NEW APPROACHES TO SHEEP PARASITE CONTROL - THE POTENTIAL FOR INDIVIDUAL SHEEP MANAGEMENT

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SUMMARY
Sheep worm control has become significantly less effective throughout Australia due to the increasing severity of anthelmintic resistance. Integrated parasite management recommendations aim to minimise the need for drenching, through the use of new management programs and non-chemical worm control such as breeding worm resistant sheep. New approaches through the Australian Sheep Industry Cooperative Research Centre include novel tests for worm burdens, biological control methods, and nutritional strategies to maximise the immune response. In the shorter term, an effective strategy to reduce the development of resistance is to ensure the survival of a worm population not exposed to drenches, so that resistant worms are diluted and do not increase at an unmanageable rate. The marked variation between and within flocks in the size of worm burdens, and the tolerance of their effects, provides an opportunity to selectively target anthelmintic treatments, hence reducing the selection pressure for resistance of worms to anthelmintics. The efficiency of individual sheep and flock management will be enhanced by the use of electronic sheep identification and measurement.

Keywords: sheep nematodes, worms, anthelmintic resistance, electronic identification

INTRODUCTION
Lost productivity due to parasitic infections, and the associated costs of control, is generally regarded as the most economically important sheep health problem in Australia. Ineffective worm control commonly causes sheep mortalities, increased production losses, and the need for more frequent treatments. The annual loss to the sheep industries with current control methods, but without considering the effects of anthelmintic (drench) resistance, has been estimated at over $220 million annually (McLeod 1995).

Effective sheep worm control in Australia is threatened by widespread and increasing levels of drench resistance. On many properties, the older drench groups, the benzimidazoles and levamisole, are almost completely ineffective, and have a role only where used in various combinations (Besier and Love 2003). Critically, resistance to the only remaining drench group, the macrocyclic lactones, is common in brown stomach worm (*Ostertagia circumcincta*) in Western Australia (Palmer *et al.* 2000), and in Barbers Pole worm (*Haemonchus contortus*) in northern New South Wales (Love 2002). No new drench types are expected to reach the market in the near future, and moves towards breeding worm resistant sheep are a longer term solution. In this light, a forecast in 2000 suggested that due to anthelmintic resistance, the loss from worm infections could reach $700 million within 10 years (Welsman 2001). Clearly, the further development of technologies and strategies that minimise the reliance on chemical control is essential.

THE NEED FOR NEW APPROACHES TO WORM CONTROL
Efficient sheep worm control is at present based largely on strategic or pre-emptive treatment programs, that depend on drenching at specified times of the year. By removing worm burdens at critical times when worm larval populations on pasture are low, subsequent worm burdens remain relatively small, hence maximising sheep production and decreasing the need for frequent drenching. Examples of effective strategic programs include summer drenching in winter rainfall regions (Anderson 1972), and the Wormkill program directed mainly against *Haemonchus* in northern NSW (Dash 1986).

However, the effectiveness of strategic programs depends on highly efficient anthelmintic treatments. Failure to eliminate almost all parasites at critical times allows pasture contamination with worm eggs to continue, and hence the development of excessive worm populations later in the year. The impact of anthelmintic resistance on control programs was clearly illustrated in an experiment investigating the effects of anthelmintic resistance in Western Australia, where sheep were given routine summer drenching treatments with anthelmintics of different effectiveness. Sheep drenched with a compound of only 65% effectiveness suffered severe clinical parasitism in the following winter, and an annualised production loss of over 10%, compared with sheep treated with a fully-effective anthelmintic (Besier *et al.* 1996). With the high prevalence of anthelmintic resistance, and routine use of similar strategic programs, losses of this level are likely to be common across Australia.

Recent research has confirmed that some widely-used strategic programs can themselves be a major cause of drench resistance. Resistant worms inevitably remain after all drench treatments, but their relative proportions in subsequent worm populations vary according to the degree of dilution with non-resistant worms. Where few larvae are available on pasture to provide this dilution, the resistant worms are the main source of future populations, hence increasing the total level of resistance. Field investigations in Western Australia have confirmed this risk in regard to the summer drenching strategy. Resistance in *Ostertagia* to ivermectin increased significantly over pre-treatment levels in a flock where all lambs were drenched as they moved to a worm free pasture (crop residue) during summer, whereas resistance levels did not change in a flock in which some lambs were left untreated to allow some non-resistant worms to remain (Besier 1999, 2001).

These trials confirmed that in situations where few non-resistant worms survive *in refugia* (ie, not exposed to drenches), such as under harsh environmental conditions or where worm-safe pastures have been prepared, there is a real risk of accelerated resistance development (Besier 1996; Barger 1999; van Wyk 2001). Although this potential will be relatively lower in more temperate environments where worm larvae survive on pasture year-round (Besier 1996), the intensity of infection in these situations is typically greater, leading to an increased frequency of treatment, with an increased risk of promoting resistance. Recommendations for the use of strategic programs require revision, according to the relative risks in specific situations.

NEW APPROACHES TO COMBATTING ANTHELMINTIC RESISTANCE

Recommendations for sheep worm control have long focused on strategies to minimise the frequency of drenching, and more recently on the need to avoid treatment during periods with a high risk of promoting resistance (Besier and Love 2003). Integrated parasite management approaches, that include monitoring of worm burdens, sheep nutrition, pasture management to reduce larval intake, and breeding for worm resistance, are expected to be more sustainable in the longer term than current approaches. New research to further minimise the requirement for anthelmintics includes improved tests for worm burdens, biological control, and enhanced nutritional regimes to optimise immunity to parasites.

However, a more immediate impact on the development of resistance is essential, especially where the risk is highest. A strategy under development is to provide sufficient dilution of resistant worms after treatment with worms not exposed to drenches so that the frequency of resistant parasites in local populations does not increase at an unmanageable rate. The recognition of differences between flocks and between individual sheep in the size and effects of worm burdens provides an opportunity to develop novel management strategies to assist with sustainable parasite control.

INDIVIDUAL ANIMAL AND FLOCK MANAGEMENT STRATEGIES

Between-sheep differences in response to worm infections

There is a marked variation between individual sheep in the response to parasites, based on genetically determined (ie, hereditable) immune effects on:

- resistance to worm infection (ability to limit the size of worm burdens), and
- resilience to worm burdens (the ability to tolerate worms with minimal adverse effect).

These characters are related but not identical (ie, some sheep may have high worm egg counts but not exhibit parasitism), and typically follow a skewed distribution, with a relatively low proportion of a flock developing high worm burdens or showing extreme susceptibility (Barger 1985). This suggests that in many instances, treatment is justified in only a part of a flock, offering the potential to target treatments more specifically, and hence minimise the total flock exposure to anthelmintics. The concept of leaving some animals untreated represents a paradigm shift in the approach to worm control, and requires development within the context of a defined annual strategy to ensure significant acceptance. However, experimental evidence provides a strong basis for some new approaches.

Modified treatment strategies to maintain non-resistant worms in refugia

The maintenance of worm populations *in refugia* (not exposed to anthelmintics) is the central tenet of modifications to the summer drenching program, now under test in Western Australia. The recommended tactic is to leave some sheep undrenched, as whole or part flocks, when routine strategic treatments are given, to reduce the intensity of selection for drench resistance in environments where there is a high risk it will occur.

However, it is critical to identify the sheep and flocks in which treatment may safely be avoided. The research which confirmed the risk of summer drenching in Western Australia also showed that if even a small mean flock worm egg count remained after part of a lamb flock was not summer-drenched, the resulting pasture contamination with worm larvae in autumn led to flock-wide parasitic problems in the following winter (Besier 1999). The undrenched individuals (heavier lambs) were themselves less affected than many of the lighter sheep, and it would be expected that adult sheep are more tolerant again to worm infections, and are hence a better prospect for leaving untreated. However, the basis for a decision on individual treatment has not yet been established.

The new strategies under development (Besier 2001) rely on an early summer assessment of worm egg counts as the basis for a decision on the risk of leaving sheep undrenched. Findings indicate:

- Weaned lambs: in 75% of 27 flocks monitored in 2002, mean worm egg counts were above the critical value used to justify a summer drench (R.Woodgate *pers. com.*). The opportunity to provide worm *refugia* within these flocks may be to leave a small number of more robust individuals undrenched, rather than entire flocks. As it is essential to maximise the growth of young sheep, careful monitoring of worm egg counts of these flocks in winter also remains essential.
- Adult sheep: pre-summer worm burdens are typically low in grown sheep in good nutritional condition, and 75% of 58 monitored flocks did not require treatment in summer (R.Woodgate *pers. com.*). Leaving all animals in such flocks undrenched in summer has proven feasible in these demonstrations, and although whole-flock treatment has often been necessary in late autumn or winter, this is acceptable as the desired effect of contaminating pastures with worms not exposed to resistance selection during summer has been achieved.

Further investigations will refine the interactions between worm egg counts, sheep weights, ages and condition score, to develop a relative resilience index to indicate the potential for whole flocks or individual sheep to provide a source of non-resistant worms *in refugia*.

Targeted treatment against clinical parasitic effects

Opportunities to reduce the selection pressure for anthelmintic resistance also exist for tactical treatments, when there is a need for immediate treatment due to obvious parasitism or high worm egg counts. However, in these situations, a significant proportion of the flock often remains unaffected, and is not likely to benefit from treatment. Research in South Africa has shown that the Famacha visual index of anaemia due to Barbers Pole worm disease has allowed a major reduction in the number of animals treated (van Wyk 2001). In addition to the reduction of the selection pressure for anthelmintic resistance, and of treatment costs, animals requiring multiple treatments can be culled as genetically unsuited to the local environment. In Australia, labour costs may prevent the adoption of this system, but for the scour worms at least, indices based on weight changes, condition score and signs of scouring are likely to indicate individual sheep that require treatment. Rapid assessment of weight changes by electronic drafting would further refine the efficiency of selecting affected sheep, and repeated identification of susceptible animals could form the basis of a culling index.

Targeted nutritional strategies

There is clear evidence that nutritional inadequacies, especially of protein, can reduce the rate of acquisition and subsequent expression of immunocompetence against parasitic infection (Coop and Holmes 1996). Positive long-term benefits of the short-term provision of protein-enriched diets on resistance to nematodes, and on production performance, in sheep have been demonstrated (Datta *et al.* 1999; Kahn *et al.* 2001). The enhancement of parasite resistance and resilience through supplementation regimes tailored to different environments and sheep of varying immunological status would be a major element in integrated parasite management.

Sheep likely to benefit from targeted nutritional enhancement include lambs as they are undergoing the development of an immune response, and ewes during early lactation, when immunological competence is temporarily suspended. However, significant variation between individual sheep and flocks in the response to nutritional supplements is expected, depending on the stage of growth, existing nutritional supply, and their relative resilience to infection. Research in progress aims to assess readily-measured performance indices, such as weight gain over a short period, as indicators for the efficient targeting of feed supplements. The rapid identification of susceptible individuals by weight assessment at intervals and drafting into separate feeding groups will be facilitated by the use of electronic identification technology. Research in progress aims to concurrently develop worm management and sheep production strategies, providing integrated nutritional recommendations.

Identifying sheep with high worm burdens

A major thrust of the Australian Sheep Industry CRC research is the development of improved and novel worm detection tests, to provide more accurate, rapid and specific quantification of worm burdens. A potential additional feature would be the ability to conduct tests on-farm, further facilitating treatment decisions. Should on-farm individual-sheep tests prove viable, it may be feasible to monitor sheep prior to decisions on immediate treatment, culling, or separate management. Repeated measures could provide an indication of the susceptibility of individual sheep to worms, and in the absence of progeny measurements, could be used in conjunction with growth performance data to identify sheep for breeding programs to enhance worm resistance or resilience.

CONCLUSION

The potential for the management of sheep on an individual basis offers exciting new prospects for efficient and sustainable worm control, especially through the identification of sheep that may safely be left untreated, or are most likely to benefit from drenching or nutritional supplementation. If the potential for the rapid, on-farm assessment of worm burdens is realised, the power of individual sheep management to reduce the development of drench resistance, decrease the costs of treatments, and offer access to minimum-chemical markets, will be further enhanced. Electronic sheep identification would facilitate the selection and management of sheep for this purpose.

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