Breech Strike Genetics

This project is a collaborative research effort of Department of Agriculture and Food Western Australia, University of Western Australia, CSIRO Animal, Food and Health Sciences, Armidale, NSW supported by Australian Wool Innovation Limited.

Editorial

The Breech strike project was initiated in 2006 with the establishment of the research flock on the Mt Barker research station in Western Australia. Six hundred Merino ewes were sourced from 10 industry and 3 research station flocks from the Department of Agriculture of Western Australia. The project went through three different phases to identify the role of potential indicator traits in breech strike.

Phase 1

During the first phase (2006-2007), rates of breech strike of mulesed versus non-mulesed sheep were compared to determine whether there are sheep that have not been mulesed that have the same likelihood of being struck in the breech by flies as a mulesed flock, in a scenario where sheep are not crutched. As expected, mulesing resulted in a significant decrease in breech strike. However, some un-mulesed sheep were indeed found that had the same low risk of being struck as mulesed sheep. This indicated that some sheep were genetically more resistant to breech strike than other sheep even when not mulesed or crutched.

Phase 2

Phase 2 (2008-2010) focussed on those factors which made some sheep more resistant to being struck and the results showed that dags during late winter and urine stain at post-weaning age were the two most important factors contributing to breech strike in un-mulesed sheep and sheep that have not been crutched. However, breech wrinkle had a significant interaction with dags as a one unit increase in wrinkle score, from 1 to 2, increased the risk of being struck. Breech cover played a relatively minor role but did increase the risk by 2-3%. These results supported industry's perception of the importance of dags in breech strike.

Further investigations showed that there were huge differences between different sire progeny groups in their susceptibility to breech strike in un-mulesed and un-crutched sheep. In 2008, only 2.8% (one lamb) of the most resistant sire's progeny were struck while a strike rate of 103% was recorded for the progeny group of the most susceptible sire. Virtually every lamb of this progeny group was struck and some were struck twice between birth and hogget shearing. These large differences between resistant and susceptible sire progeny groups was a major finding but what was more interesting was that it was not possible to visually differentiate between the progeny groups using dag, urine stain, wrinkles, breech cover or any other visual indicators. Furthermore, only about 20 to 30% of the differences in breech strike could be explained genetically by dags, urine stain, breech cover and breech wrinkle traits, which indicated that other factors are contributing to making the susceptible sire progeny group more prone to breech strike.

Phase 3

The third phase (2010-2014) of the experiment focussed on identifying those factors that contributed to susceptibility and resistance to breech strike in the absence of dags, i.e, when animals are crutched or shorn just prior to the fly season. This is representative of production systems in winter rainfall regions where all sheep are normally crutched before the onset of the winter/spring. This newsletter reports some of the most important results from this phase and on the latest results from our work to identify additional factors, such as odour, that could play a role in making susceptible sheep more attractive to blowflies.

Effect of crutching and mulesing on breech strike

Figure 1 shows the incidence of breech strike in different management groups that were mulesed or not mulesed, and that were crutched or not crutched, for both males and females. A crutched plus mulesed group was not included as this would have distorted the genetic information necessary for studying the inheritance of breech strike and identifying the potential indicator traits.

Differences within treatment groups across years (i.e. within crutched or mulesed groups for females and males) can be explained by differences in environmental conditions between years. However, large differences were also found between management groups. Both the un-mulesed and un-crutched female and male groups experienced high incidences of breech strike – an average of 27% (purple) vs 15% (green), respectively. Mulesing sheep decreased the incidence of breech strike to 6% for both males (dark blue group) and females (brown group), while crutching alone decreased the incidence of breech strike to 11% for females (orange group) and 5% in the males (light blue). No difference between rams that have only been mulesed (dark blue) or have only been crutched (light blue) were found.

In summary, not crutching ram or ewe hoggets increased the risk of breech strike by 2 to 3 fold, while not mulesing ewe hoggets increased the risk of being struck by 4 to 5 fold.

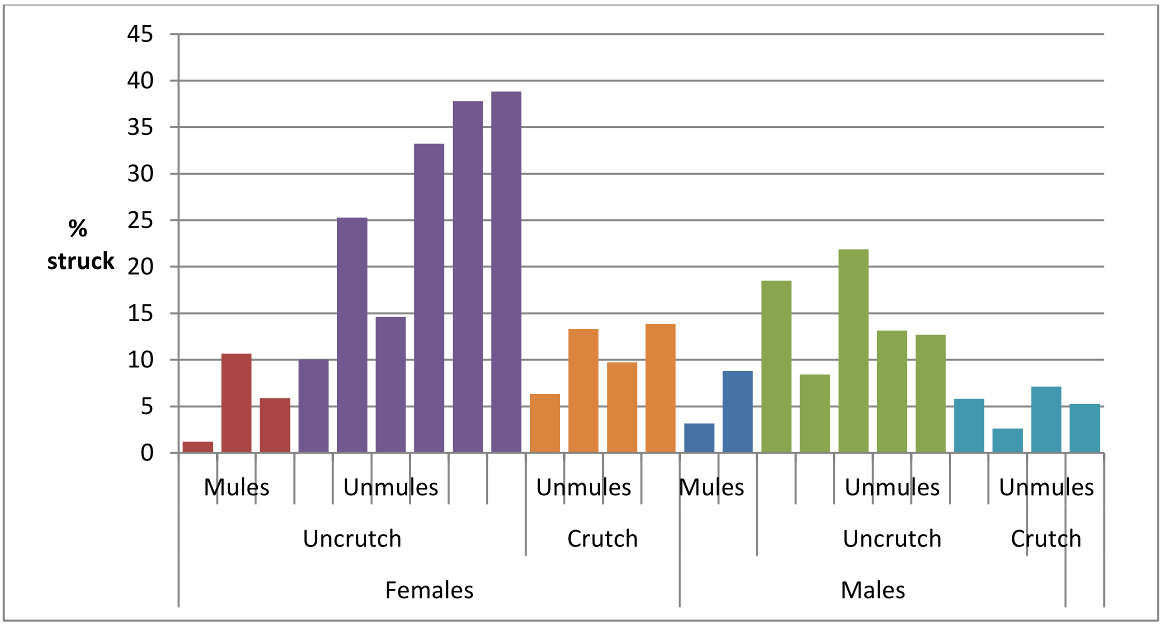


Figure 1. Incidence of breech strike for males and females that were crutched and un-crutched, and or mulesed or not mulesed in different management groups. (The x-axis shows management groups in different years)

Large differences exist between sire progeny groups

Figure 2 shows the differences in the incidence of breech strike from birth to hogget shearing among 148 sire progeny groups from 2006 to 2014 for animals that were not mulesed. The sires were sourced from research flocks (homebred), commercial industry flocks and from different ram breeding flocks (studs). The progeny were classified as being resistant or susceptible based on their breeding value for breech strike from birth to hogget age. Additional sires were progeny tested (Homebred) to assess their resistance to breech strike. The sheep that were born in 2006, 2007, 2008, 2009 and in 2014 were not crutched in those born in 2010, 2011, 2012 and 2013 were crutched at yearling age. Thirty sires were used in multiple years to generate genetic links across years.

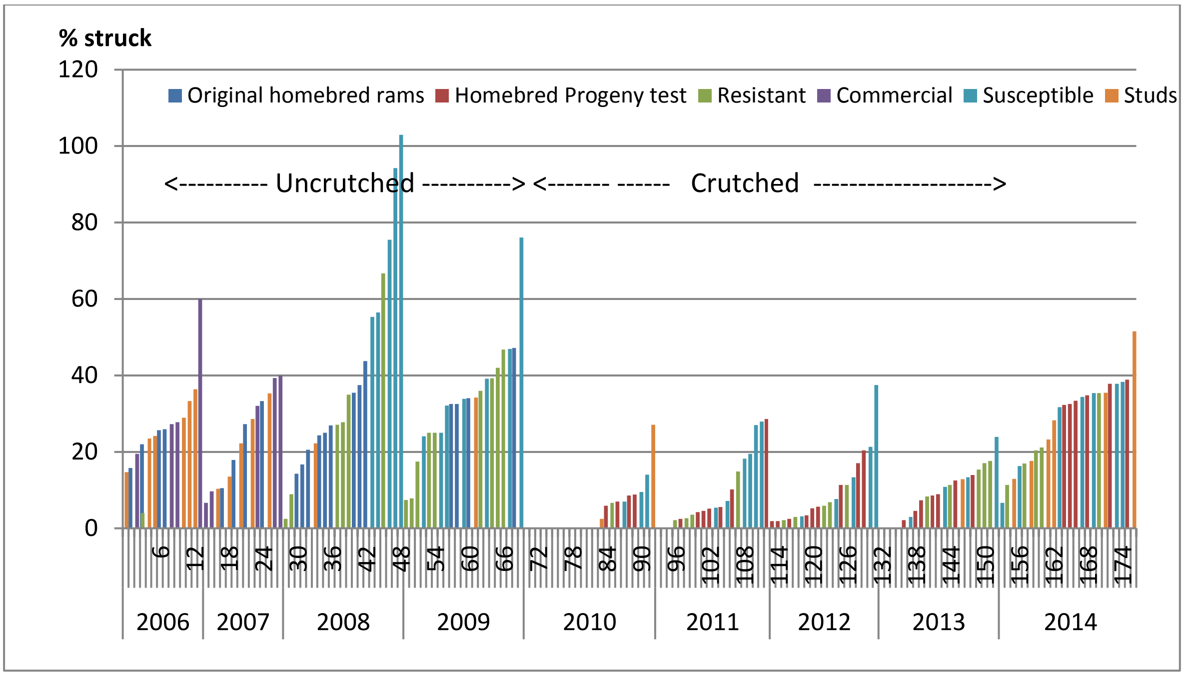


Figure 2. Differences in breech strike between sire progeny groups from 2006 to 2014 for sires sourced from different flocks.

Figure 2 clearly shows the large differences that were found between sires within each year. A very high breech strike rate was experienced in 2008 (39%) whereas a very low rate of 4% was experienced in 2010. However, in every year there were sires whose progeny were highly resistant and highly susceptible. All flocks are likely to have a similar distribution in sires for breech strike, and identifying the susceptible animals are very important. Culling sheep that have either been struck in the breech or, where records exist, have had significant numbers of progeny struck, is a simple way of reducing the incidence of breech strike in the flock.

Do not breed from any struck animal

Figure 2 shows the large differences between sire progeny groups and Table 1 shows the incidence of breech strike of the un-crutched and un-mulesed progeny of the two most resistant and two most susceptible sires that were born in 2008, over their lifetime in the flock.

The progeny of the two most resistant sires experienced a strike rate of 5.7%. This is very low considering these sheep were not mulesed, crutched, or jetted while strongly challenged and assessed in a high flystrike season prior to hogget shearing. In contrast, the progeny of the most susceptible two sires' had an average strike rate of 98.6% at hogget age, which means that virtually all progeny of the two most susceptible sires in this study, were struck prior to hogget age.

Table 1. Incidence of breech strike over their lifetime for the un-crutched and un-mulesed progeny of the two most resistant and two most susceptible sire progeny groups that were born in 2008.

	Resistant		Susceptible	
Age	n	%	n	%
Hogget*	85	5.7	66	98.6
3 year	32	0.0	37	54.2
4 year	31	0.0	33	10.7
5 year	27	0.0	30	16.5

It is clear that if sheep are struck early in life, then there is a high likelihood that they will be struck again at later ages. Therefore, one can say with reasonable accuracy that any sheep that had been struck in the breech is very susceptible to future breech strike and that all such animals should be culled and not used for breeding in future.

In subsequent years, Table 1 shows that when these animals were 3, 4 and 5 years old, none of the two most resistant sires' daughters were subsequently struck in the breech even though they were not mulesed or jetted, but only crutched. However, a significant proportion of the daughters of the two most susceptible sires were again struck at 3, 4 and at 5 years of age. The differences in breech strike within the two groups from year to year were probably due to different environmental conditions from year to year.

Important indicator traits of breech strike in winter rainfall regions

Figure 3 shows the important indicator traits for breech strike up to weaner shearing and the amount of variation these indicators explains in un-crutched and un-mulesed weaner sheep. All the factors explain about 25% of the variation in breech strike up to weaner shearing, of which dags at weaning (W) was the most important indicator trait in ram lambs. In ewes lambs dags was less important and instead, differences in urine stain and tail wrinkle contributed significantly to breech strike. However, a large proportion of the variation (>70%) remains unexplained.

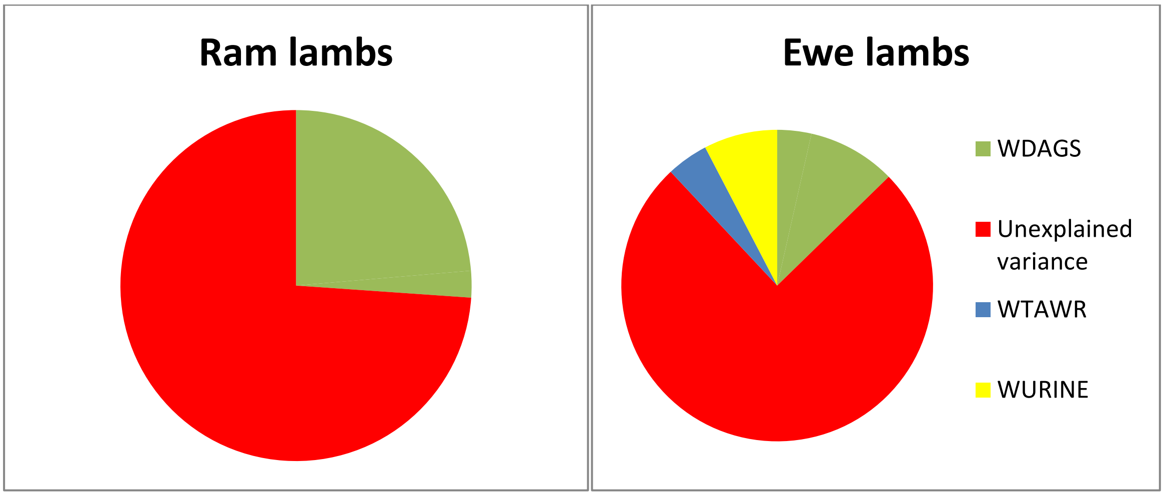


Figure 3. Proportion of variation, that the most important indicator traits explain in ram and ewes lambs up to weaner shearing (WDAGS = Dags at weaning; WTAWR=Tail wrinkle at weaning; WURINE = Urine stain at weaning).

Figure 4 shows the indicator traits for breech strike from weaner to hogget (H) shearing and the amount of variation they explained in crutched ewe hoggets. It is clear that in crutched hogget ewes, breech wrinkle (PBRWR) was the most important factor in breech strike from weaner to hogget shearing. This implies that whilst the removal of the wool by crutching hogget ewes reduces breech strike, probably through preventing the wool from getting too wet from urine and enabling it to dry much quicker, the presence of wrinkles negates this drying out effect of the urine from crutching. This then increases the risk of being struck. However, in crutched hogget rams (Figure 5), dags, breech (PBCOV) and crutch cover (HCCOV) explained only about10% of the total variation in breech strike. This leaves about 90% of the variation in breech strike unexplained.

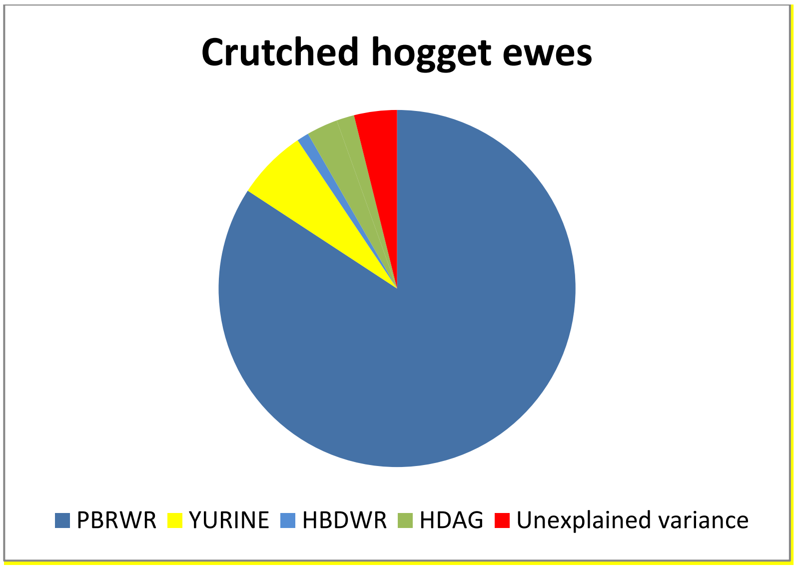


Figure 4. The importance of breech wrinkle at post weaning (PBRWR), urine stain at yearling (YURINE), body wrinkle at hogget shearing (HBDWR) and dags at hogget shearing (HDAG =) in breech strike from weaner to hogget shearing.

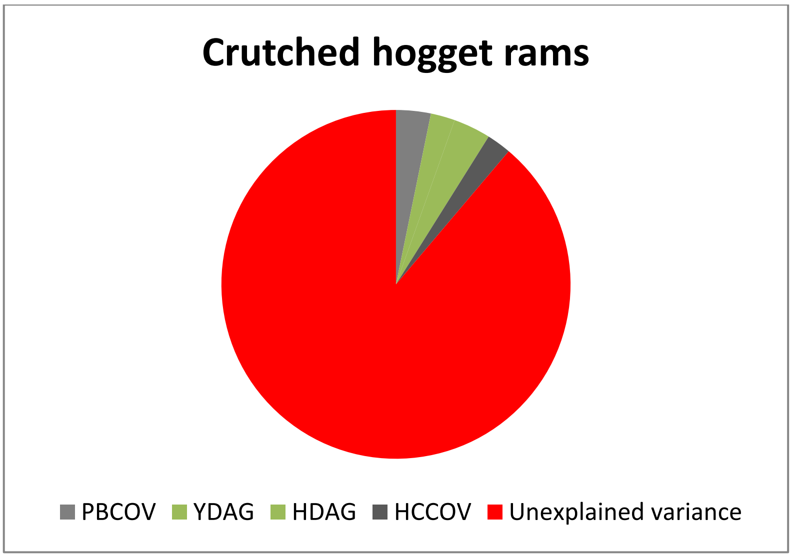


Figure 5. The importance of breechcover at post weaning (PBCOV), dags at yearling (YDAG), dags at hogget shearing (HDAG) and crutch cover HCCOV at hogget shearing for breech strike from weaner to hogget shearing in crutched ram hoggets.

How important is odour in attracting Blowflies??

Table 1 clearly indicates that breech strike is a repeatable trait and that any animal that has been struck should be culled as these animals are more likely to be struck again. This factor together with the large differences that exist between sire progeny groups in breech strike susceptibility, and the fact that we could not visually differentiate between susceptible and resistant sheep, indicated that the susceptible animals are likely to have an additional factor(s) that attracts blowfly strike. Thus the focus of the experimentation shifted towards identifying these elusive factors, the most obvious being odour. A proof of concept experiment was previously carried out with Hanrob Dog Academy where three dogs were trained to determine whether they would be able to distinguish between wool from resistant and susceptible sheep (see WA Breech Strike Newsletter No. 6). Wool from unstruck sheep taken prior to the breech strike season was collected from the breech of the extreme ewes mentioned above in the repeatability study, and regularly forwarded to Hanrob Dog Academy to train the dogs. After completing their training, one dog was 100% accurate in differentiating between the wool from susceptible and resistant sheep that was used to train him. In a double blind test (neither the handler nor the dogs knew what the samples were), the dogs were then tested on wool from the CSIRO breech strike flock in Armidale to which they have never been exposed. The best dog was 82% accurate in identifying the resistant sheep and 92% accurate in ignoring the susceptible samples and other dummy wool samples used to distract the dogs. This result indicated that an odour component was likely and that odour may contribute in attracting flies to susceptible sheep.

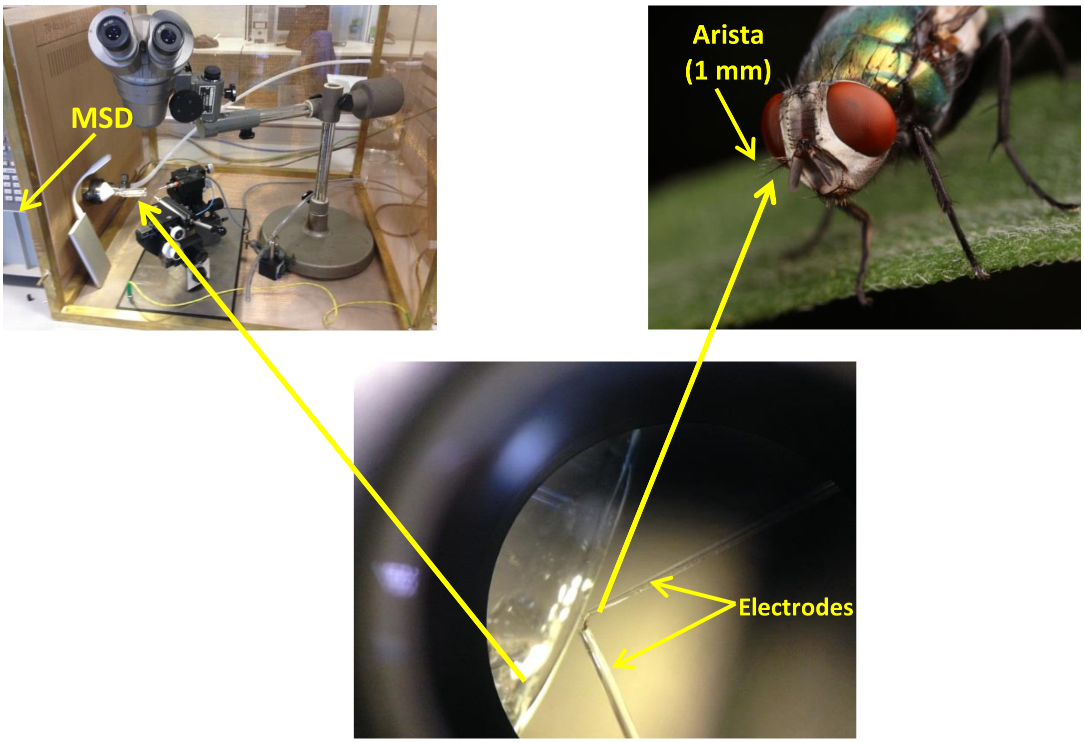
If an odour is confirmed, then it opens up additional opportunities depending on whether the odour components act as repellents or as attractants. If a repellent, then it offers opportunities to find new chemicals to protect sheep from breech strike; if they act as an attractant, then it offers opportunities to develop more effective methods to trap blowflies than are currently available, and to identify sheep that are be less attractive to blowflies.

The University of Western Australia (UWA) has extensive experience in identifying odour that attracts insects, and in the identification of volatile chemical components that contribute to germination of specific seeds. A joint project with UWA was thus initiated to identify the specific odour components that are secreted by breech wool. More than 1500 different compounds have been identified across both the DAFWA and the CSRIO Breech strike flocks, using gas chromatography. A large number of these volatile components are unknown and we are currently working our way through them to determine which will attract flies. Two different methods are being used: the electro-antennagram detector and the behaviour of blowflies when exposed to these compounds.

Electro-Antennagram Dectector (EAG)

The EAG is presented in the following picture. It is connected to a Mass spectrometer (MSD).

Electro-antennagram Detector **Arista antenna of the Blowfly**



The arista of a blowfly is placed between two electrodes and the specific volatile component is determined in the MSD and blown over the arista through a glass tube. The electrodes measure the voltage differential when the neurons fire and the resulting pattern is shown in Figure 6.

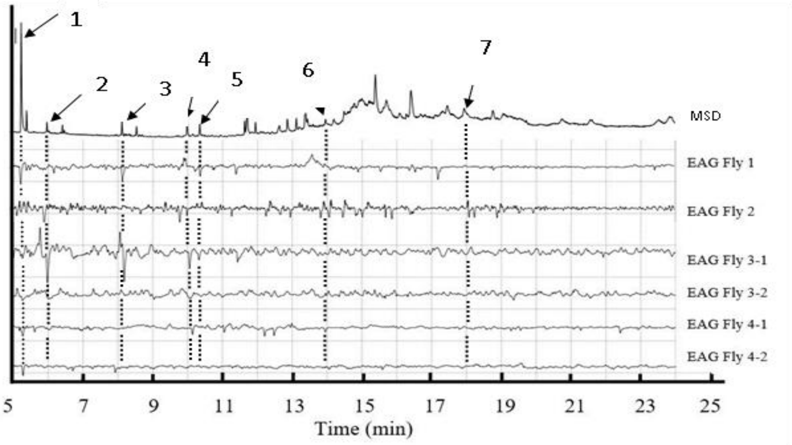


Figure 6. Output displaying seven peaks of different chemical compounds and the EAG neural responses of four different flies of which flies 3 and 4 were measured twice.

When it has been shown that the flies recognise specific volatile components through the firing pattern of its neurons, then it indicates that they have specific neural receptors for those compounds. However, it is still unknown whether these compounds will elicit a specific behavioural response (repelled or attracted), so likely candidates still need to be tested using behavioural methodology.

Blowfly behaviour

The behaviour of blowflies as they find susceptible sheep and lay their eggs is an important area of research and an area of specialist skills. We invited Dr Bekka Brodie from Ohio University (USA) to participate in this work. She has studied the ordinary bottle green blowfly, *Lucilia sericata*, a cousin of the sheep blowfly *Lucilia cuprina*, and she identified specific chemical odour signatures that attract *L. sericata*. She assisted us in fine tuning our EAG methodology to get better neural electrical responses but, more importantly, she demonstrated very quickly that *L. cuprina* is not attracted to the same odour compounds that attract *L. sericata*. This was a major finding which explains why *L. cuprina* prefers live animals while *L. sericata* prefers carrion (dead animals). Clearly, there is something specific in live sheep that attracts *L. cuprina* as they do not lay eggs on carrion.

Up to now, we have assessed fly behaviour and what attracts them in an artificial environment, but we need to determine what attracts, or repels them under natural conditions. Their behaviour and how they identify susceptible sheep under natural conditions will be an important future area of research as we determine how they are attracted or repelled by these factors.

Dr Bekka Brodie from Ohio University (USA), collecting blowfly maggots on a struck sheep. These maggots are used to refresh the blowfly population in the insectary of the University of Western Australia where the fly behaviour and odour research are being carried out.

Temperature and humidity changes in the breech during a typical day during the fly season

We believe that temperature and humidity in the breech are key driving forces in the attraction of blowflies to sheep. The following two graphs (Figures 7 and 8) show the changes in humidity and temperature in the breech of ewes from the resistant and susceptible lines over 24 hours (midnight to midnight). There are clear differences between the ewes from these two groups, particularly for humidity. We are planning to pursue differences in individual sheep in the next phase to determine whether these traits may contribute and perhaps qualify as indicator traits for breech strike.

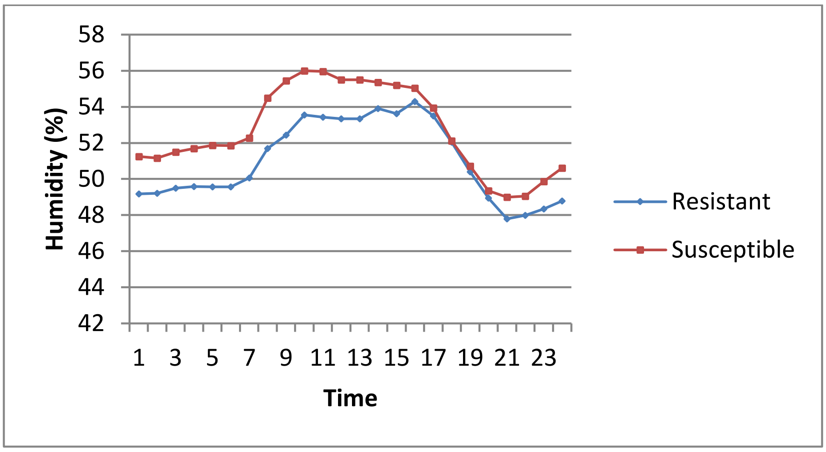


Figure 7. Changes in humidity in the breech over a 24 hour cycle in ewes from the resistant and susceptible lines.

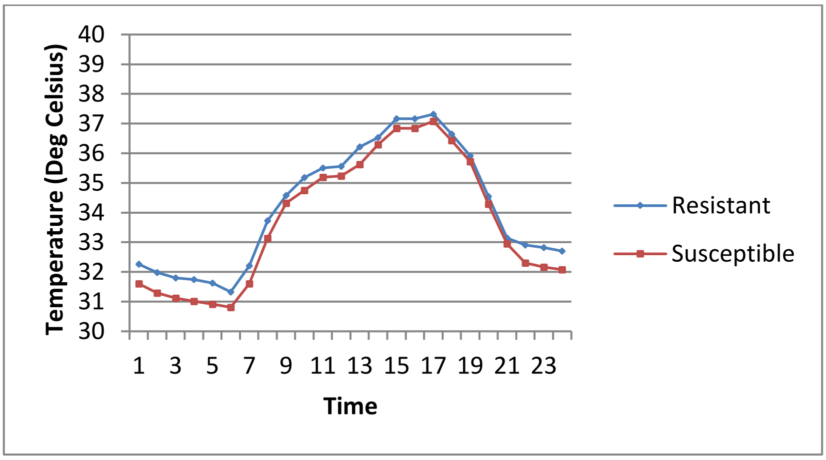


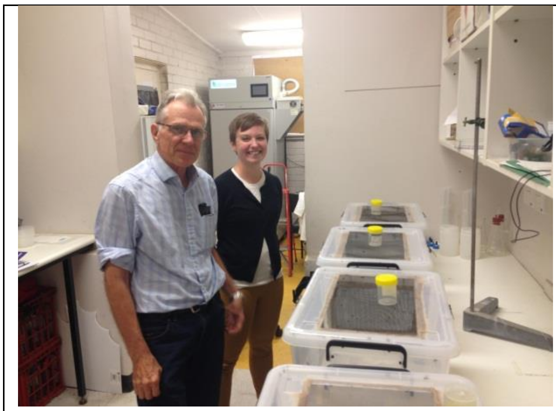
Figure 8. Changes in temperature in the breech over a 24 hour cycle in ewes from the resistant and susceptible lines.

Key messages for breeders

- Large differences in breech strike exist between breech strike susceptible and resistant sire progeny groups, irrespective of whether or not they have been crutched.
- Breech strike, in unmulesed and uncrutched and sheep, is a heritable trait similar to fibre diameter (~50%). It is lower in crutched sheep (~20%) but it still provides useful information to make selection and culling decisions.Therefore, struck sheep are likely to produce progeny that are also susceptible to breech strike and so should be culled.
- It is difficult to visually identify genetically resistant or susceptible rams unless the animals are struck.
- Progeny testing is currently the only method for accurately identifying genetically resistant sires.
- Dags in a winter rainfall region is the most important indicator trait for breech strike.
- In crutched yearling ewes, skin wrinkle is the most important indicator trait of breech strike.
- Wrinkle is a highly heritable trait and breeders can breed plain ewes by selecting high productivity rams that are free from wrinkles.
- It is not always possible to score breech wrinkle accurately in sheep with long wool. It should be done after crutching. Alternatively, neck wrinkle can be used as indicator trait. Wrinkle at birth or marking is also a good indicator of subsequent wrinkle score.
- Cull all sheep that are struck on the breech or tail. Breech strike is not well correlated to horn, body or pizzle strike.
- Time of crutching or shearing should take place just prior to the periods of high breech strike risk.
- Use the Sheep Genetics breeding values to select for low wrinkles, dags, breech cover and high production traits, in order to breed productive and more breech strike resistant sheep.
- Don't just cease mulesing…plan, plan and plan, and use the tools available to reduce lifetime breech strike.

All the helpers during the last four years

Many people helped to collect samples at different times to generate the data for this breech strike experiment. We would like to thank them for their invaluable contributions.

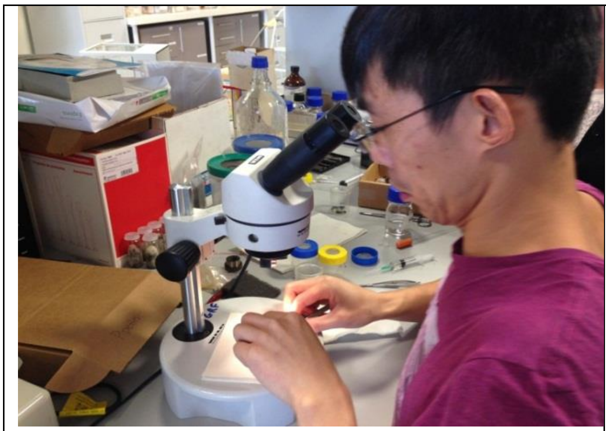


Dr Bekka Brodie (Ohio University, USA), and **Dr Tony Schlink** in the insectary at the University of Western Australia, who made significant findings into factors affecting the behaviour of blowflies.

Vince Lambert (Senior technician), **Brian Williams** and **Ryan O'Neil** (Technicians) collecting faecal samples.

French university students, **Margaux Weyer, Julian Bajard, Sebastian Abric and Camille Petit**, who were always willing to come and help at Mt Barker. These four students were on internships and worked for 6 months on the UWA Future Farm 2050 project at the University of Western Australia.

Chinese student, **Xiaodong Mu, with Assoc Prof Shimin Liu, Margaux Weyer** (France), **Dr Zhongquan Zhao and Dr Mengzhi Wang**. Zhongquan and Mengzhi were on sabbatical from their respective universities in China and made significant contributions into the immunological mechanisms of diarrhoea while in WA under the leadership of **Shimin Lui**.



Guanjie Yan, a PhD student at the University of Western Australia, preparing a fly for the EAG.

John Karlsson holding a young resistant ram. He played a major role throughout this experiment. He retired in 2015 but his leadership, dedication and commitment to the development of genetic technologies for the breeding of robust sheep has been outstanding. We wish him all the very best in his retirement.

ACKNOWEDGEMENTS

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