
VOLUME 62 2002

Suitability of the Happy Factor decision support model as part of targeted selective anthelmintic treatment in Coopworth sheep

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ABSTRACT

The suitability of the Happy Factor decision support model as the determinant of a targeted selective treatment regime incorporated into an automated weighing and drafting facility was evaluated in a Canterbury environment. One hundred and twenty, six-month-old Coopworth lambs naturally infected with gastrointestinal parasites were weighed and faecal sampled every two weeks for eight weeks. Individual performance targets during each two week period were calculated using the Happy Factor decision support model. Lambs that did not reach their performance target were automatically drafted out and subsequently treated with anthelmintic. Those deemed to benefit from treatment had significantly greater faecal egg count (FEC) than their untreated counterparts at Week 4 only, were lighter on Weeks 2 and 8, but had lower liveweight gains on all four occasions. Overall, the system provided a rapid and reliable method of identifying and separating poorer performing individuals, which were not necessarily those with a high FEC or those that were lighter. Furthermore, the optimum treatment threshold was determined to be 0.74, which is greater than previously published values of 0.66 for Scottish Blackface sheep. This suggests that validation of an optimum Happy Factor treatment threshold for each environment and/or animal genotype may be required.

Keywords: targeted selective treatment; anthelmintic resistance; gastrointestinal parasites.

INTRODUCTION

The recent focus of strategies to slow anthelmintic resistance development in gastrointestinal parasites has centred on managing the parasite population that are not exposed to the drug, that is, in refugia (Kenyon *et al*., 2009). One such strategy involves targeted selective treatments. These are part-flock treatments targeted to those lambs most likely to benefit, thus reducing both anthelmintic usage and the selection pressure applied for anthelmintic resistance. With the utilisation of electronic individual animal identification and automated weighing and drafting systems, it is envisaged that a practical method of applying a performance-based targeted selective treatment program on New Zealand farms can be developed. Recent studies under Scottish field conditions demonstrated the benefits of the Happy Factor decision support model to identify individual lambs likely to benefit from anthelmintic treatment (Greer *et al*., 2009). This approach led to the halving of anthelmintic usage compared with monthly treatment of their counterparts and preserved anthelmintic efficacy whilst maintaining production. However, despite the decision support model taking into account some of the environmental influences on animal production, such as herbage availability, quality and climate, it may be that an acceptable level of performance is also influenced by local variations in the environment and/or the lambs own genetic potential for growth. Here we evaluate the suitability of the Happy Factor decision support model when incorporated into an automated weighing and drafting system to provide a practical targeted selective treatment option for New Zealand farmers, and also validate an optimum treatment threshold for Coopworth sheep in a Canterbury environment.

MATERIALS AND METHODS

Decision support model

Full details of the decision support model used in the current study have been previously described by Greer *et al*. (2009). Briefly, the model calculates the efficiency of energy utilisation of a grazing animal by comparing an estimate of the amount of net energy deposited in the carcass with a theoretical maximum amount of net energy potentially available for growth, if feed intake and/or nutrient utilisation are not adversely influenced by parasitism. The proportion of the total net energy that is potentially available for growth and yet not deposited as net energy in the carcass represents the inefficiency of energy utilisation. An efficiency of energy utilisation is then calculated as 1, less this inefficiency. This is then adjusted for environmental conditions such as temperature and herbage availability to give a Happy Factor value. Target liveweight gain (LWG) for each sheep during each period was calculated after re-arranging the equations using a Happy Factor value of 0.66. This was previously determined to be the optimum treatment threshold for Scottish Blackface sheep in a Scottish grazing environment (Greer *et al*., 2009). The calculated LWG was then added to the previous live weight (LW) to give a target LW for each sheep at each assessment time.

Lambs and treatments

One hundred and twenty, six-month-old Coopworth lambs, that had been reared together under normal commercial conditions at the Lincoln University, Ashley Dene Research Farm, were used. They were naturally infected with gastrointestinal parasites, fitted with electronic radio-frequency identification ear tags (Allflex, New Zealand) and grazed on ryegrass pastures for ten weeks. The lambs were weighed every two weeks. At each weighing, faecal samples were taken directly from the rectum of each lamb for the determination of the concentration of nematode eggs in the faeces (FEC) (eggs per g of faeces (epg)) (M.A.F.F., 1979). From Week 2 to Week 8, an assessment was made, on an individual animal basis, of the requirement for anthelmintic intervention based on the lamb's ability to achieve its target growth rate during the previous two weeks. The target LW for each animal was calculated following an assessment of herbage mass and quality, and uploaded onto a weigh head unit (XR3000, Tru-Test Ltd, New Zealand) attached to a three-way swing gate auto draft gate (Prattley Industries Ltd, Temuka, New Zealand) equipped with an electronic identification panel reader. Lambs that failed to reach their target LW were automatically separated using the auto-drafter and subsequently treated with a combination anthelmintic (Matrix, Ancare New Zealand Limited, Auckland, New Zealand) before being returned to grazing with the remainder of the mob. In addition, all lambs were treated with anthelmintic at Week 8 to provide data on the response to anthelmintic treatment for lambs that had achieved their target LW. This enabled a treatment response curve to be plotted.

Statistical analysis

The measurements taken at each sampling time were intended to provide an assessment of the lamb at the time of treatment decision, this was made independent of their previous treatment history. Therefore each sampling time was analysed as an independent event ignoring previous treatment history. FEC were $\log_{10}$ (n+1) transformed prior to analysis with the arithmetic mean and range reported. For each assessment time, lamb FEC, LW and LWG of lambs deemed to be in need of a treatment were compared with those remaining untreated using an unpaired two-sample *t*-test using GenStat (Payne *et al.,* 2009). Although all lambs were treated at Week 8, comparisons for Week 8 were made between those which would have otherwise been treated or remained untreated. A receiver operator characteristic analysis was performed and the area under the curve determined as the response to anthelmintic treatment relative to pre-treatment Happy Factor values using the web based program of Eng (2006). The area under the receiver operator characteristic curve provided a measure of accuracy of the discriminatory test with an area of 0.50 indicating no discrimination and an area of 1.0 indicating perfect discrimination between true positives and false positives (Swets, 1988). For receiver operator characteristic analysis, positive and negative responses were defined as respective increases or decreases in the Happy Factor value for the two-week period following anthelmintic treatment relative to the value at the time of treatment. The optimum threshold for treatment was calculated from the receiver operator characteristic curve data by selecting the index score that provided the maximum combined value of sensitivity plus specificity.

RESULTS

Performance of treated versus untreated lambs

Comparison of FEC post-treatment relative to FEC at the time of treatment revealed a >95% efficacy at all times (A.W. Greer, Unpublished data). Mean FEC, LW and LWG and the number of lambs that were identified as requiring anthelmintic as they had not reached their target LWG (treated) and those not deemed to be requiring anthelmintic that had reached their target LWG (untreated) at each of the four assessment times are given in Figure 1. Those that were treated had a greater mean FEC at the time of assessment at Week 4 only ($P = 0.046$). Treated lambs were lighter than their untreated counterparts at the time of assessment at Week 2 ($P < 0.001$), had similar LW's at Weeks 4 and 6 ($P > 0.05$ for both) and were lighter at Week 8 ($P = 0.002$). Mean LWG at the time of assessment for lambs that were treated were consistently less than their counterparts that remained untreated ($P < 0.001$ for all occasions).

Optimum treatment threshold

The response to anthelmintic treatment, as measured by the percentage increase in Happy Factor values in the two weeks post treatment relative to their values at the time of treatment, for all lambs that received an anthelmintic treatment during the study, is shown in Figure 2. Successful discrimination between true positives and false positives was indicated by an area under the receiver operator characteristic curve of 0.86. The optimum treatment threshold was determined to be at a Happy Factor value of 0.74, at which point treatment would include 85% of the true positives (sensitivity) and 72% of the true negatives (specificity).

FIGURE 1: (a) Arithmetic mean faecal egg count (FEC) expressed in eggs per g faeces (epg), (b) mean live weight (kg) at each assessment time and (c) mean liveweight gain (g/d) for the two-week period prior to assessment. Lambs that had achieved their target growth rate (untreated; shaded bars) and those that had not achieved their target growth rate (treated; open bars) to obtain a Happy Factor of 0.66. Statistical comparisons for FEC were performed on $\log_{10}$ transformed data. The error bars shown for FEC represent the upper and lower quartiles. Error bars for live weight and liveweight gain represent the standard error of the mean. * P <0.05, **P <0.01.

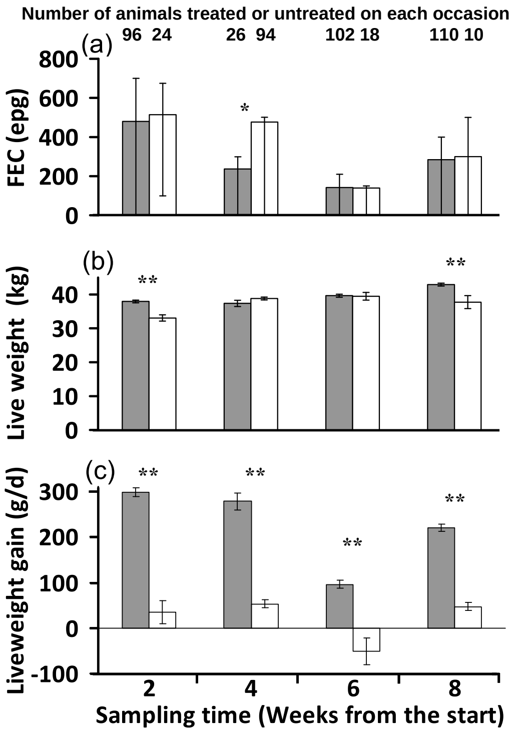
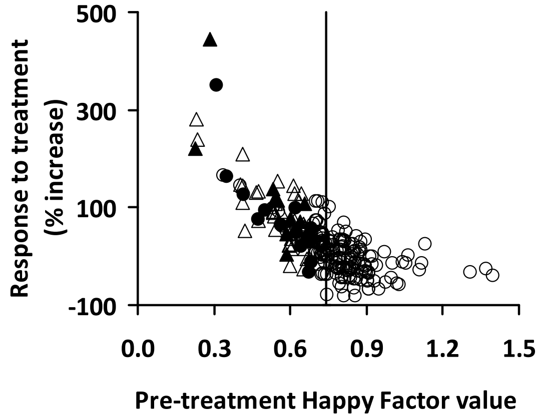


FIGURE 2: Response to anthelmintic treatment (% increase) in Happy Factor values in the two week period post-treatment relative to the Happy Factor value at the time of treatment for anthelmintic treatments administered at Week 2 (▲), Week 4 (△), Week 6 (●) and Week 8 (○). Each data point represents one animal at the time of treatment. The vertical line represents the optimum treatment threshold which was determined to be 0.74 at which point 85% of lambs treated would be expected to respond positively to treatment.



DISCUSSION

This study suggests an optimum treatment threshold or Happy Factor value of 0.74. This is greater than the 0.66 value previously reported by Greer *et al*. (2009) and presumably reflects either animal genotypic or environmental influences, such as disease/fungal challenge and vitamin and mineral imbalances, which favour animal performance in Coopworth sheep in a Canterbury environment compared with the Scottish Blackface sheep in a Scottish environment. To this end, the Happy Factor decision support model is a measure of ill-thrift and does not specifically detect losses in performance that are associated with parasitism. However, the application of a performance based system for a targeted selective treatment regime must take into account that parasitism is widely considered to be the most likely cause of ill-thrift in growing lambs (Litherland *et al*., 2004). This can be confirmed, or not, with continued monitoring following anthelmintic treatment. Furthermore, the fact that 85% of the lambs in the current study with a Happy Factor value of 0.74 or less at the time of anthelmintic treatment subsequently demonstrated a positive response to treatment, supports the conclusion that parasites were probably most likely responsible for the poor performance observed. Nevertheless, further validation of the optimum treatment threshold for individual environments and/or animal genotypes may be required in order to obtain a reliable balance between minimising anthelmintic inputs and maintaining adequate parasite control. This can be achieved simply through measuring the change in Happy Factor values following anthelmintic treatment in a cohort of lambs. Informed decisions on suitable treatment thresholds can then be made, taking into account the production goals and the risk of anthelmintic resistance development in that environment.

The incorporation of electronic identification technology with an automated drafting system, provided an important step in the development of a practical on-farm system for the targeted selective treatment of lambs. Overall, this combination of technologies worked well with lambs weighed rapidly, and those lambs which did not reach their target LWG efficiently and accurately separated from the remainder of the flock. These are aspects which are critical to the adoption of a performance-based targeted selective treatment on a commercial farm. Previous use of the decision support model to evaluate lambs requiring anthelmintic intervention in a Scottish field study, resulted in a halving of anthelmintic usage compared with a neo-suppressive monthly treatment regime with no loss in animal performance. In these groups the anthelmintic maintained its efficacy, while the efficacy of the monthly treated group declined to less than 80% (Greer *et al*., 2009). While the impact of this targeted selective treatment regime on anthelmintic efficacy was not evaluated in the current study, the successful incorporation of the decision support model with electronic identification and automated weighing and drafting technology leads the authors to believe that such systems may provide a practical and reliable method of implementing a performance based targeted selective treatment regime on New Zealand farms to assist in maintaining anthelmintic efficacy.

The ability to accurately determine which lambs in a flock are benefitting from anthelmintic treatment is crucial to the success of a targeted selective treatment anthelmintic regime. Of the parameters measured in the current study, only LWG consistently differed between those sheep requiring and not requiring treatment. While this may be expected, due to the nature of the decision support model calculations which are largely based on animal growth, treated lambs had a greater FEC on just one occasion and had a similar LW at two of the four assessment times. The lack of a consistent difference in FEC is similar to the observations of Stafford *et al.* (2009) who reported no difference in the FEC of lambs requiring and not requiring treatment using a combined assessment of visual condition, breech soiling and LWG. This presumably reflects either a poor relationship between FEC and worm burden and/or larval challenge which has been reported for some temperate parasite species (Jackson & Christie, 1979; Steel *et al.*, 1980; Symons *et al.*, 1981), or variations in the response of individual lambs to the parasite infection (Greer, 2008). Furthermore, the findings of the current study where treated lambs had a similar mean LW to their untreated counterparts on two of the four occasions, is consistent with the observations of Leathwick *et al.* (2006) who investigated leaving the 10% heaviest lambs untreated as a targeted selective treatment regime. These authors reported that on three out of five occasions those lambs remaining untreated had a reduced mean LWG in the following four weeks compared with their lighter counterparts that were treated. While this may not be surprising, as lamb LW is a measure of animal growth history, rather than just its current state, the current study confirms that the Happy Factor decision support model can identify underperforming individuals which may not necessarily be those which are lighter or have the highest FEC.

ACKNOWLEDGMENTS

The authors would like to thank Martin Ridgway, Nigel Jay, Colin Pettigrew and Anya Armstrong for their valued assistance during the collection of field data. This project was funded by the Building Research Capability in Strategically Relevant Areas Fund (BRCSRA).

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