Contributed paper

MERITS OF DEVELOPING A GENETIC EVALUATION FOR THE AUSTRALIAN DAIRY SHEEP AND GOAT INDUSTRIES

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SUMMARY

The Australian dairy sheep and goat industries have been constrained by the size of the national flock and the geographical spread of flocks across the country. The absence of a national genetic evaluation system to underpin meaningful genetic improvement has contributed to the production performance of Australian dairy sheep and goat milk production being lower compared to the more developed dairy sheep and goat industries of Europe. Implementing a national genetic evaluation scheme will aid the development and future progress of the Australian dairy sheep and goat industries through identification and selection of the genetically superior animals. This study investigated the advantages of a genetic evaluation program for traits of value in Australian dairy sheep and goats, and outlined potential gains from implementing a breeding program.

INTRODUCTION

The potential to develop breeding programs within the Australian dairy goat and milk sheep industries is constrained by the small size of the national flock, geographical spread across the country in a variety of different environments and management practises, and the ability to measure phenotypes and record pedigree (Lindsay and Skerritt 2003). Despite these challenges, both the number of Australian milking goats and production volume increased more than 62% from 2012 to 2018 (Zalcman and Cowled 2018). However, average production, expressed in number of kilos per lactation, is still lower than what is achieved in Europe. The dairy sheep industry in Australia is estimated to be growing around 10% annually (Cameron 2014) but it relies mostly on low yielding non-dairy crossbred ewes with low lactation persistency compared to animals used in other countries with more advanced dairy sheep industries (Lindsay and Skerritt 2003). Most Australian dairy ewes are East Friesian crossbred (Morrisey *et al.* 2007), and while their average flock milk yield is around 40% lower compared to Europe, there is lots of variation within and between flocks, with the performance of a number of ewes being on par with European animals. Variation in milk yield within the flock is a necessary prerequisite for genetic gain, but standardised recording protocols are needed for effective genetic evaluation which in turn will enable genetic selection. This study investigated the advantages and potential genetic gains of a genetic evaluation system for traits of value in Australian dairy sheep and goats.

MATERIALS AND METHODS

Review of genetic parameters. Milk yield represents the majority of the total income in the dairy sheep and goat industries (Carta *et al.* 2009). For both dairy sheep and dairy goats almost all of the milk produced is used for cheese production, and thus milk content traits (fat and protein) are also important as they affect cheese yield and flavour. Therefore, increasing milk yield and improving milk quality (mostly though increasing fat and protein content) are the most important components of the breeding objective for most breeds (Ramon *et al.* 2010).

For dairy goats, milk yield heritability ranged between 0.18 and 0.34 (Analla *et al.* 1996;

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Scholtens *et al.* 2019), but can be higher when estimated per lactation (e.g. 0.30 for first lactation does; Arnal *et al.* 2020). A similar pattern was observed for fat and protein yield (Analla *et al.* 1996; Bélichon *et al.* 1999; Scholtens *et al.* 2019; Arnal *et al.* 2020). Genetic correlations between milk, fat and protein yield were high, with estimates reported between 0.77 and 0.95 (Bélichon *et al.* 1999; Manfredi and Ådnøy 2012). However, genetic correlations between milk yield and milk content (daily fat and protein percentage) were negative (-0.48 to -0.12) (Bélichon *et al.* 1999; Maroteau *et al.* 2014).

For most dairy sheep breeds, milk yield standardised for lactation length was originally the only selection criterion, while milk content traits were added later. Yield traits (milk, fat and protein) were reported to have moderate heritability (between 0.16 and 0.32) with high genetic correlations between the yield traits (between 0.77 and 0.93) (Barillet and Boichard 1987; Carta *et al.* 2009). Similar to dairy goats, genetic correlations between milk yield and milk content for dairy sheep was negative but varied for different sheep breeds (-0.43 to -0.64) (Carta *et al.* 2009).

Prediction of genetic gains. Predictions of potential genetic gain based on a defined breeding objective for within-flock selection was undertaken using MTINDEX (van der Werf 2019). It was assumed that milking does/ewes entered their first lactation at 12 months and they were maintained in the herd/flock for four lactations (generation interval of 2.5 years). All milking females were recorded for lactation yield with test day records available for fat and protein percentage. Two breeding objectives were tested; (1) single trait selection based solely on total milk yield and (2) multiple trait selection placing equal economic weighting on milk yield, total fat and total protein yield. Potential gains were modelled for small, medium and large herds/flocks with flock size modelled by varying the assumptions associated with progeny and half-sib records. The number of paternal half-sibs and progeny was assumed to be 10, 30 or 100 respectively for small, medium and large herd/flocks. The modelling utilised variance components and genetic correlations for yield traits compiled from literature: a) for dairy goats, heritability of 0.25 for milk, fat and protein yield and genetic correlations between 0.77 and 0.89 (Bélichon *et al.* 1999); b) for dairy sheep, heritability of 0.28 for milk, fat and protein yield and genetic correlations between 0.82 and 0.92 (Barillet and Boichard 1987). Heritabilities and genetic correlations between traits were similar for the two species, however there were big differences in phenotypic variance; in dairy sheep, fat and protein yield phenotypic variance was a lot lower (Barillet and Boichard 1987).

RESULTS AND DISCUSSION

Genetic Gains in Dairy Goats. Potential gains in milk yield were predicted to be between 1.08 and 1.32 kg of milk per animal per year (Figure 1A), depending on farm size. Considering a national flock of ~ 30,000 milking goats (Zalcman and Cowled 2018), this equals to an additional 32k to 40k kg of milk per annum, which at Australian goat milk prices ($1.20 - $1.50/L, *J Cameron pers. comm.*) is worth between $38.4k and $60k per year to the industry. With cheese being a valuable product of the industry, selection targeting fat and protein content could increase fat and protein yields by 38.4k – 40.8k and 33.6k – 36k kg per year, respectively.

Genetic Gains in Dairy Sheep. Potential gain from selection in dairy sheep was 1.04 to 1.28 kg of milk per animal per year (Figure 1B), depending on farm size. Australian national flock size for dairy sheep is smaller than that for dairy goats, estimated at ~5,000 milking ewes. Potential gain for dairy sheep is likely to be between 5.2k and 6.4k kg of milk per annum, and this is worth between $10.4k and $12.8k per year to the industry (sheep milk valued at $2/L, *J Cameron pers. comm.*). Selecting for fat and protein content could increase fat and protein yields by 1.3k and 1.26k kg per year, respectively. Differences between predicted fat and protein yield gains for dairy sheep and goats reflect differences in the observed phenotypic variance for these traits in the two species (Barillet and Boichard 1987; Bélichon *et al.* 1999).

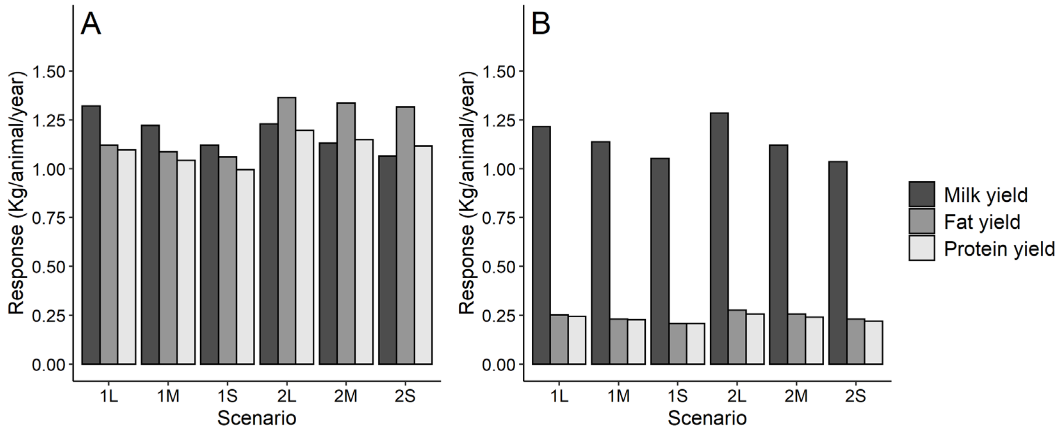

Figure 1. Estimated genetic gains for dairy goats (A) and sheep (B) under scenarios for a small, medium and large flock (S, M, L) with the objective to maximise only milk yield (1) or to maximise milk, fat and protein yield (2)

Implementation in Industry. For most livestock industries, prices received do not increase in real terms, but both fixed and variable costs do, resulting in what is usually known as the "cost-price squeeze". The effect of this is that profit from an enterprise declines in real terms over time. The only way to offset this decline is to make continual productivity improvement(s). Genetic improvement is attractive because its effects are permanent and cumulative, and provided that improvement is sufficiently rapid, the cost-price squeeze can be offset.

For highly productive dairy sheep and goat breeds, genetic improvement has been achieved through extensive recording and a pyramidal breeding structure (Barillet *et al.* 2001; Carta *et al.* 2009). As a result, some European breeds have achieved remarkable genetic progress under genetic evaluation. For example, genetic gain for French Lacaune between 1980 and 1994 was estimated at around 6 kg/year (Ugarte and Gabina 2004). Average production for improved European dairy sheep and goat breeds was very different to average production of Australian animals. For example, average milk production for dairy goats in France was 963 kg/goat per annum (IDELE 2020a), while Australian dairy goats have been reported to produce 519 kg/goat (Zamuner *et al.* 2020). Similarly, Australian dairy sheep produce 168 kg/ewe (*J Cameron pers. coms*), while European breeds like Lacaune produce 330 kg/ewe per annum (IDELE 2019). Importing and including high performance animals would be beneficial for the local dairy sheep and goat industry, but is currently prohibited under Australian quarantine regulations (Lindsay and Skerritt 2003). Consequently, the Australian industries will need to utilise the genetic variation that exists within the current population to drive genetic gains.

The principal implication from this study was that genetic improvement in dairy goats and sheep is quite feasible, and will generate significant benefits to producers. Achieving effective genetic improvement will require some changes in the current practice, principally in ensuring that records of milking performance are systematically collected, along with pedigree and fixed effects, and that the resulting data is appropriately analysed to produce EBVs, all of which will come at a cost to the operation (Banks and Walkom 2016). Previous investigations (Lindsay and Skerritt 2003) noted that despite reported support and enthusiasm from producers there has been very little progression to develop a genetic evaluation at the national level. This may be in part due to a lack of public support and R&D funding in these industries compared to other industries (Banks and Walkom 2016).

Overall, without national support the costs are too great for the smaller operations to bother recording and the larger dairies are potentially too time poor to lead a national genetic evaluation program.

CONCLUSIONS

This study provided an example of the genetic gains that could be achieved by the Australian dairy sheep and goat industries through appropriate recording schemes and genetic evaluation. The rate of genetic gain could be further improved with the use of genomic selection to increase the accuracy of breeding values and reduce generation interval. This will require groups like the Australian Dairy Goat Society to develop a vision and strategy for long-term genetic improvement, and seek to assist the R&D and extension funding to support it. It is quite likely that some individuals will move to implement modern genetic improvement systems of their own accord, but the "trickle-down" flow of superior genetics from such a fragmented approach will be slow, and in the absence of industry-wide genetic improvement, goat and sheep dairying will remain a relatively small-scale industry in Australia.

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