CPD article

Control of abortion in sheep: a risk-based approach

Abortion is a significant cost to the British sheep industry, outbreaks can severely affect flock productivity and many agents pose a zoonotic risk. As such, effective control measures are a vital part of flock health planning. This article outlines a risk-based approach to the control of ovine abortion.

10.12968/live.2016.21.1.46

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Key words: sheep | abortion | control | zoonosis

Abortion is a significant cost to the British sheep industry and has a significant impact to the productivity and welfare of flocks (Scott et al, 2007). The annual cost of abortion to the British sheep industry has been estimated at £20 million for chlamydial abortion and £12 million for toxoplasmosis (Nieuwhof and Bishop, 2005).

In addition to frank abortion losses and ewes being rendered effectively non-productive for a full year, additional costs result from the birth of small, weak lambs (Nettleton et al, 1992; Aitken and Longbottom, 2007; Garcia-Perez et al, 2009; Innes et al, 2009) and thus increased neonatal mortality rates, and further decreased growth rates seen with some causes of abortion (Nettleton, 1987) resulting in increased time to marketable weight and increased costs of production.

Abortion may also result in the death of the ewe, further compounding the losses. Less obvious are the costs of increased time and labour incurred in managing an abortion outbreak. Added to this must be the cost of human disease given that many of the agents of ovine abortion are zoonotic.

A common approach to ovine abortion management has been to identify the offending pathogen(s) on a farm and put into place reactive measures to combat them. This article describes an increasingly widely used alternative approach, in which knowledge of the nature and management of the flock is used to ascertain the abortion risks and propose control measures. As such there is minimal revision of the abortion agents present in the UK and the authors refer readers to the many excellent sources already available which cover these (see *Further reading*).

Identifying abortion hazards

In order to control the risk of abortion in a flock the potential hazards must be identified. In basic terms this involves all the potential causes of abortion which could affect the flock. In this article the authors will mainly consider infectious causes, but non-infectious causes, such as extreme stress events, e.g. dog worry, do occur. The three most common causes of ovine abortion in the UK are all infectious agents (*Chlamydophila abortus* (enzootic abortion of ewes; EAE), *Toxoplasma gondii* and *Campylobacter fetus fetus*) (DEFRA, 2013), and all infectious agents of abortion which could realistically affect a farm should be considered as potential hazards. The infectious agents of abortion currently present in the UK are included in *Table 1*. The degree of hazard posed by each agent is determined not only by the intrinsic properties of the agent but also by the properties of the flock — for example the impact of the introduction of EAE into a naïve flock will be greater (abortion rates up to 30%) than the ongoing losses seen in flocks in which EAE is endemic (5–10% per annum) (Aitken and Longbottom, 2007).

In order to avoid the failure to identify potential abortion hazards to the flock it is often helpful to consider the production cycle and risk points within it. Due to the nature of *C.abortus*, which may infect ewes at any time in the production cycle but only invades the placenta from day 60 of gestation, the entire cycle must be considered. This is illustrated in *Figure 1*.

Quantifying risks

In basic terms risk may be thought of as follows:

Risk = Hazard x Probability of exposure

While identifying the abortion hazards to a particular farm is relatively easy, quantifying the risk of each is more difficult. It

Table 1. Abortion agents present in the UK

Infectious agent	Clinical signs	Source of infection	Potential zoonosis
Chlamydophila abortus (EAE)	Abortion in the last trimester, stillbirths, weak lambs	Aborting or periparturient ewes	Yes
Toxoplasma gondii	High barren rates, abortion at any point during pregnancy, stillbirths, mummified lambs, weak lambs	Cat faeces	Yes
Campylobacter fetus fetus	Abortion (usually in last trimester)	Usually introduced by carrier ewes, may be spread by birds	No
Campylobacter jejuni	Abortion, diarrhoea in ewes	Many species can act as carriers, birds often implicated in introduction to a flock	Yes
Listeria monocytogenes	Abortion, more rarely septicaemia in ewes	Spoiled feed, usually silage	Yes
Salmonella abortus-ovis and *montevideo*	Abortion	Usually introduced by carrier ewes, may be spread by birds	No
Other *Salmonella* spp.	Abortion, enteric disease and death in ewes	Usually introduced by carrier ewes, may be spread by birds	Yes
Other bacteria (*T.pyogenes, E.coli, Y. pseudotuberculosis, F. necrophorum, B. licheniformis, Leptospira* spp. etc.)	Variable	Variable	Yes
Border disease	High barren rates, abortion, birth of 'hairy shaker' lambs, high incidence of neonatal disease	Usually introduced by persistently infected sheep	No
Fungi	Abortion	Mouldy feed or beeding	No
Schmallenberg virus	Birth of deformed lambs	Midges	No
Tick-borne fever (*Anaplasma phagocytophilum*)	Abortion, increased incidence of other diseases due to immunosuppression	*Ixodes ricinus* ticks	Yes (infection unlikely to be acquired from exposure to affected sheep)
Q-fever (*Coxiella burnettii*)	Abortion, weak lambs	Aerosol spread from aborted material, urine, faeces, milk. Potential tick-bite transmission	Yes

Table 1. This table shows the ovine abortion agents currently thought to be present in the UK. They are ranked in rough order of prevalence (if Campylobacter *and* Salmonella *species are grouped together) (based on Mearns, 2007). However, the risk and hazard each poses to a particular farm must be worked out on a farm-by-farm basis, e.g. Tick-borne fever is low in terms of national prevalence but is locally of great significance.*

requires knowledge of the biology of the abortion agents as well as a good understanding of the individual situation on each farm in terms of geography, management practices, endemic presence or absence of abortion agent. *C. abortus* is most likely to arrive on uninfected farms in infected sheep which are yet to abort and seroconvert, i.e. their infected status is undetectable (Longbottom and Coulter, 2003). As such *C. abortus* poses a higher risk to an EAE free farm which buys in replacement gimmers than to similar farms that have a closed flock or which buy in only rams. Environmental survival of *C. abortus* is limited. By contrast, since *T. gondii* is shed in the faeces of infected cats and the territories of domestic cats may extend up to 4 km across (Liberg, 1980) and *T. gondii* can survive for long periods in soil and water, most flocks must be considered at risk of *T. gondii* infection (Vesco et al, 2007). Tick-borne fever (*Anaplasma phagocytophilum*) is only a risk on those farms where suitable habitat for the vector, the sheep tick *Ixodes ricinus*, is present and where the timing of mating and the weather conditions result in pregnancy coinciding with tick activity (activity is minimal below 10°C (Urquhart et al, 1996)).

Identifying control measures

Prior to the suggestion of any control measures, the production process on farm and the hazards relevant to the farm as regards abortion must be considered. The probability of each hazard occurring is then identified and consequently major risks identified (*Box 1*). This then ensures that control measures are correctly targeted.

Following risk identification there are multiple approaches to dealing with the hazard. Two are considered below.

The first is risk assessment and management planning (RAMP). Once the management plan is put in place there is no way of checking the efficacy other than observing the effect on the targeted hazard. For instance, if a farm buys in replacement gimmers through a market every year then EAE is a hazard with a high probability of occurring, it is a high risk. The management plan may be to vaccinate all breeding replacements before mating each year with a modified live vaccine. The measure of the success of the plan is the number of abortions due to EAE seen each year. RAMP is the most relevant approach to the control of most infectious causes of ovine abortion. The problem with RAMP is that there is no way of verifying risk reduction other than the end process.

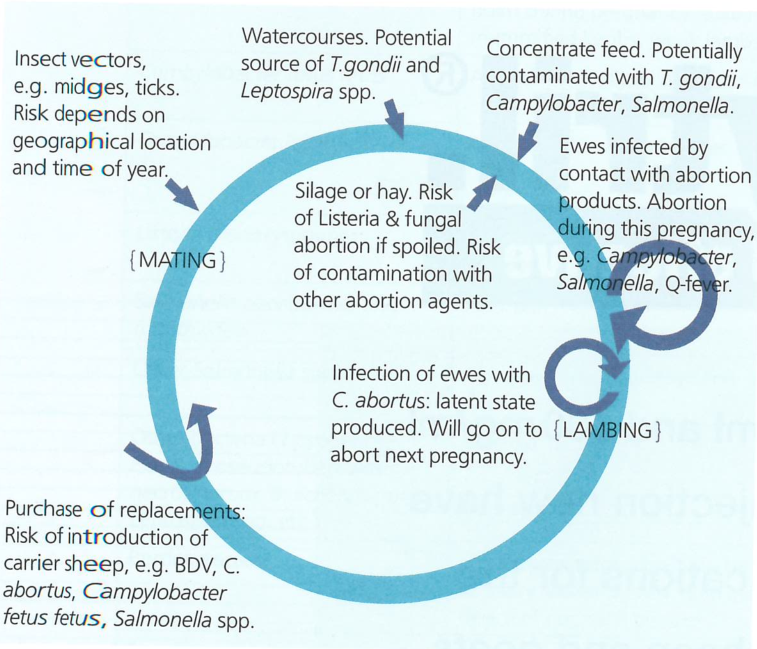


Figure 1. The sheep production cycle. This figure shows the sheep production cycle with some of the abortion hazards identified. Due to the nature of some abortifacient agents the hazard of introduction is present all year round.

Hazard analysis and critical control points (HACCP) are an alternative approach to RAMP protocols. HACCP identifies critical control points where there are opportunities for infection and implements a management standard operating protocol at this point and then monitors the effectiveness of this (see *Box 2*).

For example, a naive flock buying in replacement gimmers each year is at risk of border disease virus introduction by persistently infected (PI) animals. (The critical control point is in bold, the monitoring/verification is in italics):

- ***Screening all bought-in animals for the presence of virus.*** This would be very expensive, an alternative approach is required.
- **Buying from as few flocks as possible will reduce potential exposure.** *The number of farms of origin of purchased gimmers can be verified by checking the flock numbers on ear tags.*
- **Closed flocks are less likely to be infected (due to fewer opportunities to introduce infection) thus replacements should be sought from these.** *This assumption can be tested as on farms where border disease virus (BDV) is present and circulating at least some animals will be seropositive. A subsection of the gimmers from each flock of origin can be serologically tested for BDV exposure. The rest of the cohort of a*

Box 1. Example decision flowchart

Hazard: *Chlamydophila abortus*	Only rams ever bought in. Flock seronegative	Risk: moderate (probability: low; hazard: high)	Control measures: do not buy in any unaccredited females. Ensure boundaries are secure
Hazard: *Toxoplasma gondii*	Farm within 5 miles of other human habitation. No resident farm cat	Risk: high	Control measures: vaccinate; try to minimise feed contamination by cat faeces
Hazard: Tick-borne fever	No rough grazing, no ticks ever seen on sheep	Risk: very low	Control measures: none required
Hazard: *Listeria monocytogenes*	Clamp silage fed for 3 months	Risk: moderate	Control measures: maintain a tight feed face, reject any spoiled sections, remove any uneaten silage from troughs every 2 days

group of seronegative animals are unlikely to be PI animals.

- **The purchased sheep could be managed separately for the first year on the farm. This will minimise the risk of BDV spread to the rest of the flock.** *(Any abortions or barren ewes in this group should be investigated — this will provide evidence to confirm or disprove the presence of contagious forms of abortion in the group).*

In the rest of this article the possible control measures for different causes of ovine abortion are detailed. There is rarely one control measure that is always necessary and always sufficient. The veterinary surgeon's role in preventing abortion is to aid the

Box 2. Stages of hazard analysis and critical control points (HACCP)

- Conduct a hazard analysis
- Identify critical control points
- Establish critical limits for each critical control point
- Establish critical control point monitoring requirements
- Establish corrective actions
- Establish procedures for ensuring the HACCP system is working as intended
- Establish record keeping procedures

Table 2. Abortion vaccines available in the UK

Vaccine	Manufacturer	Target agent	Primary course	Booster	Notes
Enzovax	MSD Animal Health	*C.abortus*	Single IM or SC injection from 5 months of age. Should be given in the period 4 months to 4 weeks prior to mating	Protection is thought to last up to 4 years. It is common practice to vaccinate breeding ewes only once in a lifetime	Licensed to be administered simultaneously with Toxovax. Live vaccine should not be handled by pregnant women or immunocompromised individuals
CEVAC Chlamydia	CEVA Animal Health Ltd	*C.abortus*	Single IM or SC injection from 5 months of age. Should be given in the period 4 months to 4 weeks prior to mating	Protection is thought to last up to 4 years. It is common practice to vaccinate breeding ewes only once in a lifetime	Licensed to be administered simultaneously with a T.gondii vaccine based on live S48 strain tachyzoites. Live vaccine should not be handled by pregnant women or immunocompromised individuals
Mydiavac	Benchmark Animal Health Ltd	*C.abortus*	Single IM injection given either 1 month prior to mating or from 4 weeks after ram removal	The primary vaccination should be repeated 771 days after the initial vaccination	Killed vaccine. Licensed to be administered simultaneously with a T.gondii vaccine based on live S48 strain tachyzoites
Toxovax	MSD Animal Health	*T.gondii*	Single IM injection from 5 months of age. Should be given in the period 4 months to 3 weeks prior to mating	After 2 years. It is common practice to vaccinate breeding ewes only once in a lifetime	Licensed to be administered simultaneously with Enzovax. Live vaccine should not be handled by pregnant women or immunocompromised individuals
SBVVax	Merial Animal Health Ltd	Schmallenberg Virus	Single SC injection from 2.5 months of age. No less than 1 month prior to mating	Duration of immunity not yet fully established	Do not use in pregnant animals. Safety in breeding males has not been established

Vaccines with a license in another farmed species

Vaccine	Manufacturer	Target agent	Licensed species	Notes
Coxevac	CEVA Animal Health Ltd	*C.burnettii*	Cattle and goats	Licensed in goats to reduce abortion due to *C.burnettii* and to reduce shedding
Bovivac S	MSD Animal Health	*S.dublin* and *S. typhimurium*	Cattle	Vaccination against *S. typhimurium* has been shown to provide cross-protection against *S. abortus-ovis*
Spirovac	Zoetis UK Limited	*L.borgpetersenii* var Hardjo	Cattle	Licensed in cattle to reduce shedding of leptospires
Leptavoid-H	MSD Animal Health	*L.interrogans* var Hardjo and *L.borgpetersenii* var Hardjo	Cattle	Licensed in cattle to reduce shedding of leptospires and to reduce infertility due to Hardjo serovar leptospira infection. Only *L.interragans* serovars are reported to cause clinical disease in sheep

There are two licensed BTV-8 vaccines available in the UK (Bovilis BTV 8 and Zulvac 8 Ovis); neither are licensed for the prevention of abortion due to BTV-8 but experimental work suggests vaccination can reduce transplacental viral transmission.
The tables above detail the vaccines with a license in the UK. Licensed sheep vaccines for E.coli, Salmonella, Brucella melitensis (notifiable) and other serotypes of Bluetongue virus are available elsewhere within the EU. Campylobacter vaccines are licensed in North America, Australia and New Zealand but are not currently available anywhere within the EU. IM, intramuscular; SC, sub cutaneous.

client in correctly identifying hazards and risks to the flock and suggesting proportionate and reasoned control measures.

Preventative measures

The general principles behind these include decreasing the exposure to the cause of abortion, for example by good biosecurity, and increasing the immunity of the ewe to the cause of abortion, by vaccination, and by strategic use of other measures to reduce the impact of the cause of abortion, such as by antibiotic use in the face of an abortion storm caused by susceptible agents.

Vaccination

Vaccination can be a useful tool both to prevent infection of ewes by abortive agents, to reduce shedding of pathogens and in the face of outbreaks to reduce the incidence of disease. Vaccines currently available in the UK against ovine abortion agents are listed in *Table* 2.

Given the availability of both live and inactivated vaccines careful attention must be paid to data sheet recommendations regarding timing of administration as use of live vaccines during pregnancy can result in abortions. Careful handling of vaccines (e.g. maintenance of the cold chain) and correct administration must be emphasised in order to avoid vaccine failure. It is worth reminding clients that no vaccine is 100% effective and that the data sheet claims of many vaccines is reduced abortions or shedding rather than complete prevention. There are rare reports of abortion due to the vaccine strain of *C. abortus* (Wheelhouse et al, 2010; Sargison et al, 2015).

Off-label usage of vaccines (especially the usage of vaccines that are licensed in other species) is indicated in certain conditions. Some prior reports of such usage are available in the literature and it is recommended that practitioners consult these and the vaccine manufacturers for advice before recommending such a course to clients.

Feed quality

Listeria monocytogenes and various fungal species (e.g. *Mucor, Aspergillus*) are present in spoiled feed, the former especially in poorly-fermented or soil-contaminated silage (Sargison, 1993), and can cause placentitis and abortion. The risk of abortion due to these agents can be reduced by correct production and storage of forage (for example ensuring that big-bale silage is firmly compacted to exclude air and that hay is stored in dry conditions), and careful inspection prior to feeding. Spoiled or suspect material should be rejected entirely or fed to stock less likely to suffer ill-effects e.g. finisher cattle or store lambs. Troughs and racks should be regularly cleaned out to remove spoiled feed — this not only poses the risk of listerial or fungal abortion but will also dissuade sheep from feeding and so impair dry matter intakes.

Contamination of feed with abortion agents, for example contamination of hay with cat faeces containing *T. gondii* oocysts or contamination of feed troughs by birds (carriers of *Campylobacter* spp. or *Salmonella* spp.) should also be prevented. This may be achieved by covering the tops of stacks of hay bales to prevent cats using them as litter trays, feeding potentially contaminated bales to non-pregnant stock, and turning troughs over after feeding or if using hopper-fed troughs ensuring these exclude birds to prevent them congregating at the food source and contaminating it. More rarely, high levels of fungal toxins or phytoestrogens can result in abortion — mouldy feed should not be fed to pregnant sheep.

Other biosecurity measures

Biosecurity measures that can lower the risk posed by abortion agents are various and the appropriate measures will depend to a certain extent on the situation of the flock. For example, EAE free flocks on farms which do not vaccinate should either buy in only rams or should source replacement females only from accredited EAE free flocks (PSGHS EAE accreditation scheme, SRUC). Individual EAE infected sheep do not seroconvert prior to placental invasion (and potential abortion) and so cannot be detected by individual testing.

Unfortunately no accreditation scheme exists, nor is any vaccine available, for border disease so any flock which buys in sheep of any sort is at risk of introducing this virus, either in transiently infected animals or, more likely, in PI animals (Carlsson and Belak, 1994; Nettleton et al. 1998). Since some PI animals show clinical signs consistent with the effects of the virus on in utero development , such as myelin dysgenesis, stunted growth, abnormal hair coat (so called 'Hairy Shakers') any such animals should never be allowed in contact with pregnant ewes (Nettleton et al. 1998), however many PI animals appear perfectly normal. Maintaining a closed flock is the best way to exclude the virus. Small numbers of purchased sheep may be tested for viral antigen. For larger numbers of sheep this is very expensive and other approaches, such as that detailed above, must be used. This situation is further complicated by the fact that ruminant pestiviruses are not species-specific i.e. bovine viral diarrhoea virus (BVDV) can infect sheep (Carlsson, 1991) and BDV can infect cattle (Carlsson and Belak 1994; Braun et al, 2014). In some countries BVDV appears to be the most common cause of border disease (Paton et al, 1995). Thus, it appears that the presence of pestivirus in the cattle population on farm may pose a risk to the sheep population and vice-versa (Sandvik, 2014).

Campylobacter spp. and *Salmonella* spp. can also be introduced by carrier sheep. Unfortunately there is no way of detecting these carriers.

An effective, though logistically challenging, method of limiting the risk posed by incoming sheep is to manage bought-in sheep separately throughout pregnancy and lambing and to investigate all abortions occurring within this group. Conversely where purchased sheep are of a higher health status than the flock which they enter, i.e. they are naïve to causes of abortion endemic in the flock, there is a higher risk of abortion in these animals.

T. gondii undergoes sexual reproduction in the gut of the cat and cats are necessary for its propagation on farm. Cats are infected through consumption of infected rodents so rodent control measures will reduce the risk of farm cats becoming infected. *T. gondii* shedding is primarily by young cats or old, immunosuppressed individuals (Witt et al, 1989) as healthy adult cats mount an immune response to the parasite. Consequently if the farm has a resident population of healthy adult cats these should not be eliminated as this would merely create a territorial vacuum into

Box 3. Petting zoos and open farms

Given the zoonotic concerns about many of the pathogens involved in ovine abortion, a separate HACCP analysis should be performed for open farms and petting zoos (see the example below). Potential risks for human infection predominantly come from contact with aborted material, vaginal secretions including those present on neonatal animals and direct contact with aborted ewes.

Petting zoos should evaluate the risk: benefit of having neonatal lambs or lambing ewes on the premises and if the risks cannot be reduced significantly, should avoid having these classes of animals on farm. Best practice would be to operate a closed flock, sourced from EAE accredited flocks and depending on relative risk, consider Toxoplamosis vaccination.

Petting zoos and open farms should be encouraged to perform risk analysis with regards to protecting members of the general public by examining risk of zoonotic disease with other hazards such as biting, kicking etc. The National Farm Attraction Network (NFAN) in association with the Health and Safety Executive (HSE) has produced guidelines for risk identification and management on farm and provide ongoing support to respective members. Veterinary practitioners may find their recommendations helpful when developing protocols and as with all health strategies, ongoing monitoring and review is essential: http://www.farmattractions.net/nfan-resources/code-practice/

Clear and concise communication to the general public is essential to highlight managed risks and instructions with regards to cleansing and disinfection. The risks should be explained to the general public at the entrance to the premises.

Zoonotic Disease Risk Assessment

Disease risk category	Explanation
HIGH	A disease with severe implications for human health, e.g. *E. coli* 0157
MEDIUM	A common disease with moderate to severe implications for human health, e.g. ringworm
LOW	Uncommon in this species or with mild implications for human health

Bottle fed lambs and kids

Relevant disease	Potential transmission route	Current risk control measure	Suggested changes to risk control	Review date
Campylobacter	Petting infected animals	Prominent hand washing facilities and signs	If any animals display respiratory signs, skin lesions or diarrhoea please isolate and call vet	Ongoing
Cryptosporidiosis	Contact with animal faeces			
Salmonella	Feeding animals Touching contaminated equipment Contaminated footware	No public feeding of animals Cleaning tools off display Purchased from single source Sick animals removed from display ASAP and Synergy Farm Health contacted AVOID contact	Adapt current advice leaflet	
E.coli 0157				
Ringworm				
Orf				
Swine Flu				
Chlamydia	Inhaled			
Toxoplasma	Contact with neonates			
	Lambs, goats and adult ewes and goats			

which heavily shedding cats might move (Liberg, 1980). Farm cats should be neutered — this reduces the likelihood of kittens on farm and also reduces the risk of male cats becoming infected with immunosuppressive agents like feline immunodeficiency virus (FIV) and feline leukaemia virus (FeLV) through roaming and fighting (Hitt et al, 1992; Knotek et al, 1999).

Parasite control

Where ticks are present on farm the risk of tick-borne fever as a cause of abortion is present, as are the risks from bacteraemia due to tick bite and losses due to louping ill infection. Tick activity is low below 10°C (Urquhart et al, 1996) so the risk will be determined by the timing of pregnancy, the choice of grazing and the weather conditions. Where tick-borne diseases are considered to be a risk the use of repellent/acaricidal products should be considered. These include organophosphate (OP) dips and synthetic pyrethroid (SP) pour-on products. While the former may be used prior to mating, dipping immediately post mating or in late pregnancy is inadvisable. The different SPs available have varying periods of protection against tick attack. The agent chosen and the timing of application will be determined by local experience and weather conditions.

Midge-borne diseases such as Schmallenberg virus and bluetongue virus may be avoided as risks to the pregnant ewe purely through timing of mating, though recent work has suggested that in the south of England midge activity never truly ceases (Sanders et al, 2011). Choice of pasture can also influence midge exposure (Harrup et al, 2013; Rigot et al, 2013). Pour-on SP products of-

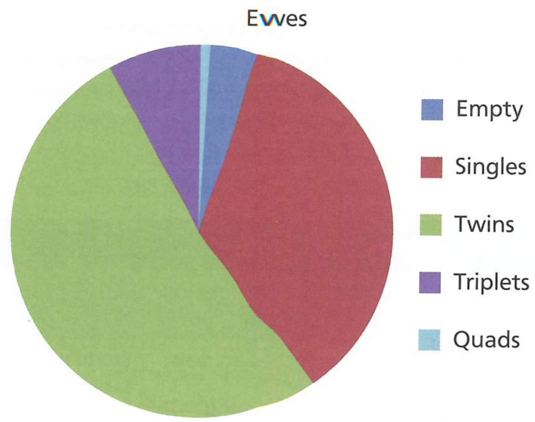
Synergy Farm Health - Tupping and Scanning Profile

Scanning percentage 2013: 188%
Barren percentage 2013: 3%

Tupping Figures 2014	Ewe Flock
Number of ewes @ weaning 2013	400
Ewes culled	83
Ewes purchased	
Gimmers introduced	83
Ewe lambs introduced	
Ewes @ tupping	400
Flock growth per cent	0
Rams @ tupping	10
Ewe: Ram	40
Replacement ewe rate	21%

Scanning Performance	Ewes
Number of ewes/ewe lambs	400
Empty	9
Singles	134
Twins	220
Triplets	36
Quads	1
Total lambs	686
Scanning %	172%
Empty%	2%

Summary	2014
Replacement rate	21%
Ewes to the tup	400
Scanning percentage	172%
Barren percentage	2%
Percentage change in scanning % 2013 vs. 2014	-9%



Comment/action needed:

Drop in scanning percentage across two years is significant. Suspected to be nutritional in origin but may be worth checking trace element status at pre-lambing visit (4 weeks pre-lambing).
Empty rate still below target!

Figure 2. Scanning record sheet. Ongoing flock health discussion and data collection can highlight issues within flocks before overt clinical disease e.g. high barren rates may warrant investigation looking for infectious diseases such as Border disease, Toxoplasmosis etc.

fer some degree of protection (Papadopoulos et al, 2009; Weiher et al, 2014), but given the lack of a license claim for any product currently available in the UK, the harmful effects of SPs on the environment and the availability of effective vaccines for the midge-borne diseases, use of SPs purely to control midge activity is probably unjustifiable in the majority of cases.

Accreditation schemes

There is currently one accreditation scheme available in the UK for abortion agents: the Scottish Rural University College's (SRUC) Premium Sheep and Goat Health Scheme (PSGHS) for EAE accreditation. The scheme developed out of the Highlands and Islands Sheep Health Association eradication scheme. There are currently 197 flocks registered as part of the SRUC's PSGHS EAE accreditation.

Participating flocks must not be vaccinated against *C. abortus*. A proportion of the breeding ewes are blood sampled for anti-*C. abortus* antibody annually in the 3 months following lambing (as seroconversion only occurs following placental invasion from day 90 of gestation and antibody levels decline thereafter) and all aborted fetuses and placentae must be submitted to a veterinary investigation centre. Blood from all aborted ewes and those found barren at lambing must be included among those blood samples.

If no evidence of *C. abortus* is detected then the flock is designated 'supervised' after 1 year and 'accredited' after 2 years of clear tests. Participating flocks are limited to bringing into the flock only sheep from another EAE accredited flock, and accredited sheep must not mix with non-accredited stocks. Further details may be found at http://www.sruc.ac.uk/info/120113/premium_sheep_and_goat_health_schemes.

Antibiotic usage

Antibiotic usage in the face of an abortion outbreak may be performed for several reasons. In the case of certain *Salmonella* spp.

infections antibiosis may be required due to systemic illness of the ewe.

Where abortion is due to placentitis, such as in EAE, treatment in the face of an outbreak is probably unlikely to have much effect on the outcome, as the damage is already done in most sheep by the time the first abortion is seen. The exception is if a prolonged lambing period is expected in which case treatment of exposed ewes from day 90 of gestation with oxytetracycline may reduce losses (20 mg/kg, repeated after 2–3 weeks) (Entrican et al, 2012). While there have been no documented cases of antibiotic resistance in ovine *Chlamydial* species, porcine strain *Chlamydia suis* has been demonstrated to have oxytetracyaline resistance capable of horizontal transmission (Lenart et al, 2001)

Treatment in the face of a *Campylobacter* or *Salmonella* outbreak, where the period between infection and abortion is less than in EAE, may be indicated. Antimicrobial sensitivities of these pathogens tend to be variable and culture and sensitivity information from aborted fetuses is useful to direct antibiotic choice. Opinion is divided as to whether there is a net benefit to antibiotic metaphylaxis in such cases (Mearns, 2007) and the long-term suitability and sustainability of such protocols should be considered.

In the event of an outbreak, the use of antibiotics may reduce the impact of the disease and reduce ewe losses, but should not become a routine component of abortion management. Where large numbers of animals are to be treated with antibiotics, culture and sensitivity is encouraged and alternative strategies such as use of vaccination should be investigated.

Control in the face of an outbreak

Control in the face of an outbreak is essential to reduce the zoonotic impact and to reduce risk to other animals.

The annual abortion rate in the flock should be less than 3%. Veterinary surgeons will be contacted at varying stages of abortion outbreak (ranging from after individual abortions up to after the end of the lambing period). Prompt investigation may enable control mechanisms to be implemented, e.g. vaccination, antibiosis, isolation, whereas delayed investigation may delay implementation of control mechanisms.

While results are pending, the ewes' and lambing environment should be managed as if the pathogen is both highly infectious and zoonotic. Animals should be placed in strict isolation, e.g. in a pen away from other animals, in a pen that can be thoroughly disinfected after use, bedding disposed of without coming into contact with other animals and with separate equipment. The total number of ewes that have aborted should be monitored, and if in doubt, there should be an ongoing dialogue with the veterinary surgeon.

Where there is suspicion of EAE abortion, adoptions onto aborted ewes should not be performed due to the risk of creating endemically infected neonatal ewe lambs.

Abortion investigation requires submission of placental and fetal materials to a local laboratory. Where possible serology samples for the aborted ewe may facilitate screening. If the causative agent is confirmed as a contagious form of abortion other than EAE (or one of the Salmonellae that cause disease in adult sheep) then exposure of lambed ewes or ewe lambs to aborted sheep can increase the prevalence of immune animals in the flock.

KEY POINTS

- Abortion is a significant cost to the national flock.
- The degree of hazard posed to any given flock by each cause of abortion is dependent on both the nature of the agent and the properties of the flock.
- The risk posed to any given flock is determined both by the severity of the hazard and the probability of its occurrence.
- Performing a risk analysis for abortion allows prioritisation of preventative measures.
- The appropriate preventative measures vary from disease to disease and from flock to flock.

Minimising zoonotic risks

Some of the abortion agents confer health risk to humans coming into contact with sheep and aborted materials including contamination equipment, clothing etc.

Individuals at increased risk include pregnant women or those trying to get pregnant, with several of the abortion agents causing miscarriage in women, and children, the elderly and those on immunosuppressive therapies as they are relative immune-compromised compared with the general population (Anon, 2013).There should be a strict exclusion policy from the lambing shed (even where no abortions have been identified).

Those handling pregnant sheep and aborted materials should be aware that people, equipment and clothing can behave as fomites and potentially be a source of infection for those not entering the lambing shed (Meijer et al, 2004). Where possible such equipment and clothing should be left in the lambing shed; if not it should be thoroughly disinfected before leaving the lambing shed. Minimising zoonotic risks is especially challenging for open farms and these challenges are addressed in *Box* 3.

Conclusion

Abortion continues to be a significant challenge to sheep health, welfare and productivity in the UK. The risks for infection introduction and propagation vary significantly between farm type and production process/model. Relative risks will differ between premises and this article highlights the alternatives to a blueprint approach, i.e. a risk-based control plan requiring an understanding of both farm management and pathogen biology. A HACCP approach requires ongoing monitoring and reassessment and verification of the protocols in place to ensure a robust management system.

Irrespective of the approach, an understanding of disease characteristics and management options is required. In addition to the acknowledged risks for animal health and productivity, the impact on human health should not be underestimated and the risk of human infection should be managed accordingly.

Veterinary surgeons, thanks to ongoing working relationships with flocks and an understanding of flock, regional and national disease prevalence as well as an understanding of the biology of the abortifacient agents, are excellently placed to deliver advice on abortion control as part of ongoing flock health planning (*Figure* 2). LS

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