Learning Objectives
On completion of this topic you should be able to:

- Describe the pre-natal influence of nutrient availability on follicle initiation and development;
- Understand the importance of feed quantity and quality in determining fibre growth rate and quality;
- Become aware of the opportunities of manipulating fibre production and quality via grazing management;

Introduction
An animal’s capacity for fibre production and the quality of that fibre is determined by its genotype. However, its ability to express this genetic potential can be modified by a number of factors, the most important of which is nutrition. Furthermore, nutrition can be used to manipulate current flock performance whereas selective breeding is used to change the ‘future’ flock. For example, the average clean fleece weight of the sheep flock can be improved through selection at a rate of around 1.5% per year. Improvements in nutrition, on the other hand, can increase clean wool production of the individual sheep by up to 250%.

4.1 The role of nutrition in wool production

Pre- and post-natal nutrition
The development of all organs and tissues in the foetus, including the follicle population for wool fibre production, is dependent on the supply of nutrients provided by its mother. Under-nutrition in the foetus can result in underdevelopment of the foetus, depending on the severity of the restriction and its timing in relation to the stages of foetal development. The most nutritionally-demanding period for the foetus is during the last third of pregnancy, coinciding with the peak in the initiation and development of the secondary follicle population. Foetal under-nutrition during this time can significantly reduce the total number of secondary follicles that ultimately form (Figure 4.1), the S/P ratio and the proportion of mature follicles at birth. This is a permanent effect, resulting in a permanent reduction in the total number of fibres that the individual is able to produce during its lifetime. Also contributing to this is the smaller size of the animal at birth, reducing the total skin surface area capable of supporting fibre production.

These effects are demonstrated in the following experiment: Two groups of Merino ewes carrying a single foetus were maintained on pasture. From day 50 of pregnancy to 11 days pre-lambing and received supplements of hay and grain from 11 days pre-lambing, one group received supplements of hay and grain and was expected to maintain maternal liveweight (maintenance group). The other group did not receive the supplements. This sub-maintenance group was expected to lose 7–10 kg maternal liveweight during the treatment period, mimicking the pasture conditions commonly found in autumn lambing ewes in WA. Both groups received supplements from 11 days pre-lambing till the weaning of the lambs. Table 4.1 summarises the performance of the progeny at birth, 5 months and 18 months age, indicating permanent effects of pre-natal nutrient restrictions on the capacity of the animal to produce fibre. A lesser effect on fibre diameter may also occur.

Post-natal nutrition is also important in the continued maturation of the secondary follicle population, there being only part of the population producing fibre at birth. In general, post-natal under-nutrition can delay the time required for full maturation to occur, and only when severe does permanent cessation of some follicles occur.
Figure 4.1: Development of primary and secondary follicles in Merino lambs when their mothers received adequate (——) or restricted (- - -) nutrition during pregnancy. Period of possible follicle initiation indicated by l——l (Black and Reis 1979).

Table 4.1: The effects of restrictions in pre–natal nutrition on lamb performance at birth and at 5 (lamb shearing) and 18 (hogget shearing) months age (Kelley et al. 1996).

<table>
<thead>
<tr>
<th>Maintenance/Sub-maintenance</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (kg)</td>
<td>5.5</td>
</tr>
<tr>
<td>5 months:</td>
<td></td>
</tr>
<tr>
<td>Greasy fleece weight (kg)</td>
<td>32.5</td>
</tr>
<tr>
<td>Fibre diameter</td>
<td>1.7</td>
</tr>
<tr>
<td>18 months:</td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>59.0</td>
</tr>
<tr>
<td>Greasy fleece weight (kg)</td>
<td>5.7</td>
</tr>
<tr>
<td>Fibre diameter</td>
<td>20.7</td>
</tr>
<tr>
<td>S/P ratio</td>
<td>21.2</td>
</tr>
</tbody>
</table>

Feed intake and fibre production

There is a direct relationship between feed intake and fibre growth rate: the more feed an animal consumes, the more fibre it produces in a given period of time. This increased rate of fibre production is associated with an increase in both fibre diameter and fibre length growth rate, mediated by cellular changes at follicle level. It is therefore expected that under–nutrition would result in reduced fleece weights, shorter staples and finer fibre diameters. “Hungry–fine” is a term used to describe wools that are of low fibre diameter due to prolonged periods of low feed availability, such as during a drought. Severe and prolonged under–nutrition can cause some follicles to cease production. These follicles may take up to 3 months to recommence production once adequate feed is available.
Sharlea (or shedded) ultrafine wool refers to the wool produced from superfine Merino genotypes (initially 18 µm or less) maintained in sheds for the duration of the fibre growth period. It is an intensive production system based on daily feeding of a ration consistent in quality and fed at levels to maintain wool growth at a constant rate. The aim is to produce an ultrafine fibre diameter—as low as 13 µm—and a fleece containing minimal environmental contaminants. Though each animal may only produce 1.5–2.5 kg clean fibre, this wool type is of exceptionally high value. Wool price and feed price volatility are critical factors in determining the viability of the Sharlea wool industry.

**Pasture seasonality and fibre production**

Unlike the Sharlea industry, grazing sheep are subjected to variations in the quantity and quality of feed on offer throughout the year due to the seasonality of pastures. Consequently, fibre growth rate varies throughout the growth period and fibre diameter varies along the length of the fibre (Figure 4.2). The major impact of this is in terms of staple strength, which declines as the degree of variation in diameter along the staple increases. Rapid changes in feed, such as occurs following the break in a drought or when sheep are moved from overgrazed to ungrazed paddocks, will induce rapid changes in fibre diameter, culminating in reduced staple strength.

![Figure 4.2: Changes in fibre diameter along the staple and in wool growth rate throughout the year for unsupplemented spring-shorn wethers set-stocked at 10 wethers per hectare on annual pastures in WA (Doyle and Thompson, 1992).](image)

Figure 4.2 shows the changes in fibre diameter from tip to base of the staple for three sheep housed for 12 months and subjected to a range of dietary treatments, including: changes in feed quantity throughout the year (Figure 4.3A); changes in feed quantity and quality throughout the year, simulating a drought (Figure 4.3B); a control group, fed a relatively constant ration (Figure 4.3C). Measured staple strength in each scenario was 32 Nktex, 15.8 Nktex and 64 Nktex respectively.
4.2 Managing nutrition for improved wool production

The impact of nutrition on wool growth and quality is probably the key factor to consider for management, and an understanding of the impact of changes in pasture availability and quality throughout the year, and in different regions, is central to understanding how to manage wool production in a flock of any particular genetic background.

Mediterranean environments of Australia, where seasonal changes in nutritional conditions are very pronounced, are the areas where the impact of age and physiological state on fleece characteristics is most obvious. In these environments there is a 'normal' pattern of weight change associated with changes in nutritional quality and quantity. This pattern is summarised in Table 4.2 along with an indication of the changes occurring in nutrition, in particular the large contrast of the Autumn 'break'.

In practice, these pasture availability patterns do not fall neatly into the four seasons due to large between year variation in the timing of the start and finish of the growing season. This large seasonal variation in the quantity and quality of feed is accompanied by large changes in liveweight, wool growth and fibre diameter which are particularly notable in young stock. The latter is partially a result of the timing of the Autumn break with the poorest pasture conditions usually occurring at the time when young stock (12-15 months old) have the largest nutritional demands for growth.

Table 4.2: Summary of seasonal changes in nutritional characteristics of average Mediterranean pastures and associated weight changes of grazing animals (Hinch 2005).

<table>
<thead>
<tr>
<th>Season</th>
<th>Feed</th>
<th>Quality</th>
<th>Weight change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>Dry feed, adequate amounts</td>
<td>Poor</td>
<td>Weight maintenance</td>
</tr>
<tr>
<td>Autumn</td>
<td>Dry feed, limited quantity</td>
<td>Poor</td>
<td>Weight loss</td>
</tr>
<tr>
<td>Winter</td>
<td>Green feed, limited quantity</td>
<td>High</td>
<td>Weight gain</td>
</tr>
<tr>
<td>Spring</td>
<td>Green feed, adequate amounts</td>
<td>High</td>
<td>Weight gain slowing</td>
</tr>
</tbody>
</table>

Figure 4.4 illustrates the liveweight changes that occurred in autumn-born Merino lambs during 1993. Weight losses occurred into late-Summer/early-Autumn until the seasonal 'break'. Such changes in liveweight are also reflected in wool growth rate and fibre diameter. For example in a trial conducted in south western WA (S. Gherardi pers. comm.) it was noted that throughout the wool growing period for Autumn-born, Spring-shorn weaners, fibre diameter ranged from 22.1 µm in October to 15.0 µm in February and increased again to 23.5 µm by the following September. This change in fibre diameter was associated with a 'tender' fleece with a staple strength of 22.4 N/ktx.
In the Mediterranean environment generally wool growth and fibre diameter in sheep decline from about the time of seed set in spring, with a major decline following pasture senescence. The major constraints for the nutrition of grazing sheep in Mediterranean environments are low digestibility of organic matter consumed during Summer/Autumn and low pasture availability during Autumn/Winter. This has major ramifications for the quantity and quality of wool produced as energy and/or protein intake can be below maintenance for a period of 1–5 months until the start of the growing season.

In contrast, in temperate regions of Eastern Australia, where rainfall patterns and temperatures dictate a winter feed deficit (both quantity and quality), the impact of seasonal changes in nutrition on fibre diameter are not as apparent. In these environments Spring lambing is normal and therefore the impact of poor nutrition occurs during Winter, often at lower weights and ages and just prior to shearing time.

It is worth noting that most specialist wool producers in Mediterranean areas budget to hand feed autumn-lambing ewes and young sheep at pasture for 3–4 months over late summer/autumn. In the past, the primary objective of this feeding has been to keep animals alive rather than to manage wool quality and the economics of feeding for improved wool quality warrants further consideration. Figure 4.5 shows the relationship between liveweight loss and staple strength in young Merinos indicating that any weight loss at all is likely to compromise staple strength and therefore wool value.

4.3 Grazing and feeding strategies

Young sheep

In general we can say that fibre diameter and thus staple strength in young sheep can be manipulated by:
• Improving weaner weight at the start of Summer or Winter depending on the environment - thus attaining a high liveweight in young sheep before the period of nutritional stress which in turn increases the minimum fibre diameter and reduces the need for additional feed
• Minimising liveweight loss (feed intake) in the period of poorest nutritional conditions - prevention of weight loss will increase the minimum diameter and staple strength and, provided feeding is restricted to the period of slow wool growth, will have only a small effect on average fibre diameter
• Restricting feed intake and rate of growth in the period of best feed conditions - high stocking rates during periods of adequate feed supply may reduce the potential for ‘blow out’ in fibre diameter and therefore increase returns per hectare.

Stocking rate
The use of stocking rate changes to manipulate seasonal effects is an important component of management of young sheep in Mediterranean environments, less so in temperate regions. A study conducted by Peterson (pers comm.), working in South Australia examined the effects of stocking rate during Winter-Spring on the productivity of weaners born in the Autumn of the previous year. All sheep were grazed at similar stocking rate until the break of season at which time, each group was split into two management groups, one having non-restricted access to pasture (set-stocked) and the other having restricted access (strip-grazed). The goal was to limit the increase in liveweight and wool growth rate associated with the green feed in Winter and Spring.

For both heavy and light weaners, the unrestricted treatment showed a rapid increase in liveweight during Winter-Spring compared to the restricted treatment. The failure for liveweights to decline over the Summer was due to the presence of clover burr, sustaining weaner growth. Heavier animals showed an initial decline in fibre diameter compared to lighter animals while the unrestricted group showed a rapid increase in diameter in Winter-Spring compared to the restricted group. The heavy unrestricted group showed the highest clean fleece weight, being approx. 1 kg heavier than fleeces produced by the light restricted group. The heavy unrestricted group also showed the highest average fibre diameter, being approx. 1.5 microns greater than that achieved by the light restricted group. This is a reflection of the high wool growth rates achieved by this group during the spring.

Restricting access to feed during the winter and spring gave less variation in fibre diameter and increased staple strength. And it is clear that management of stocking rate of weaners during their second Spring can have large effects on gross returns per hectare.

Supplementary feeding
Supplementary feeding strategies can be used to minimise the effects of seasonal changes in nutrition on the productivity of young sheep. There have been many studies on this aspect of Merino management comparing the relative merits of a range of feeding strategies. However it seems that feeding of young stock is most common in the Mediterranean environments and the response is more easily generalised in this environment.

Supplements are normally fed to sheep to prevent large liveweight losses but it is known that excessive delays (survival strategy) in commencing supplementation may result in ‘tender’ wool (< 20 N/k tex). In contrast commencing supplementary feeding to ensure maintenance of liveweight (the ‘maintenance’ strategy) will maintain staple strengths of >30 N/k tex.

Pregnant ewes
Supplements
Although feed supplements (eg canola meal) have been shown to increase wool growth rate of Merino ewes during late pregnancy, the value of these supplements depends on pasture availability and quality. In a study in a Mediterranean environment (Masters and Mata 1998), the closer to the break of season canola supplement was used the less the benefit was seen. This effect could be seen within 2 weeks of rain falling. Therefore, in Autumn lambing ewes, the strategic use of high quality protein supplements for a short period around the time of parturition is recommended as it will increase wool growth and fibre diameter for a short period and is likely to improve staple strength and, provided this period of supplementation is short, is unlikely to produce any increase in the average
diameter of the fleece. In Spring lambing ewes where pasture is usually non-limiting the provision of supplement is likely to increased wool growth and fibre diameter possibly accentuating the weakness resulting from the low fibre diameter in Autumn.

However, there will be circumstances where the depression in wool growth in late pregnancy or lactation will be greater than the seasonal depression caused by a lack of feed during Autumn. In such situations there is a biological benefit in using supplements with the intention of improving wool quality. The relative price of supplements relative to wool price differentials will determine if such management options are economic.

Irrespective of the time of lambing, it is important to consider that the point of slowest wool growth and therefore weakest point in the staple is often during pregnancy rather than lactation. For this reason, feeding during late pregnancy to improve wool growth or earlier in pregnancy to increase body condition and nutrient reserves is likely to have a positive effect on staple strength.

Readings
There are no readings provided for this topic.

Revision Questions

1. How can the level of nutrition early in the life of a sheep influence lifetime wool productivity?

2. What happens to fleece weight when you reduce the availability of feed to a sheep? Why is this wool likely to be more valuable per kg?

3. From a wool quality point of view, why is the break in a drought a time of concern for a woolgrower?

4. In what way(s) does grazing management influence fibre productivity, (1) per head and (2) per hectare?

References


