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Translating science into the next generation meat quality program for Australian lamb ☆

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ABSTRACT

This paper introduces a series of papers in the form of a special edition that reports phenotypic analyses done in parallel with genotypic analyses for the Australian Sheep Industry Cooperative Research Centre (Sheep CRC) using data generated from the information nucleus flock (INF). This has allowed new knowledge to be gained of the genetic, environment and management factors that impact on the carcase and eating quality, visual appeal, odour and health attributes of Australian lamb meat. The research described involved close collaboration with commercial partners across the supply chain in the sire breeding as well as the meat processing industries. This approach has enabled timely delivery and adoption of research results to industry in an unprecedented way and provides a good model for future research.

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1. Introduction

In the last 20 years progress in the Australian lamb Industry has been underpinned by a sustained period of research and development, to drive improvements in efficiency and product quality from farm through to retail and finally the lamb consumer (Pethick, Banks, Hales, & Ross, 2006). This work has been supported by both Meat and Livestock Australia (MLA), the Australian Sheep Industry Cooperative Research Centre (Sheep CRC) and its contributing partners on behalf of Australian lamb producers, processors, retailers, consumers and tax payers.

A series of papers has been published as 3 special editions in Australian journals relating to work undertaken prior to 2007; (i) the eating quality of Australian lamb and sheep meats (Russell, McAlister, Ross, & Pethick, 2005; Young, Hopkins, & Pethick, 2005) (ii) the growth and carcass characteristics of lamb as influenced by nutritional and genetic factors (Pethick, Warner, & Banks, 2006; Hegarty, Warner, & Pethick, 2006) and (iii) the influence of genetics, animal age and nutrition on sheep growth, carcass composition, muscle biochemistry and meat quality (Pethick, Warner, & Banks, 2007; Warner et al., 2007). This special edition reports work from 2007 focusing on whole of supply chain efficiency, and our knowledge of the genetic, environmental and management factors that determine carcase and eating quality, visual appeal, odour and health attributes of Australian lamb meat. Some of the early findings of this project have been published as an additional special edition in 2010 (Rowe, 2010).

The case for a sustained research and development program based around the three pillars of lean meat yield, eating quality and human health of lamb meat has been made previously (Pethick et al., 2006; Pethick, Ball, Banks & Hocquette, 2011) and arose from the outcomes of the previous research described in the special edition papers mentioned above and supported by the Australian Sheep Industry Strategic Plan (2010). With the industry vision of the Sheepmeat Council of Australia (www.sheepmeatcouncil.com.au) and the Australian Meat Processor Corporation (www.ampc.com.au), a national collaborative program was designed and finally delivered with additional Government support through the Sheep CRC, (www.sheepcrc.org.au).

2. The research and development program

2.1. Information nucleus flock

The basis of this research program was the information nucleus flock (INF), a distinctive feature of the Sheep CRC described by van der Werf, Kinghorn, and Banks (2010). Briefly, the INF, which had many features of a large progeny testing scheme, involved the production of around

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18,000 lambs. Of these approximately 10,000 lambs were slaughtered and measured for a large range of carcase and meat quality parameters using a standard protocol for each parameter as described in Pearce (2011). Many of the traits were "hard to measure" and not measured in commercial ram breeding operations presently, due to either the expense or the practical difficulty of measurement. The INF has run for 5 years, with about 100 different sires mated to on average 4600 ewes each year; distributed over 8 sites across southern Australia representing a wide range of production environments (wet/dry, hot/cool, winter/winter–summer rainfall). The major sire breeds represented (expressed as % of lambs slaughtered) were Poll Dorset (29.0%), White Suffolk (22.2%), Border Leicester (10.9%), Merino (9.3%), Texel (7.2%), Poll Merino (6.0%), Suffolk (5.8%) with the remaining 9.6% of lambs sired by one of the following genotypes: Bond, Booroola, Coopworth, Corriedale, Dohne Merino, East Friesian, Hampshire Down, Ile de France, Prime SAMM, Southdown or White Dorper. The selection of sires was based on genetic criteria outlined by van der Werf et al. (2010) and included trait and genetic diversity. The collaboration also extended to the slaughtering of lambs at 6 different commercial abattoirs.

The goals of the INF were to: obtain estimates of genetic parameters (heritabilities, and between trait correlations) for a range of new traits; understand the biological interactions influencing different traits; and to provide data for genomic association analyses to deliver DNA-based predictions of breeding values. The potential value of the program to develop new Australian Sheep Breeding Values (ASBVs) for new hard to measure traits, as well as an increased accuracy for existing carcase traits has been described by Banks and van der Werf (2009).

Understanding the biological interactions influencing different traits was a clear focus of the analyses reported in the papers comprising this special edition. However the priority of the INF design was primarily for genetic analyses and this needs to be kept in mind when interpreting the findings about biological interactions. Some of the associations found will require further experimentation before cause and effect can be understood in a mechanistic sense, due partly to the limitations imposed by the design priorities.

2.2. Common data set

The analyses described in the following papers have all used a subset of the INF data, typically 3–4 years involving 6–8000 lambs. The full 5 year data set will be used mainly for genetic analysis. Data for each trait measured was collated in a central database, enabling different scientists to work on different "trait groups" simultaneously whilst ensuring data integrity. This represented a large collaborative effort involving scientists with expertise in growth and development, muscle biochemistry, meat science, statistics, and genetics, both quantitative and molecular.

2.3. Overview of findings

Analysis of data from the slaughtered lambs has formed the basis of all, but 1 of the papers presented in this special edition. Together they facilitate a deeper understanding of the individual traits and how they can be manipulated through genetic and management interventions — in this case those that relate to, muscle biochemistry, eating quality, human health attributes and visual appeal of lamb meat measured on meat samples collected after commercial slaughter of the progeny. The papers describe many new associations between meat science and muscle biochemistry parameters, such as shear force, intramuscular fat and fatty acid composition, iron and zinc, retail colour, pH decline and ultimate pH, across a range of breed types and sires. They also provide valuable quantitative data on the ranges found and relationships between different parameters under commercial conditions for Australian lamb meat. The research papers in part also describe an analysis of the fixed and random effects and covariates used in subsequent genetic analyses. For example in the case of models to estimate genetic parameters associated with muscle Fe concentration, animal age would be an important co-variate.

3. Industry links and adoption

By design this research program was aligned with key industry bodies including Sheep Genetics and Meat Standards Australia. This has facilitated a seamless delivery of research outcomes directly and rapidly changed industry practice through the provision of new/more accurate genetic tools, and enhanced knowledge of factors affecting eating quality.

Each of the rams was carefully selected to ensure that the full diversity in all major sheep breeds used in Australian sheep industry was appropriately represented. The use of young commercial sires within the INF from across the full cross-section of the ram-breeding industry was very significant. It meant that as soon as new meat science information became available the genetic component could be estimated. The sheep industry could therefore immediately start to fine-tune the breeding objectives and select those rams able to deliver the right balance for meat quality and lean meat yield. Simultaneously, the genomics Research and Development component was successful in developing the ability to predict breeding values for a wide range of difficult to measure meat traits based on DNA analysis (Daetwyler, Swan, van der Werf, & Hayes, 2012).

Furthermore, collecting data at commercial abattoirs has required close collaboration to be achieved at an operational level and this has enabled immediate delivery of information to meat processors. Examples of this are the optimization of electrical stimulation systems in abattoirs (Pearce et al., 2010), the testing of carcase grading tools (Hopkins, Toohey, Boyce, & van de Ven, 2013), the investigation of new approaches to predicting meat yield (e.g. Siddell, McLeod, Toohey, van de Ven, & Hopkins, 2012) and real time feedback of factors influencing carcase and meat quality to the Australian lamb supply chain.

The approach of embedding research and development linked closely with industry has, and will continue, to facilitate the seamless integration of research results into industry. Already ram breeders are using new breeding values to enhance simultaneously lean meat yield and eating quality (intramuscular fat, shear force) and the processing sector has initiated new research to develop carcase and meat grading tools to allow for more accurate valuation of lamb carcases and cuts that reflect consumer requirements.

The combination of meat science, quantitative genetics, genomics and close industry engagement delivered by the INF is facilitating rapid use of the new information described in this collection of papers in this special edition.

4. Conclusion

While the papers in this special edition can stand alone in terms of their scientific merit and the contribution to new knowledge in the field of meat science, their greatest impact may well be through the cultural and commercial changes that this new information has initiated throughout the Australian lamb industry. This work has gone a long way to showing the extent to which genetic and non-genetic components account for the variation in each trait, and how they can be improved through genetic selection, management and processing techniques. The results reported in this special edition have already shifted the focus of ram breeders and commercial producers away from purely selecting for growth and yield to a more balanced approach that reflects both modern and future consumer needs. The science has already been applied and shifted commercial practices in both lamb processing methods and by the accelerated adoption of the Meat Standards Australia program for lamb. The speed with which the new research information has been used by industry is an important feature of this research program and contributes to optimizing returns on industry and broader community investment through government funding in the research program reported here.

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