PE1.02 Using genetics to improve the yield and quality of New Zealand lamb 28.00

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Abstract—New Zealand exports over 90% of the lamb it produces, with end consumers wanting consistent, high quality product. To achieve this many factors need to be optimized, with genetics of the animals one such factor. This paper reviews methods of genetic improvement that are being used by New Zealand sheep breeders to improve lean meat yield and meat quality. Estimation of the genetic merit of sires for meat yield and quality traits is difficult as the traits are hard to measure on a live animal. Traditionally, estimation of genetic merit for lean meat yield for sires has been via predictor traits (e.g. ultrasound or CT scanning), or through the use of progeny testing whereby the progeny of sires are slaughtered and measured for the traits of interest. More recently progeny tests have also been used to measure aspects of meat quality (colour, tenderness, pH). Genetic improvement of lean yield has been aided by the identification of MyoMAX and LoinMAX, genetic markers which are associated with improved lean meat yield. However, lean meat yield and meat quality traits are all influenced by dozens of genes. New technology, harnessing the sequencing of the ovine genome, is the development of the Ovine 60K SNP (Single Nucleotide Polymorphism) chip, the use of which will enable identification of multiple genetic markers for lean meat yield and meat quality traits and aid genetic improvement towards consistent, high quality lamb.

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OVER 90% of New Zealand lamb is exported, with an increasing proportion being exported as fresh chilled product [17; 18]. New Zealand lamb producers have traditionally been paid for their lambs by meat processing companies based on carcass weight and GR (soft tissue depth 110 mm off the mid-line in the region of the 12th rib) measurement of the carcass [13]. New Zealand meat companies are now introducing technologies to enable objective estimation of whole carcass lean meat yield, with one company Alliance Ltd using Viascan (a commercial 2 dimensional imaging system that estimates carcass lean content [6]); and paying financial premiums to farmers who can produce lambs with improved lean meat yield across the carcass. With the increasing percentage of New Zealand lamb meat being exported fresh chilled, New Zealand meat companies are also placing increased emphasis on the visual appeal and eating quality of the product. Lamb consumers want consistent, high quality product. In order to achieve a consistent, high quality product factors that result in variation in the resulting product need to be identified, they are most certainly made up of genetic and non-genetic factors [9].

Non-genetic factors can range from on environmental factors (e.g. drought), to on-farm management factors (e.g. stockmanship), to pre-slaughter handling (e.g. trucking times), to post-slaughter handling (e.g. electrical stimulation and chilling profiles). However, for any mob of animals that are raised and processed together, between animal variation remains, with this variation due to genetic differences between individuals.

Compared to many housed species such as pigs and chickens there is large genetic diversity within the New Zealand sheep population with hundreds of breeds providing sires to thousands of producers. There is considerable literature, as reviewed by Safari et al. [21], to support that meat yield and a number of meat quality traits are moderately heritable in lamb and therefore under genetic control. The purpose of this paper is to review methods of genetic improvement being used within New Zealand to improve the lean yield and quality of New Zealand lamb.

I. SELECTION VIA BREEDING VALUES

Breeding values are an estimate of an individuals genetic merit for any trait of interest and are calculated based on raw data collected on animals that is adjusted for non-genetic effects and takes into account genetic relationships. Ideally the traits of interest must have been measured either directly on the individual, or on relations of the individual (e.g. siblings or progeny). Within New Zealand breeding values for the New Zealand sheep industry are generated by Sheep Improvement Limited (SIL) [23].

The overall aim of any sheep production system is profit, and multiple traits, not just one contribute to this profit, SIL therefore has created selection indexes which provide an economic weighting on all traits that contribute to the profit, with the breeding values of an individual for each trait multiplied by the respective economic weighting for the trait then summed to give an index value for each animal. Selection indexes relating to lean meat yield also include growth traits, as growth is an equally important part of lamb production systems [23].

A. Live Animal Measurements Whereas estimating genetic merit for growth is relatively simple because all animals can be weighed, estimating genetic merit for carcass traits directly on potential breeding stock is difficult. Actual carcass and meat quality traits can not be measured directly on potential breeding stock. Instead, for lean meat yield, live animal measurements which are predictors of carcass lean meat yield have to be used.

The most common method of estimating a live sires carcass lean meat yield potential, which is used by the majority of ram breeders in New Zealand, is through a cross section of the M. longissimus dorsi between the 12th and 13th rib being scanned using ultrasound, this enables the width, depth and area of the muscle along with the fat depth above muscle to be measured, with the raw data analyzed by SIL to generate genetic merit estimates.

The accuracy with which it predicts lean meat yield is only moderate however. A more accurate live animal prediction of carcass lean yield can be achieved using Computed Tomography (CT) scanning.

Computed Tomography scanning is used, in a two stage selection procedure, by a number of large scale ram breeding operations and a small number of individual breeders in New Zealand. Breeders ultrasound muscle scan all ram lambs and select the high breeding value lambs for CT scanning, with the best breeding value lambs from the CT scanning entering into their breeding programme [11]. There are currently no live animal measurements that can be used to predict meat quality in sheep commercially in New Zealand.

B. Measurements on Progeny The most accurate way of estimating the genetic merit of sires (rams) for lean meat yield is via progeny testing, whereby progeny are generated by mating a number of sires to commercial ewes with the resulting progeny being slaughtered and measured for carcass traits, with the data collected on the progeny used to estimate the sires genetic merit. Since 2002 there has been a national progeny test set up within New Zealand – the Meat & Wool NZ Central Progeny Test (CPT) [16] which annually generates progeny, from sires from a variety of breeds, which are measured for lean meat yield using the Alliance ViaScan system.

What the CPT has demonstrated is that there is as much variation in breeding values for lean meat yield within breeds as there is between breeds and that commercial farmers can not simply rely of selection of a breed to ensure lean meat yield. An additional role of the CPT has been the development of between flock linkages, which coupled with individual breeders using common sires has enabled SIL to undertake across flock genetic analysis known as SIL ACE [22], enabling the ranking of sires from over 300 flocks on its Meat Index.

Progeny tests are also being used by smaller breeder groups and large scale breeders to estimate the genetic merit of their sires for lean meat yield. Whilst some are utilizing the Alliance ViaScan system [20], others are using the weight of commercial cuts measured in the boning room [9; 10], but all have the same objective of identifying elite sires that produce progeny with improved lean meat yield for use within their breeding programmes. Many of these progeny tests are, additionally, measuring meat quality traits including ultimate pH, colour of the M. longissimus after blooming the day following slaughter, carcass fat colour, colour stability of the M. longissimus after retail packing after approximately eight weeks chilled storage [9; 16]. To date meat quality traits have not been incorporated into the selection indexes offered by SIL, and resulting breeding values are instead used as independent culling criterion, whereby any sire that is genetically very poor for a given trait will not be used as a breeding sire. Similar progeny tests in Australia are extending meat quality to consider the nutritional aspects of lamb [19].

II. SELECTION VIA GENTIC MARKERS

Over the last 15 years attempts have been made to identify genetic (DNA) markers associated with a variety of production related traits in New Zealand sheep. Identification of genetic markers for lean meat yield and quality traits has been given a high priority in New Zealand given their economic importance, but also given that they are not easily measured on the live animal. Two genetic markers tests associated with lean meat yield in lamb have been commercialized in New Zealand, following substantial industry validation – LoinMAX™ and MyoMAX™ which are marketed by Pfizer Genetics [3]. LoinMAX™ is a genetic marker originally identified in Poll Dorsets which increases the area and weight of the M. longgismus dorsi muscle by 8-10% [12].

The underlying genetic mutation tested for by LoinMAX™ is yet to be discovered. MyoMAX™ is a test based on a mutation in the Myostatin (GDF8) gene discovered in Texel sheep which significantly increases carcass lean meat yield as assessed by ultrasound, ViaScan and CT scanning [8].

The tests are being used to increase the frequency of the favorable form of the marker in purebreds, and to introgress the favorable form of the marker into composites and other breeds.

There is evidence for other genetic markers affecting lean meat yield, but these markers are yet to be industry validated [1; 2].

A search is currently underway to identify novel Myostatin mutation in New Zealand lambs, as based on the results from cattle [5] it is likely that other variant exist which influence lean meat yield (Johnson, unpublished). Resources to search for genetic markers for meat quality traits in lamb have been developed ([1; 2; 9] but are yet to uncover any genetic markers of large effect.

III. SELECTION VIA GENOME WIDE SELECTION

The majority of meat yield and quality traits are controlled by potentially dozens of genes, not just one, all of which have a small but cumulative effect on the ultimate observation of e.g. meat yield for an individual. To date searches for genetic markers have used microsatellite or RFLP markers which limits the ability for thorough searches for associations between genetic markers and production traits as limited numbers of markers can be easily tested.

Recently the sheep genome has been sequenced and an assembly published [7; 15]. This has allowed the development of the ovine 60K SNP (Single Nucleotide Polymorphism) Chip [4; 7]. SNPs are an alternative genetic marker, that occurs more frequently on the genome than other markers and 10's of thousands can simultaneously be tested at once.

They enable discovery of multiple genetic markers all of which have a small but cumulative effect towards on the ultimate observation of e.g. meat yield for an individual.

Once identified each SNP is assigned a weighting as to how much of the variation in a trait it explains, the sum for all SNPs for all traits is referred to as the Genomic Breeding Value for an animal, the results of which can be "blended" with traditional breeding values.

With the overall result being that faster rates of genetic gain are possible. The technology has already been used in the New Zealand dairy industry whereby they have used Bovine SNP chips to determine hundreds of SNPs associated with dairy important traits, the results being that they are now marketing semen from "DNA Proven" sires [14]. The first Ovine SNP chips only became available early in 2009, and in New Zealand the first priority has been identification of genetic markers associated with parasite resistance (John McEwan, unpublished data). Lamb meat yield and quality data sets are being generated that will be suitable for use with SNP chips into the future.

IV. CONCLUSION

Consumers want consistent, high quality lamb. Genetic differences between individuals contribute to variation; therefore, genetic improvement is required to achieve consistency in lamb.

New Zealand ram (sire) breeders have traditionally carried out selection for lean meat yield using breeding values, based on live animal correlated traits, or on carcass data from progeny tests, with some breeding values now also available for meat quality traits.

More recently genetic markers for lean meat yield have become available which aid genetic selection. Moving to the future Genome Wide Selection for lamb meat yield and quality traits will become available which will further genetic selection of elite sires. With the overall aim of the genetic selection being to generate genetically consistent, high quality lamb.

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