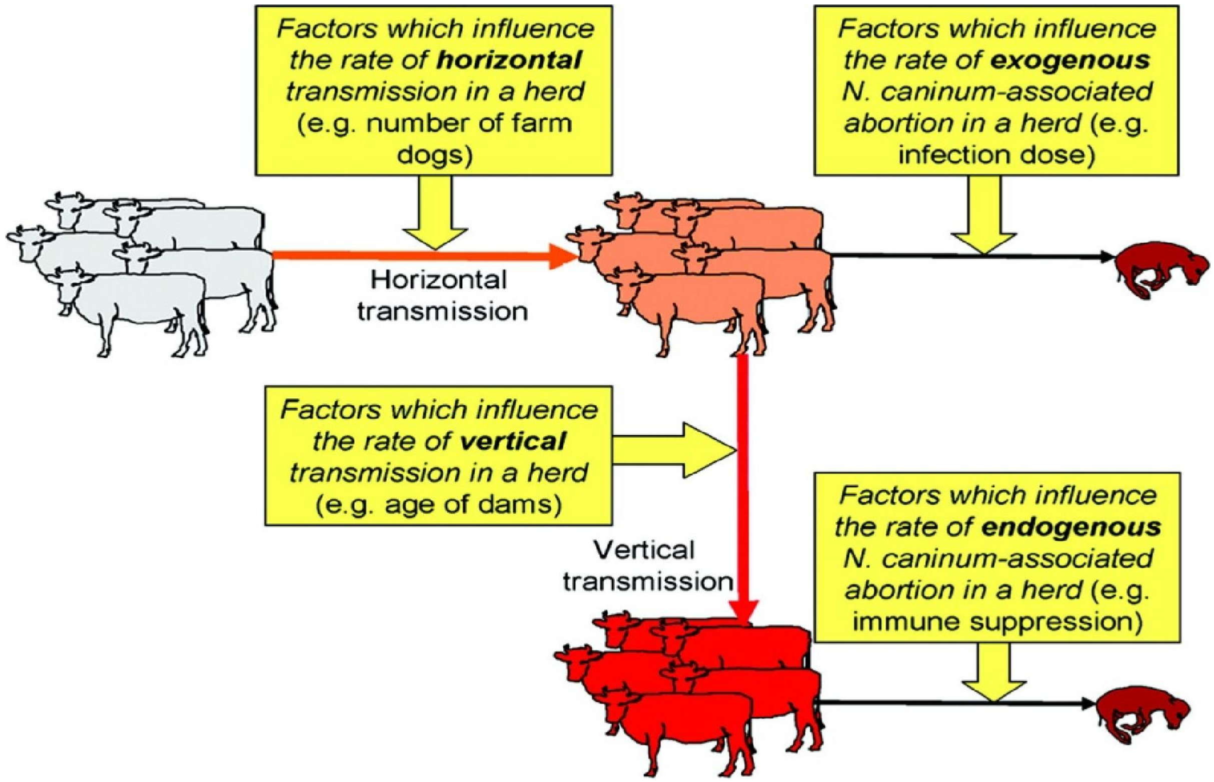

Figure 5 Potential risk or protective factors influencing transmission of *Neospora caninum* in this diagram, native cattle are gray, postnatally infected cattle are orange, and vertically infected cattle are red.
Source: *(http://cmr.asm.org/content/20/2/323/F3.expansion.html*, 2014)

Factors associated with infection of neosporosis in cattle include:

a) Age of cattle

The risk of being seropositive may increase with age or gestation number in beef and dairy cattle (Rinaldi *et al*., 2005), suggesting that horizontal transmission of *N. caninum* is of particular importance in some herds. It was hypothesized that the age effect might be influenced by variations in the probability of horizontal transmission and by management practices such as selective culling of seropositive animals (Baetels *et al*., 2006).

b) Definitive hosts (dogs and coyotes)

In most epidemiological studies of dairy herds, the presence of farm dogs, either currently or within the past 10 years or the number of farm dogs was a risk factor for seropositivity in cattle (Corbellini *et al*., 2006). Defecation by farm dogs on feeding alleys and on stored grass or corn silage was reported more often by farmers of herds with evidence of postnatal bovine infection than by those of herds with no such evidence (Dijkstra *et al*., 2002).

c) Intermediate hosts other than cattle

Not only cattle but also other intermediate hosts of *N. caninum* may present a source of infection for dogs and other canids. The presence of *N. caninum* DNA in naturally infected mice and rats suggests that these animals may be important sources of infection for carnivore hosts of *N. caninum.* Also found the presence of poultry on the farm to be a risk factor for the occurrence of *N. caninum*-associated abortion (Otranto *et al*., 2003).

d) Grazing, fodder, and drinking water

Oocysts-contaminated pastures, fodder, and drinking water are regarded as potential sources for postnatal infection of cattle. Therefore, it is important to know which feeding practices pose an increased infection risk (Barling *et al*., 2001).

e) Herd size

In a study from Italy, the risk of individual cattle becoming seropositive increased with the size of the herd. i.e., the risk of being seropositive increased in larger herds with an increasing number of dogs per farm. Possible explanations are that with increasing size of the herd there is an increasing chance of acquiring *N. caninum* infection (Schares *et al*., 2004).

4. INFECTION AND DESCRIPTION OF THE DISEASE

4.1. Clinical Findings

Naturally occurring infections have been reported worldwide in dogs and it is likely that many dogs diagnosed with toxoplasmosis before 1988 actually had neosporosis. Clinical signs predominate in neural and muscular tissues but may also include skin, lungs, liver, heart or other tissues. Both pups and adult dogs are clinically affected, and the infections can be transmitted congenitally. Features that distinguish neosporosis from other forms of paralysis are gradual muscle atrophy and stiffness, usually as an ascending paralysis; the pelvic limbs are more severely affected than the thoracic limbs. This arthrogryposis is a result of the scar formation in the muscles from lower motor neuron damage and myositis. Cervical weakness, dysphagia, megaesophagus, and ultimately death can occur. Older dogs, which are less commonly affected, often have signs of multifocal CNS involvement or polymyositis; less common manifestations result from myocarditis, dermatitis, pneumonia, or multifocal dissemination. Death can occur in dogs of any age (Dubey *et al*., 2005).

Clinical neosporosis is a result of the proliferation of tachyzoites within tissues leading to inflammation, granulomata formation, and necrosis. Tachyzoites are present within many tissues, but clinical signs are most often neuromuscular (Dubey *et al*., 2005).

In cattle Abortion can occur throughout gestation. Abortions may be epidemic or endemic (Wouda *et al*., 1999). In infected areas as many as 33% of dairy cow fetuses have been reported to abort within a few months abortion were considered endemic. Abortions were considered epidemic if more than 10% of cows at risk aborted within 6-8 weeks (Anderson *et al*., 1995).

4.2. Pathogenesis

The protozoan parasite Neospora caninum is a major pathogen of cattle and dogs, being a significant cause of abortion in cattle in many countries. It is one of the most efficiently transmitted parasites, with up to 90% of cattle infected in some herds. The pathogenesis of abortion due to Neospora is complex and only partially understood. Losses occur after a primary infection during pregnancy but more commonly as the result of recrudescence of a persistent infection during pregnancy. Parasitaemia is followed by invasion of the placenta and fetus. It is suggested that abortion occurs when primary parasite-induced placental damage jeopardizes fetal survival directly or causes release of maternal prostaglandins that in turn cause luteolysis and abortion. Fetal damage may also occur due to primary tissue damage caused by the multiplication of *N. caninum* in the fetus or due to insufficient oxygen/nutrition, secondary to placental damage. In addition, maternal immune expulsion of the fetus may occur associated with maternal placental inflammation and the release of maternal pro-inflammatory cytokines in the placenta. Thus N. caninum is a primary pathogen capable of causing abortion either through maternal placental inflammation, maternal and fetal placental necrosis, fetal damage, or a combination of all three (Dubey *et al*., 2006).

Cows with *N. caninum* antibodies (seropositive) are more likely to abort than seronegative cows. There is a rise in antibody titers 4 to 5 months before parturition. These observations strongly suggest reactivation of latent infection. Little is known of the mechanism of reactivation. It is likely that there is Parasitaemia during pregnancy leading to fetal infection (Sawada *et al*., 2000).

Although it is reasonable to speculate that pregnancy-induced immune-suppression may reactivate latent tissue cysts of *N. caninum*, such a mechanism has not been demonstrated for neosporosis. Gestational age may determine the outcome of infection. Fetuses infected early in pregnancy are likely to die (Buxton *et al*., 2002).

4.3. Diagnosis

Examination of the serum from an aborting cow is only indicative of exposure to *N. caninum* and histologic examination of the fetus is necessary for a definitive diagnosis of neosporosis. Although lesions of neosporosis are found in several organs, fetal brain is the most consistently affected organ. Because most aborted fetuses are likely to be autolyzed, even semi-liquid brain tissue should be fixed in 10% buffered neutral formalin for histologic examination of hematoxylin and eosin (HE) stained sections. The most characteristic lesion of neosporosis is focal encephalitis characterized by necrosis and Nonsuppurative inflammation (Barr *et al*., 1994).The efficiency of the diagnosis by PCR is dependent on the laboratory, stage of the autolysis of the fetus, and sampling procedures. Several serologic tests can be used to detect *N. caninum* antibodies including various ELISAs, the indirect fluorescent antibody test (IFAT), and the *Neospora* agglutination test (NAT). Diagnosis is most often presumptive based on patient history, clinical signs, and positive serology (IgM). Serologic assays available include IFA of CSF or serum (Lyon, 2010).

4.4. Treatment

There is no approved or curative treatment for canine neosporosis. Arrestment of clinical disease is best achieved when treatment is initiated before the occurrence of contracture or paralysis. Dogs typically die without treatment, and some dogs die even with treatment (Dubey and Lindsay, 1996).

The following treatment regimens are used to control clinical neosporosis:

- Clindamycin (12.5-25 mg/kg PO or IM every 12 hours for 4 weeks)
- Trimethoprim sulfadiazine (15-20 mg/kg PO every 12 hours for 4 weeks) in combination with pyrimethamine (1 mg/kg PO every 24 hours for 4 weeks) (Lyon C, 2010).

5. ECONOMICAL IMPACT

The major economic loss due to neosporosis is reproductive failure in cattle anywhere in the world but losses are estimated in millions dollars. In addition to the direct costs involved in fetal loss, indirect costs include professional help and expenses associated with establishing a diagnosis, rebreeding, possible loss of milk yield, and replacement costs if aborted cows are culled (Thumond and Hietala, 1997).

Although *N.caninum* associated abortions have been diagnosed in many countries, there are only a few data based on examination of a large number of aborted fetuses and postnatal loss due to neosporosis are difficult to document because there are no obvious ill effects in adult cattle other than fatal loss. Because of these, there are no firm data on economic losses due to neosporosis for the cattle industry (Trees *et al*., 1999).

5.1. Reduced Milk Production and Poor Reproductive Performance

There may be direct loss of milk production associated with abortion but due to extended calving interval the total milk yield during the production life of the cow will be reduced. Even in the absence of abortion a decreased milk production had been noted in seropositive cows. In some cases 3-45% reduction in milk yield has been observed. Experimental infection with *N.caninum* has been shown to cause high level of embryo mortality. A higher culling rate of *N.caninum* seropositive cow is associated with abortion and decrease milk production (Baetels *et al*., 2006).

5.2. Reduced Post Weaning Weight Gain and Feed Conversion Efficacy

Significant decrease in post weaning weight gain, carcass weight and economic return has been associated with beef calves that are seropositive for neosporosis (Baetels *et al*., 2006).

6. PREVENTION AND CONTROL

In *N.caninum*- free herds, prevention of the introduction of the infection through standard biosecurity measures is the primary goal (Haerdi *et al*., 2005), where as in *N.caninum* infected herds, control programs are based on decreasing the vertical transmission in a herd by reduction of the number of seropositive cattle and/or decreasing the risk of horizontal transmission of *N.caninum* principally by controlling the definitive host population as a source of oocyst contamination (Conraths and Ortega-Mora, 2005; Haddad *et al*., 2005; Hall *et al*., 2005; Reichel and Ellis 2005). Different control measures have been suggested including improvement of biosecurity on the farm, the introduction of new alternatives in the reproductive management of the herd, vaccination and the so-called “test and cull” strategies (Haddad *et al*., 2005).

6.1. Improving Farm Biosecurity

Biosecurity is the outcome of all activities undertaken to prevent the introduction of certain disease agents into animal population. For bovine neosporosis, the following measures are recommended to avoid the entrance of infected animals in free or infected farms and to avoid or diminish the chances of vertical and horizontal transmission in those with the presence of *N.caninum* infected cattle (Dubey, 2007).

6.1.1. *Purchase of replacement cattle from Neospora free herd*

Due to the importance of vertical transmission in maintaining the infection within a herd and the potential infective role of infected bovine tissues for the definitive host, one of the most relevant tools is purchase of replacement cattle from disease free herds (Dubey, 2007).

6.1.2. *Prevention of transmission from dogs and other potential hosts*

Dog control on cattle farms has also been proposed as a mechanism for reducing infection transmission to livestock. In intensively managed dairy farms, the presence of dog should be avoided, or at least dog proof fencing should be provided in appropriate area and the access of dogs to the housing zone, watering points, barn and feed storage areas should be avoided. Appropriate hygiene regarding dog feces on pastures is recommended in extensively managed farms (Gondim *et al*., 2004; Romero and Frankena, 2003).

6.1.3. *Reducing the occurrence of non-specific stressors*

These stressors could include BVD virus and other common viral infections; low quality feed stuff (moldy feeds), excessive heat and overcrowding (Buxton *et al*., 2002).

6.2. Reproductive Management

Several reproductive management measures have been proposed to reduce the economic impact of endogenous transplacental transmission in infected herds (Baillargeon *et al*., 2001).

6.2.1. *Embryo transfer*

Transfer of embryo from infected dams into uninfected recipients can prevent endogenous transplacental transmission of *N.caninum* (Baillargeon *et al*., 2001; Landmann *et al*., 2002).

6.2.2. *Artificial insemination*

Artificial insemination of seropositive dams with semen from beef bull could prevent the occurrence of neosporosis. The result of a study in Spain on two high producing dairy farms with a mean seroprevalence of 28% suggested that the use of beef bull semen could reduce the risk of abortion in dairy cows on those farms and proposed that this effect might be due to the favorable effect of cross breed pregnancies on placental function (Lopez-Gatius *et al*., 2005).

6.3. Testing and Culling

The culling of infected cows is a control option. Although effective, this strategy could be economically disastrous for herd with high seroprevalence rate (up to 80%). But, this is not always economically realistic. The “test and cull” strategy includes the following options:

a. Test and cull seropositive dams or seropositive aborting dams;
b. Test and inseminate the progeny of seropositive dams, with beef bull semen only; and
c. Test and exclude the progeny of seropositive dams from breeding (Hall *et al*., 2005)

6.4. Vaccinations

Ideally, any vaccine developed against bovine neosporosis should fatal (embryonic) loss and avoid vertically transmission. There is a commercially available vaccine called “naeoguarg”, which is a killed vaccine. The vaccine has proven safe but efficacy data are not conclusive. Pregnancy (and open) rates between vaccinated and non- vaccinated in naturally infected herds is not different. However, vaccination has a positive effect on abortion following experimental infection in some studies (Dubey *et al*., 2003).

7. CONCLUSIONS AND RECOMMENDATIONS

Neosporosis is a common disease, but it may result in a great economical loss, if it occurs. It should be suspected in all abortion cases where another cause has not been confirmed. Cattle could get infected by oocysts either vertically or horizontally. A general strategy to control neosporosis worldwide is not applicable because of regional differences in epidemiology of bovine neosporosis, and it is prudent to thoroughly stuffy regional epidemiology of neosporosis before embarking on a control program. Since it results in abortion and infertility, there exits heavy loss in dairy industry, therefore control measure should be implemented.

Based on the above conclusions, the following points are recommended:

- The knowledge of risk factor for herds to acquire N. caninum infection and N. caninum associated abortion is important for the development and implement of measures to control bovine Neosporosis;
- Preliminary investigation must be done on the presence of the parasite especially in areas where there is high incidence of abortion without clearly determined causes and appropriate control measure should be undertaken;
- Since it exist in other Africa countries and also in countries, from which improved breeds of cattle are imported, there is a risk of entrance of the disease into Ethiopia and hence care must be undertaken especially during importation of live animals.

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