THE INFORMATION NUCLEUS – GENETICALLY IMPROVING AUSTRALIAN LAMB PRODUCTION

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SUMMARY

Progress with the implementation of the Information Nucleus and Next Generation Meat Quality programs of the CRC for Sheep Industry Innovation is described in relation to the estimation of quantitative genetic parameters for meat production and consumer-relevant traits. The traits have importance for the prediction of lean meat yield, understanding the biochemistry of meat quality traits, consumer acceptability, eating quality acceptability and nutritional value of lamb. Measurements of a comprehensive range of carcass, meat and growth traits are nearing completion on 2007 drop progeny and have commenced on 2008 drop progeny, with records available from up to 2000 animals within each drop. Initial analyses of carcass and meat traits (predicted lean meat yield and tenderness) indicate that sufficient genetic variation exists in novel meat traits which could be used in sheep genetic improvement programs.

INTRODUCTION

The Information Nucleus (IN) is a major initiative and program of the Co-operative Research Centre (CRC) for Sheep Industry Innovation established in 2007 (Fogarty *et al.* 2007). One of the CRC's core research programs that the IN supports is program 3, Next Generation Meat Quality, through the projects 3.1.1 - Range of Meat Phenotypes Measured and 3.2.1 - Biology and Production Pathways for Desired Phenotypes (Pethick *et al*. 2009). The integration of these 2 programs will provide the Australian sheep industry with new information on the quantitative and molecular genetics of new and novel meat traits, as well as growth traits and ultrasound scan measurements on live animals. Because of its linkages to industry flocks, the IN will also support genetic evaluation conducted by Sheep Genetics (Brown *et al.* 2007) as the data from IN progeny are included in the Sheep Genetics database and used in its routine genetic evaluations. This will enable enhanced genetic improvement across the whole sheep industry and in individual flocks as more accurate quantitative Australian Sheep Breeding Values (ASBVs) become available in the short term and later as molecular breeding values are incorporated into ASBVs.

This paper describes progress with the implementation of the IN and Next Generation Meat Quality programs, specifically with reference to the estimation of quantitative genetic parameters for meat production and consumer-relevant traits. As well as the enhancement of ASBVs, the genetic parameter estimates (heritability, phenotypic and genetic correlations) derived from the records of IN progeny will provide an understanding of the consequences of current industry breeding programs aimed largely at improving meat production traits on meat quality traits. The ability to include novel meat traits into sheep breeding programs will also be improved. This information will be critical in maintaining the market acceptability of lamb as a meat that is lean, nutritious, of high eating quality and visually appealing.

IMPLEMENTATION OF THE INFORMATION NUCLEUS

Details of the design, as well as the specific objectives, of the Information Nucleus have been described by Fogarty *et al.* (2007). Briefly, following the first mating in 2007, ewes and wethers have been produced at 8 sites across Australia. These were progeny of key industry sires representative of the major production types in the sheep industry: Merino, Border Leicester X Merino, Terminal X Merino and Terminal X Border Leicester-Merino. The progeny resulted from AI matings to Merino and crossbred ewes, with approximately 4200 ewes inseminated in 2007 at 7 sites and approximately 5000 ewes inseminated in 2008 and 2009 at 8 sites. Similar matings are planned to produce another 2 drops in 2010 and 2011. To date, the progeny born in 2007-08 have been measured and/or sampled for carcass, meat and growth traits, with the potential for records to be available from approximately 2000 animals within each drop. The data for these traits were recorded on the crossbred ewe and wether lambs (except for the Border Leicester X Merino ewe lambs) and half of the Merino wether lambs. Both the crossbred progeny and Merino wether lambs were slaughtered at a target average carcass weight of 21.5 kg, while the Merino wethers were slaughtered following their shearing at 10-11 months of age.

CARCASS AND MEAT MEASUREMENTS

The extensive list of carcass and meat traits being measured on IN progeny through project 3.1.1 of the Next Generation Meat Quality Program is presented in Table 1 (after Pethick *et al.* 2009), together with growth traits being recorded from birth through to slaughter. The traits have importance for the prediction of lean meat yield, understanding the biochemistry of meat quality traits, consumer acceptability, eating quality acceptability and nutritional value of lamb.

Table 1. Summary of growth, carcass and meat traits measured on IN slaughter progeny and their relevance to lamb production (after Pethick *et al.* 2009)

Relevance	Traits
Growth	Weight at birth, weaning, post-weaning, ultrasound scanning, slaughter
Lean meat yield prediction	Hot carcass weight
	GR, Fat C and Fat5th rib depths
	Eye muscle area
	Weight of short loin subcutaneous fat
	Weight of boneless short loin muscle
	Weight of topside muscle
	Weight of round muscle
	Weight of hind leg bone
Biochemistry	ICDH enzyme activity
	Myoglobin content of the loin muscle
Consumer acceptability	GR, Fat C and Fat5th rib depths
	Ultimate pH
	Fresh 24 hour meat colour
	Retail colour stability of the loin muscle
	Skin assessment
Eating quality acceptability	Rate of pH decline
	Ultimate pH
	Shear force of the loin muscle (1 and 5 day aged)
	Compression of the topside muscle
	Connective tissue content of the topside muscle
	Intramuscular fat of the loin muscle
Nutritional value	Iron and zinc content of the loin muscle
	Long chain fatty acids (Omega-3s) of the loin muscle

Pethick *et al.* (2009) have summarised the scope of measurement of traits by project 3.1.1 and highlighted the value of these traits for lamb products. For example, lean meat yield and tenderness were among the traits discussed. Improvements in lean meat yield were suggested to be of benefit to processors (through less carcass preparation time and facilitation of trade on a lean meat yield basis). Further understanding of the genetic relationship between tenderness and muscling was indicated as necessary to improve eating quality of lamb cuts, given earlier evidence that selection for muscling may result in greater toughness of certain lamb cuts (Hopkins *et al.* 2007). The traits listed in Table 1 have relevance to basic aspects of consumer demand for red meat that have been identified (Meat & Livestock Australia market research) as being required for the development of improved red meat products (Pethick *et al.* 2006). For lamb, these aspects of consumer demand included: lamb should be tender and juicy and of good flavour; lamb should provide a good source of lean, high quality protein and nutrients as part of a healthy diet; and that lamb should represent premium quality and value for money given that production systems throughout the supply chain are cost-efficient.

EARLY RESULTS

For these preliminary analyses, available records from 2007 drop animals were analysed for predicted lean meat yield (%) and shear force (Newtons, N) on the loin muscle after ageing for 5 days, as a measure of tenderness. Measurement protocols for the carcass components used to predict lean meat yield and shear force are described by Pearce (2008). Lean meat yield was predicted for each animal using an algorithm based on hot carcass weight, fat depth at the GR site on the hot carcass, eye muscle area between the 12^{th} and 13^{th} ribs and weights of loin fat, loin muscle, topside, round and femur bone (G.E. Gardner unpub. data). The model fitted to the data for each trait included the fixed effects of sex, age of dam, birth-rearing type, site, sire breed, dam breed and the interaction of site by sire breed and a random effect of sire. Hot carcass weight and ultimate pH were fitted as covariates in the model for shear force. The analyses were performed using ASReml (Gilmour *et al.* 2006). Average values for predicted lean meat yield and shear force were 50.3 % and 34.5 N respectively (Table 2). Both traits were at least moderately heritable, with values of estimated heritability of 0.31 for predicted lean meat yield and 0.26 for shear force. Although both estimates had large standard errors, the estimates indicate that genetic variation in these traits exists and may be sufficient to allow inclusion of such traits in sheep breeding programs. Smaller potential responses, however, will be expected from selection for lean meat yield than from selection for shear force given its much lower coefficient of variation (1.8% for lean meat yield versus 21.7% for shear force). Data from Australian flocks have not been previously available to estimate heritability for these traits, but other studies suggest that most carcass composition traits and shear force are of moderate to high heritability (Lambe and Simm 2004).

Table 2. Preliminary estimates of mean, phenotypic variance and heritability, with their standard errors, for predicted lean meat yield and shear force

Trait	Records	Range	Mean	Phenotypic variance	Heritability
Lean meat yield (%)	1781	44.1-52.2	50.3 (0.22)	0.82 (0.03)	0.31 (0.09)
Shear force (N)	773	10.8-75.6	34.5 (1.88)	55.9 (3.29)	0.26 (0.12)

CONCLUSION

The implementation of the IN and Next Generation Meat Quality programs is underway with measurements of a comprehensive range of carcass, meat and growth traits nearing completion on 2007 drop progeny and having commenced on 2008 drop progeny. Initial analyses of carcass traits have indicated that genetic variation in novel meat traits may exist that could be used in sheep genetic improvement programs.

With completion of measurements on the animals slaughtered already and evaluation of progeny from the remaining 3 matings of the IN, a large body of data will be available for estimation of quantitative genetic parameters. These parameter estimates will enhance the accuracy of current ASBVs provided by Sheep Genetics and extend the range of ASBVs to include novel carcass and meat traits. Accuracy of ASBVs will be further improved by the availability of information on the influence of environmental effects on meat and carcass traits, such as birth-rearing type, dam age and management treatments. It is expected that more accurate ASBVs may be possible if molecular breeding values are used in their prediction for many traits. Research using the IN is now investigating the feasibility of predicting molecular breeding values based on the associations of single nucleotide polymorphisms (SNP) data with performance data from IN progeny (Fogarty *et al.* 2007).

The quantitative genetic parameter estimates will also be used to predict the consequences of selection on current breeding objectives, allowing responses to be monitored in unselected traits important to consumer acceptability, eating quality and nutritional value of lamb. Where responses in these traits are unfavourable, it may be necessary to develop breeding objectives and selection indexes that combine meat production traits with carcass and meat quality traits for use in individual flocks.

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