Topic 5: Physiological and environmental determinants of wool quality and quantity

UNE (Eds R. Hergenhan)

Learning Objectives

On completion of this topic you should be able to:

- Outline the effects of sex, age and reproductive status on wool production and quality
- Detail the major diseases of concern to the Australian wool industry
- Outline the key environmental factors affecting wool production and quality
- Describe the alternative strategies available to wool producers to manage the constraints imposed by physiological and environmental factors

Introduction

Many physiological and environmental factors influence the quality and quantity of wool produced on farm. These factors need to be managed to optimise wool production and quality. There are many management strategies that need to be considered including time of shearing, disease control, timing of cull sales, grazing management and reproduction management. Many of these factors interact in their influence on wool production.

5.1 Physiological determinants

Sex

Comparisons of fibre quantity and quality between the sexes are seldom valid because (1) males and females are usually kept separate for most of the year, (2) males usually receive more favourable feeding conditions and (3) breeding females experience additional nutritional demands. The male hormone, testosterone, is thought to stimulate greasy wool production and liveweight in sheep, as occurs when wethers are administered with testosterone. A study by Brown *et al* (1968), showed adult rams to be 40% larger and produced up to 50% more greasy wool than mature ewes adjusted for reproductive status. However, yields were 11% lower in rams, giving a difference of 30% in clean wool over ewes. Differences in fibre diameter, staple length and visual attributes of the fleece were generally negligible. In each instance, though, the difference between the sexes usually becomes quite small when fibre production efficiency is measured as clean fibre weight per unit liveweight.

Wethers generally produce 10–15% more greasy and clean wool than non–breeding ewes. Also, wethers and breeding ewes may produce lower strength wools compared to rams given that (1) wethers are often run in poorer paddocks, and (2) pregnancy and lactation can depress staple strength in breeding ewes.

Age

The quantity and quality of fibre produced by an individual animal changes as the animal ages. With sheep, peak productivity occurs at 2–4 years of age, declining as the sheep ages. Figure 5.1 shows the age–related changes in a number of wool traits averaged over rams and ewes, expressed relative to the overall lifetime averages. It is evident that the reduction in fleece weight is associated with a reduction in follicle density (this being a function of changing skin surface area) and staple length. In addition, some secondary follicles may cease fibre production in sheep at older ages, reducing the total number of fibres and increasing fibre diameter. Young sheep may also produce wool of lower staple strength, though this depends on environmental conditions. The age at which the peak occurs may depend on environmental factors, with less favourable conditions delaying attainment of the peak as well as hastening the rate of decline. The reduction in fleece weight at older ages is associated primarily with a reduction in staple length, suggesting reduced efficiency of wool follicle function. In addition, some secondary follicles may cease fibre production in sheep at older ages, reducing the total number of fibres and increasing fibre diameter. For some production characteristics, these age–related changes may also be more pronounced in males than in females. To manage these effects the timing of culling is important.

The visual appearance of the fleece can also change with age, including a reduction in crimp frequency and deformation in the regularity of the crimp ('doggy' wool) in sheep. Age in white sheep is also associated with increased formation of coloured skin spots resulting from cumulative exposure to UV radiation. These spots are a potential source of naturally–pigmented fibres in an otherwise white fleece.

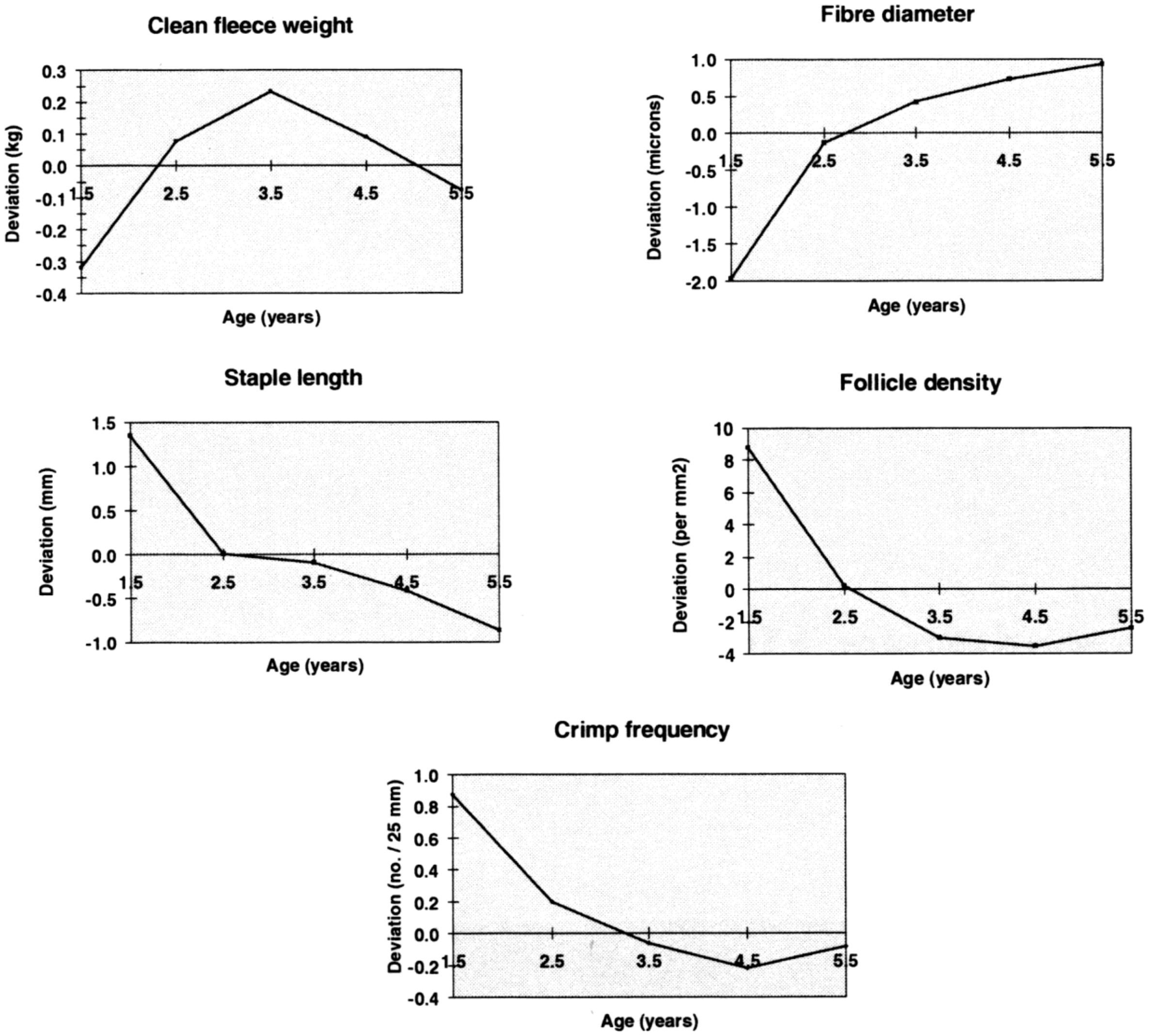

Figure 5.1: Age–related changes in wool traits (Brown *et al.*, 1968).

Pregnancy and lactation

Pregnancy and lactation represent the most nutritionally–demanding periods in the life of the breeding female, with nutrients being diverted away from fibre growth. There are also changes to the female's hormonal control over nutrient partitioning, resulting in reduced efficiency of fibre production. These factors impact unfavourably on fibre quantity and quality. The combined effects of pregnancy and lactation in sheep can be to reduce:

- annual weight of clean wool by 0.5–1 kg;
- annual average diameter by up to 1.5 µm;
- staple length by up to 9 mm;
- staple strength by up to 30 N/ktex;

though the extent depends on a number of environmental factors. The rearing of twins further depresses fibre production compared to the rearing of a single lamb. However, the effect is not twice the reduction of that associated with the single lamb.

The timing of shearing in relation to pregnancy can impact on the quality of the wool produced. Shearing should be timed to occur when fibre diameter will be close to minimum or at the point of break to improve staple strength and therefore price received. This will be at a time close to lambing so shearing is usually done within six weeks of lambing.

Disease

Any form of ill–health — whether caused by bacterial infection or attack by external or internal parasites — can influence wool productivity by way of the following mechanisms:

- reduced appetite — reduced supply of nutrients to the wool follicle;
- stress response — results in increased production of the hormone, cortisol, which interferes with normal hormonal regulation of follicle function;
- loss of nutrients — either directly due to internal parasites in the gastrointestinal tract or use of nutrients to assist in the repair of any tissues or organs damaged due to infection and parasitism;
- fever — elevated body temperatures to assist in combating infectious disease can also result in reduced appetite.

In each instance, a reduction in wool growth rate arises, causing a reduction in the total amount of wool that is ultimately produced as well as an accompanying reduction in fibre diameter. In addition, sustained high levels of cortisol can cause partial to complete cessation of follicle activity, creating a definite break in the wool and lowering staple strength (Figure 5.2).

Figure 5.2. An example of partial shedding of the fleece resulting from acute stress. The remainder of the fleece is extremely weak and can be easily removed by hand.

There are also diseases of the skin and fleece which have a direct effect on wool value. Fleece rot is a disease of the skin arising from prolonged wetting of the skin. The skin becomes inflamed and releases a proteinaceous exudate, which eventually dries on the fibre to produce a definite banding of crusty material. Associated with this is a rapid multiplication of bacteria already present on the skin. Pigments of varying colour are produced (usually blue–green) in the wool, known as bacterial stain, and an odour is also produced. Both conditions predispose the sheep to blowfly strike, as the moist conditions of the fleece and the exudate from the skin provide ideal growing conditions for blowfly larvae (or maggots). These larvae feed on the skin tissue of the sheep, inducing a strong stress response and reduced appetite. The wool produced from the struck region is stained and has an unpleasant odour as well as being of reduced strength. Mycotic dermatitis (or 'lumpy' wool) is an infection that also arises from prolonged wetting of the skin. It causes inflammation of the follicle, production of an exudate that coats the fibre and subsequent formation of hard lumps in the wool staple. While these lumps normally lift off the skin as wool growth continues, the hardened masses reduce wool value. Lice can also infest the fleece, causing the sheep to rub or bite the fleece due to the irritation that arises. The appearance of the wool is greatly reduced, especially due to yellow discolouration.

Infectious diseases - whether parasitic, bacterial or viral – invoke an immune response. This may be associated with fever and inflammation, which in turn can cause feed intake to fall abruptly. This can cause fibre growth rate to decline and possibly even cessation of fibre growth if the disease is acute, causing a break in the fibre. There may also be direct effects of inflammatory mediators on follicle activity. When infection causes damage to specific organs or tissues, appetite can be reduced and nutrient metabolism can become impaired.

Infectious diseases can also induce a stress response. For normal wool growth in sheep, a low concentration of the hormone cortisol is required. However, when sheep are subjected to stress, the concentrations of cortisol and other stress hormones are elevated and this can have a depressive effect on wool growth rate if prolonged. In very acute situations wool growth can cease. These changes may be associated with reductions in fibre diameter, fibre length and staple strength depending on severity and duration.

There are many diseases capable of reducing productivity in fibre-bearing animals. For the Australian wool industry, the diseases of major concern are blowfly strike, lice infestation, helminthosis (parasitic worm infections in the gastrointestinal tract) and footrot. Table 5.1 summarises the effects of the first three diseases on wool production, as well as indicating the economic costs involved (ie production costs and control costs). Further information on control and management of sheep diseases is outlined in Topic 13: Managing Sheep Health.

Table 5.1: Major infectious diseases of sheep in Australia (Collins, 1992).

Disease	**Major species**	**Duration**	**Impact on wool production** (FW=fleece weight; FD=fibre diameter; SL=staple length; SS=staple strength)	**Economic. costs ($M, 2006)**
Blowfly	Green blowfly	Acute	2–8% reduction in FW; potential for complete break; affected wool is stained, cotted and has an unpleasant smell	280
Lice	Body louse	Chronic	15–30% reduction in FW; other traits mainly unaffected; irritation causes biting and rubbing, causing cotting, discolouration and unpleasant smell	123
Worms	Roundworms Flukes Tapeworms	Chronic	5–30% reduction in FW; 0.5–2.0µm reduction in FD; £6mm reduction in SL; £6 Nktex reduction in SS; increased scouring and susceptibility to flystrike	369

5.2 Environmental determinants

Photoperiod

In many mammals, follicles actively produce fibre for only a short period of time followed by lengthy periods of inactivity. During this inactive period the fibre formed during the previous growth phase is retained in the inactive follicle. When activity resumes, the fibre is pushed up and out by the newly growing fibre, resulting in the original coat being shed. The environmental stimulus is day length or photoperiod, inactivity being induced by decreasing day length and activity stimulated by increasing day length. There is considerable variation between sheep breeds in the extent of seasonality in wool growth. The most extreme form involves the annual shedding of the whole fleece, as occurs with the Wiltshire Horn.

Figure 5.3 illustrates the follicle basis for this, there being a seasonal pattern in the proportion of inactive follicles. In this example, almost 100% of both primary and secondary follicles became inactive during the winter compared to almost 0% in summer. For many improved sheep breeds, there is an annual rhythm in wool growth rate, with lower rates in the winter (*e.g.* British Longwool breeds). This effect is independent of seasonal effects on nutrient availability, as the response to improved nutrition has been shown to be less in winter than that achieved in spring. The implications for wool quality are in terms of fibre diameter variation throughout the year and thus potential reductions in staple strength. In the Merino breed, photoperiodic effects are negligible, with seasonality in wool growth rate being more a reflection of seasonality in nutrition.

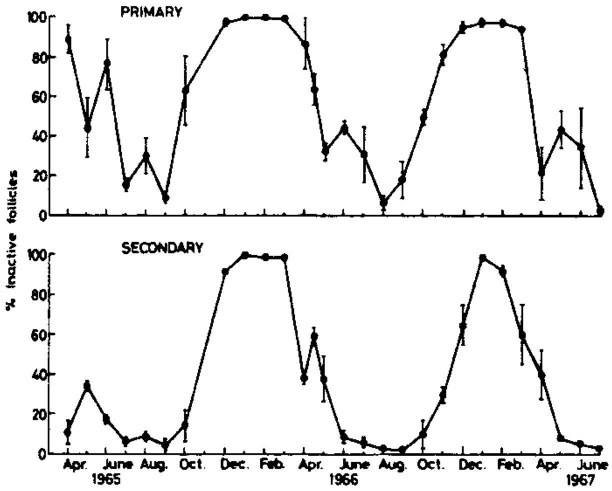

Figure 5.3. Changes in follicle activity in adult Wiltshire Horn sheep in the northern hemisphere (Panaretto 1979)

Rainfall, temperature and UV radiation

Rainfall influences the amount of moisture in the fleece and on the skin. Repeated wetting of the fleece can result in the formation of fleece rot, a condition associated with an exudation of serous fluid from the skin. The exudate, on drying, forms a crust which matts the fibres together and appears as a band across the staples of the affected part of the fleece, reducing the quality of the wool. The exudate and free moisture encourages bacterial activity, which can result in green, brown, yellow, pink and even blue discolouration depending on the bacterial types present, though green is the most common. The major concern with fleece rot and bacterial stain is that these are predisposing factors in flystrike.

High humidity and temperature combine to induce yellow discolouration in some wools, with excessive yellowness being referred to as “canary stain”. The degree of discolouration is related to the suint content in the wool and the concentration of potassium in the suint. Increases in both are associated with greater susceptibility to discolouration. The major concerns with yellowing are (1) it is associated with increased risk of flystrike and (2) difficulties can be encountered during dyeing, as the yellow colour is generally unscourable.

Weathering is a term used to describe the deterioration of animal fibres resulting from the combined effects of UV exposure, water and heat during the growth period. As it is a proteinaceous structure, the fibre can undergo deterioration in mechanical and chemical properties with prolonged UV exposure. It can also make the fleece more prone to dust penetration. The staple tips suffer a greater degree of UV damage compared to the fibre roots, given the way in which the fleece grows. The wax and suint components of the sheep fleece also provide partial protection against weathering. The water–soluble suint is easily leached from the fleece with continued wetting, but in the process saponification occurs (*i.e.* the suint salts enable detergent action) which can then remove some of the wax component. This partially removes the protective barrier of the fibre. Fleece structure also influences the degree of weathering in that more open fleeces present greater fibre area for exposure as opposed to more compact and blocky fleeces.

Dust

Dust is one of the acquired contaminants found in all fleeces, with the depth of dust penetration and the amount of dust present being major determinants of style grade as well as influencing yield and the perishing of wool fibres through abrasive action. The penetration of dust into the fleece depends on the environment. The dust band in fibre grown under favourable conditions is usually confined to the staple tip whereas in fibre grown under drier and dustier conditions, it lies further down the staple, even to skin level.

Dust penetration also depends on fleece characteristics and weathering, although it is uncertain as to whether dust penetration facilitates weathering or vice versa. In Merino sheep, a high wax:suint ratio and a compact, blocky fleece have been implicated in reducing the potential for dust contamination.

Table 5.2: Dust colour, degree of penetration and area of origin.

Dust colour	Degree of penetration	Area of origin
Grey	Minimal	Tablelands and NW slopes
Pink Red	Varying degree depending on season	Central and Southern slopes
Fiery red Earthy red	Usually well penetrated	Western plains
Red Brown Black	Upper ¼ of staple at most	Agricultural type soils, generally wide–spread on slopes and plains

Dust colour and degree of penetration can indicate the likely area of origin of the wool (Table 4–3), with the tablelands environment producing wools with the least dust content. Given the relationship between environment and Merino strain, there are also “traditional” perceptions as to what colour of dust should be associated with various wool types. For example, one would not expect to find fine Merino wool with red dust penetrating beyond the staple tip.

Pasture composition

Climatic factors indirectly influence wool quantity and quality by way of their influence on pasture availability and quality throughout the year. However, pasture composition also influences wool quality as it determines the type of vegetable matter contamination that can occur and the time at which contamination is likely to be most prevalent.

Pasture composition varies across environments. High rainfall zone pastures in NSW are predominated by introduced legumes (*e.g.* sub clover, white clover, lucerne) and perennial grasses (*e.g.* phalaris, perennial ryegrass, cocksfoot) as well as native annual and perennial grass species. Pastures in the wheat–sheep zone are generally only a short–term consideration due to the emphasis on cropping and are thus predominantly based on volunteer and sown annual species (legumes and grasses) as well as broad–leaved weeds. The composition of these pastures, therefore, is unstable and can vary year to year depending on seasonal conditions. Pastures in the pastoral zone are based mainly on native species as well as a containing a diverse range of shrubs and trees. Annual or short–lived varieties are more common than perennial types, and in conjunction with the low and erratic rainfall creates a varying composition from year to year. VM content in wools from the high rainfall zone is relatively low, and it increases west towards the slopes and plains and into the pastoral zone. Most of the burr and hard head VM contamination is found in the wheat–sheep zone, the major source of NSW wool.

Grazing management is particularly important in reducing the impact of pasture composition on wool quality. Ideally sheep in long wool will not be grazed on pastures that are setting seed as this will result in high levels of vegetable matter contamination leading to a reduction in wool quality.

Readings

There are no readings provided for this topic.

Revision Questions

1. How does the environment impact on wool quality?

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

3. How is wool quality affected by (i) internal and (ii) external parasites?

4. Why is the time of lambing an important consideration from a wool quality point of view?

5. Explain how day length affects wool growth.

References

Brown GH, Turner HN and Dolling CHS (1968) Vital statistics for an experimental flock of Merino sheep. V. The effects of age of ram, maternal handicap and year of measurement on 10 wool and body characteristics for unselected rams *Australian Journal of Agricultural Research* 19: 825 - 835

Collins GH (1992) *Veterinary parasitology* Notes for veterinary undergraduates, Department of Veterinary Pathology, University of Sydney

Panaretto, B. A. 1979. Effectc of light and cyclic activity of wool follicles and possible relationships to changes in the pelage of other mammals. pp. 327-336. In: Physiological and environmental limitations to wool growth (Ed. J. L. Black and P. J. Reis). University of New England publishing unit, Armidale.

Sackett D, Holmes P, Abbott K, Jephcott S, Barber M (2006) Assessing the economic cost of endemic disease on the profitability of Australian beef cattle and sheep producers. Final Report of Project AHW.087. Meat and Livestock Australia, Sydney