



Sheep CRC Conference Proceedings

Document ID:	SheepCRC_22_12
Title:	Management of sheep worms; sustainable strategies for wool and meat enterprises
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Key words:	sheep; parasites; wool; meat

This paper was presented at the Sheep CRC Conference 'Wool Meets Meat' held in Orange, NSW in 2006. The paper should be cited as:

Besier, R.B. (2006) *Management of sheep worms; sustainable strategies for wool and meat enterprises* in 'Wool Meets Meat' (Editors P. Cronje, D. Maxwell) Sheep CRC pp 94-100.

Management of sheep worms: sustainable strategies for wool and meat enterprises

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Abstract

Strategies that limit the development of gastrointestinal worms that are resistant to anthelmintics are essential for the sustainable control of worm infestations in sheep enterprises. These strategies involve maximizing the ability of sheep to withstand the effects of worms and reducing selection pressure for anthelmintic resistance among worms when anthelmintics are used. For sustainable use of anthelmintics, some non-resistant worms must survive either as adult worms in sheep or as worm larvae on pasture to dilute the population of anthelmintic-resistant worms and hence prevent rapid increases in resistance. However, in some situations it is necessary to allow worms to survive, which may reduce sheep productivity. The relative priorities for measures aimed at worm control and those aimed at prevention of anthelmintic resistance vary according to the goals of the enterprise, the level of the worm challenge and the capacities of various classes of sheep to tolerate worms. For instance, in prime-lamb production systems, worm control should take precedence over resistance prevention because rapid growth is of paramount importance. Well-nourished adult animals, which have strong resistance and resilience to worms, can be left untreated to combat the development of anthelmintic resistance. This article discusses guidelines for the management of worms in various sheep production systems and emphasises a whole-farm management approach to anthelmintic resistance.

Introduction

Worm control is an integral aspect of efficient sheep management because gastrointestinal worm infestation may inhibit the health and productivity of sheep. In the past, worms were effectively controlled with relatively few anthelmintic treatments that were applied strategically at key points in their annual population cycle. However, widespread resistance to anthelmintics emerged among the major ovine worm species in the late 1970s. Consequently, a need arose for sustainable strategies that ensure that anthelmintics remain effective in the long-term (Prichard et al., 1980). More recently, markets have emerged for products from animals that have not been exposed to chemical treatments, which add further complexity to worm control strategies because efficient parasite control typically requires the use of both anthelmintics and insecticides.

In the past, research on sheep worms was mainly conducted using Merinos in enterprises that focused primarily on wool production (Carmichael et al., 2005). A key theme of the Australian Sheep Industry CRC is that the management required for wool production differs from that required for meat production. There are indications that this management philosophy is applicable to strategies for worm control, which prompts the question of whether current recommendations for worm management are compatible with all sheep enterprises or whether they should be modified to accommodate different production systems.

Sustainability of worm control programs

The trend away from worm-suppressive programs to a more sustainable approach may incur a cost. In recent years, a clear link between the effectiveness of worm control and anthelmintic resistance has emerged, resulting in re-evaluation of worm control practices and the factors that affect their efficacy (van Wyk, 2001). While earlier recommendations concentrated on minimizing the frequency of anthelmintic treatments and avoiding under-dosing (Prichard et al., 1980), it is now recognised that strategic treatment programs may in some instances promote anthelmintic resistance (Besier and Love, 2003). A multi-strategy, integrated parasite management approach is now recommended (Dobson et al., 2001; Besier, 2004), which is the main theme of the parasite research program of the Sheep CRC. However, measures designed to combat the development of anthelmintic resistance may compromise the efficiency of worm control measures.

Modified drenching strategies

It is becoming increasingly evident that strategic control programs, which suppress worm populations during seasons in which worm numbers are low to pre-empt subsequent increases in worm populations, often require modification to achieve sustainability. A clear demonstration of the heavy selection pressure exerted by a common strategic program was given by Besier (2001). In this study, the level of resistance of *Teladorsagia* (*Ostertagia*) *circumcincta* to ivermectin in weaner sheep in Western Australia was substantially higher in sheep exposed to a routine “summer drench” program than in those that were not drenched.

The concept of refugia in which non-resistant worms are able to survive is central to the development of sustainable programs because the existence of non-resistant populations determines the degree to which populations of resistant strains may be diluted (van Wyk, 2001; Besier and Love, 2003). As worms may exist in refugia either as larvae on pasture or as adult worms in untreated host animals, the measures required to ensure a sufficient number of refugia vary according to environmental conditions.

Under regional and seasonal conditions that are favourable for the survival of worm larvae on the pasture, the continual intake of larvae by grazing sheep may dilute populations of anthelmintic-resistant worms remaining after drenching with non-resistant worms. In these situations, worm control may be more difficult than managing anthelmintic resistance. When larvae are not present, as may be the case with pastures during dry seasons or “worm-safe pastures” that have been prepared to prevent worm infection, the provision of refugia in untreated animals will prevent an increase in anthelmintic resistance (Besier and Love, 2003). This may entail not drenching some sheep or entire flocks, which creates the potential for reduced productivity if worm control is inadequate.

Besier et al. (2001) reported that although anthelmintic resistance was reduced when part of a flock of weaner sheep was not drenched, weight gain was reduced by up to 13% and there was a significantly greater incidence of scouring in winter. However, recent research conducted at several properties showed that the absence of drenching of adult sheep—not lambs—in summer had minimal effects on production (R. Woodgate, pers. com.), which reflects the greater worm immunity of mature sheep compared to lambs.

Grazing management

Grazing management can greatly reduce the requirement for drenching and sustain optimal animal performance. The main aim of grazing management for worm control is to ensure that susceptible classes of sheep (young sheep, lactating ewes and nutritionally-stressed animals) do not ingest excessive numbers of worm larvae from pasture. Pasture management tactics include grazing sheep on pastures such as stubble, which have low worm populations, and alternate grazing of sheep pastures by species

such as cattle or horses, which are not hosts for the major sheep gastrointestinal parasites. It is often difficult to balance competing priorities for agronomy, sheep nutrition and parasite management, but pasture rotations can significantly reduce the need for drenching. However, potential limitations associated with the practice of grazing sheep on pastures with low worm populations can complicate paddock management decisions. Transfer to worm-free situations after anthelmintic treatment can place heavy selection pressure on worm populations (Barger, 1999; van Wyk, 2001). In addition, lambs require a certain level of exposure to worm larvae to develop effective immunity against worm infections. In some cases, it may be necessary to accept a level of continued worm intake in the interests of maintaining drench effectiveness even if worm-safe pastures are available.

Targeted treatment approaches

A relatively new tactic for ensuring a high level of refugia involves restricted drenching of animals that suffer a significant degree of parasitism. The FAMACHA system, which involves examination of the eye membrane colour of all animals in a flock, indicates the level of anaemia caused by infection with the blood-sucking parasite, *Haemonchus contortus*. This approach, which was developed in South Africa where abundant labour facilitates frequent inspection of individual sheep or goats, has reduced the number of treatments to a fraction of that usually required (van Wyk and Bath, 2002).

Other approaches are necessary when frequent restraint or sampling of individual animals is not feasible, as is the case on most Australian sheep farms, and for gastrointestinal parasites that do not cause anaemia. The use of weight changes to identify animals with resilience to gastrointestinal parasites (the ability to maintain production despite the presence of worm burdens) has been investigated as a breeding index (Bisset and Morris, 1996) and could be adapted as a management tactic. The Sheep CRC is investigating the feasibility of using short-term weight changes to identify the relative effects of worms on individual sheep and to restrict drenching to sheep likely to benefit from worm removal. Electronic sheep identification systems and automated weighing systems are expected to facilitate the rapid throughput of large flocks, which would make frequent assessment practicable during periods of high worm challenge. Definition of appropriate intervention indices is required for this approach, which is likely to be more applicable for the worms that cause scouring (especially *Teladorsagia* and *Trichostrongylus* spp.) than for *H. contortus*. However, whether overall flock performance will be improved due to more timely treatments and whether the production loss of non-treated sheep will be substantial remain to be established.

Breeding of sheep resistant to worms

The feasibility and practicality of genetic selection of sheep with consistently lower worm egg counts is well established (Woolaston and Baker, 1996; Greeff et al., 1999) and has been incorporated into routine selection indices by many ram breeders. Recent work has shown that there are no adverse production effects on Merino sheep compared to non-resistant sheep infected with *Teladorsagia* or *Trichostrongylus* species (Liu et al., 2005a) although, in some environments, an increased propensity for scouring has been noted (Bisset et al., 2001; J. Karlsson, pers. com.), which is presumably a hypersensitivity response to larvae ingested by sheep with superior immune status (Larsen et al., 1995). However, in New Zealand, some reduction in growth rate and wool production has been reported in sheep selected for worm resistance (summarized in Bisset et al., 2001); whether this applies to other breeds such as the Merino has not been established. A major benefit of worm-resistant sheep is the significant reduction in pasture contamination with worm larvae, and hence reduced worm burdens (Bisset and Morris, 1996).

Breeding for resilience against the effects of worm infestation (worm tolerance) has been suggested as an alternative to breeding for resistance to worm infection (Bisset and Morris, 1996). Although early investigations indicated a lower heritability for resilience than for worm resistance,

recent evidence suggests that the heritability of these two traits is similar when sheep are exposed to a significant nematode challenge (Bisset et al., 2001). Results from field experiments in New Zealand have shown that sheep selected for resilience have superior weight gains, require less frequent drenching and exhibit a decreased incidence of scouring (Bisset et al., 2001).

As with other strategies for sustainable use of anthelmintics, genetic solutions have a potential cost. While there is a long-term benefit from lower pasture contamination, several generations—and time—are needed to achieve a useful reduction in the count of worm eggs. It can be argued that because production is not increased in worm resistant sheep, some high-producing rams that are worm-susceptible must be culled during the selection process. When low susceptibility to scouring induced by *Ostertagia* and *Trichostrongylus* is incorporated as an additional index, progress will be slower. In the case of *H. contortus*, the close relationship between egg count and the effects of worm infestation presumably allows genetic progress to be made using a single selection index. The alternative genetic approach of selecting for resilience also has potential disadvantages: although production is maintained or increased, worm burden and larval contamination of pasture are not reduced, because of the poor relationship between resilience and egg counts for species other than *H. contortus* (Bisset and Morris, 1996).

Nutritional approaches

There is abundant evidence that the expression of resistance to worms can be increased by supplementation when the basal diet is deficient in protein (Steel, 2003; Kahn, 2003). The pathophysiological consequences of gastrointestinal parasites, including inappetence, reduced efficiency of feed utilisation and increased loss of endogenous protein, are more severe in animals fed at a low plane of nutrition, and protein supplementation can increase the rate of development of immune competence (Coop and Kyriazakis, 1999). Increased resilience to worms of sheep fed at levels above maintenance was demonstrated by Liu et al. (2005a) using pen trials and by recent Sheep CRC research at several sites throughout Australia (B. Besier, M. Knox, I. Carmichael, J. Steel; pers. com.).

Further investigations into the relative benefits of supplementing to enhance immunity against worms and to develop easily applied, cost-effective supplementation strategies are required. Additional basic research is required to determine whether supplementation with nutrients critical for maximum expression of immunity is feasible (Liu et al., 2005b).

Is sustainability compatible with effective worm control?

In practice, the acceptability to sheep producers of real or potential production losses associated with sustainable worm control will be dictated by factors such as the aim of the enterprise, class of sheep and the potential for worm infestation. One approach is to consider worm populations on a property-wide basis with the aim of preventing an increase in anthelmintic resistance while allocating different priorities for worm containment or sustainability of worm control to different flocks or environments.

Some principles of this approach include:

- In sheep at risk of developing severe problems from worm infestation, worm control should take precedence over sustainability. Such instances include young sheep with signs of worm infections, sheep in particularly poor body condition and situations in which *H. contortus* is an immediate threat.
- In systems where any reduction in sheep performance is undesirable (e.g., prime lamb production systems), maximum worm control should take precedence.
- In sheep that are able to tolerate worm burdens (e.g., mature sheep and sheep in good body condition), worm control may be reduced to a level below the maximum to provide refugia

for non-resistant worms.

- In environments that are especially favourable for worms (e.g., in cool temperate climates and tropical climates), effective worm control will usually be the primary concern, but adequate dilution of surviving anthelmintic-resistant worm populations must be ensured.
- In environments that promote anthelmintic resistance because of seasonal or management factors, sustainability strategies are critical, and some production loss may be necessary to achieve this.

As the practice of allocating different treatment regimens to various flocks results in differences in levels of anthelmintic resistance, transfers of flocks to various paddocks must be planned to ensure that worm populations are mixed in such a way that populations of anthelmintic-resistant worms are diluted.

Prime lambs

Any impediment to the rapid growth of prime lambs is undesirable. There is evidence that worm control is sub-optimal on many properties (Besier et al., 2004), occasionally resulting in disastrous losses (Carmichael et al., 2005). Worm management should involve preparation of pastures with low worm populations for pregnant ewes in order to avoid exposing newly-born lambs to excessive worm burdens. More frequent drenching of ewes and lambs than is recommended for general practice may be necessary. Ewes and their lambs may be relocated to worm-safe pastures after drenching, as there is less need to ensure adequate immune stimulation for the lambs. However, it must be recognised that the higher level of worm control will also promote the development of anthelmintic-resistant worms, and although resistant worms are removed from the property when lambs are marketed, the risk to other sheep from anthelmintic-resistant larvae that remain in the paddocks must be considered. The resilience (tolerance) of prime lambs to infection is likely to be strong as they would rarely suffer from undernutrition, but lambs drafted out for slow weight gain may justify better worm control. Furthermore, there may be a greater benefit in breeding for resilience by prime lambs to the effects of worms than for worm resistance, as their chief need is to tolerate the effects of worms, regardless of the extent of worm burdens.

Wool-enterprise lambs

It is also important that lambs intended for wool production or for replacement of breeding ewes are protected from excessive worm intake during the first year of life, when they are most susceptible to worms. These sheep require some contact with worms to stimulate immune development, and optimal nutrition is essential to maintain resilience in the face of infection. Strategic drenches without measures to establish refugia are recommended. Worm egg counts should be monitored more frequently than for mature sheep. A targeted treatment approach to drenching individual sheep may be feasible once worm resistance has been attained (Besier, 2004). A low plane of nutrition at this age will have more impact on worm tolerance than in older sheep. Selection of rams for worm resistance (or resilience, if applicable) is usually conducted at this age.

Breeding ewes

From immediately before lambing until weaning, ewes exhibit less resistance to worms and their effects, and worm egg production increases significantly (Kahn, 2003). Management of worm burdens during this period is important for the health of ewes and lambs. Although pre-lambing drenching and the use of worm-safe pastures may be necessary, the effects of these practices on the size and anthelmintic-resistance status of future worm populations should be countered by ensuring

that such sheep subsequently graze pastures that have been managed in such a way that their worm populations include non-resistant worms.

Dry ewes and wethers

The inherently strong worm resilience of mature wethers and ewes that are not in the reproductive phase offer the best prospects for the safe provision of refugia. It is possible to achieve optimal sheep production using a targeted treatment approach. Although these classes of sheep are more tolerant to low planes of nutrition than immature sheep, poor nutrition is often responsible for high worm egg counts and problems related to worms in this age group. Consequently, additional drenching is necessary. Because scouring due to larval hypersensitivity is a significant problem, selection of worm-resistant rams should be based on worm egg counts as well as a low propensity to scour.

Conclusions

The prevention of increased anthelmintic resistance involves more than simply reducing the frequency of drenching, as worm populations in the sheep and on the pasture must both be considered. That the most effective and practical strategies differ according to the age of sheep and the type of enterprise, increases the complexity of this task. However, with the appropriate information, differential management of flocks and individual sheep can reduce whole-farm selection pressure for anthelmintic resistance. Future research should take cognisance of differences between meat and wool enterprises in worm-control priorities and strategies for avoiding the development of anthelmintic-resistant worms, and ensure that strategies to achieve effective and sustainable worm management are integrated at a whole-farm level.

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