Will genetics offer a permanent solution to breech strike?

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Abstract. There are several options for managing flystrike other than mulesing. Breeding for plainer animals that do not require mulesing is an attractive, permanent long-term solution. Breech wrinkle is the key predisposing factor for breech and tail strike. Little effort has been made to reduce wrinkle score in sheep because mulesing was so successful and because there is a perception that reducing wrinkle score will reduce fleece weight. Fleece weight will be reduced if single-trait selection for wrinkle is applied, but if breech wrinkle is included in an index, the negative effect of wrinkle on other production traits can be minimised using the same method as that used to accommodate the negative correlation between fibre diameter and fleece weight. Breeding programs for reduced breech wrinkle should be used in combination with short-term tactical management strategies, especially during the initial stages of the breeding program. The need for tactical management will decrease as the program progresses. This approach can be applied using information that can be recorded easily and at low cost.

Introduction

Flystrike has been an issue for sheep producers for many decades. Prior to the introduction of mulesing, breech and tail strike accounted for 90% of all flystrikes (Table 1). Sheep of all ages were affected, but ewes were especially susceptible because of urine staining of the fleece at the breech (Belschner 1937, 1953; Joint Blowfly Committee 1940). Studies in the 1930s demonstrated that breech conformation has a large effect on susceptibility to flystrike. Sheep that were very wrinkly around the breech were 5–10 times more likely to be struck than those with a plain breech (Seddon 1931; Seddon et al. 1931; Joint Blowfly Committee 1933) and could be struck several times over the course of a year.

The mules operation (Joint Blowfly Committee 1943), named after its inventor Mr J. Mules, was introduced to reduce the susceptibility of sheep with wrinkly breeches to flystrike. Mulesing reduced the number of strikes in susceptible animals, although the recommendation from the Joint Blowfly Committee in 1940 was that ‘the mules operation must not be regarded as an alternative to the policy of breeding towards plain breeched sheep’. However, with developments in mulesing practice that gave added protection to plain breeched animals, mulesing was extended to virtually all Merinos and to many Merino crossbreeds as a flystrike protection technique (Johnstone and Graham 1941; Moule 1948). This reduced the need to select for plain breeches and this criterion was removed from most breeding objectives thereafter.

Mulesing has been successful in reducing the incidence of breech strike ever since it was introduced (Johnstone and Graham 1941). Although the technique is a radical surgical procedure, most producers considered the alternative of a potential lifetime of suffering much worse in the absence of a better alternative. More recently, there has been widespread concern about this procedure and aggressive campaigns have been launched that threaten the future of this preventative measure (Blackman 2005). An alternative solution needs to be found and implemented quickly.

The aim of this study was to provide industry with genetic strategies that could result in a permanent solution to breech strike within a relatively short time. There are other alternative strategies to consider (that could be implemented separately or combined with breeding), but the focus in this paper is minimising breech wrinkle through breeding. This provides a permanent solution to managing breech strike that is cost effective, as the measurements are cheap and will offset the high costs of husbandry and treatment. Herein, we review current knowledge on responses to selection strategies aimed at reducing breech strike.

Genetic parameters for breech wrinkle and associations with production


\begin{itemize}
  \item The average phenotypic standard deviation (or phenotypic variance) for wrinkle score was affected little by data source or scoring system (average = 0.88, variance = 0.75).
  \item Relatively few estimates of repeatability across ages have been published for wrinkle score, and they ranged from 0.48 to 0.62 (average = 0.55).
\end{itemize}
• Average heritabilities for wrinkle score at the neck, body and breech sites were all close to 0.3. The heritability of summed or averaged scores was a little higher (0.35–0.39).
• Phenotypic correlations in wrinkle score between sites were high (>0.6) and of similar or greater magnitude than the repeatability estimates.
• Genetic correlations in wrinkle score between sites were extremely high (>0.9). Thus, wrinkle score at each site can be regarded as the same trait genetically.
• Correlations between wrinkle score and major production traits, consolidated from the literature and combining information from various sites, are summarised in Table 2.

Realised responses to selection provided further information on genetic parameters. Lines selected for more wrinkle (Folds Plus) or less wrinkle (Folds Minus) were maintained at Trangie Agricultural Research Station between 1951 and 1971 (Crook and James 1991, 1994). The lines confirmed that breech wrinkling is highly correlated with body and neck wrinkle (McGuirk 1973). Although selection was based on a score across the three sites, responses at each site were similar. Fig. 1 shows the response in breech wrinkling during the first 10 years of the experiment (McGuirk 1973). Direct responses of two wrinkle score units in both directions were achieved after 10 years (Fig. 1). These responses were based on the 3–9 scoring system at Trangie (Dun and Eastoe 1970), which is equivalent to the new 1–5 scoring system (MLA and AWI 2007) but with half- or intermediate scores, which are both shown in Fig. 1. All further reference to wrinkling score in this paper is based on the 1–5 scale unless stated otherwise. Therefore, the Trangie experiment showed a change of about one wrinkle score unit in each direction over a period of 10 years.

The lines also demonstrated correlated responses with other traits (Table 3) as a result of single-trait selection. The largest antagonism was with greasy fleece weight (GFW): the GFW of the flock that was selected for reduced wrinkling score (Folds Minus) was 10% less than that of the control line while that of the flock that was selected for increased wrinkling score (Folds Plus) was 4% greater. Clean fleece weight (CFW) was lower in the Folds Minus flock (–8%) but was almost unchanged in the Folds Plus flock (–2%). Selection for reduced wrinkling score had little effect on fibre diameter (FD), bodyweight (BW) or reproduction (+0.4 μm, +1% and –2%, respectively). There was a 26% reduction in lambs weaned per ewe joined in the Folds Plus flock, which suggests that although reducing wrinkling score from a flock average of 3 will not affect reproduction, if the flock average is 5 (very wrinkly), reproduction may be improved by reducing wrinkling score. Given the asymmetry of responses in reproduction, we have assumed a zero correlation (based on the response in Folds Minus) and thus no correlated changes over time.

Table 2. Genetic and phenotypic correlations between wrinkle score and production traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Genetic correlation</th>
<th>Phenotypic correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greasy fleece weight</td>
<td>0.35</td>
<td>0.30</td>
</tr>
<tr>
<td>Clean fleece weight</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>Fibre diameter</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Coefficient of variation for fibre diameter</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>Bodyweight</td>
<td>–0.15</td>
<td>–0.05</td>
</tr>
<tr>
<td>Staple strength</td>
<td>0.05</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 3. Correlated responses with wrinkle score after 10 years of selection for increased (Folds Plus) and decreased (Folds Minus) wrinkle flocks that commenced in 1951 at Trangie

<table>
<thead>
<tr>
<th>Age</th>
<th>Trait</th>
<th>Selection lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Folds Plus</td>
</tr>
<tr>
<td>Hogget</td>
<td>Greasy fleece weight</td>
<td>+3.5%</td>
</tr>
<tr>
<td></td>
<td>Clean fleece weight</td>
<td>–2.1%</td>
</tr>
<tr>
<td></td>
<td>Fibre diameter</td>
<td>+0.1 μm</td>
</tr>
<tr>
<td></td>
<td>Bodyweight</td>
<td>–2.5%</td>
</tr>
<tr>
<td>Adult</td>
<td>Lambs weaned per ewe joined</td>
<td>–26%</td>
</tr>
</tbody>
</table>
Prediction of selection responses

Ram breeding flocks

Selection indexes and likely responses to selection were previously generated by the authors using OBJECT software (Atkins et al. 1994). A set of MERINOSELECT (national genetic information and evaluation service delivered by Sheep Genetics (2010) for the wool sector of the sheep industry) micron premium indexes were derived for Merino flocks that had the following objectives:

1. 3.5% micron premium: maintain FD at its current level and increase fleece weight when measuring FD, fleece weight and BW;
2. 7% micron premium: reduce FD and increase fleece weight simultaneously when measuring FD, fleece weight and BW;
3. 14% micron premium: reduce FD while at least maintaining fleece weight at its current level when measuring FD, fleece weight and BW.

To accommodate breech wrinkle selection, a Microsoft Excel tool was developed as an add-on to OBJECT (Atkins et al. 1994), which enabled wrinkle to be included as a trait in the breeding objective as an additional selection criterion. This enabled prediction of responses in wrinkle and the associated responses in production traits in the index. Genetic parameters for breech wrinkle were based on the parameters detailed previously. Responses in wrinkle score were translated into changes in the frequency distribution of the five scores within the flock in response to selection using standard properties of the normal distribution.

Commercial flocks

To model responses in commercial flocks, an elaborate Microsoft Excel tool developed for precision wool production (Atkins et al. 2006) was modified. This model incorporates variable age structures, specified production levels (reproduction, fleece weight, FD and BW) and variable selection practices ranging from single-trait selection to multi-trait indexes. Genetic parameters and gene flow methods are used to map production changes over a 20-year time horizon from purchase of a sire and subsequent selection of replacement ewes. Breech wrinkle was added as a trait for predicting responses and was included as a potential selection trait. The phenotypic and genetic parameters used for wrinkle score were as defined above, and parameter estimates used for the other breeding objective traits (e.g. CFW and FD) were as reported by Atkins (1997). Responses in wrinkle score were also translated into frequency distributions of scores as previously described.

Outcomes

Responses in ram breeding flocks

If a ram breeder places all selection emphasis on reducing breech wrinkle, the maximum response achievable is ~1.1 units of wrinkle score in 10 years. Given a more realistic scenario of 70% selection on reducing breech wrinkle and 30% on visual and conformational traits, the expected change with a within-flock selection program is ~0.8 wrinkle score units over 10 years. This will affect the distribution of scores within a flock by increasing the proportion of plainer sheep (scores 1 and 2) and reducing the proportion of wrinkly sheep (scores 4 and 5).

Fig. 2 shows the change in the distribution of scores that would occur over 10 years for a flock with an initial average wrinkle score of 3 in which wrinkle score is reduced by 0.8 units (final average wrinkle score = 2.2). The number of animals with scores of 4 or 5 is reduced by 22% and the number of animals with a score of 1 is increased by 17%.

This distribution of scores is important because the high breech wrinkle score animals are highly susceptible to strike. By removing them from the flock, a much lower incidence of flystrike may occur than is suggested by the smaller change in mean wrinkle score for the flock.

If a breeder decides to put all the emphasis on reducing breech wrinkle and ignores the effect of this on other traits, an economic loss would be incurred due to the antagonism between fleece weight and breech wrinkle shown in Tables 2 and 3. By reducing the emphasis on breech wrinkle and using an index to simultaneously select for other traits, this potential loss in production and income could be greatly reduced, although the cost of treatment and prevention of flystrike may be higher in the short to medium term.

Using an index designed to reduce FD and increase fleece weight (Merino 7%), if wrinkle score was reduced by 0.8 over 10 years, the opportunity cost to other traits would be 70% (Fig. 3). That is, of the total genetic gain possible in production traits, 70% would be forfeited in reducing wrinkle.

Fig. 2. Frequency distribution of wrinkle score within a flock when reducing wrinkle score by 0.8 over 10 years when starting with an average wrinkle score of 3. Distribution at (a) the start of the period and (b) the end of the period.
With an index designed to reduce FD and maintain fleece weight (Merino 14%), ~60% of the total genetic gain possible in production traits would be forfeited, and with an index designed to increase fleece weight and maintain diameter (Merino 3.5%) nearly 80% of the total genetic gain possible in production traits would be lost. The main reason for the loss is the antagonism between fleece weight and breech wrinkle and that the lower micron premium indexes put more emphasis on fleece weight than FD.

It is therefore unrealistic to focus on reducing wrinkle score exclusively, as little selection emphasis can be given to other traits in the selection objective. If the aim is to reduce wrinkle score by only 0.5 units in 10 years, these opportunity costs are only 20, 25 and 30% for the Merino 14, 7 and 3.5% indexes, respectively.

Fig. 4 shows expected changes in wool production for the three indexes with and without the inclusion of breech wrinkle. As expected, there are small differences in FD and large differences in fleece weight, and the largest change is for the low micron premium index.

Responses in commercial flocks

The simplest genetic strategy for a commercial producer is to rely on genetic gains made by a stud breeder. Fig. 5 shows the effect of purchasing average rams from a stud that is reducing wrinkle score by 0.5 units over 10 years. If average rams are used, a 30% increase in the proportion of animals with wrinkle scores of 1 or 2 would be achieved in 20 years. The same result could be achieved in 12 years by actively selecting rams from the stud, or 6–7 years by combining the former strategy with ewe selection. Active selection of rams could be achieved by choosing rams with low breech wrinkle scores or breech wrinkle breeding values.

A 15–20% reduction in the number of animals with high wrinkle scores (scores 4 and 5) could be achieved over 20 years by selecting average stud rams. This could be achieved in less than 15 years by actively selecting rams and in 5 years when the former strategy is combined with ewe selection.

Opportunities for progression

Several replacement strategies for mulesing are under investigation. Pain relief improves animal welfare but does not resolve the surgical nature of mulesing. Management techniques
such as strategic shearing and crutching, preventative jetting, control of gastrointestinal parasites and nutritional management to minimise scouring and fly trapping can reduce the incidence of flystrike, but the increased labour for these practices with unmulesed sheep makes reliance only on these methods an unattractive long-term option. Moreover, an increase in the use of chemicals may cause a residue risk.

There are reservations about including reducing breech wrinkle in breeding programs among sections of the wool producing industry because of the long time frame required for progress and the expectation that it would not be as effective as mulesing. It is also believed that selecting to reduce breech wrinkle will reduce production. However, if a selection strategy to reduce breech wrinkle were adopted, the need for alternative management strategies would be reduced in the future. The results presented in this paper show that a reasonable change in the distribution towards low wrinkle score animals can be achieved in the medium term through breeding, which meets the objective of reducing flystrike. The negative correlation between wrinkle score and GFW (0.35 and 0.30 for genetic and phenotypic correlations, respectively), presents little more of a challenge than that between FD and GFW (0.27 and 0.24 for genetic and phenotypic correlations, respectively) (Safari et al. 2007). Results from QPLUS (Merino breeding project established to demonstrate the use of Australian Sheep Breeding Values and indexes to achieve various breeding objectives at Trangie) show that it is possible to achieve significant, rapid improvements in traits that are unfavourably correlated (Mortimer et al. 2006). Selection for breech wrinkle alone will compromise wool production, but if included in a carefully designed breeding program breech wrinkle can be reduced with little loss in the potential gains of production traits.

Faster responses for ram breeders

Ram breeders have several opportunities to improve the response in wrinkle score and reduce the effect of wrinkle score reduction on other traits. As well as selecting for reduced breech wrinkle, ram breeders can also record neck and body wrinkle. These traits are highly correlated with breech wrinkle (>0.9, Jackson and James 1970; Lever et al. 1995) and therefore will improve accuracy of selection if used together.

Compared with selection based on the phenotypic degree of wrinkle, selection based on wrinkle score breeding value will increase the rate of change. Breeding values can account for environmental effects that distort relative wrinkle scores between sheep, such as feed effects and rearing types. Breeding values will also improve the accuracy of selection as they include information on the performance of relatives when making predictions.

Sourcing low wrinkle score rams from ram breeding flocks that have high performance levels for other associated traits may also increase the rate of progress. This is possible because Sheep Genetics (2010) now reports across-flock breeding values for wrinkle score and production traits.

Faster responses for commercial breeders

Options for commercial breeders include purchasing rams with lower wrinkle scores or lower wrinkle breeding values. If breech wrinkle scores or breeding values are not provided by the ram breeder, ram buyers can quickly and easily assess neck wrinkle score to identify low breech wrinkle rams. This is particularly useful when sale rams have long wool, which makes evaluation of breech wrinkle very difficult.

Selection of replacement ewes according to wrinkle score and mating of plain ewes with the plainest Merino rams will significantly accelerate the rate of progress towards less wrinkly sheep. Ewes with a higher wrinkle score may be used to breed sale sheep, for example if they are joined to a terminal sire and all the progeny are sold. In this instance, the progeny would not be retained for breeding in a self-replacing flock, and thus heavily wrinkled animals would not pass on their genes to purebred Merino progeny.

The ability of commercial producers to influence the speed of genetic progress is evident from Fig. 5. If a producer chooses average rams from a stud and relies on the progress being made in the stud to provide progress in his flock, the process may take a long time. By actively selecting rams for reduced wrinkle score, the speed of this process can be increased considerably. The fastest rate of improvement is obtained when actively selecting rams is combined with ewe selection for reduced wrinkle score.

Combining breeding and management to manage flystrike

It may be advantageous to reduce mulesing by implementing management strategies targeted at sheep most at risk of being flystruck. For these sheep, a producer may choose to use breech clips (Woodhouse et al. 2010), schedule a second crutching or carry out preventative chemical treatment.

In the early stages of the breeding program, integration of breeding with targeted management is likely to be the best approach. During the phase-out period, some animals will require no intervention, some will require moderate intervention, such as a mulesing replacement or a more intense management protocol, some will require severe intervention, equivalent to mulesing, and some should not be retained in the flock.

Similarly, some animals should be kept in the breeding program to produce replacement progeny, some should be used only to produce sale progeny and the most wrinkly should not be retained in the flock. These decisions require visual assessment of the breech (or the neck or body if adult ewes have been mulesed) and a system for identifying individual sheep. With time, discrimination into management groups may include breech and neck wrinkle, dags or bare area, depending on the contribution of these traits to breech flystrike susceptibility. But in the first instance a simple classification based on breech wrinkle is likely to be highly effective. The objective of the breeding program would be to reduce the proportion of the flock that requires other flystrike management intervention.

Conclusion

Immediate and effective measures are required to reduce the incidence of flystrike while reducing reliance on mulesing. There are a range of options available to prevent and treat flystrike, but the best long-term solution is to breed animals that have natural resistance to flystrike; that is plain breeches, as breech strike is the most common form of strike in unmulesed sheep. This genetic approach provides a permanent solution, which will reduce
labour and management costs as well as the risk of contamination of wool from additional chemical application for prevention and control of fly strike. Alternative management strategies are necessary, especially during the initial stages of a breeding strategy, but they should target at-risk animals rather than the whole flock. As a breeding program progresses, the need for management approaches to fly strike will decrease. It is important to select a strategy that will achieve the breeding objective, and also achieve the goals in a timely manner. If a suitable breeding strategy is selected, there will be minimal production loss in other traits, and the proportion of animals requiring alternative flystrike management will decrease.

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