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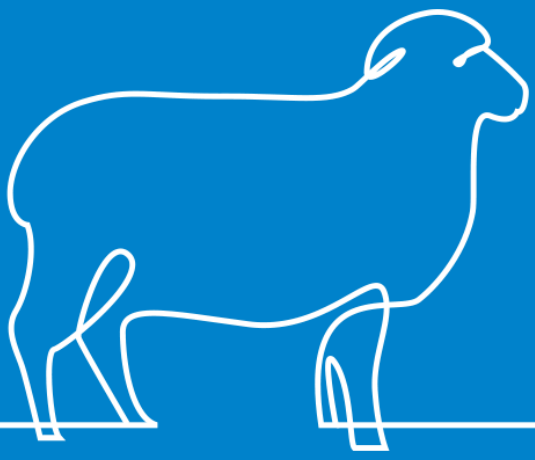

RESEARCH REPORT:

Prevention and control of flystrike in sheep

First published January 2019
Updated March 2024

The RSPCA is Australia's leading animal welfare organisation and one of Australia's most trusted charities.

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CONTENTS

The RSPCA is Australia's leading animal welfare organisation and one of Australia's most trusted charities.

Research report: prevention and control of flystrike in sheep

Flystrike in sheep occurs when the eggs of flies hatch in moist wool and the maggots feed on the flesh of the live animal. The maggots create painful wounds which, if undetected, can debilitate the animal to the extent that it eventually dies of blood poisoning.

THE RSPCA VIEW

The RSPCA promotes an integrated approach to the prevention and control of flystrike in sheep. Breeding sheep that are resistant to flystrike combined with enhanced on-farm sheep management practices is a viable, practical, and better-welfare alternative to mulesing.

The RSPCA believes that it is unacceptable to continue to breed sheep that are susceptible to flystrike and because of this susceptibility require mulesing (or other breech modification procedure) to manage flystrike risk.

The RSPCA position on mulesing is that:

- It must only be done as an interim measure where a flystrike-resistant sheep breeding and selection program is in place
- It must only be done if other humane procedures cannot protect sheep from flystrike
- It must only be done in a location where it is known it will reduce the incidence of flystrike
- It must only be done by a competent and accredited person
- It must only be done on a well-restrained lamb that is less than 8 weeks of age
- It must only be done using appropriate pain relief; that is, a combination of an anaesthetic and a non-steroidal anti-inflammatory drug
- It must only be done on lambs that will be raised to adulthood, not for animals sold at a young age for meat.

The RSPCA urges the wool industry to continue to invest research, development, and extension effort into a comprehensive flystrike-resistant sheep-breeding program. On-farm extension to facilitate the rapid adoption of breeding solutions must be a priority for the wool industry.

The RSPCA urges retailers sourcing Australian wool to indicate to suppliers their intention to purchase only non-mulesed wool within the shortest possible time frame, noting that such wool should be sourced from flystrike-resistant sheep.

The wool industry's research, development and extension program must be underpinned by achievable milestones and provide regular updates to the general public as a means of demonstrating the wool industry's genuine commitment to phasing out mulesing in the shortest possible term.

March 2024

INTRODUCTION

Increased scrutiny of painful farm animal husbandry practices such as mulesing, has led to public and retailer demand for 'non-mulesed' wool. For over a decade, the wool industry's research and development and marketing body has invested in an extensive program that aims to provide wool growers with alternatives to mulesing for preventing and controlling flystrike in the breech area (the area of the hindquarters consisting of the hindlegs near the tail), including breeding options. Despite these ongoing efforts, a high proportion of woolgrowers (around half of surveyed Merino producers) continue to mules their sheep (Colvin 2022).

The RSPCA advocates for the selection and breeding of sheep that are resistant to flystrike and do not require mulesing or other breech modification procedures to achieve this.

The RSPCA supports an integrated approach to the prevention and control of blowfly strike and this research report examines measures to prevent flystrike without mulesing. This research report is not limited to Merino sheep for wool production - some non-Merino and first cross prime lamb mothers are also routinely mulesed (Colvin et al 2021).

FLYSTRIKE

The most prevalent cause of flystrike in Australia is the sheep blowfly, *Lucilia cuprina*. It initiates more than 90% of all strikes on sheep (NSW DPI 2007). Female blowflies lay eggs in the fleece of the sheep, and the resulting maggots cause mechanical damage by feeding on the flesh of the sheep, and chemical damage due to the ammonia they excrete. The sheep blowfly thrives in warm and humid environments. The female blowfly is particularly attracted to sheep with wool stained and wet from urine and faeces. However, it is not the wet wool but the subsequent skin irritation it causes that attracts the fly and creates the ideal environment for her to lay her eggs (QDPI&F 2005b). Sheep that are affected by skin infections such as fleece rot or dermatophilosis (lumpy wool or dermo) are also susceptible to flystrike (Norris et al 2008).

Flystrike (also known as blowfly strike) causes considerable pain and suffering. Flystruck sheep have increased rectal temperature, rapid breathing, and suffer weight loss caused by loss of appetite (Broadmeadow et al 1984). They may also show increased restless behaviour, abnormal postures, an exhausted/irritated demeanour, and behaviour directed at the struck area, such as biting or attempting to bite at the rump (Grant et al 2019). Affected animals may eventually succumb to blood poisoning and die if they are left untreated. Flystrike is a seasonal issue, and individual sheep can experience recurring bouts of flystrike every year. Prime (meat breed) lambs, because of their less wrinkly skin and the fact that they are slaughtered at an early age, have a significantly reduced risk of becoming flystruck.

Flystrike is widespread among the Australian sheep flock. This is due to a combination of factors, including the Merino sheep breed's general susceptibility to flystrike, the presence of *Lucilia cuprina*, the extensive nature of Australian sheep production (and the subsequent reduction in frequency of monitoring), and Australia's climate (Phillips 2009). The introduction of the Vermont Merino – a sheep type with extremely wrinkly skin - in the late 1800s, resulted in significant outbreaks of flystrike (Karlsson et al 2012) and as far back as the 1930s (Seddon 1931) it has been known that heavily-wrinkled sheep, particularly those with a soiled breech area, are most susceptible and over 90% of strikes generally occur in the tail and breech area (AWI 2007). However, flystrike may also occur on the body of the sheep (a major problem in warm, humid conditions), the poll, the pizzle, and on wounds. The type of strike (body vs. breech) can vary greatly depending on the environmental conditions. In addition, individual sheep vary in their ability to resist external parasites due to variation in the immune response.

Flystrike has been estimated to cost the wool industry $324 million a year in flystrike treatment/prevention costs and loss of production, which includes sheep deaths, weight loss, and loss of wool growth/value, although yearly costs will vary depending on the weather (Shepherd et al 2022). Mortalities have been

estimated to occur in around 10% of flystruck adult sheep and 20% of flystruck yearling sheep (Shepherd et al. 2022).

MULESING

In 1929, John Mules developed a surgical technique for reducing the amount of wrinkle in the breech area of sheep in order to lower the risk of flystrike (Beveridge 1984). This operation became known as 'mulesing', also referred to as 'live lamb cutting'. Mulesing is effective in reducing the risk of flystrike – one study estimated that unmulesed Merino sheep had a six-fold increased risk of flystrike compared with mulesed sheep under the same conditions, where no preventative treatments were given (Horton et al. 2021). Because the procedure is effective in reducing the risk of flystrike, this reduces the motivation for farmers to breed sheep that are resistant to flystrike, and the procedure continues to be practiced to this day.

Mulesing involves the removal of crescent-shaped pieces of skin, from the base of the tail down either side of the perineal area, using sharp shears designed specifically for this procedure. In addition, a strip of skin is removed from each side of the tail. The resulting wound, when healed, increases the bare area (as wool does not grow on the scar tissue), while at the same time reducing the amount of skin wrinkle in the area.

The purpose of the mules operation is to reduce the susceptibility of sheep to flystrike by making the breech area less attractive to flies. With less wrinkle and more bare skin, faeces and urine don't accumulate as easily, thereby significantly reducing the risk of flystrike. The mules operation also results in a number of secondary benefits, for example, reduced wool stain and dags (accumulations of faeces in the wool), increased ease of shearing and crutching, lower chemical residues in the wool, and a reduction in labour costs associated with inspection and treatment of animals (James 2006).

Mulesing is usually carried out during lamb 'marking' when the animal is between 6 to 10 weeks of age. Lamb marking often also includes a series of other painful procedures that are all carried out at the same time: tail docking, castration (for males), ear notching or ear tagging, and vaccinating (Windsor 2013). Based on available data from the ABS (ABS 2020) and 2022 National Wool Declaration data, it is likely that more than 10 million lambs are mulesed every year.

Mulesing is performed without prior anaesthesia or numbing of the area, and though pain relief is often given after the surgery, it does not eliminate the pain of the procedure (see 'Pain relief' section below). The operation is quick; however, the associated pain is long lasting – at least up to 48 hours (Lee et al 2007), but potentially from several days to several weeks (Small et al 2018b). The resulting wound takes 5-7 weeks to completely heal (Lepherd et al 2011b). Mulesed lambs have been observed to socialise less (Fell et al 1989), and exhibit behavioural indicators of pain including less time lying and feeding (Fell et al 1989) and standing in a hunched position (Paull et al 2007; Hemsworth et al 2012, Inglis et al 2019). Lambs lose weight in the week following mulesing and have reduced weight gain compared to non-mulesed lambs for several weeks following the procedure (Edwards 2012, Inglis et al 2019, Chapman et al 1994). The effect on gait and growth may be apparent for up to three weeks following the procedure (Hemsworth et al 2009). Following mulesing, lambs may avoid humans and, in particular, the person who carried out the procedure, for a period of 3 to 5 weeks (Chapman et al 1994, Edwards 2012). This avoidance behaviour is indicative of fear and the extent to which the animal experiences the procedure as aversive. Mulesing lambs between 2 to 8 weeks of age minimises the size of the wound compared with mulesing older animals.

In addition to the reduced growth and behavioural responses to mulesing, a significant physiological stress response is also evident. This is illustrated by high blood cortisol levels and elevated neutrophil:lymphocyte ratio (both indicators of physiological and/or psychological stress) up to 48 hours post mulesing (Chapman et al 1994, Edwards 2012). Similarly, haptoglobin (also found in blood and used as an indicator of tissue damage and inflammation) is significantly elevated for up to a week post mulesing (Edwards 2012).

Both mulesing and flystrike have substantial negative impacts sheep welfare. Mulesing is a quick and effective method of reducing the risk of flystrike in Merino sheep, hence its popularity with producers. However, mulesing results in poor welfare both during and after the procedure and the following section of this report discusses alternatives to mulesing.

AN INTEGRATED APPROACH TO FLYSTRIKE PREVENTION AND CONTROL

The key to effectively managing flystrike in the absence of mulesing is to make the sheep less attractive to blowflies through an integrated approach to blowfly control (AWI 2018; QDPI&F 2005a). Such an approach includes management strategies such as:

- monitoring blowfly activity
- strategic application of chemical treatments (if required)
- animal husbandry and farm management practices that take into account the timing of shearing and crutching
- effective control of scouring (especially through the control of dags and worms)
- improved body condition and general health to increase robustness
- shorter joining (3-6 weeks) for more flexible management
- regular inspection of the flock for flystrike.

These options for preventing and controlling flystrike in the absence of mulesing should be accompanied by a breeding and selection program that aims to reduce wrinkle, dag, and urine stain and increase the bare area in the perineal region, combined with removing susceptible sheep from the flock.

Together these proactive strategies will have a cumulative effect on the flock's overall resistance to flystrike. A dedicated decision support tool called FlyBoss is available to producers to assist in the decision-making processes that lead to effective flystrike control.

It is unacceptable to continue to breed sheep that are susceptible to flystrike, and because of this susceptibility require mulesing (or other breech modification procedure) to manage flystrike risk.

Breeding and selection

As early as 1931, researchers concluded that breeding could reduce flystrike incidence (Seddon et al 1931) but with the emergence of mulesing and, later, mulesing in combination with shearing, crutching, and chemical treatments, breeding received little attention. Many of the fine-wool Merinos in particular, still have a highly wrinkled body type (Windsor et al 2013).

The breeding of flystrike-resistant sheep is a long-term process whereby animals with a naturally bare and low-wrinkle breech area are selected from or introduced into the flock in order to produce progeny with no or low wrinkle in the breech area and a large bare perineal area.

In addition to low wrinkle and bare breech traits, selection pressure focuses on reducing the flock's overall disposition to flystrike by removing animals that have fleece rot (as susceptibility to this infection is heritable (Colditz et al 2021)), are repeatedly flystruck, or are repeatedly affected by worms and scours (AWI 2007). Selection pressure will also depend on the environment in which sheep are raised. If dags and scours are a regular occurrence, then selection against dags will reduce the risk of breech strike (Tyrell et al 2014). Accumulation of dags is a significant contributor to breech strike regardless of whether sheep are in summer or winter rainfall regions (Karlsson et al 2012). Keeping a record of sheep that have been affected by flystrike

will identify those that are repeatedly struck – one quarter of strikes are found on previously affected animals (AWI 2008a).

Key indicator traits for breech strike are dags, urine stain, skin wrinkle, wool coverage in the breech area, and wool colour (Edwards et al 2009; Scholtz et al 2010; Karlsson et al 2012; Greeff et al 2019, Greeff et al. 2021). Breech strike itself is moderately heritable (Dominik et al 2017) but these key indicator traits can be used to indirectly identify flystrike-resistant animals, including through the use of visual score guides (available for dags, breech wrinkle, body wrinkle, urine stain, and fleece rot) and Australian Sheep Breeding Values (available through MerinoSelect since 2009). Although single-trait selection for flystrike resistance traits has been linked to a reduction in fleece weight, production losses are avoidable if other traits are selected for at the same time using index selection (Kotze and James 2022, Brien et al 2021). Some research has also found that selection for a barer breech had little if any detrimental impact on key wool production and wool quality traits (Hatcher et al 2017). Since 2017, the sire lists in the MerinoSelect database include key breech traits (wrinkle, breech cover, and dag) allowing wool growers to understand the association between one or more of these traits and how these affect production and wool quality traits. For example, where sheep with lower wrinkle have lower fleece weights, woolgrowers can improve fleece weight by using the Australian Sheep Breeding Values to select rams with the best fleece weights for low wrinkle. It would benefit the industry greatly if more animals with desirable (low) scores in the key breech traits were included in the database.

In a Mediterranean environment (i.e. winter rainfall), flystrike tends to occur between mid-October and end-December, and the presence of dags in sheep is strongly correlated with early breech strike in these environments. Breeding for low dag score could be used to breed for breech strike resistance, with urine stain, neck wrinkle, breech and face cover being additional indicator traits in a Mediterranean environment (Greeff et al 2013). In another environment (New England, NSW), selecting for breech cover or wrinkle at 10-13 months of age, would, over time, reduce either wool cover or wrinkle on the breech thereby reducing the incidence of flystrike (Hatcher et al 2015). Research trials have shown that, in a certain climatic environment and using certain bloodlines, the bare-breech trait is moderately to highly heritable and does not significantly affect other wool traits such as fibre diameter, staple length and strength, and greasy fleece weight. For example, a study in 2017 (Hatcher et al 2017) found that selection for low breech cover, and low breech, body and neck wrinkle, had little if any detrimental impact on key wool production and wool quality traits in Merinos in the New England environment. In general, there is greater variation in wrinkle and lower wrinkle score in sheep with medium fibre diameters than in sheep with finer fibre diameter which tend to have higher wrinkle. Where there is greater variation in wrinkle, there is greater potential for genetic progress towards lower wrinkle (pers. comm. Geoff Lindon 2018).

In the future, gathering of phenotype data relating to breech strike, breech cover, wrinkle score, and dag score could allow for the development of genomic breeding values or identification of genetic markers and, with these, provide an avenue for genomic testing to identify animals that are resistant to breech strike (Dominik 2018).

Breeding and selection - SRS® Merino

Most Merino sheep in Australia are wrinkled. However, a plain-bodied (low wrinkle) Merino sheep exists and is called the SRS® Merino (SRS stands for soft rolling skin). This Merino type has been bred in Australia since the late 1980s and comprises about 7% of the Australian Merino sheep flock. Rather than relying on wrinkle (i.e. large skin surface area) to obtain high fleece weights, the SRS® Merino has a loose and supple skin that is closely associated with high fibre density and length (i.e., more wool per area of skin) and wool of high quality (Watts et al 2017). The high fibre density is achieved through the presence of secondary fibre follicles in the skin. The loose, supple, non-wrinkly skin of the SRS® Merino dries rapidly, ensuring these sheep are resistant to fleece rot and flystrike, and do not require mulesing.

Introducing plain-bodied sires into a wrinkly flock that requires mulesing can dramatically change the requirement for mulesing within five years. In the SRS® Merino, the traits associated with wool production (fleece weight and fibre diameter) and wool quality (softness, lustre, bundle size, skin) are moderately to highly heritable and correlated with high fleece weight and low fibre diameter (Brown et al 2002 in Greeff 2009; Watts et al 2017). The visual classing system based on fibre density and length also sees an increase in numbers of secondary follicles (Watts et al 2017). Follicle density, in turn, is highly negatively correlated with fibre diameter (Moore et al 1989; Moore et al 1998). Wool from SRS® Merinos has been found to be softer than non-SRS Merino wool of the same fibre diameter (Yu et al 2022). Selecting traits qualitatively, based on skin type (e.g. SRS® Merino), rather than quantitatively, using an index-based selection method (e.g. fibre diameter or fleece weight), is unconventional but has documented merit (e.g. Daily et al 1997; Kopke et al 1998; Charry et al 1999), although others have suggested this is not the case (e.g. Mills et al 1998).

Some SRS® Merinos have naturally short tails and this presents an opportunity to select for short tails, thereby also removing the need for tail docking these sheep.

Breeding - getting started

Breeding for flystrike resistance is the permanent solution to reducing flystrike risk, and some woolgrowers have already bred sheep that do not require mulesing. The sooner woolgrowers introduce a breeding program, the sooner improvements will be seen and the sooner the costs and animal welfare impacts of managing and treating flystrike will be reduced. The wool industry's dedicated decision support tool - FlyBoss - suggests four key steps to get the processing going:

1. Use Australian Sheep Breeding Values or visual scores to select rams with low wrinkle, breech cover and dags
2. Select ewes for breeding with low fleece rot susceptibility, wrinkle scores, breech cover, and dag scores; when culling ewes, choose to cull those with high flystrike susceptibility
3. Develop a joining strategy that reduces the proportion of at-risk ewes that are susceptible to fleece rot and have high wrinkle, dag and breech cover
4. Assess lambs based on their flystrike risk to determine which lambs can be left unmulesed

The greater the selection pressure – i.e., selecting for flystrike resistance traits in both ram and ewe – the more quickly the desired results will be achieved. Performing strategic management procedures such as shearing, crutching and chemical application) to reduce flystrike risk is important, especially in the early stages of a flystrike resistance breeding program.

Monitoring blowfly activity and reducing blowfly populations

Blowfly activity can be monitored at those times of the year when conditions are likely to be warm and humid as this is when the blowfly is most active. Blowfly numbers increase as temperatures go up (Phillips 2009).

Blowfly populations can be monitored and reduced in some situations using fly traps at these strategic times in the year. A trap specifically developed to lure the sheep blowfly has been shown to reduce the incidence of flystrike by 46% (Ward 2001). Flies entering the trap die from lack of water and food, as they cannot escape. The lure lasts for up to 3 months and the trap is most successful in areas where sheep tend to congregate, for example, near water (Tellam et al 1997). Guidelines for using a lure will be specific to the region in which it is being used. The lure is most effective when exposed to the sun, sheltered from the wind, and attached to posts rather than trees. Effectiveness is enhanced when adjacent farmers all use traps at the same time. Trapping can also be used strategically to identify increases in fly numbers, which can assist in decision making around timing of chemical treatments and closer monitoring of sheep for flystrike (Kotze and James 2022).

Paddocks that are wet, heavily shaded and sheltered provide ideal conditions for blowflies. Weaners, heavily wrinkled sheep, and previously struck sheep are at high risk of becoming flystruck if moved to such high-risk paddocks (AWI 2007).

When used as part of an integrated approach to controlling flystrike – for example when used in combination with strategic shearing and crutching – flytraps have the potential to reduce or eliminate the need for chemical fly treatments.

Preventative chemical fly treatments

Chemical treatments are part of an integrated approach to control flystrike – they are not a stand-alone option. Blowflies are exposed to the chemical treatment as they land on the wool and, depending on the active ingredient, the chemical works by interfering with the larval stage of the blowfly's lifecycle, by affecting the blowfly's nervous system, or by reducing motor activity and causing paralysis of the blowfly (DAFWA n.d.).

Chemical treatments are commonly applied when flystrike is expected, or to provide protection during the period of the year when the risk of flystrike is high (Horton 2015). If chemical fly treatment is necessary, it has been found to be more effective if applied to the breech six weeks after shearing or crutching rather than immediately after shearing or crutching (James et al 2009). It is recommended to avoid the use of chemicals within three months of shearing unless treatment and/or prevention is necessary, in which case compliance with wool and meat withholding periods is required. To reduce the number of flystrike incidents as well as the cost of chemical treatments, the timing of shearing and crutching and the application of the treatment should be carefully managed (Lucas et al 2013). Any chemical applied prior to shearing is removed along with the wool (Horton 2015).

An additional beneficial effect of chemical fly treatments is that, by reducing the capacity of flies to lay eggs, fewer maggots develop into pupae. This reduces the pupae population in the soil, with fewer flies emerging the following spring. It has also been suggested that applying chemical treatment before flies emerge in early spring in regions with moderate to high flystrike risk, will kill emerging flies before they are able to produce offspring (Horton 2015).

An additional consideration when using chemical treatments, particularly where there is heavy reliance on them, is the development of resistance in the fly larvae, which has been documented for some commonly used flystrike prevention chemicals (Sales et al 2020). The small number of chemicals available further highlights the importance of limited and strategic use of chemicals to protect sheep against flystrike.

Crutching and shearing

Compared with short wool, long wool can form more dags and retains more moisture if the skin gets wet (Phillips 2009). Crutching is the trimming of wool from between the back legs and around the tail of sheep. It may also include trimming wool on the head (particularly rams) and the bellies of male sheep. Shearing, on the other hand, is the trimming of wool over the whole body of the sheep. The timing of crutching and shearing is key in reducing the risk of flystrike. Because the sheep blowfly thrives in warm, moist conditions, the periods of greatest risk of flystrike occur when rainfall is followed by warm weather or vice versa.

With shearing or crutching, maximum impact is obtained if it is done just prior to or at the start of the period of expected maximum blowfly activity. Although it should be acknowledged that timing of shearing is also affected by availability of shearers. Flystrike risk is reduced following shearing and reaches maximum risk around 4 months after shearing (Horton 2015).

Twice-yearly crutching is another strategy woolgrowers use to reduce the flystrike risk. For example, an autumn and spring crutch for those shearing in summer, and a late-spring and autumn crutch for those

shearing prior to lambing in spring (8x5 Wool Profit Program 2008). Alternatively, a smaller 'bung-hole' crutch could be as effective as a second crutch (AWI 2008d).

Tail docking

Wool-bearing skin on and near the tail can be subject to flystrike, particularly as the wool grows longer and becomes stained with urine and faeces (James 2006). The length of the tail also affects susceptibility to flystrike. Studies carried out in the 1930s and 1940s reported that long to medium-long tails, i.e. just below the lower border of the natural bare area and just below the tip of the vulva respectively, gave the best protection against flystrike in unmulesed Merinos under the studied conditions (Lloyd 2012). In these studies, very short tails took longer to heal and were more likely to become infected. The theory is that moderately short tails reduce the risk of faeces building up in the breech area, and thus reduce the risk of flystrike.

However, there is sparse and conflicting evidence that tail docking does in fact reliably reduce the risk of flystrike or dag formation (Orihuela and Ungerfeld 2019, Sutherland and Tucker 2011). For example, one study found no difference in dag scores for docked versus undocked sheep (Soriano et al 2020), but other studies found increased dag scores in undocked sheep, and an increased risk of flystrike for undocked sheep compared with docked sheep, at least under some conditions (French et al 1994, Webb-Ware et al 2000). Nevertheless, undocked sheep are reported to be at lower risk of flystrike than short-docked sheep (reviewed in Lloyd 2012). The lack of clear evidence linking tail docking to a reduced risk of flystrike is concerning given how common this painful procedure is in the sheep industry.

Muscles controlling movement of the sheep's tail and skin underneath the base of tail are designed to push faeces out and over the wool in the breech area thus avoiding contact with the wool. If a tail is docked too short, this will result in the loss of that skin, the loss of muscle, and the loss of the ability to direct faeces outwards thereby increasing the risk of a soiled breech area (dags) which is attractive to flies. Sheep with very short or butted tails are more susceptible to breech strike for this reason (Watts et al 1979; Lloyd 2012). Very short tails (as well as shearing and mulesing) also increase the risk of bacterial arthritis in lambs, which is caused by bacterial infection at the site of the wound (Lloyd et al 2016). In addition, very short tails also predispose sheep to cancer, prolapse, and poorer wound healing (Woodruff et al 2020).

By avoiding very short tails (the tail of female lambs no shorter than the lower tip of the vulva (Watts et al 1979) and an equivalent length in males), these areas will be protected from sunburn and cancer (James 2006). Effectively, this means docking no shorter than at the third palpable joint. However, despite the well documented risks of docking tails very short, there is evidence that this practice continues for a large proportion of sheep. One study found that 86 per cent of ewes assessed on 32 Victorian farms had tails docked shorter than the industry recommended length of three palpable joints (Munoz et al 2019). This means that many sheep that have their tails docked in Australia could in fact be at higher risk of flystrike (and arthritis, cancer and prolapse) compared with undocked sheep. Reasons identified that Victorian farmers docked tails too short included a lack of awareness of the recommended docking length, and docking at a length that shearers approved of (Woodruff et al 2020).

Tail docking is painful, with evidence indicating that it causes both acute and chronic pain, increased pain sensitivity, and in some cases neuroma formation, which can be associated with neuropathic pain (Larrondo et al 2019). Alternatives to docking are to breed sheep with shorter tail lengths (Greef et al 2015, Teubes et al 2023), or to manage sheep with undocked tails where flystrike risk can be effectively minimised through other measures. Where it is considered necessary for animal welfare reasons, tail docking must be done by a competent operator, with no fewer than three palpable joints left remaining, and using multi-modal pain relief. Docked lambs must be provided with appropriate care to minimise infection and promote healing.

Control of dags and worms

Dags are formed when faeces accumulate in the wool of the breech area. Reducing dags is therefore important to reducing the attractiveness of this area to flies.

Dags can be caused by scouring (diarrhoea) which, in turn, can be due to internal parasites (worms). Effective treatment of worms using a targeted drench should quickly stop the scouring. Scouring could also be related to worm-immune sheep becoming hypersensitive to worm larvae ingested after a long period of worm absence. In some sheep, an abnormal immune response to these larvae results in inflammation of the gut, which causes the scouring. A dedicated decision support tool called WormBoss is available to producers to assist in controlling worms in sheep.

Breeding and selecting sheep resistant to worms may be the long-term solution to reducing worm-related scours while at the same time managing the problem of drench resistance (Bisset et al 2001; Gray 1997). Selecting for less dags (or low dag weight) is part of this approach (Larsen et al 1999; Greef et al 1997; McEwan et al 1997; Scobie et al 2010), although there has been limited progress with regard to breeding for less dags (pers. comm. Geoff Lindon 2018). Additionally, dags scored at different ages may not be the same trait genetically, meaning that selection of low dag young sheep may not translate to low dag adult sheep (Greef et al 2021). There are now Australian Sheep Breeding Values available for 'late dag', which can help producers to select rams that produce progeny who will have lower dag scores as adults.

Scouring is not necessarily related to worm/larvae burden and may have other causes (AWI 2008b; Watts et al 1978). Diet, for example, can also lead to scours. Improved pastures in higher rainfall areas; rain-soaked grass-dominant pastures, including rye grass pastures, which have rapidly regrown following a dry summer; cereal crops or cereal grain; and sudden changes in diet can all lead to scouring (Watts et al 1979).

A strategy of placing high-risk animals in the lower-risk paddocks (i.e. dry, lightly shaded, and sheltered from rain) may assist in reducing scours and subsequent dags.

Strategic timing of shearing and crutching also helps to reduce dags.

General flock management

Key learnings from interviews with 40 wool-growing enterprises that have phased out mulesing (AWI 2018) found that improving sheep body condition through increased nutrition and improving general sheep health by reducing parasite load and disease were all factors that reduced flystrike risk. Many of these enterprises also introduced joining periods of 3 to 6 weeks to reduce any impact of flystrike during lambing when opportunities to intervene are limited due to the risk of mismothering. Early weaning (10-12 weeks) was another strategy used by these enterprises, which, in combination with early joining, allowed 6-monthly shearing to fit into the calendar year by shearing ewes and weaning lambs at the same time. These less traditional flock management strategies were reported to be effective at managing flystrike risk.

ALTERNATIVES TO MULESING

The wool industry has sought to develop viable and humane alternatives to mulesing. To date, none of these alternative solutions has had wide industry uptake and/or been proven to be commercially viable.

The RSPCA believes that humane practices that preclude the need for mulesing or breech modification should be adopted. Any breech modification procedure should only be considered an interim, short-term solution that accompanies a breeding program that focusses on flystrike resistance. Fisher (2011) argues that for a high-end product such as fine Merino wool, the welfare advantages and benefits of market access of sheep that do not have to be mulesed or modified are incontestable.

Clips

The development of clips aimed to mimic the effect of the mules operation and in 2007 commercial prototypes were available for testing (Lloyd et al 2010). Application of clips is a non-surgical procedure whereby folds of skin on either side of the perineal area as well as the tail are clamped together with moulded plastic clips. Four clips are required – one on each side of the tail and one on each side of the breech area next to the tail. The clips need to be left on for at least four to six days to have the desired effect (Evans et al 2012b). The loss of blood supply causes the occluded skin flaps to die and fall off after about 2 weeks, with the remaining, now stretched skin leaving a bare area around the tail. Compared to the mulesing procedure, the effect of clips in terms of reducing breech wrinkle, breech cover, dags, and urine stain is less but the effect on the tail bare area is good, providing up to 80% control of flystrike (AWI 2011). Clipped sheep have less dag and urine stain compared to unmulesed sheep so less time is spent on crutching clipped sheep (Larsen et al 2012). However, overall, clipped sheep require similar flystrike prevention strategies to unmulesed animals (Larsen et al 2012).

The results of research trials (Hemsworth et al 2009) indicate that clips offer a significant welfare advantage over mulesing in terms of lamb survival, daily weight gain, and pain response. In terms of flystrike, clipped lambs are more susceptible than mulesed lambs but better protected than untreated lambs (AWI 2008c). Clipped lambs have a greater breech bare area and lower wrinkle, dag, and urine scores compared to untreated lambs (Playford et al 2012) although not to the extent achieved through mulesing (Evans et al 2012a). The clips have better results in terms of greater bare area when applied to loose-skinned lambs compared to tight-skinned lambs; similarly, less-wrinkled lambs have a better bare area result than highly wrinkled lambs following clip application, as do lambs with less dag (Rabiee et al 2012).

Compared to mulesing without pain relief, clip application is less painful, with lambs spending less time standing immobile with their head down and more time walking and feeding than mulesed lambs (Hemsworth et al 2012).

Clips must be applied by trained operators to ensure correct use. However, adoption of clips was low due partly to poor results on sheep with heavy wrinkle and heavy dags (clips appear to be more effective on sheep with lower breech wrinkle, lower breech cover, and less dags). Biodegradability of the plastic clip was also a concern as producers were reluctant to find plastic clips strewn among their paddocks, and double handling of the sheep is required to remove the clips before they drop off in the pasture. Clips are no longer available on the market.

Needleless intradermal injections

This procedure uses a needleless applicator to inject directly into the skin a special formulation which causes skin cells to die and a thick scab to form at the injection site. The skin tissue surrounding this scab closes in under the scab and, when the scab falls off, it leaves an area of stretched skin similar to the result of mulesing (Lee et al 2010). The procedure is non-surgical. The use of an insecticide to control flies after the procedure is important as the needleless injection causes a high-protein exudate to come out of the holes made in the skin - the exudate is attractive to flies.

Various chemical formulations have been trialled, however a number of problems have prevented commercial uptake. For example, when the effectiveness of one particular formulation (cetrimide) was trialled, signs of significant discomfort and pain were noted in treated lambs and, consequently, further research with cetrimide ceased (Levot et al 2009; Colditz et al 2009a; Lepherd et al 2011a). Use of an anti-inflammatory drug (carprofen) following the cetrimide intradermal did reduce the time lambs spent in abnormal (pain-related) behaviours such as hunching and stiff walking (Colditz et al 2009b), confirming that this intradermal treatment was painful.

Another intradermal formulation – sodium lauryl sulphate – was compared to clip application and mulesing without pain relief (Hemsworth et al 2009). Both alternatives were found to be more humane than mulesing without pain relief and both alternatives showed no significant behavioural differences compared to the untreated control group. However, both the clips and particularly the intradermal treatment showed elevated cortisol (indicative of physiological stress) and haptoglobin (response to inflammation and tissue trauma) concentrations compared to the control. Additionally, the neutrophil to lymphocyte ratio (again indicative of physiological stress) was higher in the intradermal treatment. These results indicate that the alternative treatments caused physiological stress due to tissue trauma, which is likely to be associated with pain. Another study (Edwards et al 2011) comparing the clips and sodium lauryl sulphate intradermal treatment with mulesing without pain relief found that the welfare impact of the non-surgical treatments was less than mulesing. Lambs in the clip and intradermal treatments differed little behaviourally from control lambs other than spending more time kneeling in the first 2 hours following treatment. They also had higher plasma cortisol concentrations than control lambs. But both clip and intradermal treatments caused far less acute behavioural change than surgical mulesing. It seems both alternative procedures are painful, although less intense and not as long lasting as mulesing without pain relief.

Whereas the studies above compared sodium lauryl sulphate intradermal treatment to mulesing without pain relief, another study looked at a comparison with mulesing using topical pain relief (Colditz et al 2010). In this study, lambs treated with the intradermal spent less time in abnormal behaviours (hunched standing, stiff walking, pawing, lying down) than lambs mulesed with pain relief. Blood analysis showed the intradermal taking effect within 12 hours (fever) accompanied by an inflammatory response similar to mulesing but not as long lasting (7 days versus 14 days).

By 2011, research was continuing to progress on the applicator, particularly the precise areas to inject, and on ensuring that the right dose enters the skin and does so without being contaminated or obstructed by the lamb's fleece or the thickness of the skin. Further trials also aimed to improve the speed of the treatment as well as improve the results for wool cover on the tail to more closely resemble the results after mulesing (AWI 2011).

The Australian Pesticides and Veterinary Medicines Authority (APVMA) registered the sodium laurel sulphate intradermal technology (SkinTraction®) in May 2015. However, registration included strict use requirements, e.g. the need for sheep to be >30kg and >12 months old. A key concern was the risk of the active ingredient – sodium laurel sulphate – moving through the skin and into underlying tissue, including muscle. These restrictions on the use of SkinTraction® severely limited its use and made it effectively unviable for most producers.

Vaccines

The research into a vaccine against flystrike has not yet led to a commercial success (Elkington et al 2007). A recent research update indicated that, while there had been some success in developing prototype vaccines that reduced maggot growth, production of an effective vaccine that was scalable to commercial quantities had not yet been achieved. In the last decade, advancing technology (including genomics) have allowed the identification of genes in the blowfly that are important for larval development and which, in the future, may be able to be knocked down or disrupted with a targeted vaccine (Perry 2018).

Topical applications

Certain compounds can be applied directly to the skin of the animal causing the treated region to slough off and leave an area of stretched, bare skin similar to mulesing (Phillips 2009). Compounds such as phenol and caustic potash were applied in the past but are no longer used due to OH&S concerns and length of time required to apply the product. Application of liquid nitrogen was also trialled whereby excess skin on the lamb's breech and tail is tightly clamped and liquid nitrogen applied to the clamped skin until it is fully frozen.

The clamp is then removed and treated skin eventually falls off. The method is painful and no benefits in terms of reduced pain were found over mulesing regardless of whether pain relief was provided (Small et al 2018a). An adaptation of this liquid nitrogen technology aims to reduce the amount of liquid nitrogen required while at the same time achieving a tertiary freeze. However, for any method where liquid nitrogen is applied directly to the skin, the process will still be painful to the lamb.

Sheep odour

In an effort to determine whether the odour of sheep has a role to play in their attractiveness to the blowfly *Lucilia cuprina*, sniffer dogs were trained to identify wool from sheep resistant to flystrike. When tested on a selection of wool samples, dogs were able to sniff out the wool from resistant animals with 82% accuracy. It has been suggested that differences in odour between sheep could be used as a future indicator trait to select for flystrike resistance (Sandeman et al 2014). More recently, specific compounds in wool have been identified as attractive to pregnant blowflies, and the concentrations of some of these compounds in wool have been found to be heritable in Merino sheep (Yan et al 2024).

The fly genome

Insecticides have been used for many decades to treat flystrike; however, their excessive use has led to issues with chemical residues in the fleece and resistance in the blowfly *Lucilia cuprina* with warnings that it is only a matter of time before the blowfly develops resistance to all available classes of insecticide. So, in addition to breeding flystrike resistant sheep, the possibility of transforming the blowfly is being investigated. The recent sequencing of the *Lucilia cuprina* genome offers future prospects for finding ways to prevent flystrike (Anstead et al 2017). Blowfly control strategies could be developed that use knowledge of the genes responsible for blowfly larvae feeding off sheep or, in future, it could be possible to employ gene editing technology to provide more effective control options (Sandeman et al 2014), e.g. knocking out the gene responsible for the blowfly's ability to see or smell (Trent 2018).

Laser epilation

Two varieties of human epilation (hair removal) lasers were trialled on superfine Merinos. The sheep were first clipped around the flank, breech, pizzle, and eyes, and then any remaining wool was removed by the laser treatment. The sheep appeared to tolerate the treatment well. When, after 6 weeks, the scab resulting from the laser treatment fell off there was some scarring and evidence of wool growth in unscarred skin. Wool growth was not permanently prevented by the laser treatment (Colditz et al 2015). At this stage, it is not known whether further work in this area will be pursued.

PAIN RELIEF

A 2021 survey of 1203 Merino woolgrowers across Australia reported that 52% of the producers mulesed their ewe lambs and 44% of the producers mulesed their male lambs, with at least 92% of lambs receiving pain relief at mulesing (Sloane and Walker 2022). This is significantly more than the usage of pain relief declared through the mulesing status declarations on NWDs even taking into account that as at 31 December 2023 only 74% of bales were accompanied by an NWD (see 'National Wool Declaration' section below). It is also significantly more than a 2014 Sheep CRC survey which found that 61% of Merino lambs were mulesed with pain relief (Sheep CRC 2014) and a 2016-17 unpublished joint survey conducted by Australian Wool Innovation and Meat & Livestock Australia which found that around 77% of Merino lambs were mulesed with pain relief (pers. comm. Geoff Lindon 2018).

The RSPCA's position is that where an invasive procedure such as mulesing or other painful breech modification is carried out, it must be accompanied by adequate, timely, and effective pain-relieving and/or pain-preventing products.

The development of long-acting drugs administered before or at the time of the mulesing operation has been on-going for over a decade (Paull et al 2007; Paull et al 2008). The purpose of this research is to develop drugs that can reduce or eliminate the pain of the mulesing or other breech modification procedure. Providing pain relief to lambs at marking will help lambs 'mother up' after the procedure and have their first drink more quickly compared to lambs that have had no pain relief (Lomax et al 2013). A delay in mothering up risks lambs being susceptible to exposure and possible death.

In 2006, Tri-Solfen® (Bayer HealthCare 2006), a topical anaesthetic for application post mulesing, became available under permit to producers. Tri-Solfen® is a spray-on local anaesthetic formulation containing lignocaine (a fast-acting local anaesthetic), bupivacaine (a longer acting local anaesthetic), adrenaline (to reduce blood loss) and cetrimide (an antiseptic) (Windsor et al 2013). There has been a steady uptake of the topical gel since its introduction with over 60% of mulesed lambs having topical anaesthetic applied following mulesing by early 2011 (Bayer 2011) and up to 88% of mulesed Merino lambs being treated by 2021 (Sloane and Walker 2022). Tri-Solfen® was registered by the APVMA in 2012 and, in 2014, rescheduled as a Schedule 5 drug, allowing it to be sold 'over the counter' rather than having to be prescribed by a veterinarian.

Tri-Solfen® is sprayed onto the mulesing wound, that is, after the procedure has been performed. The gel-like nature of the product ensures it adheres to the wound and provides a barrier to help keep the wound clean and promote healing. Pain relief provided by Tri-Solfen® may last 12-24 hours largely due to the protective barrier of the gel (Lomax et al 2013) following the procedure. However, Tri-Solfen® does not diminish the pain during the procedure of skin removal from the breech area and the tail.

In 2016, an oral analgesic product (Ilium Buccalgesic® OTM) became available to producers, with a second similar product, Butec OTM now also available. Like Tri-Solfen®, these products have now been scheduled so that they do not need to be supplied by a vet. Both products are applied against the inside of the sheep's cheek (buccal administration) via a dosing gun immediately prior to the mulesing procedure. The active ingredient in this oral pain relief is meloxicam, a non-steroidal anti-inflammatory drug that is quickly absorbed in the blood stream within 15-20 minutes of administration, reaching maximum concentration after 2.6 hours (Small et al 2018b). A field trial using topical pain relief (Tri-Solfen®) and the oral pain relief separately and in combination, found that the topical pain relief acted the fastest and reduced pain-related behaviours such as hunched standing for 4 hours post mulesing; the oral pain relief did not become effective until 2 hours after mulesing but lasted at least 6 hours; combining the two products reduced pain-related behaviours for 6 hours (the total observation period). Two days later, the combination of products resulted in less behavioural impacts being observed compared to the topical pain relief on its own (Small et al 2018b).

Metacam®20mg/ml, an injectable form of meloxicam, also became available in 2016 and is designed to alleviate pain and inflammation, e.g. post mulesing. Other brands of injectable meloxicam for sheep are also now available. Injectable meloxicam products require a vet to prescribe the drug. Injectable meloxicam products are injected subcutaneously high on the neck behind the lamb's ear prior to the procedure. Inglis et al (2019) reported that a combination of Tri-Solfen® and injectable meloxicam given 15 minutes prior to mulesing was more effective than using either product alone.

Even when pain relief products are used, lambs still feel pain when mulesed. With Tri-Solfen®, the product is not administered until after the skin has been cut away, so the pain felt during the procedure is not reduced. In the case of meloxicam, the drug reduces pain associated with inflammation, but it can do little to address the acute pain felt during the procedure (Stillman and Whittaker 2019). One study which assessed behavioural measures of pain (facial expression, activity levels, and time spent with dam) in lambs was able to detect a difference in behaviour between mulesed and unmulesed lambs on the day of mulesing, but not between lambs that were mulesed with pain relief (Tri-Solfen®, meloxicam or both) compared to lambs that were mulesed without pain relief (Hancock et al. 2021). This illustrates that the pain relief options currently

available for mulesing do not fully alleviate the pain of mulesing even in the short term. In addition, once the pain relief wears off (within hours to days), lambs are likely to experience pain again (Hancock et al. 2021), and chronic pain due to mulesing is possible, especially considering mulesing wounds take weeks to heal.

Best practice pain relief for mulesing is considered to be the use of a topical anaesthetic (Tri-Solfen®) in combination with a non-steroidal anti-inflammatory drug (e.g. meloxicam). However, even best practice pain relief does not prevent nor adequately treat the pain experienced during and after mulesing.

For tail docking (and castration), administration of a meloxicam product results in reductions of indicators of pain, such as hunched postures or walking stiffly (Small et al 2014). Meloxicam products can be used for any method of tail docking (and castration). The application of Tri-Solfen® has been demonstrated to reduce pain-related behaviours in lambs that are tail docked using surgical (cold blade) or hot iron methods, plus surgically castrated (Lomax et al 2010). Tri-Solfen® can only be used for tail docking (and castration) methods where the skin is cut. For ring methods where skin is not cut, injectable local anaesthetic can be used. There is now a device available to deliver a dose of lignocaine at the time of ring tail docking or castration. It is called Numnuts® and together with the specially branded lignocaine product (NumOcaine®) it is now available without veterinary prescription or supply. Acute pain behaviours and abnormal postures have been reported to be reduced in lambs ring tail docked (+/- castrated) using the NumNuts® device for the first hour after ring application, compared with lambs tail docked (+/- castrated) without it (Small et al 2020, Small et al 2021).

Best practice pain relief for tail docking (and castration) is considered to be the use of a local anaesthetic (Tri-Solfen®, Numnuts® or veterinarian injected, depending on method used) in combination with a non-steroidal anti-inflammatory drug (e.g. meloxicam). However, as with mulesing, even best practice pain relief does not fully prevent or treat the pain experienced during and after tail docking and castration.

TREATMENT OF SHEEP WITH FLYSTRIKE

Preventative strategies will significantly reduce the risk of flystrike within the flock. However, they may not eliminate the incidence of flystrike altogether.

To reduce animal suffering, flystruck sheep need to be identified quickly – for example, through regular monitoring of the flock – and treated immediately. An animal that has been struck can be identified by the presence of dark areas on the wool, isolation from the flock, reduced feeding (resulting in marked loss of body condition) and/or behaviour such as rubbing or biting the affected area.

If an individual animal is struck, treatment consists of shearing the affected area as well as at least 5 cm of unstruck wool around it close to the skin. Maggot trails through the wool are followed to ensure that other areas have not been affected. Shearing will remove many of the maggots and will help the area to dry out (NSW Agriculture 1999). Removing any remaining maggots and placing the affected clippings into an airtight bag will kill the maggots. A registered dressing (NSW DPI 2004) is then applied and the sheep returned to the flock and monitored to confirm that they are recovering well. The dressing kills any remaining maggots and allows the wound to heal without it becoming re-struck (NSW Agriculture 1999).

Immediate treatment of flystruck sheep is essential. Not only is the condition painful, affected animals may eventually succumb to blood poisoning and die.

NATIONAL WOOL DECLARATION

In 2008, the Australian Wool Exchange (AWEX, through which around 90% of Australian wool is auctioned) introduced the National Wool Declaration (NWD) to allow woolgrowers to voluntarily declare the mulesing status of their sheep, and thus their animal welfare credentials, to wool buyers at auction (AWEX 2017). Woolgrowers are asked to declare, on a mob basis, whether wool from that mob is from sheep that have not been mulesed (NM), whether some or all sheep have been mulesed (M), mulesed using liquid nitrogen (LN), or

whether all sheep were mulesed using analgesia and/or anaesthesia (AA). If sheep are no longer mulesed on the property (and have not been for the last 12 months), and mulesed sheep have not been bought in, then the grower can declare 'ceased mulesing' (CM) status. Each of these categories attracts a premium per kilogram of wool sold at auction compared with non-declared wool, with non-mulesed wool typically attracting higher premiums than mulesed wool.

As at December 2023, 20% of the wool bales sold through AWEX were declared 'non mulesed', 3% 'ceased mulesed' and 42% declared that analgesia and/or anaesthesia was used at mulesing (AWEX 2023). The national percentage of bales with mulesing status declared was 74%, with Queensland and Tasmania at the top declaring 86% and 83% respectively (AWEX 2023). Even assuming that the remainder of bales, i.e. those without NWDs, had similar mulesing status declarations, considerably more work needs to be done towards achieving a phase out of mulesing and, in the interim, 100% uptake of pain relief.

Growing interest from wool buyers in mulesing status has seen a significant increase in premiums. As at 31 December 2023, national premiums for 'non mulesed', 'ceased mulesed' and 'analgesia/anaesthesia' were 15c/kg, 12c/kg and 2c/kg respectively for 18 micron wool (AWEX 2023). Clearly and encouragingly, the market preference is for wool from sheep that are not (or no longer) mulesed. Interest is also rising in declaration status of all wool (not just fine wool) as well as non-Merino wool, evidenced by discounts routinely being applied to bales that have not been declared (AWEX 2023).

Because the National Wool Declaration is voluntary, it is difficult to accurately track progress within the wool industry towards an end to mulesing and, in the interim, the extent to which mulesing is carried out with pain relief. It is the RSPCA's view that declaring mulesing status on the NWD must be mandatory. This would not only allow the wool industry to demonstrate their commitment to improving animal welfare and to provide transparency to the market and the opportunity for customers to make an informed choice, but would also provide stakeholders with the ability to monitor progress towards a long-awaited phase out of mulesing. Recently, wool industry associations have announced unanimous support for making the NWD mandatory, however, as yet, there is no industry agreement on the mechanism by which to do this (AWEX 2024).

COMMUNICATION

Research on woolgrower attitudes towards mulesing and possible alternatives, showed that most believe that mulesing is more effective and more efficient (in terms of time, cost, and effort) than any alternative (Wells et al 2011). Targeted communication with woolgrowers regarding breeding strategies that suit their sheep in their particular environment and their particular circumstances will likely promote better understanding of the breeding options available to growers. There are a number of online tools and information sources as well as in person workshops available for producers wanting to learn about how to transition away from mulesing. For example, Australian Wool Innovation has a range of resources available as part of their flystrike extension program, and the FlyBoss website also provides detailed information on flystrike risk reduction strategies. Awareness and use of the flystrike prevention tools and resources available to woolgrowers are likely to encourage wider uptake of mules-free breeding strategies. However, many woolgrowers may not be aware of the resources available to them. For example, a 2021 Merino woolgrower survey found that less than 50% of growers were aware of the FlyBoss website (Sloane and Walker 2022). For woolgrowers to confidently move away from mulesing, greater awareness and application of the principles outlined in this and other decision-support tools is imperative. Australian Wool Innovation published key learnings from interviews with 40 wool-growing enterprises that have phased out mulesing (AWI 2018):

- *"It is important to have a detailed plan in place before starting the move to a non-mulesed enterprise, that has the support of everyone in your business, including staff, contractors, shearers, livestock agents and ram suppliers.*
- *The business needs to be brave, organized and determined to make it work especially in the early years.*

- *Moving to a non-mulesed enterprise often requires fundamental change to the whole business."*

The diversity of Australia's sheep population, its climate and its environment mean the risk of flystrike is equally diverse. However, whatever the size and structure of the sheep enterprise, with the right attitude and the right management, a mules-free future for the Australian sheep flock is entirely possible.

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