AUSTRALIA YOU HAVE FOOTROT, TIME TO START BREEDING AGAINST IT!

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SUMMARY

Footrot affects all aspects of sheep production and has substantial welfare and economic impacts in the New Zealand (NZ) and Australian sheep industries. Merino sheep managed in high rainfall environments are particularly susceptible. Funding and support from the NZ fine wool industry has enabled development of a breeding value for footrot susceptibility. Currently, breeding values with a reportable accuracy are available for approximately 30,000 MERINOSELECT animals. However, only 97 of these animals are from Australian flocks. The following manuscript challenges Australian sheep breeders to take advantage of the resource developed by the NZ fine-wool industry and consider their own input into improving the outcomes for Australian breeders looking to reduce footrot susceptibility within their flocks.

INTRODUCTION

Footrot is a highly contagious and difficult to manage hoof disease in sheep and other ungulates that begins with interdigital dermatitis and progresses to separation of the hard horn from the foot (Mulvaney 2013). Both infection and the progression of footrot within the flock are heavily influenced by the prevailing weather conditions and the virulence of the essential infective bacterium *Dichelobacter nodosus* (Egerton and Raadsma 1991). Virulent footrot costs the Australian sheep industry $32M pa (Dhungyel *et al.* 2017) and remains a notifiable disease in many states at the time of this publication. The governmental attitudes to footrot differ between Australia and NZ, and to date the NZ industry (or a section of it) has taken a more proactive approach to reducing footrot susceptibility.

Estimates of heritability for footrot resistance range from 0.10 to 0.30 across populations of Romney (Skerman *et al.* 1988), Australian Merino (Raadsma *et al.* 1994), Scottish Black Face and Mule breeds (Nieuwhof *et al.* 2008) and NZ fine wool Merino (Walkom *et al.* 2018). Accordingly, an opportunity exists to select for reduced susceptibility to footrot. Preliminary research into the development of footrot breeding values for the NZ fine wool industry, and by extension the Australian Merino industry, has been reported (Walkom *et al.* 2018). This paper outlines progression of the development of a footrot breeding value, for Sheep Genetics MERINOSELECT, and the capacity and role of Australian Merino breeders in reducing footrot susceptibility.

GENETIC EVALUATION OF FOOTROT IN NEW ZEALAND MERINO SHEEP

Walkom *et al.* (2018) previously reported the development of research breeding values (RBV: breeding values that are still under development) for the NZ fine wool industry. Briefly, the genetic evaluation of footrot was developed around an initial Central Progeny Test (CPT), commencing in 2013, where approximately 2,000 commercial fine wool NZ Merino ewes are mated to 20-40 Merino type rams annually. Following a standardised protocol for field challenges, resulting wether progeny (and ewes since the 2017 drop) were challenged as hoggets under conditions of virulent footrot. Each foot was then scored on a 5 point scale by trained NZ Merino Company Limited staff, with 0 being not affected, and scores 1 to 5 representing increasing degrees of severity of foot lesions /damage, from

* A joint venture of NSW Department of Primary Industries and the University of New England

water maceration (1) to chronic footrot (5) (Mulvaney 2013). To date the CPT challenge has provided 3,727 footrot phenotypes, and the CPT progeny have been DNA sampled and genotyped (15k Illumina ovine panel). In conjunction with the CPT and in response to the release of sire breeding values in 2016 from the challenged 2013-2014 drops, 16 industry flocks, consisting of Merino, Poll Merino, Polwarth and quarter-bred Merino sheep, have conducted field challenges for yearlings/hoggets and in turn provided a further 8,069 additional phenotypes for genetic evaluation.

The footrot breeding value has evolved since the Walkom *et al.* (2018) publication to a weighted average of the footrot scores, with scores of zero and one grouped with a weighting of 0.5 and score two given a weighting of 1. Thus, an animal with no underrun feet cannot produce a phenotype worse than an animal with a single underrun foot (Score 3+). The phenotypes are also transitioned pre-analysis to a minimum of 40% underrunning, if the challenge strength was below this threshold, as per Walkom *et al.* (2018). Adjusting for differences in disease incidence and transitioning the data to a similar incidence based on the biological progression through footrot scores helps to standardise means and variance across the CPT and industry challenges.

Genetic parameters and breeding values have been estimated from a single-step genomic BLUP (Legarra *et al.* 2014) model incorporating genomic and pedigree information with an equal weighting on the pedigree and genomic information, using WOMBAT (Meyer 2007). The population is predominantly purebred fine wool Merino, with Corriedale and Polwarth influences in some flocks. To account for the effects of breed composition on allele frequencies, the genomic relationship matrix has been adjusted, as per Gurman *et al.* (these proceedings), by utilising a combined NZ Merino and Sheep Genetics genotype reference population and BreedComp (Boerner 2018) to describe an individual animals' breed composition.

To date the analysis produces RBVs, at reportable accuracy of greater than 43% ($\sqrt{h^2}$ * 0.80), for just over 30k sheep. The footrot RBVs range from –0.99 to 1.19, with lower breeding values associated with an animal less susceptible to footrot under a severe challenge. Consequently, an RBV of -0.24 (one sd. superior to the mean of 0.00) is associated with a 7% decline in the proportion of progeny expected to present with under-running in at least one foot and 5% decline in progeny expressing at least one chronic foot under severe footrot conditions than the average sire (Figure 1).

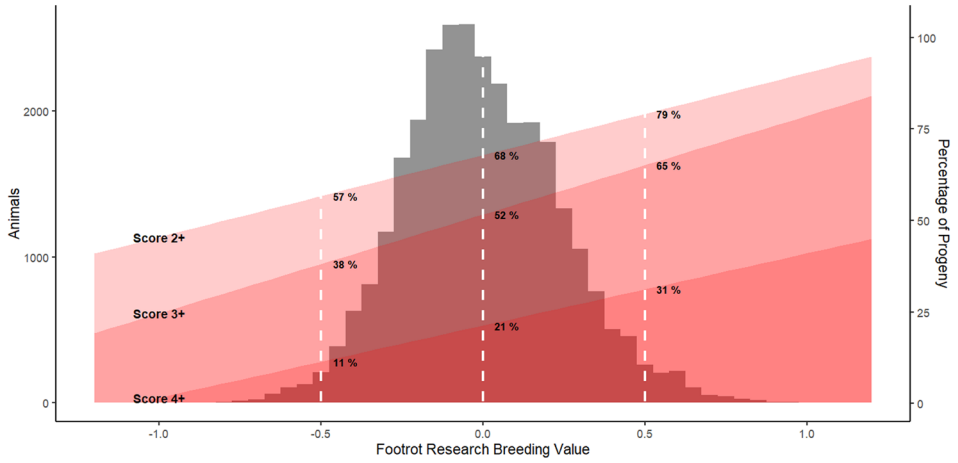

Figure 1. Relationship between footrot RBVs and the expected proportion of progeny to show a minimum of one foot affected (score 2+), underrun (score 3+) or chronic (score 4+) under a severe footrot challenge, as expressed under Central Progeny Test challenge conditions

GENERATING FOOTROT BREEDING VALUES FOR AUSTRALIAN SHEEP

Relying on New Zealand. At the time of publishing, Australian sheep will only get a footrot RBV if an Australian ram has been used in the CPT (32 sires to date), or if a NZ stud has sourced Australian germplasm. Currently, 97 Australian animals (from 27 Australian flocks) have reportable footrot RBVs. The diversity in RBVs for the Australian sires is relatively large and shows no obvious relationship with the major MERINOSELECT indexes: fibre production plus, merino production plus and dual purpose plus (Figure 2). Breeding values reliant on having sires in the progeny test are limited by cost and sires deemed to be relevant to the NZ fine wool industry. An alternative is to sell rams to NZ flocks which are phenotyping their flock for footrot. However, Australian sheep breeders are limited as the trade of live animals between the two countries is currently one-way (from Aus to NZ), which prevents importing evaluated NZ germplasm. Consequently, if they wish to progeny test a sire and then use it on farm they are limited to selling semen into NZ.

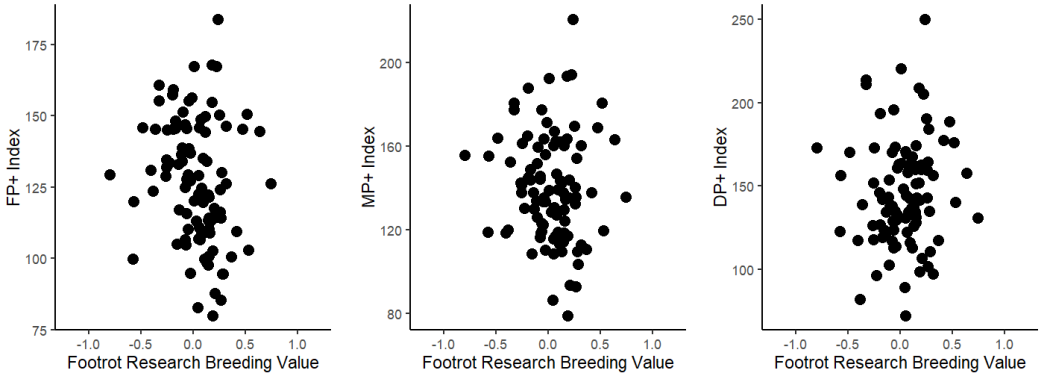

Figure 2. Footrot RBV plotted against index values for fibre production plus (FP+), merino production plus (MP+), and dual purpose plus (DP+) for Australian Merino sires with publishable footrot RBVs

Structured Australian reference flock. The establishment or addition of footrot recording to an existing reference flock of a current reference population, similar to the CPT in NZ, is an appealing option for Australian sheep breeders. This would increase the number of animals with phenotypes collected under common environmental footrot challenge, without the need for outbreaks of footrot on their own property. However, while projects based on large reference populations typically supply good quality data for hard to measure or novel traits, they are limited in the number of records that can be produced and are expensive on a per animal basis. Breeders will also have limited capacity to progeny-test all sires of interest since choice of sire is primarily based on industry good, not their own. Progeny testing provides highly accurate comparisons of sires but require scale and careful design to provide appropriate levels of genetic linkage. Organisers of current resource flocks may also be reluctant or unable to incorporate footrot phenotypes into existing programs. Challenging progeny with footrot is likely to influence the expression of genetic variation in production traits and due to the notifiable status of the disease, animals may not be able to return to breeding flocks. Challenging animals with a disease deliberately is a potential welfare issue and will require ethics approval, something that can become difficult for industry flocks.

Industry recording in Australia. In a single-step genetic evaluation, any animal that has both a genotype and phenotype forms part of the reference population. The phenotypes for such animals are often being collected independently of the need for a reference population and as such should

be cost effective if the phenotype is part of standard management / recording practices. However, the notifiable status of the disease in some states and the social stigma of having footrot (something NZ breeders have moved beyond) means that implementing a footrot recording program on-farm in Australia will not be undertaken lightly, even by early adopters. Similar to recording phenotypes for worm egg count, the ability to record the footrot phenotype is challenging as it depends on both suitable environmental conditions and the presence of appropriate strains of *Dichelobacter nodosus*. However, by recording in diverse industry cohorts, multiple strains of the bacterium will be captured within the challenges. As has been shown by NZ breeders, the recording protocols are achievable and reliable footrot phenotypes can be captured by industry for genetic evaluation. The advantage of industry recording is that a phenotype and in turn a highly accurate breeding value can be achieved at a young age i.e. before the animals become selection candidates.

Genomic Prediction. A suitable reference population where large numbers of animals are phenotyped and genotyped underpins the accuracy and utility of any genomic enhanced prediction. Currently, under the single-step model, industry animals that have a genomic relationship with the reference population (from non-phenotyping flocks) are obtaining RBV accuracies ranging from 0.09 to 0.70, with a mean accuracy of 0.22. Low accuracies are expected for most Australian flocks if phenotyping only occurs in NZ, reflecting relatively low genetic relationships between animals in the two countries. As the reference population grows, hopefully including Australian data, the mean accuracy of genomic predictions will improve, and accordingly the potential contribution of genomics to industry breeding programs.

CONCLUSIONS

NZ fine-wool breeders have lead the way in championing the development of a footrot RBV and its likely future publishing as an ASBV in MERINOSELECT. Australian sheep breeders will need to move beyond the social stigma associated with footrot and work together to develop a genomic reference of footrot phenotyped animals within Australia if they wish to take advantage of the current research. If this is achieved, Australian sheep breeders will be able to join their contemporaries in NZ in selecting effectively to reduce footrot susceptibility.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution of New Zealand Merino Company, New Zealand Merino Incorporated and Ministry for Primary Industries (MPI) for their funding contribution at different stages of the project. The authors also wish to acknowledge the New Zealand fine-wool flocks for their contribution of phenotypes, genotypes and pedigree information and their support for the CPT.

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