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Software-based decision-support: a basis for the development of a predictive system for sustainable management of haemonchosis in small ruminants

By

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PROTOCOL APPROVAL

This study was approved as PROTOCOL V 023/05 by the Research Committee and the Animal Use and Care Committee of the University of Pretoria, under the Belgian Co-Operation Grant, Number AG 534.

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THESIS SUMMARY

Data generated by five years of FAMACHA© clinical evaluation trials on one farm, and two years of trials on a second farm in South Africa, where targeted selective treatment was applied to treat haemonchosis in sheep, was used as a basis to explore new computational epidemiological methods to analyse the results of the trials. The research flowed from the earlier work of Dr. J.A. van Wyk and co-workers at the Faculty of Veterinary Science, University of Pretoria, who did much to develop, introduce, and validate the FAMACHA© system in South Africa and elsewhere in the world.

Clinical haemonchosis was common during the summer rainfall season, and was found to increase in severity during January and February of each year. Sensitivity analysis of FAMACHA© data indicated that on the first farm (Farm 1) investigated, many of the animals that were clinically non-diseased were in fact anaemic, but due to misclassification, these animals were not detected. This was not the case on the second farm (Farm 2), where most animals that were clinically diseased according to FAMACHA© were found to be truly anaemic. The high prevalence of misclassification on Farm 1 has important implications for monitoring and chemotherapy of haemonchosis. The results indicated that under the conditions where the data were generated, the FAMACHA© system is sensitive enough, and adequately specific, to detect anaemic sheep despite misclassification.

The application of Receiver Operating Characteristic curve analysis to the FAMACHA© method to select FAMACHA© categories for treatment, was in agreement with the findings that misclassification on Farm 1 would of necessity require that different treatment thresholds would need to be implemented to achieve the same test sensitivity as on Farm 2. Although the use of the Receiver Operating Characteristic method requires the use of dedicated software to generate results, especially if large data sets are analysed, it was found to be an accurate and valid way of indicating FAMACHA© threshold categories for treatment on both farms, for a desired sensitivity.

A previously published multiple regression model was modified to incorporate stochasticity in the FAMACHA© proportions and the body mass of sheep, in order to simulate probable worm count. The fluctuations in simulated worm count adequately reflected the changing epidemiological situation of haemonchosis as indicated by temporal histograms of differential FAMACHA© proportions in flocks. The model was most sensitive to changes in

FAMACHA© proportions in the sample, followed by increasing variability in body mass as a worm season progressed. Furthermore, for a given class of animal, a range of probable haemoglobin values could be associated with a preselected threshold worm burden. The model was sensitive to blanket drenching events, as a lower intensity of infection was predicted immediately after blanket drenching in all samples. It followed that model indications could be used probabilistically, to indicate minimum haemoglobin levels that would need to be sustained in order to prevent overwhelming worm burdens in a given class of animal.

The penultimate chapter of the thesis is concerned with alternative methods of evaluation of rainfall as a risk factor for haemonchosis. Three different periods of rainfall, in relation to FAMACHA© sampling events, were evaluated in terms of entropy, or spread, and tested for strength of association with simulated flock haemoglobin values by regression analysis. Shannon's entropy was used as an indicator of rainfall variability. Findings indicated a negative, and significant, correlation between rainfall entropy and flock haemoglobin level. On the strength of the association, a simulation model was proposed, which could theoretically indicate a probable range for expected flock haemoglobin level in a subsequent two-week period following FAMACHA© evaluation, provided that rainfall entropy is known.

This work attempts to bridge the gap between implementation of the FAMACHA© system, and the investigation of several vital issues that would need to be addressed in the development of a wider ranging anthelmintic treatment decision-support system to delay anthelmintic resistance.

The application of important quantitative methods, such as two-graph Receiver Operating Characteristic analysis, Monte Carlo simulation, and Shannon's entropy to the FAMACHA© system, have provided new perspectives from which to develop an integrated computerized decision-support system. The thesis strongly supports the continued use of the FAMACHA© system in its present form, but the work has emphasised several key issues, such as misclassification, the need to develop decision-support systems that are useable in real time at farm level as opposed to regional level, and that the FAMACHA© system can and should be used as a basis for further development of decision-support software.