Salmonella hindmarsh – more ‘stuff’ down south

KIM KELLY
MSD Animal Health, Upper Hutt

Introduction

The first discovery of enteric salmonellosis in sheep in NZ was in 1949, this was *Salmonella typhimurium* in a ewe with a scour (Salisbury 1958). There are currently 127 different serovars isolated in NZ (Clark *et al.* 2002). The most important to sheep farmers pre-1996 were *Salmonella hindmarsh* (mostly in sheep) and *Salmonella typhimurium* (more common in cattle), which caused enteric or gut forms of the disease and the odd abortion. After 1996 a new strain, *Salmonella* Brandenburg, emerged causing heavy abortion storms and deaths in sheep in Canterbury, Southland and Otago. During the years 1998–2007 there were very few, if any, cases of *Salmonella hindmarsh* in sheep in this country.

Since 2008, there has been a constant increase in the number of cases of *S. hindmarsh* diagnosed (Figure 1), with a large proportion of these cases in Otago and Southland. This contrasts with the east coast of the North Island, where cases seem to have reduced. In Hawkes Bay, since the 2007 drought farmers have fewer ewes. Farmers also do less risky mob stocking, at least for extended periods (R Hilson, pers comm). In Wairarapa, cases still occur from December to June/July; however it is suspected a lack of reporting now occurs also (S Bruere, pers comm). In the current season in Southland, farmers are contacting vets with suspected hogget Salmonella cases which often turn out to be massive immature parasite burdens. There is confusion about how much of this disease is actually around!

Salmonella as a species

These bacteria are facultative, anaerobic, gram negative rods. They can be motile or non-motile and have flagella. They are very tough organisms and in ideal conditions can survive well. They can tolerate pH levels ranging from 4 to 9 and are said to be able to grow in temperatures from 4.5°C to 48°C.

Since 1918, the Kauffmann/White/Le Minor classification of *Salmonella* organisms has been used based on the somatic (O) and flagella (H) antigens. This has led to the identification of 2,249 serovars. As mentioned above, only 127 of these have been identified in NZ. The majority of cases are *S. typhimurium*, *S. hindmarsh* and *S. Brandenburg* (Figure 2).
### Immunology of *Salmonella* infections

The immune system responds to *Salmonella* organisms invading in two different ways. The innate response is the first line of defence, and this is the physical barriers such as skin and mucous membranes. This response is often limited and insufficient. If this is the case, a more specific immune response will occur. This can be broken into humoral immunity and cell mediated immunity.

Cell mediated immunity involves T cells which either directly kill host cells, or cause the activation of phagocytic defence. This type of immunity IS NOT altered by current vaccinations against *Salmonella*. The humoral immunity involves B cells producing antibody and this antibody level is what we increase with the use of vaccinations.

In the case of *Salmonella* organisms, both cell mediated immunity (CMI) and humoral immunity (antibody) are important. The relative roles of these in protection against *Salmonella* organisms can be illustrated by using innately susceptible or resistant mice. Innately resistant mice can be protected well by using a killed vaccine, whereas innately susceptible mice require live vaccines for optimal protection (Mastroeni *et al.* 1993). This may be due to live vaccines eliciting CMI in addition to an antibody response, suggesting CMI is more important for protection against *Salmonella* organisms. Intracellular survival is a prerequisite for virulence of *Salmonella* species. A perfect vaccine would be live, would need the ability to induce opsonizing antibody directed to the bacterial cell surface, as well as to elicit cell mediated immunity.

After two weeks of infection with *Salmonella*, an antibody response has been detected in sheep and cattle (Brennan *et al.* 1994). IgM is often first to be detected, then IgG and IgA. IgG concentration persist for about two months after infection.

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**Table:**

<table>
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<tr>
<th>ESR results</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<td><strong>S. Brandenburg</strong></td>
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<tr>
<td>Cattle</td>
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<td>94</td>
<td>42</td>
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<td><strong>S. hindmarsh</strong></td>
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<td>4</td>
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<td><strong>S. typhimurium</strong></td>
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<tr>
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<td><strong>Total cases (main three serovars)</strong></td>
<td></td>
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<tr>
<td>Cattle</td>
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<td>578</td>
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<td>113</td>
<td>157</td>
<td>112</td>
<td>108</td>
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</tbody>
</table>

*Figure 2.* New Zealand Salmonella cases in sheep and cattle, 2008–2014, source: ESR
S. Brandenburg in cattle

While in sheep the cases of S. Brandenburg appear to have been relatively constant, a large amount of ‘on-farm self-diagnosis’ is occurring, with farmers not submitting samples to the laboratories. For this reason we expect the number of cases per year to be well in excess of these figures. We do however see an increasing number of cases of S. Brandenburg in cattle, especially dairy cattle, and this needs to be investigated further (Figure 3).

![Salmonella Brandenburg cases](image)

**Figure 3.** Cattle S. Brandenburg cases in New Zealand, source: ESR

Human health risk

After consulting the ESR reported human *Salmonella* isolates data from 2008–2014, it is apparent there is a large number of cases of S. Brandenburg in humans, especially in Otago/Southland, and there is a peak in these cases in the months of August, September and October, when over half the annual cases occur. However, for *S. hindmarsh* this is not the case, with the highest annual result eight cases NZ wide in 2014 (Figure 4).

<table>
<thead>
<tr>
<th>Human cases (NZ)</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. hindmarsh</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>S. Brandenburg</td>
<td>33</td>
<td>36</td>
<td>47</td>
<td>34</td>
<td>34</td>
<td>52</td>
<td>35</td>
</tr>
</tbody>
</table>

**Figure 4.** Human cases of Salmonellosis, 2008–2014, source: ESR

In 2014, when there were eight cases, these were in January (1 case), February (3), March (1), July (1) and August (2), so no seasonal pattern exists as it does with S. Brandenburg.
From the years 1984 to 1997 there were very few cases of S. Brandenburg in humans (Smart 1999) but this changed dramatically in 1999 with around 170 cases diagnosed. All cases appear to have work related exposure to the organism – farmers or abattoir staff.

Clinical signs in sheep/cattle

In most cases the ewes were in very good condition, had not been yarded and were on good or even a rising plane of nutrition. The ewes, both mixed age (MA) and two-tooths (2T), were either found suddenly dead or were seen lethargic with a typical khaki coloured diarrhoea. In some cases one or two dead ewes a day for a week or so were noted and then stopped. In other cases it was more dramatic, with up to eight dead at once. Cases began in February and were even reported as late as June.

Salmonellosis is often associated with wild birds such as ducks and seagulls, and in the case of S. Brandenburg it has been shown (Clark et al. 1999) to be transferred from paddock to paddock in seagull faeces. In one of these outbreaks S. hindmarsh was isolated in soil around a water trough where birds such as pigeons and seagulls had been seen. However, despite a lot of effort, it was not able to be isolated from the birds themselves using swabs of the intestinal tract of recently killed birds. Salmonella is often a water borne disease, isolation from the soil near water could be from shedding (all mobs will contain carrier animals) and diseased sheep.

The following case studies illustrate the nature of the disease outbreaks.

Case study 1

- Lost 45 ewes in 2009 due to S. hindmarsh, including two-tooths, four-tooths and mixed age ewes.
- Vaccinated all sheep including rams in face of outbreak.
- A small number of losses in 2010.
- Sheep grazed duck pond paddock three days before deaths began, MA ewes grazed three days behind the two-tooths.
- Did not have as many deaths as neighbours (unvaccinated), many responded to antibiotic treatment.
- All ewes prior to 2009 had been vaccinated as two-tooths with Salvexin®+B (MSD Animal Health) in the previous seasons (sensitiser and booster, May and July). From 2010 on this continued but was moved earlier to January and February.
- Since 2014 they now use two vaccine shots in hoggets, even though they do not lamb them, so they can use only one booster in two-tooths, either in autumn or winter as it fits.
It is worth noting that this outbreak occurred in Southland, just prior to mating, and there was no negative effect on reproductive performance in these ewes, both scanning and lambing percentages. It is often a concern of farmers who have disease during or immediately prior mating that vaccination will affect fertility. The risk of further disease or even death will always outweigh these small risks.

Case Study 2

The farmers have a high performing sheep property located in Southland. They farm a Romney Cross ewe and usually have 150–165% lambing percentage.

They have historically had a small amount of *S. Brandenburg*. They do not use *Salvexin+B* but do use *Toxovax* and *Campyvax* (MSD Animal Health) in their hoggets. They lamb some as hoggets, the remainder lambing for the first time as a two-tooth.

The clinical signs began in August 2013. On 12 and 13 August a mob of 1,037 ewes, (which was made up of 960 two-tooths and some lighter mixed age ewes) were yarded for 36 hours and shorn. Weather at this time was good.

The first death of a ewe was seen on 18 August. In the paddock where the first deaths occurred ducks had been seen in water troughs recently. Two to four deaths occurred for a couple of days before the ewes had a FEC sample taken and this revealed a range of counts from 0 to 1,350, with an average of around 400. The ewes had been previously FEC tested but their last drench was in November 2012 as a hogget.

The ewes were immediately yarded and drenched with a triple combination product, and then stocking rate was reduced but the ewes were not totally spread out due to availability of feed. The deaths slowed.

On 29 August the ewes were yarded again for scanning, and also given a clostridial vaccine at this time. They were only scanned for wets and dries, and of the 960 scanned there were 53 dries (6%). This is an acceptable rate in these two-tooths, some of which had lambed as hoggets.
Soon after this the ewes began to abort as well as some just dying. Those that aborted were usually sick, and unless given a long-acting tetracycline most often died. An aborted lamb sample was sent to the lab on 2 September and returned a heavy growth and diagnosis of *S. hindmarsh* soon after. This is unusual for an aborted lamb as historically *S. hindmarsh* has not caused abortions, per se.

The *S. Brandenburg* organism has a predilection for the uterus and this is why so many lambs are aborted. The ewes often get toxic and die due to incomplete expulsion of the fetal materials. In the case of *S. hindmarsh*, it appears the ewes get sick from the enteric form of the disease and abort due to becoming toxic or having a high temperature.

Ewes were set stocked on 10 September, and it was noted that they had put on one condition score since drenching. Abortions and deaths continued until lambing started on around 20 September.

In total around 40 ewes died (4%) and an additional 30 (3%) ewes aborted but survived after being given antibiotics. This was an example of the farmer assuming that *S. Brandenburg* was the cause of the problem, when it was not!

**Comments**

It is suggested by many veterinarians who have experience of both enteric and abortion disease that the increased number of cases of this more ‘traditional’ salmonellosis is an indicator that overall sheep population protection is waning. Especially in the lower South Island, flocks are now vulnerable to both forms of disease – enteric salmonellosis (*S. hindmarsh*) between late summer and late winter, and abortion losses (*S. Brandenberg*) during late pregnancy. It is thought the majority of properties which had *S. hindmarsh* in the autumn did not have any abortions in the spring, however they had vaccinated with Salvexin+B as a result of the problem in the autumn.

Since 1998, laboratory diagnosed cases of *S. Brandenburg* have peaked in 2000 and again in 2005/06. This cyclical pattern is typical of a disease like *S. Brandenburg* as it becomes endemic in the sheep population.

Since the peak of 2005/06 we appear to be ‘at the bottom of the trough’ again. *S. Brandenburg* has certainly not gone away however, and there is no cause for complacency. Salvexin+B, the vaccine used to protect ewes against abortions and deaths in late pregnancy from *S. Brandenburg* also protects against the salmonella species that cause the enteric form of the disease. However vaccine usage has steadily declined over the last 10 years. This decline, plus reduced recent exposure to the disease and culling of previously exposed sheep and introduction of naïve replacements, means the overall sheep population immunity to all *Salmonella* organisms will be low.

**Vaccination strategies**

These differ depending on which form of disease is of most concern. There is definitely a lot of further work that needs to occur in this area. However, currently recommendations are as below:
Enteric disease: vaccination from weaning onwards. Replacements or sheep not previously vaccinated need a Salvexin+B sensitiser and booster 4–6 weeks apart. An annual booster is recommended but not always given, and this should occur a few weeks before this ‘risk period’ of disease. Vaccination in the face of disease can give some protection providing it is early in the outbreak and risk factors are taken into account e.g. reduction in stocking density. The difficulty arises when the risk period for S. hindmarsh seems to now be from January to September!

Brandenburg disease: vaccination in early pregnancy prior to the risk of disease. Sheep not previously vaccinated require a sensitiser and booster and an annual booster is recommended (as per Salvexin+B label). Vaccination in the face of disease is problematic and yarding and stress of vaccination may result in rapid escalation of disease. The decision to vaccinate must be on an individual farm basis and must take all risk factors into account.

Rams should not be forgotten. Often this enteric disease occurs right at the time of mating. This disease is spread via faecal shedding, and any close observation will see rams putting themselves at great risk of faecal-oral transmission occurring. The minor risk of a slight temperature spike after vaccination is less than the risk of a sick or dead ram. It is very difficult for them to get any ewes pregnant when they are sick, or dead!

As discussed elsewhere, vaccination against S. Brandenburg may be a factor in the reduction in enteric salmonellosis reported in Otago and Southland from the late 1990s to recently.

Future work

There is a lot we need to learn about Salmonella. In the ‘deep south’ we are now faced with a quandary as far as implementing a vaccination policy to protect against both enteric and abortive forms of the disease. A complicating factor is the ‘normal’ patterns of enteric do not exist anymore – meaning there is difficulty defining the ‘risk period’ to vaccinate before. A MSD coordinated farmer survey will occur in the next few months which will hopefully help with defining this. The importance of cell mediated immunity and not just high levels of antibody have been illustrated and mean there will have to be further science used to investigate this area.

References

KERSLAKE JI. Salmonella Brandenburg in NZ sheep: the development of a serological diagnostic test and a case control study; Master's thesis, 2003


MASTROENI et al. Adoptive transfer of immunity to oral challenge with virulent Salmonellae in innately susceptible mice requires both immune serum and T cells. Infection and immunity 61 (9), 3981–3984, 1993

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