Yersiniosis is an important and costly disease of young merino lambs in the high rainfall areas of Southern Australia. It has been associated with a morbidity rate of over 80% and mortalities as high as 30%. A commercial vaccine against Yersinia pseudotuberculosis serotypes I, II and III (Yersiniavax™) has been widely adopted by the New Zealand deer industry, but is not available in Australia. New Zealand studies investigating the efficacy of that vaccine indicate that it reduces mortalities, from 2.1% to 0.8%, and also the severity of Yersiniosis in deer (Mackintosh, Buddle et al. 1991; Wilson, Mackintosh et al. 1999).

The current study investigated the efficacy of an autogenous bacterin containing formalin-killed Y. pseudotuberculosis. It was conducted in weaned merino lambs in two flocks in southern Victoria that regularly experience outbreaks of yersiniosis during the winter.
non-parasitic scouring, being 97% of isolates (McGregor et al. 2014). The study showed that shedding of *Y. pseudotuberculosis* increased during winter and was associated with morbidity rates (scouring) averaging 40% and mortality rates ranging from 0-9%. Very little quantitative detail is known about risk factors associated with outbreaks of Yersiniosis, or the success of commonly used prevention and control measures, but attempts to identify them are being undertaken with the current study.

There has been limited recent work conducted in Australia to investigate this disease but comprehensive studies have been undertaken in the New Zealand deer industry. Where outbreaks occur, animals develop severe acute enteritis and mortality exceeding 30% is common. Consequently, ‘Yersiniavax’, a commercially available vaccine, was developed and is widely used within the NZ deer industry. The vaccine decreases mortalities in young deer and also reduces the severity of disease in affected animals (Wilson, Mackintosh et al. 1999).

Following the observation that *Y. pseudotuberculosis* serotype III was isolated from 97% of cases of yersiniosis in the sentinel flocks study during 2013, a basic formalin-killed bacterin was developed and evaluated as a potential control measure in 2014.

**Methodology**

Two flocks with a known high prevalence of yersiniosis were selected to participate in this study in December 2013. On each farm, 490 recently weaned merino lambs were randomly selected, tagged with radiofrequency ear tags (‘RFID’) and allocated to one of three trial mobs (‘replicates’). In each mob, 75 animals were vaccinated twice, one month apart, with an autogenous bacterin, containing formalin-killed *Y. pseudotuberculosis* III isolated from that farm, and 75 were identified as controls. In July 2013, a significant peak in the proportion of weaners shedding *Y. pseudotuberculosis* occurred on farm 1 (88%). This was followed by an outbreak of clinical yersiniosis with an 8% mortality rate. In 2014, the proportion of weaners shedding *Y. pseudotuberculosis* peaked at only 5% in September, and no outbreak of yersiniosis occurred (Fig 1). Of note was that the average live weight of the 2014 weaners in June was 4kg heavier than for the 2013 cohort of weaners that were enrolled in the sentinel flock study on this farm.
No outbreak of yersiniosis occurred on Farm 1 during 2014, and so a final collection of individually identified samples was conducted in September.

The percentage of vaccinated and control lambs shedding *Y. enterocolitica* and *Y. pseudotuberculosis* in each of the three trial mobs at this final sample collection is shown in Figure 2. There were more control animals shedding *Y. enterocolitica* than vaccinated animals in one replicate (green), but this trend was not reflected in other replicates (blue and red). It is not clear why this occurred, but factors associated with the paddock grazed by the green replicated may have contributed to this difference.

In both the blue and red mobs there were more control animals than vaccinated animals shedding *Y. pseudotuberculosis*, but these differences are unlikely to be statistically significant (analysis yet to be completed at the time of writing).

On farm 2, shedding of *Y. pseudotuberculosis* in the sentinel flock weaners peaked at 54% in August 2013 and was associated with a typical outbreak of yersiniosis, with 9% mortalities (Figure 3). In 2014, shedding of *Y. pseudotuberculosis* exceeded 60% but no disease outbreak occurred. Contrary to what occurred on Farm 1, the 2014 weaners were only 1 kg heavier in June compared to the 2013 cohort.

Similar to Farm 1, no clear association between bacterial shedding and vaccination was observed on Farm 2 (Figure 4). In the blue and green replicates, there was very little difference in the proportion of vaccinated and control animals shedding *Y. pseudotuberculosis*. In the red mob, more vaccinated animals were shedding *Y. Pseudotuberculosis* compared to the controls.

No clear difference between the isolation of *Y. enterocolitica* was evident between the vaccinated and control groups on either farm.

**Discussion**

The farms used in this study are located in high winter rainfall areas in western (Farm 1) and northeast Victoria (Farm 2). Both farms experienced an excellent spring in 2013. This,
Figure 2: The percentage of control and vaccinated weaner merinos shedding *Yersinia enterocolitica* or *Y. pseudotuberculosis* in their faeces at the trial conclusion (Sept 2014) - Farm 1

Figure 3: The live weight of weaned merino lambs and the percent shedding *Yersinia pseudotuberculosis* during 2013 and 2014 - Farm Two
combined with an early autumn break in 2014, meant that pasture availability and quality was exceptional and weaners were in excellent health and comparatively higher bodyweight than the previous year (Farm 1) coming into the winter. Whilst each property experienced short periods of cold temperatures and heavy rainfall, conditions were generally milder compared with a typical season, including the winter of 2013.

Environmental factors, including temperature, rainfall and chill factor, as well as host factors such as live weight, growth rate and the proportion of animals shedding *Yersinia* spp., are identified as putative risk factors for yersiniosis. Results from Farm 1 indicate that the live weight of weaners as they enter the high risk period of winter (June-July) may influence the development of disease. In 2013, weaners on Farm 1 were 15% lighter in June compared to the same time in 2014 (22 and 26kg, respectively). On this farm, the proportion of animals shedding *Y. pseudotuberculosis* reached 88% in 2013, when a typical and severe outbreak of yersiniosis occurred. In comparison, shedding peaked at only 5% in 2014 and no outbreak occurred. This trend was not apparent on Farm 2, where there was little difference in live weight between the 2013 and 2014 cohorts of weaners, but a higher proportion of animals shedding *Y. pseudotuberculosis* in 2014 but no outbreak of clinical disease. Consequently, live weight may contribute to the development of this disease, but is unlikely to be the primary risk factor.

The absence of an outbreak in 2014 may have also been associated with decreased environmental contamination, due to fewer animals shedding *Y. pseudotuberculosis*. This may have reduced the degree of oral-faecal cycling compared to what is needed to precipitate an outbreak. When fewer animals are shedding the bacteria, pasture contamination is low and recirculation within the mob is minimal. Results from Farm 1 support this hypothesis, with the proportion of sheep shedding *Y. pseudotuberculosis* remaining low throughout the year. In contrast, Farm 2 did have higher proportion of animals shedding *Y. pseudotuberculosis* in 2014 compared to the previous year, but this was not associated with a disease outbreak. On this farm, exposure
to the bacteria was presumably high, but was not sufficient to cause disease. These contrasting observations highlight the complex and multifactorial nature of the weaner scour syndrome.

In the absence of an outbreak of yersiniosis in the study flocks, more information on the likely efficacy of the vaccine will be made by comparing the antibody response to both natural exposure and vaccination. If outbreaks of yersiniosis occur in these two flocks during 2015, vaccinated and control animals from the 2014 study will be sampled to compare faecal shedding of Yersinia and antibody titres. Antibody titres from a cross section of age groups in these flocks will also assessed to determine the longevity antibodies produced in response to natural exposure.

Results from this trial indicate that a vaccine against Y. pseudotuberculosis may not be a cost-effective option for control, due to the sporadic nature of the disease and difficulty in predicting when outbreaks will occur. Further work will include a cost-benefit analysis, to determine what protection is required for a vaccine to be financially viable in sheep, and an investigation of the potential benefit of a Yersinia vaccine to other conditions, such as scouring in dairy calves.

Conclusion

It is difficult to accurately assess the efficacy of the pilot vaccine in the absence of an outbreak of yersiniosis. Results from the natural challenge that occurred during the 2014 season found that it had no beneficial effect on the bodyweight of animals, and did not decrease shedding of Y. pseudotuberculosis. However, we are unable to draw any firm conclusions regarding protection from the vaccine in the face of an outbreak of yersiniosis. Measuring the humoral response of the study animals, to both vaccination and natural challenge, is yet to be completed. This will give additional information on the feasibility of vaccination and the potential of developing a vaccine as part of a strategy to control yersiniosis.

References