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breeders in the country that does not allow gene importation come only from sales of genes, as semen or as live animals and they miss-out on the opportunity to source superior genetics from the other group.

Fortunately, breeders in New Zealand and Australia can readily exchange genetics and capture both genetic improvement and marketing opportunities. One of the groups we are reporting on is discussing how to best establish ongoing transfer of genetics in both directions in order to strengthen genetic connectedness in the long-term.

## CONCLUSIONS

Exchanging data and performing separate analyses on the combined dataset with each national system is most robust and appropriate for the breeders in each country. Breeders in both countries benefit from their Trans-Tasman genetic evaluations providing a wider pool of animals from which they can source genetics, with results being presented in familiar formats using selection indexes optimised for their industry.

Breeding groups wishing to spread the net wider than their own country in order to aid genetic progress should actively develop and maintain strong genetic links with like-minded groups in other countries.

# Developments in the sheep meat industry: Genetic evaluation of meat yield

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## ABSTRACT

Sheep Improvement Ltd. has a 'MEAT' Goal Trait Group which is used to select animals on their genetic merit for meat production. Breeding values are calculated for weight of carcass lean, carcass fat and carcass weight. These breeding values are estimated from live weight and ultrasonic eye muscle dimension data, with the option of incorporating computed tomography (CT) measurements. This served the sheep industry well while carcasses were graded on the basis of carcass weight and GR tissue depth. However, deregulation in the meat industry has seen individual meat processors developing carcass grading systems which not only improve estimates of lean and fat, but also estimate retail yield within individual cuts. SIL have developed a 'MEAT YIELD' module in response to these changes which estimates breeding values for lean weight in the shoulder, loin and hindleg primal cuts. Meat yield data collected from surplus slaughtered progeny are added to live weight and ultrasonic eye muscle data to predict the breeding values. Slaughter progeny should be randomly selected to avoid biasing the meat yield data. This module is likely to be developed further as additional grading systems are implemented, and equations to translate data into standardised measurements will be required.

**Keywords:** sheep; genetic evaluation; SIL; meat yield; VIAscan®.

## INTRODUCTION

The sheep meat industry in New Zealand has developed from humble beginnings with a shipment of frozen carcasses to London in 1882, through to 320,000 tonnes of lamb meat exported and around NZ$2.38 billion in export earnings in the 2007/2008 season (Meat and Wool New Zealand, 2008b). Up until the 1970s, lamb meat had been exported in the form of whole carcasses, with around 92% of lamb meat exported as carcasses in the 1970/1971 season (Meat and Wool New Zealand, 2007). However, the proportion of the national kill exported in this manner has declined steadily over a twenty year period to fall below ten percent in the 1999/2000 season, and was around four percent for the 2005/2006 season (Meat and Wool New Zealand, 2007). Meat companies now further process almost all carcasses, with 81% of product being exported as cuts and 15% of product as boneless cuts in the 2005/2006 season.

While meat processors now sell a complex mix of further processed cuts, they purchase carcasses from farmers. In turn, 'quality' signals are sent to commercial farmers via their payment system. Carcass payment systems have until recently been based on a reward for weight of lean tissue in the carcass and a penalty for the weight of fat, with the weights of lean and fat estimated from carcass weight and GR tissue depth (Kirton *et al.*, 1999).

GR tissue depth is an assessment of fat content in a carcass based on the measurement of the total tissue depth over the 12th rib at a point 110 mm from the midline of the carcass. Carcass weight and GR have been used because they can be measured on every carcass at the speeds which meat plant chains operate. While they are useful in estimating the weight of lean and fat in a carcass, they are not able to give any indication as to the value of the lean tissue in the various regions of a carcass, meaning there is a mismatch between maximising profit for a farmer and maximising profit for the meat processor. The step grades for fat content have also resulted in considerable payment averaging. Deregulation of carcass classification in the New Zealand meat industry has seen individual meat processors developing or purchasing carcass grading systems which not only give better estimates of the weight of lean and fat in the carcass, but also give an indication of retail yield or yield within individual cuts.

Genetic evaluations for meat production within Sheep Improvement Ltd. (SIL) were designed to reflect the criteria on which payments were made to commercial farmers. As such, they have focused on the weights of lean and fat in the whole carcass, even though the meat processors have been further processing the vast majority of carcasses for a number of years, and the fact that carcasses that are the same weight can vary considerably in the weight of retail cuts that can be recovered (Kirton *et al.*, 1983). It has been possible to measure meat cuts in live animals using computed tomography (CT) scanning for some time (Kvame *et al.*, 2004) and use these measurements in breeding programmes. However, while it has been possible to collect measurements on the weight of meat with specific carcass cuts, the lack of a meat processor payment system that rewarded selection for this approach has limited the widespread adoption of the technology.

A video image analysis system has been developed for sheep carcass grading (Hopkins *et al.*, 2004) and has recently been implemented by at least one meat processor in New Zealand. This meat processor provides information to their suppliers on the yield of lean meat in the hindleg, loin and shoulder primal cuts as a percentage of carcass weight and rewards for high yielding carcasses in their payment system. Given that there is now a direct financial reward for selection for meat yield within a carcass region, there is increased interest in identifying genetics that will perform well under such a carcass grading system. In response SIL has recently developed a new 'MEAT YIELD' goal trait group which is designed to use data from carcass grading systems to estimate breeding values for the weight of lean meat within the hindleg, loin and shoulder primal cuts.

## SIL MODULES FOR MEAT PRODUCTION

There are currently four separate modules for meat production with SIL. In addition to the MEAT and MEAT YIELD modules listed above, there are two additional modules, namely the 'CT MEAT' and 'INNERVALUE'. The four modules are mutually exclusive in the SIL system. The MEAT module was the first to be developed and was the only module operating when SIL commenced operation in 1999. The MEAT module was developed to use live weight and ultrasonic scanning measurements to produce breeding values for the goal traits carcass weight, and carcass lean and fat weight, all on a constant age basis.

The CT MEAT module was added to SIL genetic engine in 2003. The module produces the same breeding values as the MEAT module, but incorporates measurements of carcass lean and fat weight as determined by CT scanning where they are available. Only a small subset of animals has data recorded for the CT traits because it is used in a two stage selection process. However, that data increases not only the accuracy of the breeding values for animals that have been evaluated, but also increases the accuracy of breeding values for all the relatives as well.

The INNERVALUE module was incorporated into the SIL genetic engine in 2006. A new CT scanning protocol was developed which predicted the weight of both lean and fat in the hindleg, loin and shoulder cuts (Kvame *et al.*, 2004). The INNERVALUE module was developed to produce breeding values for these six traits as well as the breeding values already estimated in the CT MEAT module. That is, the INNERVALUE module replaced the CT MEAT module for those breeders who used the INNERVALUE CT scanning protocol to measure meat cut yield.

The MEAT YIELD module was developed in 2008 and is scheduled for release in 2009. The module is described in detail below, but was developed to be able to use cut yield information collected at the meat plant to calculate breeding values for the distribution of lean in the carcass.

## MEASUREMENT TECHNOLOGIES FOR MEAT YIELD

Ultrasonic scanners provided the first technology to be used in the live animal that gave information over and above live weight (Purchas *et al.*, 1981), and more advanced B-mode ultrasound scanners are now widely used. Lambs are generally scanned over the twelfth rib and lean and fat measurements collected. The lean traits measured included the eye muscle width, eye muscle depth and the usual measure of fatness as the depth of fat over the eye muscle (measurements A, B and C, respectively, Palsson, 1939) width at the same site. These measurements are used in genetic evaluation to predict the weights of lean and fat in the carcass. While the proportion of variation in carcass lean and fat weight accounted for by the ultrasonic measurement of eye muscle dimensions, fat depth over the eye muscle and live weight is around 83% for carcass muscle and 63% for fat content (Young *et al.*, 1996), the measurement is inexpensive and can be collected on large numbers of animals. However, as the measurements come from a single specific site, it is not possible to accurately estimate lean weights of the various cuts. The existing measurements are evaluated within the SIL 'MEAT' module.

CT scanners have also been used in breeding programmes for meat production in New Zealand. Initially whole carcass measurements were collected (Jopson *et al.,* 1995; Young *et al.,* 1996), but measurement protocols have been refined to also measure the weight of lean meat within the three major primal cuts (Kvame *et al*., 2004). CT scanning provides very accurate estimates of the various tissues and regions within a carcass, but has had limited use because of both the expense of CT scanning and the distances that the animals have to travel to be evaluated. CT scanning is cost effective when used in a two-stage selection programme with ultrasonic scanning as the first stage (Jopson *et al.*, 2004). Measurements are evaluated in the SIL genetic engine using the INNERVISION and INNERVALUE modules for carcass traits and carcass cut traits, respectively.

Progeny testing with slaughter and dissection is also used in the New Zealand industry (Johnson *et al.,* 2002). Very accurate measurements can be collected with slaughter and dissection. However, dissections of progeny are slow, expensive and the rams take an extra year to evaluate compared to ultrasound and CT scanning, because the progeny have to be generated and grown to slaughter weight. Collecting these measurements is also difficult because the process is disruptive to operations in meat processing facilities. Finally breeding values have to be calculated outside of the SIL system as there is no standard protocol for progeny test slaughters and therefore the measurements cannot be incorporated into an automated evaluation.

Many on-line grading technologies have been proposed and developed over the last 30 years, but few have made it to the stage where they have been implemented commercially. Video based systems are a promising technology in that they can operate in a very harsh physical environment at the required speed and the carcass is not touched during grading. The VIAscan® system has been installed by one meat processor in New Zealand and has been already been used for routine progeny testing (McLean *et al.*, 2006). The weight of lean tissue in the hindleg, loin and shoulder are estimated from a video image of the whole carcass (Hopkins *et al.*, 2004). A major advantage of the system is that every animal slaughtered at each facility passes through this grading system, and the output is a well defined and calibrated set of measurements that can be used in a genetic evaluation programme. Measurement is inexpensive because it is part of the standard processing of a carcass and the information is available immediately. SIL have therefore developed a genetic evaluation module called "MEAT YIELD" able to calculate breeding values from the traits measured by the VIAscan® system. Other meat processors in New Zealand also have yield based recording systems or are working on their implementation. SIL's intention is to incorporate measurements from these systems as and when they come on line.

## SIL MEAT YIELD goal trait group

The new MEAT YIELD goal trait group introduces some additional breeding values to the SIL system. In addition to the breeding values for carcass weight, eye muscle area, lean weight and fat weight calculated in the existing MEAT and CT MEAT modules, the following breeding objectives are included:

- Weight of lean tissue in the hindleg primal cut,
- Weight of lean tissue in the combined loin and rack primal cuts and
- Weight of lean tissue in the shoulder primal cut.

These breeding values are calculated on an age adjusted basis and are estimated from data collected in meat processing plant using the VIAscan® carcass grading system. The data which is retrieved from the VIAscan® system are stored in the SIL database as total carcass weight and kilograms of lean tissue from each of the three cuts. Similar traits are recorded in the INNERVALUE module, but the data cannot currently be used from both sources simultaneously. The breeding values also use the predictor traits weaning weight, live weight at six or eight months of age, ultrasonic eye muscle depth, width and fat depth over the eye muscle measured on live animals. Breeding values are not calculated for weight of fat in each of the three cut regions because the weight of fat is not in the standard output from VIAscan®. Variance components used in the MEAT YIELD module were derived from literature estimates and unpublished data for similar traits. A recent analysis of data collected in the Meat and Wool New Zealand Central Progeny Test (Jopson *et al.*, 2009) has estimated variance components for the traits directly.

The MEAT YIELD module has been designed around the traits that can be measured with the VIAscan® system. However, other groups are known to be working on alternative grading systems and it is likely that some of these will be implemented in New Zealand. Theoretically, it will be possible to incorporate other carcass grading systems and SIL's intention will be that they are transformed into the above measurements for analysis. The ease of incorporating new measurements will depend on trait specifications in any new system. Transformations to data may well be required which may be difficult because the system involved propriety technology. It is likely that any new system will need to be worked through on a case by case basis to determine its suitability to be incorporated into the MEAT YIELD module.

## Using the MEAT YIELD module

The MEAT YIELD module requires a progeny test design. As such it requires a greater degree of structure than most of the other SIL modules. Accuracy of selection for a progeny test is a function of heritability and number of progeny per sire (Simm, 1998) such that:

$$Accuracy_{PT} = \sqrt{\frac{n}{n + \frac{4 - h^2}{h^2}}}$$

where $n$ is the number of progeny per sire and $h^2$ is heritability of the trait. The heritability for age-adjusted lean weights per cut from VIAscan® range from 0.37 to 0.42 (Jopson *et al.*, 2009). A minimum of 18 progeny per sire need to be evaluated to give an accuracy of selection of 80% if the lowest value of heritability listed above is used. In addition, it is important that selection of slaughter candidates is not biased across sires, although the evaluation system can adjust to some degree for live weight based preselection. Preferably allocation to slaughter should be by random selection.

Individual animal identification is required within the meat plant to preserve identity from the animal's individual tag through to the meat plant's individual identifier. This is essential to relate the meat yield measurements back to other measurements on the animals such as live weight collected prior to slaughter and the animal's pedigree. Currently, no New Zealand meat processing plant has fully integrated individual animal traceability systems from external tag or electronic identification through to carcass data capture and identification. Carcass identification other than at the mob level begins at the carcass weighing and grading station. The best current manual implementation is based around ordered bar coded labels attached to the carcass soon after slaughter against which tag numbers are manually recorded. This system allows rapid tag to carcass number reconciliation with minimal staff. Such a system could be easily fully automated with capture of electronic identification information linked to positive chain positional identification.

## Future directions in meat yield

Plans are underway to rationalise the four modules for meat production. How this will be implemented is still under discussion, and it is unknown whether the four modules will be rationalised into a single module producing all of the breeding values, or into two modules being a CT and a non-CT module. In addition, the basis for presenting the meat yield breeding values is under evaluation. Breeding values are currently presented on an age constant basis, and consideration is being given to presenting the breeding values on a carcass weight adjusted basis. There are benefits to presenting the breeding values using either method. However, expressing the breeding values on a carcass weight adjusted basis gives the breeding value for weight of lean within a cut compared at the same carcass weight. This presents the breeding value independent of growth rate and indicates whether an animal has more or less lean tissue within a cut than we would expect at a given live weight.

It is likely that SIL will add meat quality traits such as meat pH and colour, to the standard genetic evaluations in due course. Increasing use of the meat yield module will aid this as it will be possible to also collect these measurements for daughter progeny. At this stage it is likely that meat quality measurements would go into a separate module within the SIL genetic engine. While it is desirable to be able to calculate the meat yield and quality breeding values in a single module, it will be some time before sufficient data can be collected to estimate the appropriate variance parameters.