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Application of a body condition score index for targeted selective treatment in adult Merino sheep—A modelling study

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ABSTRACT

This study aimed to establish whether sheep flock production losses due to nematode (worm) infections are typically greater in mature sheep selected for anthelmintic treatment at random compared to sheep selected for treatment based on low (poorer) body condition score (BCS). The study also examined the proportion of sheep in flocks that could be left untreated before production losses became evident, and projected worm egg pasture contamination. Sheep were monitored at two experimental sites in Western Australia (Mediterranean climate). Sheep were stratified for BCS, liveweight and faecal worm egg count (WEC) and allocated into treatment groups (treated or untreated), with equal numbers for each. Liveweight, BCS and WEC measurements were taken on 6 occasions at Farm A and 10 occasions at Farm B. Comparisons of sheep production (liveweight and BCS change) and pasture contamination potential (WEC) were conducted by generating “virtual flocks” of varying proportions sheep untreated (10%, 20%, 30%, 40%, and 50% untreated). For the comparison of the selection mode of sheep for treatment, the untreated sheep were either selected at random, or as the highest BCS animals at the commencement of observations. Univariate general linear models with least square difference post-hoc tests were used to examine differences between flocks for liveweight, BCS and WEC, and regression analysis was used to examine relationships between BCS and WEC, and liveweight and WEC. No difference in body weights was observed between flocks with varying proportions of ewes notionally left untreated at Farm B, and until more than 30% were left untreated at Farm A. There was no difference in BCS between flocks with varying proportions of ewes left untreated at either site. At no point were there differences in cumulative liveweight change or BCS between selection methods (BCS versus random) where the same proportion of sheep in virtual flocks were left untreated, suggesting that effort committed to individual BCS assessment would be of no benefit under these circumstances except for identifying low BCS sheep at risk of falling below critical limits associated with health or welfare risks. No consistent relationship between WEC and BCS or bodyweight was observed, indicating that BCS selection would have no lesser or greater impact on worm pasture contamination compared to random selection. Summer treatments based on a random selection index (with a minimum BCS limit), with up to 30% of adult sheep untreated can be expected to delay the development of anthelmintic resistance, with minimal adverse effect on sheep health or production.

1. Introduction

The effectiveness of ruminant nematode control is increasingly compromised due to widespread resistance to anthelmintics worldwide (Wolstenholme et al., 2004; Kaplan and Vidyshankar, 2012). Anthelmintic resistance has been a significant problem in Australia for many years (Besier and Love, 2003), and in Western Australia the predominant ovine gastrointestinal nematodes (*Trichostrongylus* spp. and *Teladorsagia circumcincta*) have become increasingly difficult to effectively control. Resistance to the benzimidazoles and levamisole anthelmintics in several nematode genera is widespread, and macrocyclic lactone resistance in *T. cir-*

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cumcincta is present on the majority of sheep properties (Playford et al., 2014).

The concept of 'refugia' has been the focus of considerable research into sustainable control strategies that aim to minimise the development of anthelmintic resistance by allowing a proportion of the worm population to escape treatment, and so ensure the survival of sufficient nematodes of susceptible genotypes to dilute the resistant individuals surviving treatment (Van Wyk, 2001; Jackson et al., 2009; Leathwick et al., 2009; Leathwick and Besier, 2014). One refugia-based strategy under development is Targeted Selective Treatment (TST) which restricts anthelmintic treatment either to the animals judged most likely to suffer significant production loss or health effects if not treated, while leaving others in the group unexposed to anthelmintics (Van Wyk and Bath, 2002; Kenyon et al., 2009; Leathwick et al., 2009; Besier, 2012). Recent investigations into the TST concept for non-haematophagous nematodes in small ruminants have considered animal production traits, such as body condition score (BCS) and body weight, as indicators of which individuals in a flock are likely to benefit from anthelmintic treatments (Hoste et al., 2002; Leathwick et al., 2006; Cringoli et al., 2009; Greer et al., 2009; Stafford et al., 2009; Gaba et al., 2010; Cornelius et al., 2014).

In Australia, TST investigations have centred on the use of easily-applied criteria to indicate those sheep in large flocks which can be left untreated when anthelmintics are given, especially the use of BCS (Besier et al., 2010). Recent investigations in Western Australia demonstrated that mature sheep (ewes) in the lowest BCS showed a greater BCS response to treatment than their higher BCS counterparts where nutrition was low and worm burdens high (Cornelius et al., 2014). The study by Cornelius et al. (2014) confirmed that BCS provides a simple (but effective) index for TST decisions and suggested a benefit in committing the effort required to select sheep on this criterion, as opposed to simple random selection, to minimise the possibility that some sheep in low BCS may escape treatment and suffer adverse consequences. Furthermore, Cornelius et al. (2014) also indicated that selecting sheep for treatment on the basis of high faecal worm egg count (WEC) was not an appropriate index, as there was no consistent relationship between egg counts and production-based indices.

This study aimed to investigate the production and refugia consequences of using BCS as a treatment selection criteria in situations where non-haematophagous worm species (*Trichostrongylus* spp. and *T. circumcincta*) dominate and adult sheep carry worm burdens typically associated with sub-clinical parasitism. Three questions about use of BCS as a treatment selection index and TST worm control programmes were addressed. Firstly, are production losses due to parasitism (worms) in a mature sheep flock likely to be greater if the sheep are selected for treatment at random (no selection index) rather than based on low body condition score? Secondly, what notional proportion of these flocks could be left untreated before production losses become evident, and would these production losses differ in comparison to treating all animals in the flock? Finally, what are the consequences for worm egg pasture contamination in flocks where a proportion of animals are not treated, in recognition of the epidemiological effects of allowing continued worm egg excretion after flock treatment?

2. Materials and methods

The experiment was conducted according to the guidelines of the Australian Code of Practice for the Use of Animals for Scientific Purposes, with approval from the Animal Ethics Committees of both the Department of Agriculture and Food Western Australia, and Murdoch University.

2.1. Experimental sites

Two experimental sites were used: a commercial farming property (Farm A) located near Woodanilling, approximately 265 km southeast of Perth, Western Australia (August 2011–March 2012), and a research station (Farm B) near Mt Barker, approximately 370 km southeast of Perth (July 2011–May 2012). The region has a Mediterranean climate characterised by hot, dry summers and cool, wet winters, with a mean annual rainfalls of 460 mm and 730 mm for Woodanilling and Mt Barker, respectively.

2.2. Experimental design and animal management

Approximately 267 Merino wethers aged 3 years were selected at Farm A and 205 Merino ewes aged 3 years and over at Farm B. Sheep were individually identified with radio-frequency identification ear tags. Sheep were stratified for BCS, liveweight and WEC at the initial sampling occasion (Table 1) and allocated into treatment groups (treated or untreated), with equal numbers for each. The mean measurements at the initial sampling (Table 1) were BCS 2.3, liveweight 40 kg and WEC 85 eggs per gram (epg) for Farm A and BCS 2.5, liveweight 51 kg and WEC 91 epg for Farm B. There was no significant difference in BCS, liveweight or WEC between treatment groups at the start of the study for either site.

The ewes at Farm B commenced lambing in June 2011 (four weeks prior to the experiment start date) and had lambs at foot when the experiment commenced (Table 1). Lambs were weaned in October 2011.

Sheep were grazed as a single group at each site in paddocks with pastures predominantly of annual rye-grass (*Lolium* spp.), subterranean clover (*Trifolium subterraneum*) and capeweed (*Arcotheca calendula*).

2.3. Anthelmintic treatments

Sheep in the treated group were treated at each visit (i.e. at approximately monthly intervals; Table 1) with long-acting moxidectin at 1 mg/kg of liveweight (Cydectin LA^{TM}, Virbac Australia). This interval was used to ensure continuous activity against all major nematode species, especially as a degree of macrocyclic lactone resistance was present on both farms. Sheep in the untreated group received no treatment.

2.4. Measurements

Sheep were weighed, assessed for BCS and faecal samples collected on five occasions at Farm A and nine occasions at Farm B after the initial sampling and treatment days (Table 1). Only five of the nine sampling occasions at Farm B were used in the analyses (Table 1) due to very low WECs in the untreated sheep from September to December. Body condition was measured using a BCS scale of one (thin) to five (fat) assessed by palpation of the lumbar vertebrae by a single experienced operator (Jefferies, 1961; Thompson and Meyer, 1994). Faecal samples were collected directly from the rectum of all sheep at each sampling occasion and WEC performed using a modified McMaster technique whereby 2 g of faeces were used from each sample and each egg counted represented 50 epg of faeces (Hutchinson, 2009). The genera of trichostrongylid nematodes present was determined using larval culture and differentiation performed on pooled faecal samples (Lyndal-Murphy, 1993; Hutchinson, 2009).