Control of Toxoplasma Abortion in Sheep

Elisabeth Innes BSc Hons., PhD | Moredun Research Institute
Alison Burrells BSc Hons., PhD | Moredun Research Institute
Beth Wells BSc Hons., PhD | Moredun Research Institute
key points

- *Toxoplasma gondii* is the most successful parasite worldwide, capable of infecting all warm blooded animals, including humans, and causes the disease toxoplasmosis.
- The cat is the definitive host of the parasite and young kittens often get infected when they go out hunting for the first time. The parasite develops in the gut of the cat and *Toxoplasma* oocysts (eggs) are shed in faeces into the environment.
- *Toxoplasma* oocysts sporulate, i.e. they become infectious, outside the host and they have a tough outer shell enabling them to survive in the environment in moist temperate conditions for several years.
- Sheep may become infected by ingesting infective oocysts on pasture or in contaminated feed and water.
- If the parasite infects the pregnant animal for the first time, *Toxoplasma* can cause disease in the placenta and the developing foetus.
- Infection early in pregnancy may result in abortion, whereas infection later in pregnancy may cause still birth, mummified foetus or birth of a live, infected and weak lamb.
- Following infection, sheep develop immunity against the parasite which will protect them against disease in a subsequent pregnancy.
- There is an effective vaccine to prevent congenital toxoplasmosis in sheep (disease caused by the parasite passing from the dam to the foetus).
- Once animals or people become infected with *Toxoplasma* it is thought that they will remain infected for life with the parasite remaining dormant within tissue cysts.
- *Toxoplasma* may also be transmitted to humans from the ingestion of oocysts or from eating undercooked meat containing parasite tissue cysts.
- Pregnant women and immuno-compromised individuals are major risk groups and should also avoid any contact with ewes at lambing time.
Infectious abortion is one of the major flock health problems faced by sheep farmers and has a significant financial impact on production.

A wide range of microorganisms including bacteria, viruses and protozoa are capable of infecting sheep and causing abortion. In the UK the most important of these are *Chlamydia abortus* and *Toxoplasma gondii*, whilst other pathogens include Campylobacter species, Schmallenberg virus, Salmonella species, *Listeria monocytogenes*, Border Disease Virus and *Coxiella burnetii* (Q-fever). *C. abortus* and Toxoplasma were responsible for 33% and 25% respectively of ovine abortions submitted to veterinary investigation centres in 2018 (Veterinary Investigation Diagnosis Analysis) and as such were the two most commonly identified abortive pathogens.
Toxoplasma oocysts sporulate in the environment and become infective. They can survive in the environment for several years. Sporulated oocysts infect livestock and wildlife via contaminated feed, water & soil. Oocysts infect humans via contaminated food, soil & water. Unsporulated oocysts shed in cat faeces. Infected rodents and birds eaten by cats - cycle continues. Breeding ewes can become infected from consuming toxoplasma oocysts on pasture or in contaminated food/water. Humans infected via toxoplasma cysts in undercooked/raw meat from infected food animals. Foetus infected by toxoplasma via placenta. Foetus infected by toxoplasma via placenta. Depending on stage of gestation when infection occurs, clinical outcomes include: Foetus reabsorption, abortion, still birth, mummified lambs, weak lambs (see figure 2).

Figure 1: Toxoplasma life cycle

Toxoplasma abortion
- Toxoplasma parasites are tiny single celled organisms (the size of a red blood cell) and are the most successful parasites worldwide. Toxoplasma can infect all warm blooded animals, including humans.
- Domestic cats and members of the cat family are the definitive hosts of the parasite, i.e. the parasite can only complete its life cycle in a member of the cat family (see Figure 1). Cats become infected for the first time when they start hunting and eat infected wild rodents and birds. Following a primary infection, cats can shed millions of tough shelled oocysts (parasite eggs) into the environment, where they can survive and remain infective for several years, preferring temperate, moist conditions. Following infection, most cats develop immunity to the parasite and tend not to re-shed oocysts. As young cats are the main shedders of the parasite, it is good practice to have resident, neutered and healthy farm cats.
- Sheep may become infected with Toxoplasma through the ingestion of infective oocysts on pasture or in contaminated feed or water. A primary infection during pregnancy may cause disease and abortion of the foetus. Following infection, the parasite persists in the animal within tissue cysts and consumption of undercooked meat from infected food animals is a common route of transmission to people.

- Sheep develop immunity following a primary infection which will protect against disease in a subsequent pregnancy.

- If sheep become infected outwith pregnancy they show very few clinical signs but may have a transient fever.

- Research at Moredun has shown that as few as 200 sporulated (infective) oocysts may cause Toxoplasma abortion in a susceptible ewe.

Q1

At what stage of pregnancy am I most likely to see Toxoplasma abortion in my flock?

If ewes become infected with Toxoplasma for the first time during pregnancy the consequences may be very severe for the developing foetus. The earlier in gestation that Toxoplasma infection occurs the more severe the clinical consequences (see Figure 2).

Infection in early pregnancy is likely to result in loss of the foetus where resorption may occur and the ewe will either return to service or may remain barren. Death of the lamb later in pregnancy results in abortion of the foetus, usually a few days before the expected lambing time. Infection occurring in very late pregnancy may not always be fatal to the foetus as the foetal immune response matures throughout gestation and can respond against the invading pathogen. Lambs that survive the infection may be born live but weak and some die shortly after birth. Ewes may produce a live lamb alongside a dead and often mummified twin lamb.

Figure 2: Stage of ovine pregnancy and outcome of Toxoplasma infection

Toxoplasma Infection

- Not pregnant
  - No clinical effect
  - Resorption
  - Barren ewe
- Early pregnancy
  - Mummified lambs
  - Abortion
- Mid pregnancy
  - Abortion
- Late pregnancy
  - Stillbirth
  - Weak lambs
Q2 How does infection spread within the flock and what are the consequences?

- Infection occurs from ingestion of oocysts on pasture or in feed, therefore all ewes with exposure to Toxoplasma oocysts are at risk of infection.
- Research at Moredun has shown that there is extensive contamination of oocysts in the environment and they are long lived and difficult to remove or inactivate.
- If a ewe gets infected with Toxoplasma for the first time during pregnancy, the parasite may be transmitted to the placenta and then on to the foetus causing disease.
- Toxoplasma is not spread horizontally between sheep in a flock i.e. the parasite cannot spread between sheep.
- Abortion storms may occur if a flock of naive pregnant sheep encounter Toxoplasma for the first time.
- Once infected, ewes develop good protective immunity against the parasite which protects against disease in subsequent pregnancies.
- It is advised to retain ewes that may have aborted due to Toxoplasma for breeding, as their immune response will protect them against disease in subsequent pregnancies, or better still vaccinate all breeding females before first mating (see Q5).

Q3 How do I diagnose Toxoplasma abortion?

As with all disease outbreaks, early and accurate diagnosis of the problem is key to minimising losses and administering successful treatment.

Always isolate the aborting ewe immediately, clean up the aborted material and bedding and get a diagnosis as soon as possible, in case the diagnosis informs that an infectious agent is responsible which could spread to other animals in the flock.

For this reason it is advisable not to use ewes which have had late abortions, mummified lambs or suspiciously weak lambs as foster mothers until diagnostic tests have confirmed this is due to toxoplasmosis and not enzootic abortion, which is transmissible to lambs.
Sensitive and specific diagnostics are available for Toxoplasma diagnosis.

- Dead lambs and their placentas (if available) should be submitted to the veterinary investigation laboratory, where tissue samples will be examined for the presence of Toxoplasma and for lesions associated with Toxoplasma infection.
- Molecular diagnostic tests (PCR) are able to detect Toxoplasma specific DNA from infected tissue samples.
- In addition, your vet can take blood samples and submit these to the lab to be examined for the presence of Toxoplasma antibodies which will indicate exposure to the parasite.

Figure 3: Cats being allowed access to sheep feed present a risk. Keep feed in containers with fitted lids to deny cat access.

Q4 How do I restrict the numbers aborting in my flock once an outbreak has been diagnosed?

- As Toxoplasma is transmitted from consumption of oocysts on the pasture or in feed and water, it is difficult to prevent the disease spreading within a flock or from occurring through the maintenance of a closed flock.
- Feed bins should be covered to prevent cats from gaining access to feed (see Figure 3) and cats should be kept away from hay destined for sheep feeding if at all possible.
- There are no drugs that can cure sheep infected with Toxoplasma, although research has shown that lamb losses due to toxoplasmosis may be reduced by feeding the coccidiostat decoquinate during pregnancy. Decoquinate is most effective if it is already being fed to susceptible ewes at the time they encounter the parasite rather than after the infection is established.
- Appropriate samples should be collected and submitted for laboratory diagnosis, including foetal serum/fluid, foetal and placental tissues for pathology and microbiology.
- Foetal and placental tissues, along with any contaminated bedding, should be handled and disposed of carefully by burial or burning as Toxoplasma can be transmitted to people.

NB pregnant women or immunocompromised individuals should not handle any material from aborting ewes.
Q5  Can I vaccinate against Toxoplasma?

- Vaccination is an effective method to prevent toxoplasmosis which works by stimulating protective immunity in ewes prior to mating.
- Research in New Zealand discovered an incomplete strain of Toxoplasma that would only undergo limited multiplication within the host and would not persist as tissue cysts.
- Further work at Moredun showed that this New Zealand strain induced immune responses that would protect sheep against disease with Toxoplasma.
- This strain is the basis of the vaccine, Toxovax® which is licensed for use in the UK and it is recommended to be used at least 3 weeks prior to mating.
- One shot gives long lasting immunity for up to at least 18 months.
- The vaccine should not be used on pregnant animals and as it is a live vaccine it should not be administered by at risk people such as pregnant women or immuno-compromised individuals.
- As a live vaccine, Toxovax® has got a short shelf life and should be used strictly according to manufacturer’s instructions to maintain efficacy. Using before expiry dates and storage conditions are particularly important.

Q6  Is there a risk when buying in replacement sheep?

There is no risk of introducing toxoplasmosis in a flock via replacement or brought in sheep.
- As Toxoplasma is easily transmitted from consumption of oocysts on the pasture or in feed and water, it is difficult to prevent infection and disease from occurring through the maintenance of a closed flock.
- Any ewe that has not been exposed to the parasite is vulnerable to infection and disease, in particular during pregnancy.
- Once ewes are infected with Toxoplasma they develop good and long lasting immunity against abortion associated with this parasite.
- Use of the available vaccine is an effective way to ensure breeding and replacement females have effective immunity to the parasite, if they are vaccinated at least 3 weeks prior to their first mating.
Toxoplasma in Scottish sheep flocks

A Moredun study indicated a high level of environmental contamination with Toxoplasma oocysts

In 2011, Moredun conducted a Scotland wide seroprevalence study of Toxoplasma in sheep. Of the sheep tested, 56.6% were seropositive (i.e. they were positive for Toxoplasma antibodies in serum) with an increase in seropositivity as the animal aged. The study also showed a difference in seroprevalence within sheep from different regions of Scotland. The North of Scotland and the Islands had a seroprevalence of 60.5%, whilst sheep tested in Central Scotland and the South of Scotland had a seroprevalence of 54.8% and 36.8% respectively. But what was most interesting was that all farms had at least one animal that was seropositive, indicating that all flocks had exposure to the parasite. These results indicate that there is a high level of environmental contamination with Toxoplasma oocysts. NB Vaccination had no significant effect on seropositivity.

Toxoplasma in the Scottish human population

The seroprevalence of Toxoplasma within the Scottish population has been shown to be 13.2% and, similar to studies with sheep, seroprevalence increases with age. Although this figure is relatively low compared to other countries such as Germany and France (where seroprevalence can be as high as 59%) it does highlight the large proportion of the population at risk of becoming infected.

- The parasite may be transmitted vertically from mother to foetus if a pregnant woman becomes infected for the first time during pregnancy (Figure 1)
- Many food animals may become infected with Toxoplasma and the parasite is present within tissue cysts. Consumption of undercooked meat from animals infected with Toxoplasma is an important transmission route to people. Cooking meat thoroughly (internal temperature of 67°C) or freezing meat (-20°C for 2 days) will help to inactivate the parasite
- Toxoplasma may also be present in unpasteurised milk or raw cheese in particular from infected goats and sheep

Q7 Can Toxoplasma infect humans?

Toxoplasma is zoonotic, that is, the parasite can be passed from animals to humans and is therefore a particular risk to pregnant women and immunocompromised individuals. The main transmission route of Toxoplasma to people is through the consumption of oocysts or eating undercooked meat containing Toxoplasma cysts.
Transmission of Toxoplasma oocysts by water

Contamination of water with the oocyst stage of the parasite is a possible route of infection for humans and is also likely to be more important than previously thought. Research at Moredun has demonstrated the presence of Toxoplasma DNA (detected by PCR) in water from catchments across Scotland. It can therefore be presumed that oocysts are present in these water sources, although further work to confirm this is needed.

Risky rodents

Infection with Toxoplasma has been shown to affect the behaviour of mice and rats by making them less fearful of cats. Without the fear of felines, these risky rodents are more likely to be caught, killed and eaten by a cat. Ultimately this benefits the parasite as the cat is the one essential host where the parasite can complete the sexual stage of its life cycle. As the parasite often takes up residence in the brain it has been reported that it can effect human behaviour. Studies have been published blaming Toxoplasma for increased road traffic accidents, suicide, aggression, schizophrenia and even entrepreneurship. All this from one tiny microscopic parasite!
Current Toxoplasma research at Moredun

- Is aimed at advancing our understanding of how sheep can be protected against toxoplasmosis and using this knowledge to develop next generation vaccines that will be safer, offer better protection and cost less
- Development of new molecular diagnostics to identify Toxoplasma strains in livestock, wildlife, humans and the environment and understand transmission routes
- Develop new in vitro systems to study virulence of Toxoplasma parasites and help develop new prevention and control strategies