

Sexual maturity and yearling reproductive performance in ewes:
Genetic analysis and implications for breeding programs

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this and all sources used have been acknowledged in thesis

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Abstract

The successful breeding of ewes before the age of 12 months presents an opportunity to improve flock reproduction efficiency and increase returns for sheep producers. However, uptake of this practice is currently low in Australia and New Zealand. A contributing factor to this is that reproductive performance at 1 year of age is lower and more variable than in older ewes; between flocks and also from year to year. Whilst previous research has explored what factors contribute to successful reproduction at 1 year of age, there is no universally accepted measure of puberty and sexual maturity in sheep nor is there an accurate phenotypic predictor of yearling reproductive success. Although established genetic correlations between reproduction and production traits exist, reproduction has previously been analysed as a repeated records trait across parities, rather than treating first parity as a separate trait. Model studies show that genomic information offers the opportunity to select animals more accurately at younger ages. However the implications of a lower and more variable fertility rate of ewes mated prior to 1 year of age has been largely ignored. The aim of this thesis was to evaluate the impact of mating ewes prior to 1 year of age on flock genetic progress and to quantify the relationship between potential pubertal traits, yearling reproduction traits, reproduction traits at later parities and other key production traits.

The aim of the first experiment in this thesis was to evaluate how young ewe fertility rate affects risk and expected genetic gain in Australian sheep breeding programs. Stochastic simulation was used to model different flock age structures and young ewe fertility levels with and without genomic information for Merino and maternal sheep breeding programs. Ram and ewe age at first mating, availability of genomic information on males and young ewe fertility level all significantly ($p < 0.05$) affected expected genetic gain in both Merino and maternal breeding programs. Provided fertility levels above 10% can be achieved, the mating of young ewes is unlikely to reduce flock genetic progress and at levels above 50% will result in greater genetic gain. Although mating of young ewes did not increase breeding program risk in terms of genetic gain, variable fertility levels may contribute to other aspects of farm risk such as management and labour costs, which will require consideration before adopting early mating of ewes.

The second study quantified the relationships between age at first oestrus (AFO), as recorded using teaser wethers, and yearling reproductive performance and estimated the relationship between reproductive performance defined at three ages, yearling, hogget and adult. Maternal-cross ewes with yearling (n=2218) and hogget (n=2047) reproduction records and AFO (n=910) records and Merino ewes with hogget (n=3286) and adult (n=2518) reproduction records from the Sheep CRC Information Nucleus Flock were used for this analysis. The heritability of AFO was low, 0.02 ± 0.06 . Positive genetic correlations between AFO and reproduction traits ranged from 0.07 ± 0.49 to 0.94 ± 0.39 indicating that animals that were older when oestrus was detected were more likely to have a lamb/s. Genetic correlations between yearling and hogget reproduction were generally lower than one, ranging from 0.46 ± 0.68 for lamb survival to 0.79 ± 0.50 for fertility. This supports earlier findings that the analysis of yearling reproductive performance should be considered genetically as a separate trait from later parities. The low heritability estimates, the intensive nature of data recording and the error associated with the use of teaser wethers suggests that it is not a suitable strategy for identifying ewe sexual maturity and predicting yearling reproductive performance. The small number of records in this study limits the strength of conclusions that can be drawn.

The third experiment's aim was to assess if the novel trait; progesterone concentration measured during joining was heritable and was associated with yearling reproductive performance. Ewes born in 2012 (n=1896) and mated in 2013 across nine industry ram-breeding flocks representing maternal, terminal and Merino breeds were used for this study. Progesterone concentration was determined via enzyme linked immunosorbant assay from blood samples collected 14 days after initial male exposure. Linear mixed animal models were fitted to estimate variance components and heritabilities. Unadjusted progesterone concentrations (PROG) and the base 10 logarithmic transformation (PROG-LOG) were moderately heritable; 0.26 ± 0.07 and 0.18 ± 0.06 , respectively. The binary trait, progesterone concentration less than or greater than 1 ng/ml had a low heritability, 0.08 ± 0.04 . Mean progesterone level was 1.14 ng/ml with a standard deviation of 1.43 ng/ml. 59% of ewes with progesterone concentration >1 ng/ml lambed at 1 year of age whilst only 35% of ewes with progesterone concentration <1 ng/ml lambed. Although progesterone concentration is heritable and shows phenotypic variation, before its' usefulness as a phenotypic predictor

for reproduction or its' potential to improve the rate of genetic progress for reproduction can be assessed, accurate estimates of its relationship with reproduction are required.

The final study builds on the third experiment quantifying the relationships amongst progesterone concentration, yearling and hogget reproduction traits and other key production traits. Yearling (n=5877) and hogget (n=3641) reproduction records from ewes born in 2012 and 2013 from 12 industry flocks were used in this study. Ewes had a range of other production traits recorded including; liveweight (n=various), progesterone concentration (n=1896), pre-joining condition score (PJCS, n=1771) post-weaning fat and eye-muscle depth (n=4966) measurements. Mixed models were fitted to estimate variance components and calculate heritability, phenotypic and genetic correlations amongst traits. Ewes who weaned a lamb at 1 year of age weaned 7% more lambs at 2 years of age than their contemporaries that did not lamb at 1 year of age. Difference in reproduction parameter estimates recorded at yearling and hogget age support analysing first parity as a separate trait from later parities. The magnitude of the genetic correlations between yearling reproduction traits and PJCS, PROG-LOG and pre-joining liveweight are favourable. As all three traits have higher heritabilities than reproduction traits they have the potential as indirect selection criteria to increase the rate of genetic gain for reproduction. PJCS has the most potential as an indirect selection criteria, based on the magnitude of correlations found here and the relative ease of measurement compared to progesterone concentration. Positive phenotypic correlations were found between yearling reproduction, PROG-LOG, PJCS and pre-joining liveweight but they are too low for any trait to be a useful phenotypic indicator of yearling reproduction outcomes. Further measurements of progesterone concentration and PJCS will enable correlations of higher accuracy to be determined.

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In memory of a kind-hearted farmer who fostered a young girl’s passion for agriculture, Stewart Dufty.

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Bunter, K. L and Newton, J. E. (2014). B.LSM.0046. More lambs per ewe lifetime through better genetic evaluation systems. Meat and Livestock Australia Limited, North Sydney

Dominik, S., Newton, J.E., Hayes, B.J. and van der Werf, J.H.J (2014) Exploring Genotype x Environment Interaction and Heritabilities for a Reproduction Trait in Merino Sheep Using Three Approaches. In ‘Proceedings 10th World Congress on Genetics Applied to Livestock Production’ (American Society of Animal Science: Vancouver, Canada)

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Newton J.E., Brown, D.J, Swan, A.A., Dominik, S. and van der Werf J.H.J (2014) Effects of selection accuracy, risk and young ewe fertility on breeding program design. In ‘Proceedings 10th World Congress on Genetics Applied to Livestock Production’ (American Society of Animal Science: Vancouver, Canada)

