Genetic parameters for traits associated with resistance to *Haemonchus contortus* in South African Dohne Merino sheep

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Summary

Resistance of *Haemonchus contortus* to anthelmintics in South Africa is a well-documented problem. In some areas, farming with animals resistant to nematode infestation seems to be the only solution in the long run. The farm Wauldby, in the Stutterheim district of South Africa, has a well-documented history of heavy *Haemonchus contortus* challenge and of *Haemonchus* resistance to all five major anthelmintic groups on the market prior to 2011. At the end of 2011, a project aimed at goal oriented selection for resistance to *Haemonchus contortus* was implemented in the Dohne Merino stud at Wauldby. Data on faecal egg counts (FEC), Famacha© score (FAM), body condition score (BCS) and log-transformed faecal egg counts (LFEC), recorded on the 2011- to the 2015-born lambs were analysed in this study. Between 10 and 12 two-weekly recordings of FAM, BCS and FEC were done each year. The number of individual data records available per year for these recorded resistance traits varied between 2,365 and 3,003 for a total of 13,648 records from 1257 animals. Various univariate, multivariate and repeatability animal models using the ASReml program were fitted to estimate genetic parameters for these traits. The most suitable model of analyses for FAM, BCS, FEC and LFEC averaged over all recordings per year, included only direct additive genetic effects. Direct heritabilities of 0.20 ± 0.06, 0.32 ± 0.07, 0.15 ± 0.05 and 0.22 ± 0.06 were estimated for FAM, BCS, FEC and LFEC respectively. Direct heritability increased for all traits when data from all 12 available recordings were included. Various combinations of FEC taken at the different recordings were analysed in an effort to obtain the most suitable recordings for inclusion in a protocol for selection against resistance to *Haemonchus*. The combination of the 1st (January), 6th (March) and 9th (May) recordings yielded the most promising results as it had the highest heritability of all the combinations that was evaluated. Genetic correlation among these three recordings for BCS (0.89 to 0.98), FEC (0.40 to 0.92) and LFEC (0.58 to 0.96) were high and positive. Univariate heritability estimates obtained for FEC and LFEC, averaged for the 1st, 6th and 9th recordings, compared well with those obtained under univariate analyses where all available data were averaged (0.16 vs. 0.15 for FEC and 0.20 vs. 0.22 for LFEC). However, it was much lower for FAM and BCS (0.02 vs. 0.20 for FAM and 0.23 vs. 0.32 for BCS).

Keywords: faecal egg count, Famacha, body condition score, heritability

Introduction

Resistance of internal parasites to anthelmintics has become a worldwide problem, with resistance of *Haemonchus contortus* in South Africa one of the most evident (Van Wyk et al., 1997). In some areas, farming with animals resistant to nematode infestation seems to be the only long-term solution. Genetic variation in resistance to nematode infestation in sheep, based on faecal egg count as criterion, have been reported for various breeds (Morris et al., 1997; Nieuwoudt et al., 2002; Khusro et al., 2004; Yadav et al., 2006; Cloete et al., 2007). Successful breeding programs for resistance have been reported for Australian (Pocock et al., 1995; Greeff et al., 2006) and New Zealand (Morris et al., 2005) sheep. No reports on active breeding programs for resistance in South African sheep could be found.

The objectives of this study were to estimate genetic parameters for resistance to *Haemonchus contortus* and these parameters will be used for the development of protocols for selection for resistance to *Haemonchus contortus* in South African sheep.

Materials and methods

The farm Wauldby, in the Stutterheim district of South Africa, has a well-documented history of heavy *Haemonchus contortus* challenge and of *Haemonchus* resistance to all five major anthelmintic groups on the market prior to 2011. In 2011, a *Haemonchus* resistant line was established in the Dohne Merino stud at Wauldby. Faecal egg counts (FEC), Famacha© score (FAM) and body condition score (BCS) of all lambs were recorded annually from January until July for the 2011- to the 2015-born lambs. FAM was recorded weekly and FEC and BCS every 14 days. Lambs were only drenched when they had a FAM of 2.5 or more, in conjunction with a BCS of less than 1.5. Replacement lambs for the resistant line were selected from those that did not receive any anthelminthic treatment. Selection was based on a selection index incorporating FEC, FAM and BCS.

Data on FEC, log-transformed FEC (LFEC), FAM and BCS recorded on the 2011- to the 2015-born lambs were analysed. Between 10 and 12 two-weekly recordings of FAM, BCS and FEC were done each year. The number of individual data records available per year for these recorded resistance traits varied between 2,365 and 3,003 for a total of 13,648 records. Various univariate, multivariate and repeatability animal models using the ASReml program (Gilmour et al., 2009) were fitted to estimate genetic parameters for the resistance traits.

Results and discussion

Variance components and genetic parameters for FAM, BCS, FEC and LFEC averaged over all recordings per year are presented in Table 1. The most suitable model of analyses for all the resistance traits included only direct additive genetic effects.

Table 1. Variance components and genetic parameters for Famacha© score (FAM), body condition score (BCS), faecal egg count (FEC) and log-transformed FEC (LFEC) averaged over all recordings per year.

Component / Ratio	FAM	BCS	FEC	LFEC
σ^2_a	0.007	0.007	564961	0.025
σ^2_e	0.030	0.015	3095490	0.090
σ^2_p	0.037	0.022	3660500	0.115
h^2_a	0.20 ± 0.06	0.32 ± 0.07	0.15 ± 0.05	0.22 ± 0.06

As it will be impractical and expensive to record FEC every second week under commercial farming conditions, various combinations of FEC taken at the different recordings were analysed in an effort to obtain the most suitable recordings for inclusion in a protocol for selection against resistance to *Haemonchus*. The combination of the 1st (January), 6th (March) and 9th (May) recordings yielded the most promising results as it had the highest heritability of all the combinations that was evaluated. Heritabilities for and genetic and phenotypic correlations among the resistance traits collected at the 1st, 6th and 9th recordings, estimated with multivariate animal models, are summarised in Table 2. Except for FAM, genetic correlation among these three recordings for BCS, FEC and LFEC were high and positive.

Table 2. Heritabilities (on diagonal) for genetic (above diagonal) and phenotypic (below diagonal) correlations among resistance traits collected at the 1st, 6th and 9th recordings.

Trait	FAM1	FAM6	FAM9
FAM1	**0.05 ± 0.04**	-0.56 ± 0.65	-0.29 ± 0.45
FAM6	0.04 ± 0.03	**0.04 ± 0.04**	0.92 ± 0.44
FAM9	0.11 ± 0.03	0.11 ± 0.03	**0.10 ± 0.05**
	BCS1	**BCS6**	**BCS9**
BCS1	**0.11 ± 0.05**	0.98 ± 0.10	0.89 ± 0.18
BCS6	0.47 ± 0.02	**0.21 ± 0.06**	0.93 ± 0.10
BCS9	0.36 ± 0.03	0.46 ± 0.02	**0.14 ± 0.05**
	FEC1	**FEC6**	**FEC9**
FEC1	**0.10 ± 0.01**	0.40 ± 0.00	0.73 ± 0.00
FEC6	0.11 ± 0.03	**0.07 ± 0.01**	0.92 ± 0.00
FEC9	0.11 ± 0.03	0.21 ± 0.03	**0.07 ± 0.01**
	LFEC1	**LFEC6**	**LFEC9**
LFEC1	**0.17 ± 0.01**	0.75 ± 0.00	0.58 ± 0.00
LFEC6	0.09 ± 0.03	**0.09 ± 0.01**	0.96 ± 0.00
LFEC9	0.10 ± 0.03	0.19 ± 0.03	**0.07 ± 0.01**

Variance components and genetic parameters for FAM, BCS, FEC and LFEC averaged over the 1st, 6th and 9th recordings, estimated with univariate animal models are presented in Table 3. Heritability estimates obtained for FEC and LFEC compared well with those obtained under univariate analyses where all available data were averaged (0.15 for FEC and 0.22 for LFEC). However, it was much lower for FAM and BCS (0.20 for FAM and 0.32 for BCS).

Table 3. Variance components and genetic parameters for FAM, BCS, FEC and LFEC averaged for the 1st, 6th and 9th recordings, estimated with univariate animal models

Trait	FAM	BCS	FEC	LFEC
σ^2_a	0.019	0.007	1156490	0.040
σ^2_e	0.085	0.023	6072540	0.159
σ^2_p	0.104	0.030	7229030	0.199
h^2_a	0.02 ± 0.03	0.23 ± 0.06	0.16 ± 0.05	0.20 ± 0.05

Conclusions

Data collected on FAM, FEC and BCS at the beginning, middle and towards the end of the *Haemonchus* season can be used for selection of sheep resistant to *Haemonchus contortus.*

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