

# **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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# TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
TABLE OF CONTENTS.....	iii
PROTOCOL APPROVAL.....	vii
LIST OF FIGURES.....	viii
LIST OF TABLES.....	x
THESIS SUMMARY.....	xiv
CHAPTER 1 General introduction.....	1
1 Preamble.....	1
1.1 <i>Haemonchus contortus</i> : the parasite and its epidemiology.....	2
1.1.1 <i>Ecology and pathology of Haemonchus contortus</i> .....	3
1.2 Control of haemonchosis.....	4
1.2.1 <i>Chemical control</i> .....	4
1.2.2 <i>Biological control</i> .....	6
1.2.3 <i>Resistance management</i> .....	8
<i>Acquired immunity</i> .....	8
<i>Nutritional supplementation</i> .....	9
<i>Grazing management</i> .....	9
<i>Parasite community replacement</i> .....	10
<i>Selective breeding to withstand parasite challenge</i> .....	10
1.2.4 <i>The FAMACHA® system of selective treatment</i> .....	12
1.3. Scope of the study.....	13

<b>CHAPTER 2 Blueprint for a software-based decision-support system for countering anthelmintic resistance at farm level.....</b>	<b>19</b>
<b>2.1 Introduction.....</b>	<b>19</b>
<b>2.2 Refugia for sustainable worm management.....</b>	<b>21</b>
<b>2.3 Optimal application of targeted selected treatment is complex.....</b>	<b>22</b>
<b><i>2.3.1 Worm infection not “all or nothing”; worm burdens are important.....</i></b>	<b>22</b>
<b><i>2.3.2 Extension services progressively depleted.....</i></b>	<b>22</b>
<b>2.4 Can software-based decision-support offer a solution?.....</b>	<b>23</b>
<b>2.5 Factors to consider in an automated decision-support system.....</b>	<b>24</b>
<b><i>2.5.1 Farm location.....</i></b>	<b>27</b>
<b><i>2.5.2 Rainfall and other sources of moisture.....</i></b>	<b>28</b>
<b><i>2.5.3 Temperature.....</i></b>	<b>29</b>
<b><i>2.5.4 Animal hosts.....</i></b>	<b>29</b>
<i>Host species and breed.....</i>	29
<i>Host reproductive status.....</i>	29
<i>Host age.....</i>	30
<i>History of a given flock.....</i>	30
<i>Stud or commercial flock.....</i>	31
<b><i>2.5.5 Pastures.....</i></b>	<b>31</b>
<i>Number of paddocks.....</i>	31
<i>Pasture type - current paddock and planned movement to the next paddock.....</i>	32
<i>Pasture herbage species.....</i>	32
<i>Pasture grazing history.....</i>	33
<b><i>2.5.6 Worm species and anthelmintic resistance.....</i></b>	<b>33</b>
<b><i>2.5.7 Diagnostic methods.....</i></b>	<b>33</b>
<b><i>2.5.8 Anthelmintics to use or avoid.....</i></b>	<b>34</b>
<b><i>2.5.9 Treatment in relation to movement of animals to other pastures.....</i></b>	<b>35</b>

2.6 Modelling approach.....	35
2.6.1 Retrospective analysis of clinical evaluation data.....	35
2.6.2 Model framework.....	36
2.7 Effective technology transfer.....	37
2.7.1 Technology transfer previously ineffective.....	37
2.7.2 New approach required.....	38
2.8 Discussion.....	39
2.9 Conclusion.....	40
<b>CHAPTER 3 Validation of the FAMACHA<sup>®</sup> eye colour chart on two South African sheep farms under commercial farming conditions.....</b>	<b>41</b>
3.1 Introduction.....	41
3.2 Materials and methods.....	43
3.2.1 Origin of data and FAMACHA <sup>®</sup> test procedures.....	43
3.2.2 Statistical analysis.....	46
3.3 Results.....	47
3.4 Discussion.....	55
3.5 Conclusion.....	60
<b>CHAPTER 4 Use of receiver operating curves for selection of treatment thresholds using the FAMACHA<sup>®</sup> diagnostic system for anaemia in sheep naturally infected with <i>Haemonchus contortus</i>.....</b>	<b>62</b>
4.1 Introduction.....	62
4.2 Materials and methods.....	63
4.2.1 Origin of data and FAMACHA <sup>®</sup> test procedures.....	63
4.2.2 Receiver operating characteristic analysis.....	64
4.3 Results.....	64
4.4 Discussion.....	69



4.5 Conclusion.....	73
<b>CHAPTER 5 A stochastic model to estimate worm burdens and associated risk factors in sheep naturally infected with <i>Haemonchus contortus</i>.....</b>	<b>75</b>
5.1 Introduction.....	75
5.2 Materials and methods.....	76
5.2.1 <i>Origin of data and the model system</i> .....	76
5.2.2 <i>Statistical analysis</i> .....	77
5.3 Results.....	84
5.4 Discussion.....	88
5.4.1 <i>EWEREP class</i> .....	89
5.4.2 <i>RAMREP class</i> .....	91
5.5 Conclusion.....	97
<b>CHAPTER 6 Use of Shannon’s entropy to process rainfall data as a risk factor in sheep naturally infected with <i>Haemonchus contortus</i>.....</b>	<b>99</b>
6.1 Introduction.....	99
6.1.1 <i>Calculation of rainfall entropy</i> .....	100
6.1.2 <i>Probabilistic interpretation of rainfall</i> .....	101
6.2 Materials and methods.....	101
6.2.1 <i>Rainfall data</i> .....	101
6.2.2 <i>Sheep haemoglobin data</i> .....	102
6.3 Results.....	102
6.4 Discussion.....	103
6.5 Conclusion.....	107
<b>CHAPTER 7 General results and conclusion.....</b>	<b>108</b>
<b>REFERENCES.....</b>	<b>117</b>



# 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.

## LIST OF FIGURES

FIGURE 2.1	Schematic presentation of factors to consider in arriving at decisions, their interactions with one another, and the envisaged outputs, represented by the shaded circles (I) to (V) for <i>Haemonchus contortus</i> infection in sheep.....	27
FIGURE 2.2	Example of FAMACHA® results for eight evaluations over a <i>Haemonchus</i> season in South Africa for a group of 130 ewes. FAMACHA® category 5 not present.....	36
FIGURE 3.1	Map of South Africa indicating position of Farm 1 (red square) and Farm 2 (blue square). Refer to text for geographical co-ordinates.....	46
FIGURE 4.1a	Farm 1 Receiver Operating Characteristic curves. The area under the curve for a haematocrit cut-off of $\leq 22\%$ is 0.790, and for $\leq 19\%$ the area under the curve is 0.835.....	65
FIGURE 4.1b	Farm 2. Receiver Operating Characteristic curves. The area under the curve for a haematocrit cut-off of $\leq 22\%$ is 0.867, and for $\leq 19\%$ the area under the curve is 0.901.....	65
FIGURE 4.2a	Farm 1. Two-graph Receiver Operating Characteristic plot for a haematocrit cut-off of $\leq 22\%$ .....	66
FIGURE 4.2b	Farm 1. Two-graph Receiver Operating Characteristic plot for a haematocrit cut-off of $\leq 19\%$ .....	66
FIGURE 4.2c	Farm 2. Two-graph Receiver Operating Characteristic plot for a haematocrit cut-off of $\leq 22\%$ . FAMACHA® category 5 not represented.....	66
FIGURE 4.2d	Farm 2. Two-graph Receiver Operating Characteristic plot for a haematocrit cut-off of $\leq 19\%$ . FAMACHA® category 5 not represented.....	67
FIGURE 5.1	Cumulative distribution function for the body mass of a sample of 179 RAMREP sheep on Farm 1 for the 2000/2001 <i>Haemonchus</i> season. The stepped blue line represents the observed body mass values in the sample and the red line represents the @Risk fitted Normal (35.90,3.65) distribution.....	78

FIGURE 5.2	The Discrete distribution for the FAMACHA <sup>®</sup> variable for a EWEREP sample (n = 133). The mean haemoglobin value was 7.78 g/dl, and 90 % of the simulated haemoglobin values were between 5.26 and 10.02 g/dl.....	82
FIGURE 5.3	Schematic diagram of the model used to simulate mean worm count of sampled sheep. Fitted statistical distributions are given in bold italicized letters. Bold red arrows indicate Monte Carlo simulated outputs of the model.....	83
FIGURE 5.4a	EWEREP (n = 130). Model output for simulated worm count, 2001/2002 season. The black line represents the simulated mean worm count.....	85
FIGURE 5.4b	EWEREP: Proportional representation of the FAMACHA <sup>®</sup> categories per sample. Rainfall between sampling events is given in parentheses, in mm.....	85
FIGURE 5.5a	RAMREP (n = 120). Model output for simulated worm count, 2001/2002 season. The black line represents the simulated mean worm count.....	86
FIGURE 5.5b	RAMREP: Proportional representation of the FAMACHA <sup>®</sup> categories per sample. Rainfall between sampling events is given in parentheses, in mm.....	86
FIGURE 5.6a	Ascending cumulative output distribution for worm count for the EWEREP class, 7 January 2002.....	95
FIGURE 5.6b	Ascending cumulative output distribution for worm count for the RAMREP class, 7 January 2002.....	96
FIGURE 6.1	Farm 1. Mean sample haemoglobin level at different 14-day rainfall entropy values, as calculated by the Shannon entropy model. The regression equation is $y = -0.433(\text{entropy}) + 8.81$ .....	103
FIGURE 6.2	Cumulative distribution function for flock haemoglobin level (g/dl), for a maximum calculated rainfall entropy value ( $H'$ ) of 2.....	105
FIGURE 6.3	Farm 1. The relationship between rainfall entropy, number of rain days and total recorded rainfall for eight selected 30-day periods.....	106

## LIST OF TABLES

TABLE 1.1	Anthelmintic drug groups and their modes of action.....	5
TABLE 1.2	Summary of non-anthelmintic nematode control measures applied to small ruminants.....	12
TABLE 2.1	Worm populations found in a survey in Paraná State, in Brazil, to be less than 80 % susceptible to moxidectin drenched either alone or together with other compounds (After C.S. Sotomaior, personal communication 2006).....	20
TABLE 2.2	Information required for modelling with decision-support software for <i>Haemonchus contortus</i> infection.....	26
TABLE 3.1a	Farm 1. Haematocrit cut-off value is $\leq 22$ %. Results of two-way frequency tables of haematocrit by FAMACHA <sup>®</sup> score. Percentage of total is given in parentheses for sheep with assigned ranges in haematocrit values which are based on drenching of sheep with FAMACHA <sup>®</sup> scores of 3, 4 and 5.....	48
TABLE 3.1b	Farm 1. Haematocrit cut-off value is $\leq 19$ %. Results of two-way frequency tables of haematocrit by FAMACHA <sup>®</sup> score. Percentage of total is given in parentheses for sheep with assigned ranges in haematocrit values which are based on drenching of sheep with FAMACHA <sup>®</sup> scores of 3, 4 and 5.....	48
TABLE 3.1c	Farm 1. Haematocrit cut-off value is $\leq 15$ %. Results of two-way frequency tables of haematocrit by FAMACHA <sup>®</sup> score. Percentage of total is given in parentheses for sheep with assigned ranges in haematocrit values which are based on drenching of sheep with FAMACHA <sup>®</sup> scores of 3, 4 and 5.....	49
TABLE 3.2	Farm 1. Sensitivity (Se), specificity (Sp), positive predictive value (Pv+), negative predictive value (Pv-), and prevalence (P) for trial data for given haematocrit cut-off values and treatment of sheep in FAMACHA <sup>®</sup> categories 3–5. The value for prevalence was calculated from standard two-way frequency tables.....	49

TABLE 3.3a Farm 1. Haematocrit cut-off value is  $\leq 22$  %. Results of two-way frequency tables of haematocrit by FAMACHA<sup>®</sup> score. Percentage of total is given in parentheses for sheep with assigned ranges in haematocrit values which are based on drenching of sheep with FAMACHA<sup>®</sup> scores of 2, 3, 4 and 5.....50

TABLE 3.3b Farm 1. Haematocrit cut-off value is  $\leq 19$  %. Results of two-way frequency tables of haematocrit by FAMACHA<sup>®</sup> score. Percentage of total is given in parentheses for sheep with assigned ranges in haematocrit values which are based on drenching of sheep with FAMACHA<sup>®</sup> scores of 2, 3, 4 and 5.....50

TABLE 3.4 Farm 1. Sensitivity (Se), specificity, (Sp), positive predictive value (Pv+), negative predictive value (Pv-), and prevalence (P) for trial data for given haematocrit cut-off values and treatment of sheep in FAMACHA<sup>®</sup> categories 2–5. The value for prevalence was calculated from standard two-way frequency tables.....51

TABLE 3.5 Farm 1. FAMACHA<sup>®</sup> score vs. haematocrit assigned values, observed values and percentiles (n = 675).....51

TABLE 3.6 Farm 1. FAMACHA<sup>®</sup> categories, sample size, assigned haematocrit range and percentage of observed haematocrit values within the assigned range.....52

TABLE 3.7a Farm 2. Haematocrit cut-off value is  $\leq 22$  %. Results of two-way frequency tables of haematocrit by FAMACHA<sup>®</sup> score. Percentage of total is given in parentheses for rams with assigned ranges in haematocrit values which are based on drenching of sheep with a haematocrit of  $\leq 15$  %. FAMACHA<sup>®</sup> categories 1–2 were considered test negative.....53

TABLE 3.7b Farm 2. Haematocrit cut-off value is  $\leq 19$  %. Results of two-way frequency tables of haematocrit by FAMACHA<sup>®</sup> score. Percentage of total is given in parentheses for rams with assigned ranges in haematocrit values which are based on drenching of sheep with a haematocrit of  $\leq 15$  %. FAMACHA<sup>®</sup> categories 1–2 were considered test negative.....53

TABLE 3.8	Farm 2. Sensitivity (Se), specificity (Sp), predictive value of a positive (Pv+), predictive value of a negative (Pv-), and prevalence (P) for trial data for given haematocrit cut-off values and proposed treatment of sheep in FAMACHA <sup>®</sup> categories 3–5. The value for prevalence was calculated from standard two-way frequency tables. FAMACHA <sup>®</sup> categories 1–2 were considered test negative.....	54
TABLE 3.9	Farm 2. FAMACHA <sup>®</sup> score vs. haematocrit (rams: Farm 2): assigned values, observed values and percentiles (n = 806). FAMACHA <sup>®</sup> category 5 not represented.....	54
TABLE 3.10	Farm 2. FAMACHA <sup>®</sup> categories, sample size, assigned haematocrit range and percentage of observed haematocrit values within the assigned range for rams. FAMACHA <sup>®</sup> category 5 not represented.....	55
TABLE 4.1	Farm 1. Haematocrit cut-off is $\leq 22$ %. Results of the rating method for FAMACHA <sup>®</sup> cut point, sensitivity, specificity, percentage of sheep correctly classified and likelihood ratios (LR).....	67
TABLE 4.2	Farm 1. Haematocrit cut-off is $\leq 19$ %. Results of the rating method for FAMACHA <sup>®</sup> cut point, sensitivity, specificity, percentage of sheep correctly classified and likelihood ratios (LR).....	68
TABLE 4.3	Farm 1. Haematocrit cut-off, area under Receiver Operating Characteristic curve, standard error (SE) of area under the curve and confidence limits (CL) of the area under the curve.....	68
TABLE 4.4	Farm 2. Haematocrit cut-off is $\leq 22$ %. Results of the rating method for FAMACHA <sup>®</sup> cut point, sensitivity, specificity, percentage of sheep correctly classified and likelihood ratios (LR). FAMACHA <sup>®</sup> category 5 not represented.....	68
TABLE 4.5	Farm 2. Haematocrit cut-off is $\leq 19$ %. Results of the rating method for FAMACHA <sup>®</sup> cut point, sensitivity, specificity, percentage of sheep correctly classified and likelihood ratios (LR). FAMACHA <sup>®</sup> category 5 not represented.....	69

TABLE 4.6	Farm 2. Haematocrit cut-off, area under Receiver Operating Characteristic curve, standard error (SE) of the area under the curve and confidence limits (CL) of the area under the curve.....	69
TABLE 5.1	Farm 1. FAMACHA <sup>®</sup> score vs. haematocrit: assigned mean haematocrit values, fitted mean values, and percentiles and standard deviations of the fitted Normal distribution for haematocrits of 675 sheep of both sexes from 2000-2005.....	79
TABLE 5.2	EWEREP class, 2001/2002 season. Table of summarized data input into the simulation model for worm count.....	87
TABLE 5.3	EWEREP class, 2001/2002 season. Fifth, 50 <sup>th</sup> and 95 <sup>th</sup> percentile values of simulated worm count.....	87
TABLE 5.4	RAMREP class, 2000/2001 season. Table of summarized data input into the simulation model for worm count.....	88
TABLE 5.5	RAMREP class, 2001/2002 season. Fifth, 50 <sup>th</sup> and 95 <sup>th</sup> percentile values of simulated worm count.....	88
TABLE 5.6	Relationship between number of <i>H. contortus</i> , blood loss and clinical signs of haemonchosis in adult sheep (After Reynecke 1983).....	93
TABLE 5.7	Severity of <i>H. contortus</i> infection in sheep (After Hansen & Perry 1994).....	93

# THESIS SUMMARY

Data generated by five years of FAMACHA<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> system is sensitive enough, and adequately specific, to detect anaemic sheep despite misclassification.

The application of Receiver Operating Characteristic curve analysis to the FAMACHA<sup>®</sup> method to select FAMACHA<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> proportions in flocks. The model was most sensitive to changes in

FAMACHA<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> evaluation, provided that rainfall entropy is known.

This work attempts to bridge the gap between implementation of the FAMACHA<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> system can and should be used as a basis for further development of decision-support software.