Lecture 9: Managing Lean Meat Yield

MLA (updates by Luke Stephen)

Learning objectives

- Understand the relationship between lean meat yield and the profitability of prime lamb businesses
- Learn the practical measures that the sheep industry uses to assess lean meat yield
- Learn more about the application of genetics and management of growth through nutrition to manage a lamb enterprise to comply more closely with market specifications.

Key terms and concepts

Lean meat yield; genetics; post weaning weight; post weaning fat depth; post weaning eye muscle depth; selection index; nutrition; growth rate

9.1 Managing lean meat yield on farm

The key tools for improving lean meat yield (LMY) are:

- Improved genetics.
- Improved management of feed supply and growth.
- Better animal health coupled with feedback.

9.2 The effect of genetics

Growth rate, muscle development, fatness and therefore lean meat yield are heritable. Genetically faster growing and leaner rams and ewes breed faster growing and leaner lambs. Faster growing lambs also reach heavier weights earlier.

A question frequently asked by producers is; "Which breed is best for yield"? The politically correct answer is that no one breed is better or worse for lean meat yield. However, in a breed comparison conducted by Meat and Livestock Commission in the UK (Kempster *et al.*, 1987) the Texel breed had an average lean meat yield greater than the other breeds compared at that time. Some of the key breeds used in Australian prime lamb industry were included in that trial (with the exception of Merino). Since then there has been intense selection for growth and yield traits in meat sheep (in Australia and around the world) and it is generally thought that the variation in growth, muscling and fatness within a breed is equal to or greater than the variation that exists across breed types. There is no doubt that improvements in lean meat yield have resulted from careful selection and breeding from animals superior for growth and muscle and against fatness within each breed.

Seedstock breeders (studs) are under significant pressure to improve the elite animals that they can provide to clients to improve lean meat yield. Single trait selection, for growth, leanness or muscling independently, offers very little for the seedstock breeder aiming to improve yield. Accordingly, sheep genetic improvement programs (in Australia, LAMBPLAN) provide a selection index that contains a balance between growth (weight for age) and eye muscle depth and fat depth measured at the C site. Generally, selection for improved growth and leanness will give the greatest response in lean meat yield. Lambs sired by rams with higher growth will be proportionally leaner than other lambs when compared at the same age and weight. They will also have a higher yield of lean meat than lambs bred from lower growth sires. This suggests that lambs sired by rams with higher Estimated Breeding Values (EBVs) for growth may be leaner and will have higher lean meat yields, at the same age and weight, compared to lambs sired by rams with average or lower growth EBVs. Selection against fat at a constant weight, using LAMBPLAN EBVs for fat, will improve lean meat yield. The addition of Eye Muscle Depth (EMD) to an index that contains growth rate and fat score information will lead to a minor increase in yield, but will give significant improvements in eye muscle area and loin weight. Selection for EMD alone will not improve LMY.

Lean meat yield (LMY) is a measure of the total meat; it is not a measure of where that meat is located or what the value of that meat will be. For this reason, lamb breeders are also conscious of the need for improved muscling and location of the muscles within the carcase (sometimes referred to as shape). This is particularly important for the loin from which the higher priced cuts are derived, more so than the hind quarters and forequarters.

Key point: Higher lean meat yields will result from a combined approach of selecting for higher growth, leanness and improved muscling (Kempster, *et al.*., 1987).

Maternal sires. The dam provides half the genes of every prime lamb (and everything else as well). There is considerable genetic variation in maternal breeds and this contributes to the variation in growth, muscling and fatness that contributes to variation in lean meat yield. Genetic improvement of the dams is an important source of systematic improvement in meat yield. The traditional maternal breed for the Australian prime lamb industry is a "purebred" Merino or a first cross from the joining of Merino ewes to a specialist maternal sire such as Border Leicester. Industry is increasingly experimenting with different breeds of maternal sires (including East Freisan, Coopworth and dual purpose Merino). Within Australia, a Maternal Central Progeny Test (MCPT) has been used to derive genetic parameters for Prime Lamb dams and to illustrate the benefits of selection for maternal traits that contribute not only to reproductive success (a key profit driver) but to the component traits that affect lean meat yield (growth, eye muscle and fat depth) of their progeny.

The selection indexes that are used by maternal breeders using LAMBPLAN have appropriate weighting on growth, leanness and muscling to improve yield, as well as placing pressure on improving maternal performance and reproductive ability.

9.3 Important traits for selection for improved lean meat yield

LAMBPLAN information is provided in the form of Australian Sheep Breeding Values (ASBVs). These provide a simple picture of the value of an animal's genes for a production trait. ASBVs are based on the animal's own measured performance and that of its relatives (see Lecture 15 for more detail). For each trait the ASBV is shown as a positive or negative difference from the breed base which is set at zero. The average ASBVs for different traits change over time as a breed makes genetic progress. Current breed average and top 20% ASBVs are therefore more relevant for benchmarking than the zero base.

LAMBPLAN ASBVs for three commercially important traits:

Post weaning weight (pwwt)
Weight ASBVs describe the animal's genetic merit for growth rate (post weaning weight ASBV is calculated as weight corrected for a standardized age, in this case post weaning or approx 225d after birth although the measurements may be taken from 5 to 11 months). The higher an ASBV, the greater the genetic potential of that animal to grow quickly. This will mean that animals with a higher weight ASBV will be heavier at a constant age.

Post weaning fat depth (pwfat)
Fat depth ASBVs describe the fat depth of an animal at constant weight. A negative ASBV means a genetically leaner animal. Measurements are taken by accredited LAMBPLAN scanners, using ultrasound technology. The units are millimetres. The ASBV for post weaning fat depth is adjusted to a constant liveweight of 45 kg. A reduction of 1mm pwfat ASBV is estimated to increase Lean Meat Yield by 0.5% - 1.0%.

Post weaning eye muscle depth (pwemd)
Eye muscle depth ASBVs describe each animal's genes for eye muscle depth at constant weight. A positive ASBV means a genetically heavier muscled animal and one that will have slightly more of its lean tissue in higher priced cuts. The units are millimetres. ASBVs are calculated at constant liveweight of 45kg. Eye muscle depth and eye muscle area are highly correlated. Accordingly measurement of eye muscle depth is an effective estimate of eye muscle area.

Single trait selection
Lean meat yield is less sensitive to selection for eye muscle depth, than to fat thickness. This is because the muscle and fat depth ASBVs are presented as deviations from the mean and in units of mm. The mean values for PEMD and PFat are typically 2-3 fold different. Typical mean values are 15mm for PEMD and 5 mm for PFat. Accordingly, if we compare two rams with post weaning eye muscle depth ASBVs of -2 and +2, this will give a difference of 2mm, which will only give a 1.2% increase in LMY (at

the same PFat ASBV).However, by reducing the fat ASBV from +2 to -2, this will give a difference of 2mm of fat at the GR site, which will in turn increase LMY by 1.8% (at the same PWEMD ASBV).If selection were based on both traits equally and simultaneously (PWEMD and PWFat) it is possible to increase LMY by the sum of the contributions of each (1.2% + 1.8% = 3%).

9.4 Effects of environment on lean meat yield

There are three major environmental influences that have a bearing on lamb growth, muscle development and fatness, and lean meat yield.

- Birth type
- Nutrition
- Disease (principally intestinal parasite burden, and to a lesser extent a number of protozoan and bacterial infections).

Unlike genetics where decisions are made annually on choice of sire, and less frequently for the dam, management of nutrient supply and disease state are ongoing throughout the annual production cycle. Although nutrition and disease effects can sometimes have profound impact on yield and productivity most producers have in place well established systems in which they manage their stock. Moreover, these systems are invariably intended to maximize number and weight of lambs that reach slaughter, and hence whole of system profitability, rather than maximize yield per head. Decisions about nutritional management are made to maximize whole of flock productivity, usually without consideration of nutritional effects on lean meat yield.

Lean meat yield is a function of growth rate, muscle development and fat deposition. These components of yield are subject to variation from nutritional inputs throughout the life of the lamb.

Some of the variation in a lambs growth and yield can be attributed to in-utero effects. Birth type, single, twin, triplet, and nutrition of the dam during pregnancy affect birth weight. Moreover, birth type and ewe nutrition also affects the amount of milk that is available for each lamb. Birth weight, in particular, is a major determinant of subsequent growth rate.

Birth type

Major factors affecting birth weight are parity (i.e. single, twin or triplet born), and nutrient supply to the dam in the last trimester. Individual twins are typically born 15% lighter than singles and subsequently grow 10% slower. Individual triplets may be born up to 30% lighter than singles and subsequently grow 20% slower. Multiple births are associated with changes in fatness, initially multiple born lambs are less fat because they are each able to obtain less milk from their mother than a single born lamb. Later in life, and particularly if they have been fed to catch up, twin and triplet lambs may become slightly more fat (and thus have lower lean meat yields) than single born lambs.

Nutritional management of lambs - effects on growth, fatness and yield

Most lamb production systems are pasture based. This makes use of detailed nutritional calculations to meet requirements for growth difficult to implement in practice. Approaches to simplify the complexity of prediction of pasture intake by sheep with different genetic potential, at different weights and that predict growth rate, are available as computer based models such as GrassGro and GrazFeed. These are seldom used because producers (and advisors) rarely have sufficient of the required data to the run the simulations. Nonetheless, it is important to understand the principles upon which they are based. A good overview of the principles upon which nutritional requirements of grazing sheep are calculated is given by M. Freer (2002) in Chapter 16 “The nutritional management of grazing sheep” (pp357-375) of Sheep Nutrition (eds M Freer and H Dove) CAB International & CSIRO Publishing.

The basic principles for pasture based systems are:-

- Feed intake is a function of an animal’s capacity to eat (set in part by genetic potential, age and weight of the animal, and past growth) and the amount of pasture and the nutrient availability in that pasture. Heavier animals, more pasture availability and better quality pastures are associated with increased nutrient intake.
- Growth rate is determined by the ingestion of nutrients (predominantly energy and protein) relative to the maintenance needs of the animal. Higher growth is associated with nutrient intakes much greater than required for maintenance.

- Fat deposition is determined by the weight of the animal (relative to mature weight) and growth rate. Faster growth is associated with increased fat relative to protein deposition.

In practice these are converted into general rules of thumb such as the following example,

Growing lambs can eat from 3-4% of their body weight (from 1.2 -1.6 kg dry matter /day).

Growth rate is determined largely by the nutrient density of the feed (as shown in Table 9.1). The amount of protein in the diet should be sufficient to:

a) Maximize microbial protein synthesis in the rumen.
b) Make up for any shortfall in requirements between microbial protein produced in the rumen and that required by the animal's tissues.

Minimum amounts of dietary protein are determined by the energy density of the diet (higher energy density, greater rates of fermentation in the rumen) and the proportion of dietary protein degraded in the rumen (more degradable, lower dietary protein requirement). Except in the case of lambs less than 20 kg (and these are likely to be suckling mum), and around weaning when intake will be affected by stress at separation from mum, and by the rapid development of rumen, the minimum dietary crude protein contents shown in Table 9.1 are likely to be sufficient to meet both rumen and tissue needs for maximum growth.

Table 9.1: Relationship between Energy and Protein content of feed and estimated growth rate of a 40kg lamb* (MLA 2003).

Estimated lamb growth rate (g/day)	M/D (MJ metabolisable energy/kgDM)	Minimum Crude Protein % in dry matter+
<150	9	11.6
~180	10	12.9
~220	11	14.1
~275	12	15.4
>300	13	16.7

* Assumed between 40 - 50% of mature size
+ based on degradability of dietary protein in the rumen of 70%

However, maximizing growth rate may not be conducive to maximizing lean meat yield. Growth rate (predominantly determined by energy density of the diet) has a major effect on the relative proportions of fat and protein deposited in the carcase (Figure 9.1).

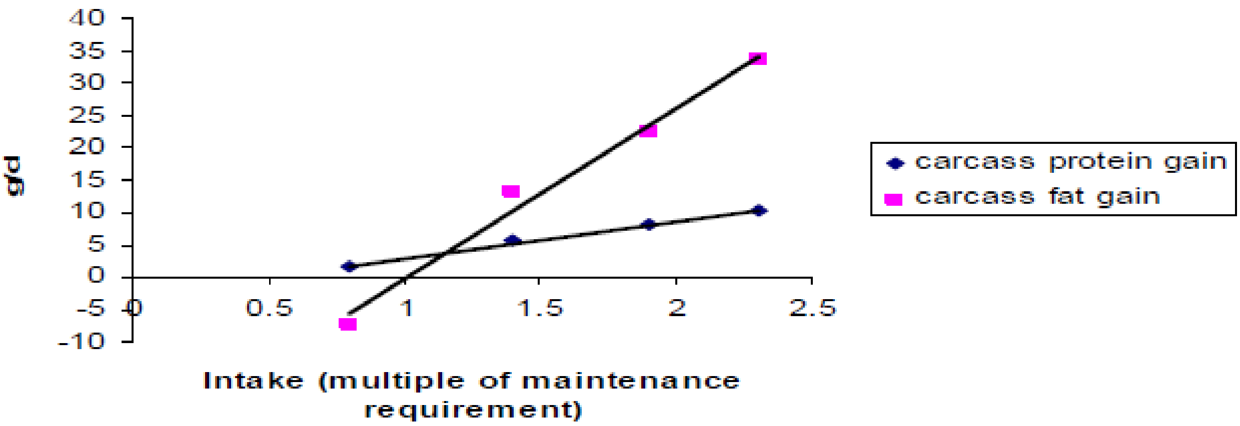

Figure 9.1: The effect of feed intake relative to maintenance on protein and fat deposition in the carcase of lambs. Castrate males lambs from Border Leicester X Merino ewes and Poll Dorset sires were fed different amounts of a pelleted ration with M/D =10 MJ ME/ kgDM. The lambs were approximately 6 months old and weighed 52 kg at the start of the experimental period (Hegarty *et al.*. 1999).

Figures 9.1, 9.2 and 9.3 illustrate that higher growth rates achieved by eating more of the same feed, or by eating more of nutrient dense feedstuffs are associated with increased rates of fat and protein deposition in lambs near finished weights. Higher growth due to nutrient intake is associated with much more fat than protein deposition.

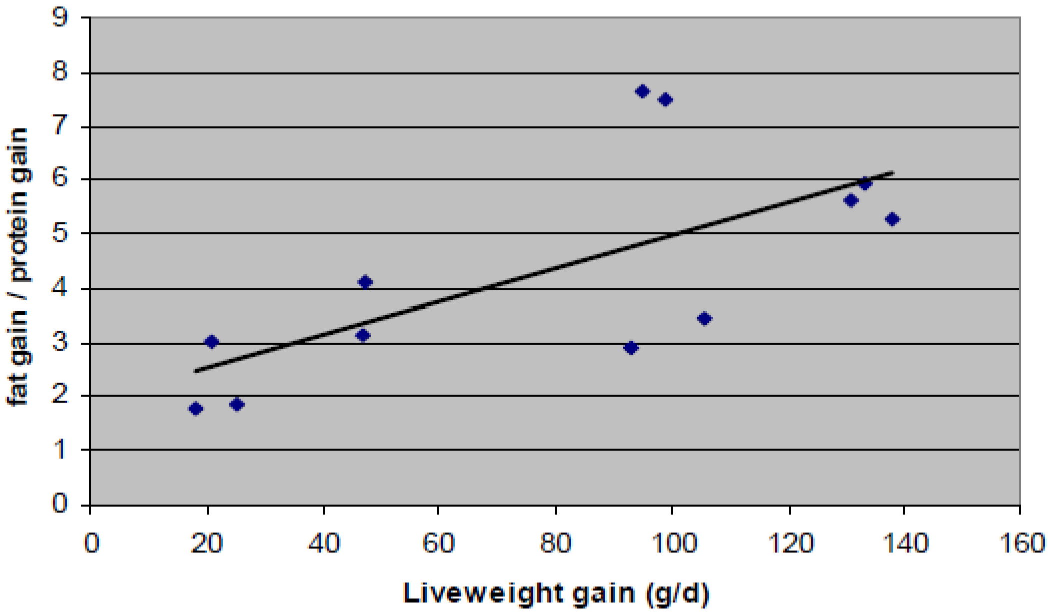

Figure 9.2: The effect of liveweight gain on the ratio of fat gain to protein gain in the carcase of lambs. Castrate male lambs from Border Leicester X Merino ewes and Poll Dorset sires were fed different amounts of a pelleted ration with M/D = 10 MJ ME/kg DM. The lambs were approximately 6 months old and weighed 52 kg at the start of the experimental period (Hegarty *et al.*. 1999).

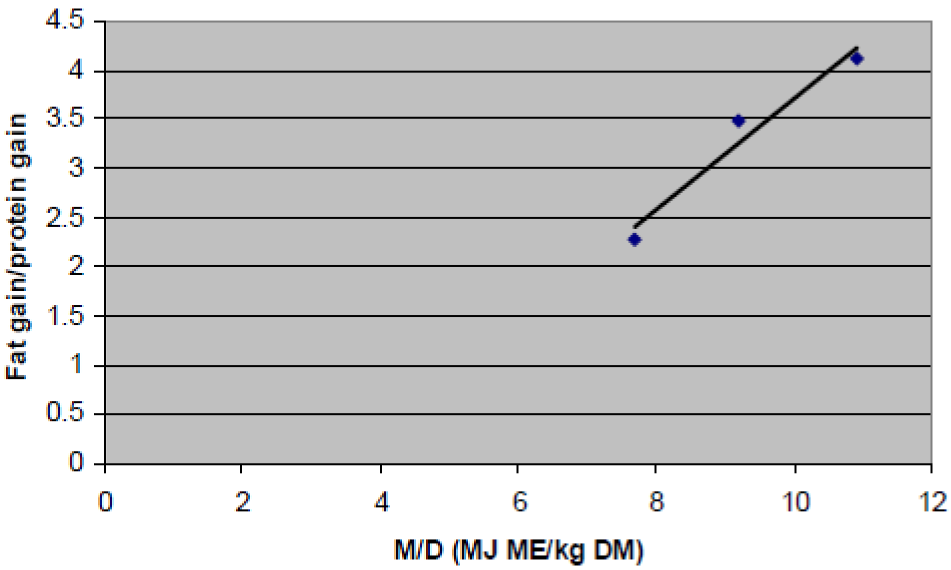

Figure 9.3: Effect of diet energy density on ratio of fat to protein gain in the carcase of lambs. Data from castrate male lambs from Dorset Horn sires over Merino X BorderLeicester ewes approx 6 month of age, weighed approx 35kg at the start and 50kg at the end of the feeding period (Oddy and Sainz 2002).

The amount of protein relative to energy available to the tissues of the animal also affects the ratio of fat to protein deposition in the carcase, and thus lean meat yield. At energy intakes close to maintenance, increasing rumen bypass protein content of the diet facilitates muscle growth while reducing fat deposition (Figure 9.4, see Bell and Bower, 1990 for a practical example).

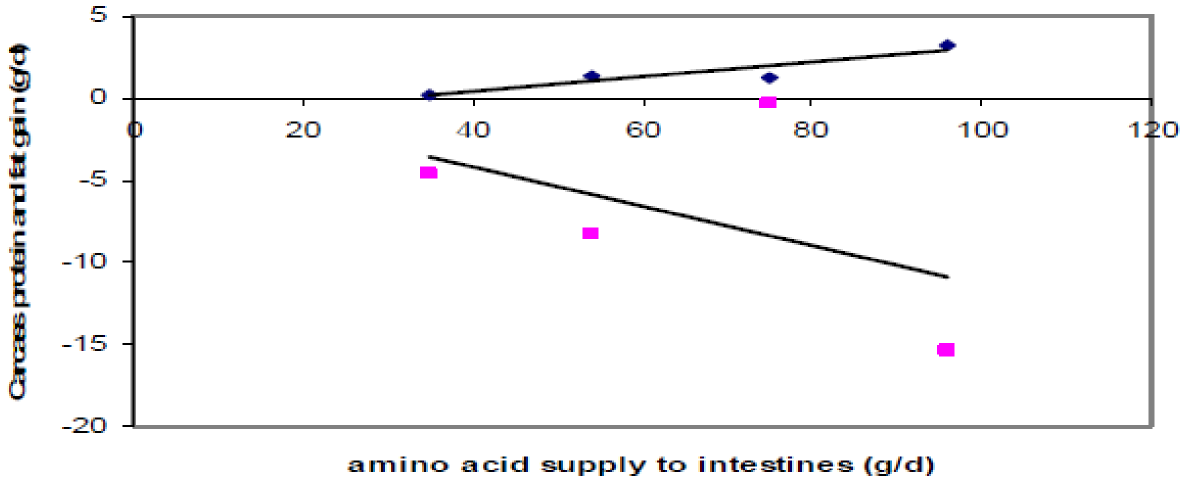

Figure 9.4: Effect of increasing amino acid supply to the intestines at 0.8 x maintenance energy intake on carcase protein and fat gain. Data from castrate males lambs from Border Leicester X Merino ewes and Poll Dorset sires fed different amounts of a pelleted ration with M/D =10 MJ ME/ kgDM. The lambs were approximately 6 months old and weighed 52 kg at the start of the experimental period (Hegarty *et al.*. 1999).

In summary, nutritional management of overfatness (to increase yield) can be achieved by reducing the energy density of the feed, by slowing growth rate and by increasing dietary protein supply relative to energy.

Guide to weight gains

As seen above, there are many variables that will influence the performance of lamb growth and fattening. In practice, farmers should be monitoring lamb growth during finishing by regularly weighing lambs. Fat scoring will also provide an indication of growth rates.

Influence of pasture intake on LMY

Managing nutrition for growth rate is a sophisticated and complex undertaking.

The most cost-effective way is to produce lambs on quality pasture. Lamb intake of pasture and hence growth rate is highest on green pasture with an availability of about 1,500kg per hectare.

As seen above the nutrient density of pasture is critical to lamb growth. Growth rates can drop considerably as pastures mature. This is because digestibility (and therefore energy and protein content) of pasture decreases, as demonstrated in Figures 9.5 and 9.6.

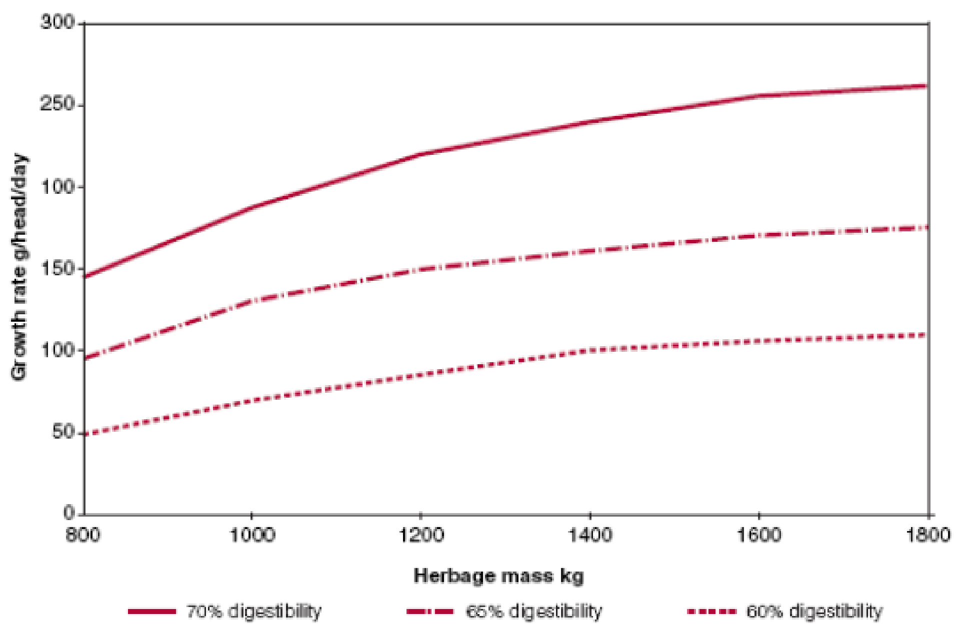

Figure 9.5: Relationship between herbage digestibility and growth rates – second cross lambs (MLA 2003).

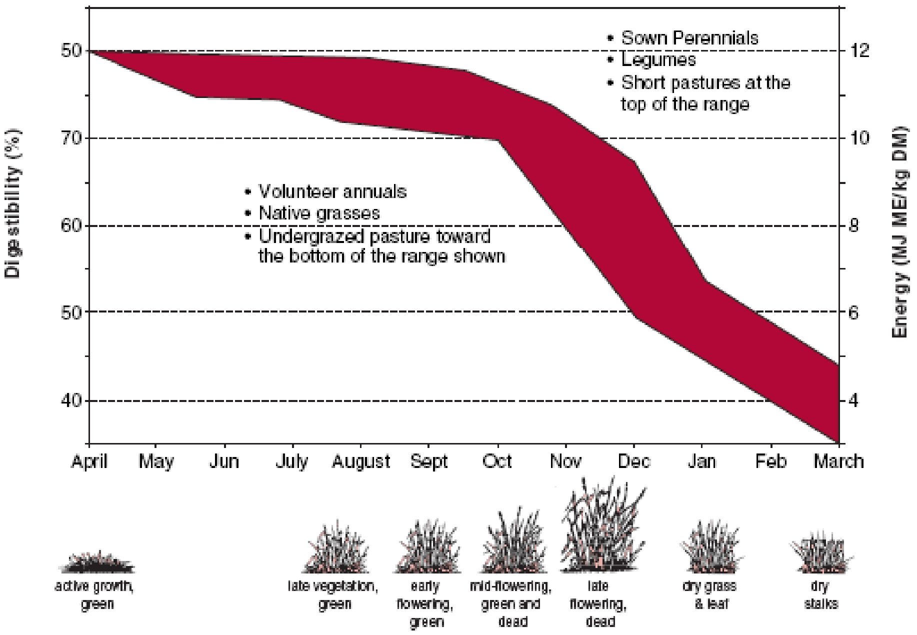

Figure 9.6: A guide to digestibility decline as temperate pastures mature. Note the legend to Figure 9.6 should show the top value for digestibility should be 80% not 50% as shown (MLA 2003).

Digestibility
Digestibility is a useful practical measure of pasture quality. It is directly related to the energy density of the diet (high digestibility = high energy density, see Figure 9.6):

- To achieve fast lamb growth of 250grams per day or better, a green pasture of 70% or higher digestibility and 1500kg per hectare green availability is required.
- Young green pasture is the most digestible.
- The legume content will increase pasture quality by increasing feed intake and digestibility. Ideal pastures contain about 30% legume content.

Managing for growth rate and Lean Meat Yield
The following concepts are key elements to be considered when managing for growth rate and Lean Meat Yield:

- Target growth rates for lambs.
- Pasture quality is influenced by digestibility and the proportion of legume.
- Animal production will be determined by pasture intake.
- Intake is determined by herbage mass (the amount of pasture) and the digestibility of the pasture.
- Digestibility decreases with plant maturity.
- Digestibility is positively related to energy and protein content of pasture.
- Digestibility of a pasture will be influenced by pasture species, stage of growth and legume percentage.
- Pasture benchmarks are a prediction of the minimum herbage mass of green pasture that a particular class of livestock can graze to and still meet their production requirements.
- Herbage mass and digestibility interact to influence intake.

Body composition in the lamb
Assuming that growth is occurring, the growth of the young lamb can be regarded as having four phases:

- Milk feeding (very efficient).
- Weaning (may involve a growth check).
- Pre-finishing.
- Finishing (fat deposition rapidly accelerates).

Throughout these phases, there is a relatively constant rate of muscle deposition in the body and it is the rate of fat deposition that is highly variable until, in the finishing phase it becomes the dominant process. Females will enter the finishing phase at a younger age than males of the same genetic potential. Carcases weighing 25kg from ewes typically contain 2-3kg of fat more than males and this will reflect in a lower LMY% for females, consistent across breeds. Castrates (wethers) will be fractionally leaner than ewe lambs. For a typical lamb, most of the early weight gain development is muscle tissue. However, as the animal approaches maturity, muscle gain per day begins to noticeably decline while fat deposition rapidly increases. Therefore, as lambs get heavier, the proportion of fat increases significantly, whilst the proportion of bone declines and the proportion of muscle slightly declines.

Once a lamb reaches maturity, the growth rate also slows whilst its' feed intake increases. This means that feed conversion ratio also declines and it will be eating greater quantities of feed per kilogram of weight gain. Younger lambs will tend to have faster growth rates and better feed-conversion efficiencies than older lambs. It will be the final carcase weight and growth rate during finishing that principally determines LMY% of a lamb, except where lambs suffer a growth check in the first 6 weeks. In order to support high growth rates during finishing without producing over-fat, lower LMY lambs, careful selection of sire and dam genetics for breeders with a high propensity for lean growth is essential. Selection of high growth rams will produce lambs that are heavier at the same age than the average lamb. Therefore, the genetically superior lamb will reach heavier weights before reaching maturity and before it enters the fattening phase.

Manipulating growth rate pathway

Nutrition affects LMY (weight and percentage) by influencing the final carcase weight, but also by affecting the composition of the carcase at any given weight. Alterations in growth rate arising from differences in the overall plane of nutrition can alter body fat and protein content and the eating quality of the meat produced. In general:

- Slower growth rates can result in higher lean meat yields, due to less fat deposition in the carcase, however if growth is too slow this may reduce eating quality and decrease profit.
- Faster growth rates towards the end of finishing are associated with faster rates of fat deposition, which can lower the lean meat yield.

Animals that have an early growth check due to inadequate nutrition early in their life (prior to weaning) end up being fatter, because their long-term capacity to grow muscle and bone has been reduced. Despite this, animals that have a late growth check (during the finishing phase) will compensate for this when sufficient nutrition is supplied. Animals that have been held back try to catch up by growing muscle and this 'catch-up', or compensatory growth is normally leaner than normal growth because the body puts the priority on growing carcase muscle in preference to laying down fat.

Fat development may then be delayed until muscle growth has caught up to that appropriate to the animal's maturity. Once lambs enter the finishing phase, there is little change to the 'muscle: bone' ratio, and therefore most of the impacts of feeding on LMY percentage, can be assessed by monitoring lamb fatness.

Table 9.2: Pasture benchmarks for sheep and lambs – Minimum pasture requirements (MLA 2003).

Sheep Pasture Category	Minimum pasture requirement (kgs Green DM/ha) (15% legume content)
Dry Sheep	400 – 500
Pregnant Ewes – mid	500 – 600
– last month	800 – 1000
Lactating Ewes – singles	1000 – 1200
– twins	1400 – 1600

Example: To ensure optimal lamb growth, with single or twin rearing ewes, they would require 1500kg/ha green dry matter and a legume content of 15%.

Table 9.3: Pasture requirements of lambs for varying potential growth rates. The growth rates in brackets are based on a weaned four month old crossbred lamb of about 32kg liveweight, on a pasture where the green component was 73% digestible, there was 1500kg DM/ha of green herbage and 15% legume (MLA 2003).

Percent of Potential Growth rate	Minimum pasture requirement (kgs Green DM/ha) (15% legume content)
30% (90g/d)	500 – 600
50% (150g/d)	700 – 800
70% (190g/d)	900 – 1000
90% (250g/d)	1500 – 1600

Benchmarks provide "ball park" estimates for the minimum green herbage mass to which stock can graze and still maintain satisfactory levels of production. There are a number of courses available to lamb producers to help them develop pasture assessment skills and pasture management skills. Prograze is one of these courses which looks at grazing management and the affect of pastures on livestock.

Effect of intestinal parasites on lamb performance and lean meat yield.
Infection with intestinal parasites occurs routinely in lambs. The effects of infection are usually greatest shortly after weaning. At this time, lambs are under nutritional and behavioural stress, and well as reaching the point where their immune systems are becoming capable of mounting a response to intestinal parasites. In practice, management of lambs by weaning onto pastures with a low worm burden, and treatment with anthelmintics is used to reduce the chances of intestinal parasitism affecting growth (and survival) of the lambs. Where treatment is not effective (increasingly the case as resistance of parasites to anthelmintics is increasing), infected lambs may not gain weight as quickly as uninfected, and this may impact on subsequent capacity to grow and on future lean meat yield. Examples of the impact of parasitism are shown in the following table. One of the major effects of intestinal parasitism is a reduction in feed intake. However, the reduction in growth and in particular growth of protein during infection is disproportionately more than the reduction in feed intake.

Table 9.4: Growth of lambs and of fat and protein during a three month period of parasitism (intestinal – Trichostrongylus colubriformis, abomasal – Ostertagia circumcincta). ALI = ad-libitum intake, infected, ALC = ad-libitum intake, control uninfected, PF = pair fed uninfected, fed same amount as eaten by ALI (Sykes and Coop 1998).

	ALI	ALC	PF
Intestinal parasites			
Growth rate (g/d)	94	194	151
Fat gain (g/d)	39	74	55
Protein gain (g/d)	6.3	18.8	16.2
Abomasal parasites			
Growth rate (g/d)	78	156	124
Fat gain (g/d)	36	63	52
Protein gain (g/d)	8.9	18.1	12.0

9.5 Other factors influencing lean meat yield

Trace element deficiency
The major trace element deficiencies in prime lamb producing districts of Australia include Vitamin B12 (cobalt), copper, selenium, Vitamin A and Vitamin E. Producers should test the blood of fast growing young animals for these deficiencies. Testing is recommended to determine the extent of the problem so that appropriate strategies can be developed. Trace element deficiencies can reduce growth rates and influence fertility levels in ewes and rams.

Health
Sheep diseases and/or parasites can compete for nutrients, depress food intake and reduce feed conversion efficiency. Follow correct vaccination recommendations for your area. Remember not to vaccinate lambs and ewes on the body as this reduces skin quality, only vaccinate in the upper neck. As lambs approach marketable weights it is important to be mindful of the withholding periods of the drenches, lice and fly treatments you may have given your lambs. There are withholding periods of 3 to 180 days for chemicals used on animals that are for sale for meat. There may be even longer export slaughter intervals set by the importing country.

Condemnations at slaughter
Condemnations at slaughter can cause significant losses of lean meat yield, due to removal of parts of the carcase prior to the hot weight scales. This means lower carcase weights and consequently lower lean meat yield (kg).Reasons for trimming include arthritis, pleurisy (secondary pneumonia), broken ribs, cheesy gland, vaccination abscesses, dog bites and bruising.

The trimming for these conditions occurs before the carcase is weighed, and therefore not only do you lose the weight trimmed from the carcase, you may also drop down in weight to a lower price per kg. A lamb with arthritis gets it's leg chopped off below the affected joint, a lamb with pleurisy will get one or two sides of it's rib cage removed, and a lamb with cheesy gland or abscesses in the hind leg will sometimes lose the whole back leg. Trimming for this type of condition could amount to 1-5kg loss in carcase weight per lamb, and therefore a high incidence of pathological problems at slaughter could result in lower carcase values. A number of these conditions can be prevented if better management and hygiene practices were employed throughout the lambs' life – starting at lamb marking.

Readings

There are no prescribed readings for this lecture. Students are advised to access and read papers in the reference section that interest them.

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