Innovations for sustainable worm and blowfly control programs of sheep

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1. Introduction

Sheep and are managed under diverse seasonal conditions and management systems, both within Australia and other major sheep-producing countries. Because of these differences, it is difficult to make universal recommendations about what 'sustainable' control programs for gut roundworms ('worms') and sheep blowflies should be. However, some broad principles can be applied. For example, to be effective and profitable in the longer term, control programs should cost-effectively prevent unacceptable production losses, but also avoid practices that encourage rapid selection for resistance to worm drenches or the groups of insecticides that are available for blowfly control.

Major issues to be addressed in the future, for both worms and blowflies, include different patterns of infection due to climate change and addressing the challenges of resistance. The best way to tackle these will be to integrate other control and monitoring strategies into programs rather than just relying on chemicals, although these will remain a key tool. This approach is referred to as Integrated Pest (or Parasite) Management ('IPM').

2. Gut roundworms

To slow the development of drench resistance, an integrated worm control program ('IPM') is preferable to relying solely on drenching.

IPM programs still use drenches, with the timing of <u>strategic drenches</u> based on the patterns of infection of the most important worms in each region. However, these should be integrated with other tools such as grazing management, using effective combinations of drenches, good nutritional management of young sheep and selection for resistance (or resilience/ tolerance) to worms.

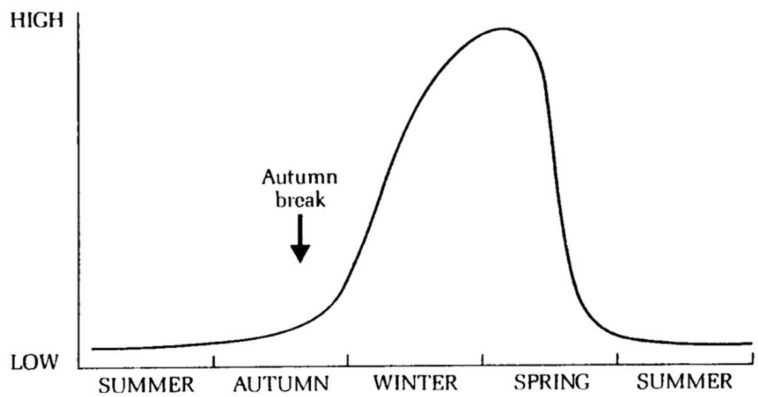
Currently, 'best practice' programs are based around:

1) <u>Testing for drench resistance</u> every 3-4 years.
2) <u>Correct timing of the 'strategic' drenches</u> and using <u>effective drench combinations</u>. In southern Australia these are referred to as the 'summer drenches'.
3) <u>Monitoring worm egg counts</u> (WECs) at critical times – this includes before the first or second summer drenches, and at other times when deciding if additional drenches are needed to different classes of sheep, eg. weaners every 4-6 weeks after the autumn break & ewes before lambing.
4) <u>Grazing management</u>, to provide 'lower risk' pastures for those sheep more susceptible to worms (eg. weaners and lambing ewes, especially hogget ewes lambing at 12 m.o).
5) <u>'Quarantine drenching'</u> any sheep introduced from outside the flock, using an effective combination of drenches (typically with 3 or 4 different compounds). This prevents the introduction of resistant worms.

2.1 Why we use summer drenches

In south-eastern Australia, contamination of pastures with worm eggs during the late-summer and autumn (from Feb-May) determines the size and timing of the peak of infective larvae the following winter (Figure 1). Decreasing this peak helps control worms during winter, and is the basis of the single- or double-summer drench program devised by Dr Norman Anderson in the 1970s.

Figure 1: Seasonal variation in the number of infective larvae on pastures in a winter rainfall area



2.2 Modifying worm control programs

Many factors influence the need to modify a worm control program. These include whether worms are being well controlled (or not), stocking rate, time of lambing, the type of enterprise (Merino, dual purpose or prime lamb) and the genetic resistance and resilience of the sheep.

Mediterranean climates – In areas with a Mediterranean climate, such as Western Australia, giving two summer drenches can increase the risk of drench resistance because fewer infective larvae survive on the pastures during summer (this is referred to as 'low refugia'). Consequently, a modified program is now suggested for parts of WA – a single summer drench is given to adult ewes later, often in Feb-Mar rather than Nov-Dec. In this modified program young sheep still get two strategic ('summer') drenches, the first at weaning and second in Feb, then worm egg counts are monitored after the autumn break.

There is little need for this modified strategy in other high winter and uniform rainfall areas, such as western Victoria, because the number of infective larvae that survive on pastures during the summer is much greater. This is because the pasture growing season is longer (7-9 months vs. 6 months or less in WA), with shorter, cooler & wetter summers. Pastures are also based on perennial grasses, and so there is greater residual pasture mass and less bare ground during the summer, whereas most sheep areas in WA have annual pastures. These differences mean that worm larvae are exposed to less extreme conditions during summer in south-eastern Australia; temperatures within faeces can still reach 50^0C or more, but a reasonable proportion of infective larvae still survive.

'Targeted selective treatment' – this aims to reduce selection for drench resistance by only treating a proportion of sheep within a mob. Targeted treatments can be applied 'strategically' (at key times, to disrupt the worm life cycle), or when frequent treatments are needed (which often occurs with Barber's

Pole Worm (*Haemonchus*) infections). Selecting sheep to be drenched can be at random, or based upon them suffering more effects from worms. For the 'scour worms' (*Teladorsagia* and *Trichostrongylus*), this means only drenching sheep below a lower critical condition score, bodyweight or average daily weight gain.

No detailed research into the effects of targeted treatments has been undertaken in SE Australia (eg. are there no undesirable production losses or any decreased selection for drench resistance?). However, a producer demonstration project in SW Victoria used targeted treatment in selected ewe mobs on 7 farms over 2 years. No observable increase in the clinical signs of worms were seen in prime lamb ewes on 6 farms, but they did find increased worm egg counts in Merino ewes on one farm (Carmichael et al. 2013). This highlights that modified programs should only be undertaken with increased monitoring, and they are is not suitable for all farms.

Where Barber's Pole Worm (*Haemonchus*) is the main parasite, treating only those adult sheep that are anaemic has been suggested – the FAMACHA system developed in Sth Africa. This requires increased labour to examine sheep, and so is only cost-effective for smaller flocks of sheep and goats in Australia.

2.3 Selection of Sheep with Enhanced Immunity

Increased immunity to worm infections is an inherited trait. Therefore, it is possible to gradually increase the resistance of flocks by selecting rams or ewes that have low worm egg counts (WECs). Usually the selection of ewes would only be done to establish a ewe nucleus flock. Despite their limitations, low WECs are the most practical way of identifying resistant sheep.

Estimated Breeding Values (EBVs) for WEC are now available for Australian rams, including several Corriedale sires, and these can be incorporated into a selection index (eg. a dual purpose index for Corriedales).

2.4 Vaccines to control worms

A vaccine against the bloodsucking worm *Haemonchus* (Barber's Pole Worm) is now registered and being used in high risk flocks in Australia and South Africa (Barbervax™). It is based upon a 'hidden' antigen from the gut of the worm, and so effective protection requires three priming doses before weaning, then booster vaccinations at six-weekly intervals. Consequently, a total of five vaccinations are needed during a typical risk period for haemonchosis in summer rainfall areas.

A lot of work has been done attempting to develop vaccines against the 'scour worms', but a vaccine to control these is unlikely in the short- to medium-term future.

2.5 Fungi that eat worm larvae ('nematophagous fungi')

The biological control of free-living larvae, using a nematode trapping fungi *Duddingtonia flagran*s, has recently become commercially available in Australia (BioWorma®). Bioworma® contains fungal spores which, when fed to grazing animals (sheep, goats, cattle, horses), pass through and hatch in the faeces (manure). They then produce 'nets' which trap and kill worm larvae in the faces, and this can reduce the populations of worm larvae on pasture by up to 80%.

A relatively high dose of spores is needed (1.5 million/ day for a 50 kg sheep), and they must be fed continuously for 2-3 months to have a beneficial effect. The best timing for feeding spores hasn't been thoroughly investigated, but for winter rainfall areas the most beneficial time is likely to be for 8-10 weeks before the autumn break (ie. after or instead of the 2nd summer drench).

Unfortunately, at the moment this product is not cost-effective for use in sheep worm control programs, even when compared to drenches with considerably reduced efficacy. Putting the spores into a controlled-release capsule has been investigated, and would be a more convenient and flexible option, but is not yet available.

2.6 Grazing management

These can be highly effective strategies but are generally underutilised.

Cattle-sheep interchange – This is the 'Rolls-Royce' system. Sheep and cattle share only one gut roundworm (*T.axei*), so pastures grazed by cattle are relatively 'safe' for sheep, and vice versa. At least 12 weeks grazing by mature cattle (>12 months old) is needed to reduce contamination for sheep, with the optimum system being a 6-monthly interchange (Jan-Jun was the original system proposed, but this can be varied).

Cattle can be disadvantaged when shifted to shorter sheep pastures, but this can be overcome by shifting the sheep a few weeks earlier and allowing some regrowth of pastures for the cattle.

Smart grazing – A highly effective method of preparing pastures is the 'Smart grazing' system developed by the Mackinnon Project. Paddocks to be grazed by weaners the following winter are prepared by intensive grazing with sheep (at 2-3 times the normal stocking rate) for 30 days the previous summer, straight after each summer drench (called the 'preparation period'). This reduces the contamination of those pastures with worm eggs because eggs only appear in the faeces 18-21 days after each drench, and so WECs are still very low 30 days after the drench.

This strategy is quite flexible, as any mob of sheep can be used to prepare the smart grazed paddocks provided they receive a fully effective drench. They can also be removed before the 30-day grazing period if pasture availability becomes too low (say <700-900 kg DM/ ha). In the original study, Merino weaners grazed on 'smart grazed' paddocks during winter had lower worm egg counts, grew 12% more wool (2.29 vs. 2.03 kg) and were 3 kg heavier in October (46.5 vs. 43.2 kg) compared to weaners on paddocks continuously grazed the previous summer by mature wethers.

2.7. Prime lamb & dual-purpose systems

Most Australian research into the control of sheep roundworms has been conducted in Merinos and then adapted for meat or dual-purpose systems. Meat systems have become more profitable, and Merino numbers declined, so differences in worm control between self-replacing wool and prime lamb flocks have drawn more attention. Meat sheep breeds are generally more resistant (immune) and resilient (able to tolerate worms). However, they have a ewe dominant flock structure, and so if worm problems occur they can be difficult to manage, especially in hoggets and older ewes. In addition, grazing management strategies, such as cattle-sheep interchange, may not be an option.

A study of 15 prime lamb flocks in south-eastern Australia, from 2004-2008, found pasture quality limited lamb growth as much or more than sub-optimal worm control (Carmichael 2009). Poor growth rates (<150 g/d) occurred especially when pasture quality declined in spring and early summer. These flocks used a variety of control programs, often not 'best practice', but most used some form of a strategic summer drench.

A follow-up study from 2012-15 looked at worm control programs in 4 prime lamb flocks in Western Victoria (Kahn et al 2015). Ewes managed according to the worm control program on each farm were compared to a 'gold standard' ('worm-supressed' ewes given consecutive controlled release capsules; this is <u>not</u> suggested as a control option, it was just an experimental tool). Worm-suppressed ewes were 1 to 5 kg heavier at weaning and their next joining (an average of 3.8 kg in Year 1, and around 2.0 kg in each of Years 2 and 3). These consistent but modest differences showed that worms were generally well controlled in these flocks, sometimes despite less than optimum programs. Similar studies were undertaken in 12 flocks from three other regions of eastern Australia, and the results were remarkably similar regardless of the region and management system.

Lambs born to the worm-suppressed ewes were sometimes slightly heavier at marking, but early or suppressive drenching of the lambs didn't increase their growth rates. This differed from the previous study on 15 farms in SA and Victoria, which found that worms reduced the growth rate of lambs by an average of 19 g/d (12%) on over one-third of farms (Carmichael 2009).

Another study in NZ, which compared a drench with 50% efficacy (ie. severe drench resistance) to a completely effective one, is probably the upper estimate for the effect of poor worm control in prime lambs in a high winter rainfall area (Miller et al. 2012). In that study, lambs given the effective drench in their 'standard' worm control program (5 drenches during a 5-month grazing period) were 9 kg heavier at slaughter, giving a 4.7 kg increase in carcass weight and 10.4% increase in carcass value. However, stocking rates, rainfall and worm populations are much higher in NZ prime lamb systems, and so these production responses are unlikely to be seen anywhere in Australia.

3. Sheep blowflies

The lifecycle of the sheep blowfly (*Lucilia cuprina*) is quite different. In cool, temperate regions adult flies are absent during the winter but arrested third stage larvae survive ('overwinter') in the ground. There is a high mortality, but surviving larvae resume their development and pupate when soil temperatures increase in the late winter, subsequently emerging to provide a new generation of flies in the early spring.

Early in the season, hidden ('covert') strikes can increase the population of adult flies until obvious strikes are detected in late spring and early summer. Thus, in areas where breech strike is a consistent problem, a strategic treatment with a long-acting insecticide in spring can prevent the build-up of fly populations and reduce the likelihood of strike. This 'early season treatment' is generally a more cost-effective approach than waiting until a certain percentage of sheep are struck and then treating with insecticide.

3.1 The genetics of the fly

The genome of the Australian Sheep Blowfly has recently been 'mapped', unearthing more than 2000 genes that have never been detected in other animals or plants. Blowflies have been able to rapidly develop resistance to many insecticides, but studying how their genes work may make it possible to 'design' insecticides that are less prone to resistance, or develop new baits to reduce fly populations more effectively than those developed for the old Lucitrap™ flytraps.

The sheep blowfly also has incredible ability to smell, hence detect and initiate strikes on susceptible sheep – typically those with innate odours, or dermatitis from fleece rot, wetting with faeces or urine, or existing strikes. Knowing the genetic mechanisms behind this ability introduces the possibility of new approaches to control, such as breeding and releasing flies without the ability to smell.

Any new control strategy has to be applied over a population of blowflies, so another thread of this research is to compare how much variation there is, and how much migration occurs, between blowflies in different regions.

3.2 Parasites in the blowfly?

Up to 70% of insect species harbour a parasite called *Wolbachia*, which can be lethal to male offspring. It is not known if this parasite is present in *Lucilia cuprina*, but if it is then this may be a novel control strategy, albeit in the more distant future.

3.3 Other research

Other recent research into blowflies includes breeding sheep for increased resistance to breech strike, such as fewer dags, reduced attractiveness to egg-laying ('gravid') flies and those with increased resistance to the establishment of maggots.

Interim alternatives to mulesing, to make Merinos less susceptible to breech strike, have also been investigated, including the intra-dermal injection of sodium lauryl sulphate ('Skintraction') and the application of liquid nitrogen to the breech. These have less relevance to Corriedales.

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