PRACTICAL BREEDING FOR RESISTANCE AND RESILIENCE TO *HAEMONCHUS CONTORTUS* IN SOUTH AFRICAN SHEEP

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INTRODUCTION

The issue of resistance of internal parasite species to worm remedies is widespread throughout South Africa (Van Wyk, 2001) and the world and affects all small stock farmers. *Haemonchus contortus* is the most important parasite and causes the most losses among sheep in the summer rainfall regions of South Africa. In some areas, farming with animals resistant to nematode infestation seems to be the only solution in the long run.

Because of the difficulty of routinely collecting phenotypic data associated with resistance to internal parasites, suitable data sets for the estimation of genetic parameters for resistance against *H. contortus* are scarce in South Africa. The history of and recent selection practices followed in the Wauldby Dohne Merino flock makes it an ideal resource for research into resistance to *H. contortus* in South African sheep (Fisher et al., 2015). The farm Wauldby is located in the Stutterheim district in the Eastern Cape Province in a high summer rainfall area (800 mm annually). Wauldby has a well-documented history of heavy *H. contortus* challenge and *H. contortus* resistance and in the past the farm was used for several trials relating to resistance of *H. contortus* to anthelmintics (Fisher & Van Sittert, 2013; Fisher et al., 2015).

PROJECT BACKGROUND

In 2011, a project aimed at selection for resistance against *H. contortus* was started on the Wauldby Dohne Merino flock (Snyman & Fisher, 2018). Data on faecal egg counts (FEC), Famacha© score (FAM) and body condition score (BCS) were collected annually on all lambs born since 2011. FEC, FAM and BCS of all lambs were recorded from the middle of January onwards. FAM was recorded weekly and FEC and BCS every 14 days until the end of June when Haemonchus challenge had decreased. Lambs were only drenched when they had a FAM of 2.5 or more, in conjunction with a BCS of less than 1.5. Any lamb that was drenched was recorded as “Dosed” and those lambs that did not require any drenching as “Not dosed”. Data on all lambs were recorded all the way through until the end of June, irrespective whether they needed drenching or not.

Selection in the flock was aimed at increasing resistance to *H. contortus*, while maintaining reproductive performance, body weight, wool weight and fibre diameter and improving wool quality traits. Selection for the production traits was done on the basis of selection indices and BLUP of breeding values for the mentioned traits measured at 14 months of age. Selection for resistance to *H. contortus* was based on a selection index incorporating FEC, FAM and BCS (Snyman & Fisher, 2018).

The data collected over the years were used to estimate heritabilities and genetic correlations among the traits. Moderate heritabilities for and favourable genetic correlations among FEC, FAM and BCS were estimated (Snyman & Fisher, 2019). FAM had a high genetic correlation with FEC. In this study ongoing first stage selection was done by identifying animals unsuitable for selection on the basis of FAM and BCS. Identifying animals that required anthelminthic treatment according to FAM will ensure that only truly susceptible animals are identified and destined to be culled. Resilient as well as resistant animals will not be targeted and will remain untreated and available for final stage selection.

The highest heritability and repeatability of the resistance traits were recorded for BCS, but BCS had a moderate genetic correlation with FEC (Snyman & Fisher, 2019). In this study, BCS of the lamb, in combination with FAM, were considered in the decision whether to treat the lamb or not. However, due to the low phenotypic correlation between BCS and FEC, BCS of an animal alone is not an accurate indication of the existing level of *H. contortus* infection. By the time BCS is affected by *H. contortus per se,* the animal would have shown other clinical signs of Haemonchosis.

The general trends in FEC and FAM over the annual recording periods are given in Figure 1. It can be seen that FEC peaked in February (Recording 3), and again in the middle of March (Recording 5), after which it steadily declined. FAM roughly followed the same trend as FEC.

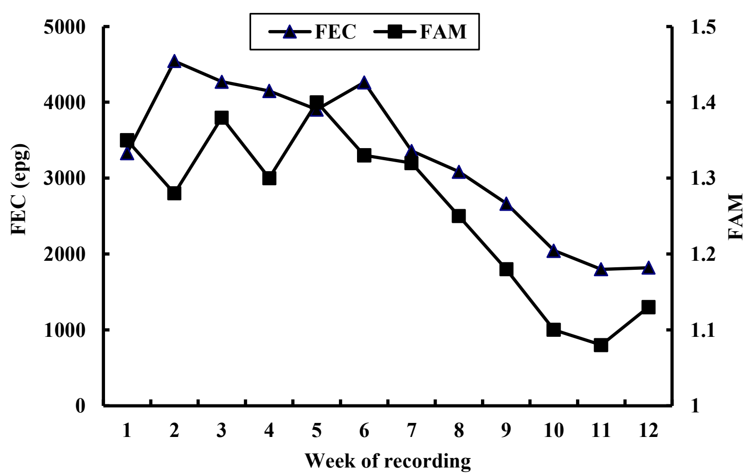

Figure 1. Mean FEC and FAM over the annual recording period pooled for the 2011- to 2018-born lambs

COMPILING SELECTION INDICES

As it will be impractical and expensive to record FEC every second week under commercial farming conditions, various combinations of the available FEC recordings were evaluated. A combination of FEC recordings at the beginning (January: 1st recording), during mid-season (March: 5th or 6th recording) and towards the end of the season (May: 9th recording) proved to be the best alternative for selection purposes in terms of heritability and correlations with average FAM (Snyman & Fisher, 2019).

Subsequently, the average values for FEC, FAM and BCS recorded at the 1st, 6th and 9th recordings were calculated (FEC169, FAM169 and BCS169). These values were used in the construction of selection indices. The MTINDEX program (Van der Werf, 2008) was used to compile selection indices including FEC with or without incorporating FAM and BCS. The log transformed FEC (FEC + 10 transformed to logarithms to the base of 10; LFEC) were used in all indices. As far as the application of FAM as criterion for the selection of resilient or resistant sires and dams is concerned, it should be used in combination with other resistance traits such as FEC. Due to the fact that BCS of the Not dosed lambs in this study was higher than that of the Dosed lambs, BCS was included in one of the selection indices.

The following selection indices (SI) were compiled or are suggested:

SI1 = (-1 x FEC169 -1 x FAM +1 x BCS169) +10

SI2 = (-1 x FEC169 -1 x FAM) +10

SI3 = (-1 x FEC169) +10

SI4 = EBV-FEC

For all the animals born from 2015 to 2018, selection indices for the four selection index options were calculated. Subsequently, the animals born in 2015, 2016, 2017 and 2018 were ranked on each selection index. These rankings were done separately for the rams and ewes within each lambing season. Spearman rank correlations were estimated (SAS, 2016) among the four selection index rankings for each sex and each year group of animals to determine if the same or different animals would be selected by the four selection indices. Firstly, correlations were estimated for all animals in each subgroup, and secondly for a proportion of 5% rams and 25% ewes respectively, selected within each subgroup on the selection index incorporating FEC and FAM.

COMPARISON OF SELECTION INDICES

Spearman rank correlations among the four selection index rankings for all the rams and ewes born from 2015 to 2018 are presented in Table 1. From Table 1 it is evident that generally the same animals will be selected with SI1 and SI2. Where selection is based only on FEC (SI3), a small proportion of different animals were selected in some years (especially 2016) than when FAM and BCS were included in the selection index (SI1 and SI2). The correlations between SI4 and the other selection indices were much lower. This could be ascribed to the heritability of FEC in this flock ranging from 0.14 to 0.26, estimated with different models (Snyman & Fisher, 2019) and the accuracy of the estimated breeding values for FEC for individual animals in the flock ranging from 0.55 to 0.92 (average = 0.67).

Table 1. Spearman rank correlations among selection index rankings including all animals born per year

Trait	SI2R	SI3R	SI4R
2015-Born rams			
SI1R	0.98	0.82	0.56
SI2R		0.83	0.55
SI3R			0.50
2016-Born rams			
SI1R	0.98	0.65	0.40
SI2R		0.68	0.41
SI3R			0.60
2017-Born rams			
SI1R	0.99	0.91	0.60
SI2R		0.92	0.61
SI3R			0.67
2018-Born rams			
SI1R	0.99	0.87	0.56
SI2R		0.89	0.57
SI3R			0.54
2015-Born ewes			
SI1R	0.99	0.92	0.76
SI2R		0.93	0.76
SI3R			0.78
2016-Born ewes			
SI1R	0.98	0.69	0.40
SI2R		0.73	0.38
SI3R			0.49
2017-Born ewes			
SI1R	0.99	0.89	0.67
SI2R		0.90	0.67
SI3R			0.72
2018-Born ewes			
SI1R	0.99	0.93	0.75
SI2R		0.93	0.75
SI3R			0.75

Spearman rank correlations among the four selection index rankings for the top 5% rams and 25% ewes born from 2015 to 2018, selected within each subgroup on SI2, are presented in Table 2.

Table 2. Spearman rank correlations among Selection index rankings (select 5% rams and 25% ewes per year selected on SI2)

Trait	SI2R	SI3R	SI4R
2015-Born rams			
SI1R	0.88	0.38	0.83
SI2R		0.55	0.64
SI3R			-0.10
2016-Born rams			
SI1R	0.81	-0.10	-0.26
SI2R		0.41	-0.10
SI3R			0.45
2017-Born rams			
SI1R	0.90	0.93	0.17
SI2R		0.98	0.24
SI3R			0.38
2018-Born rams			
SI1R	1.00	0.90	0.18
SI2R		0.90	0.18
SI3R			0.00
2015-Born ewes			
SI1R	0.96	0.87	0.50
SI2R		0.89	0.46
SI3R			0.44
2016-Born ewes			
SI1R	0.78	0.67	0.55
SI2R		0.87	0.43
SI3R			0.44
2017-Born ewes			
SI1R	0.97	0.91	0.47
SI2R		0.95	0.43
SI3R			0.41
2018-Born ewes			
SI1R	0.99	0.94	0.84
SI2R		0.95	0.85
SI3R			0.88

Similar results were observed for SI1 and SI2, where the same animals were selected when FAM and BCS were included in the selection indices. The difference between SI3, where only FEC was included, compared to SI1 and SI2 was more pronounced when comparing only a selected proportion of animals, especially in the case of the 2015 and 2016 rams. Variable correlations, but low in most cases, were obtained between SI4 and the other selection indices.

When the data of only a selected proportion of 5% rams and 25% ewes were evaluated, again generally the same animals will be selected with SI1 and SI2. However, a higher proportion of different animals will be selected when only FEC was used as selection criteria. This implies that selection should preferably be done on SI1 or SI2. FAM should be included together with FEC to accommodate resilient animals, but the inclusion of BCS is optional.

PROTOCOL FOR SELECTION FOR RESISTANCE AGAINST *H. CONTORTUS*

The following protocols can be used for selection for resistance against *H. contortus* in stud and commercial flocks respectively.

Stud animals

- Follow the normal internal parasite control program before weaning, i.e. routine pooled faecal samples.
- If the lambs needed to be drenched before weaning, FEC, FAM and BCS of all the lambs may be recorded before drenching.
- After weaning, recording of FEC, FAM and BCS on individual ram and ewe lambs should take place.
- FAM should be recorded every 14 days until the end of June when Haemonchus challenge has decreased.
- Individual FEC and BCS should be recorded at the beginning (January) and twice during the summer season (March and May).
- Lambs should only be drenched if they have a FAM of 2.5 or more.
- Any lamb that was drenched should be noted and culled.
- Replacement rams and ewes should be selected from the animals that did not need dosing on the basis of one of the above selection indices incorporating FEC and FAM, with or without BCS.
- Adult ewes should only be drenched based on FAM. Note and cull ewes that need repeated drenching.
- Evaluate existing sires on the performance of their offspring.
- If rams are bought, select only rams resistant to internal parasites.

Commercial animals

- Follow the normal internal parasite control program before weaning, i.e. routine pooled faecal samples.
- After weaning, recordings should only be done on the ewe lambs.
- FAM should be recorded every 14 days until the Haemonchus challenge has decreased.
- FEC should be monitored through monthly pooled faecal samples.

- Lambs should only be drenched if they have a FAM of 2.5 or more.
- Any ewe lamb that was drenched should be noted and lambs that needed two or more drenchings should be culled.
- Adult ewes should only be drenched based on FAM. Note and cull ewes that need repeated drenching.
- Individual FEC of all adult rams should be recorded during the peak Haemonchus season. Before faecal sampling, the rams should not receive any anthelmintic treatment for at least 3 to 4 weeks. Cull rams with the highest FEC.
- Buy only rams resistant to internal parasites.

The balance between the levels of resistance and resilience required in a specific flock depends on the level of anthelmintic resistance on the specific farm. On farms where anthelmintic resistance is already a severe problem and no anthelmintic susceptible strain exists, resistant animals would be preferable in an attempt to keep pasture contamination as low as possible. Resilient animals would just contaminate the pasture with anthelmintic resistant worms. On farms with less severe anthelmintic resistance, it is important that a population of susceptible *H. contortus* be maintained. To achieve this, FAM could be used as management tool for identification of susceptible animals in the adult ewe flock for treatment which will leave resilient animals untreated and thus contributing to maintain a population of susceptible worms in refugia (Burke et al., 2007). FAM has been used successfully as management tool for the identification of animals that need anthelmintic treatment (Kaplan et al., 2004; Burke et al., 2007; Molento et al., 2009; Pereira et al., 2016). This practice reduces the number of animals that needs to be treated and subsequently saving anthelmintic treatment cost.

CONCLUSIONS

Selection indices and protocols for selection of animals for resistance and resilience against *H. contortus* were compiled and developed. It is suggested that selection in stud animals be based on a selection index incorporating FEC and FAM, with or without including BCS. Commercial animals that required more than two drenchings, based on FAM, should rather be culled. The developed protocols need further validation on additional farms before they can be implemented on a wider scale.

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