Lecture 4: Contamination – Dark and Medullated Fibres and Vegetable Matter

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Learning Objectives

On completion of this lecture you should be able to:

- discuss the relevance of dark and medullated fibre contamination in wool
- document the main origins of dark and medullated fibres and the economic implications
- justify practices implemented to prevent or control occurrences of dark and medullated fibres and the opportunities for improvement
- document the causes of Vegetable Contamination (VM)
- calculate how VM is measured
- describe the effect of VM on wool processing
- describe the economic importance of VM
- list and describe the plant species causing VM problems
- illustrate your understanding of the strategies which can be employed to reduce VM
- plan management strategies in a sheep management system to reduce VM problems in wool.

Key terms and concepts

Dark and medullated fibres in wool, measurement and description, economic importance and occurrence, strategies to reduce, vegetable matter (VM), VM Types, Names of VM Types, VM Type categories, Economic importance, Wool processing and VM, Strategies to reduce VM, Sheep coats, Shearing, Grazing management.

Introduction

Australian wool is primarily of Merino origin (AWEX 2004a) and this together with sheep management and wool classing practices (AWEX 2004b) has assisted in generating a reputation for relative freedom from dark and medullated fibres (Satlo 1963; Cardellino 1978; Pattinson and Hanson 1993; Burbidge *et al.* 1991, 1993; Hansford and Swan 2005). Furthermore, this wool is primarily used for finer apparel end-uses that are more sensitive to objectionable fibres even when present in trace amounts. The type and level of objectionable fibre that can be tolerated will vary widely with the end-product application but a common threshold for dark fibre in Merino top is 100 per kg (Foulds *et al.* 1984; Hatcher 2002).

Dark fibres can be a fault in white or pale dyed products while medullated fibres can be objectionable in dyed products, with such faults leading to the rejection of or costly repairs to the product. Reliance is placed on sheep breeding and management and wool classing requirements to ensure that lots (other than those appropriately labelled/identified) are likely to have low risk of dark fibre and/or objectionable medullated fibre. However, this reliance may not be entirely effective and recent developments involving crossbreeding of Merinos with coloured and/or highly medullated sire breeds has increased wool industry concerns and interests to develop an information system to assess risk and a rapid presale test for both isolated dark and objectionable medullated fibres (AWI 2002, 2003a). Should these marketing developments become established then the discounts associated with the presence of dark and medullated fibres will be more equitably passed back to individual producers as well as improving processing prediction and confidence in wool fibre in this regard.

Vegetable matter is another contaminant of importance to the production of high quality wool products and will be discussed in this lecture.

4.1 Dark and medullated fibres

Dark Fibres

Although many dark contaminants are encountered in wool, the most common, other than vegetable matter, are of sheep origin, being either urine stain or melanin pigment (Burbidge *et al.* 1993). The primary dark fibres of sheep origin (urine stained and melanin-pigmented) can be distinguished after microscope examination. Melanin pigmentation is characterised by an uneven appearance and presence of discrete granules whereas urine stain is usually uniform across the section of the fibre (as if dyed) though may vary in intensity along the fibre (Figure 4.1). Presence of numerous vacuoles can be a source of confusion and medullation affects the appearance of urine stain and pigmented fibres.

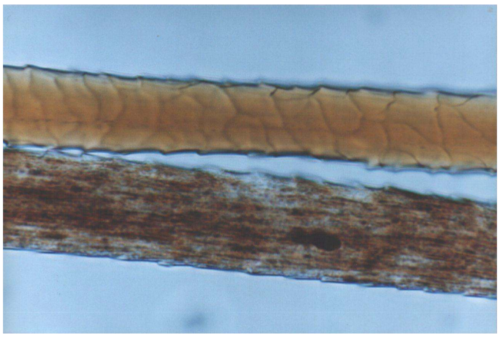

Figure 4.1: Urine stained (above) and melanin-pigmented (below) wool fibres (Malcolm Fleet, SARDI 2004).

Pigmentation

The inherited colour that darkens wool, hair and skin involves melanin pigment, which is packaged in granules or melanosomes within specialised cells called melanocytes. The melanosomes move from the main body of the cell to extensions of the cell (dendrites) and are then forced into other surrounding cells (keratinocytes). These take-up the granules and ultimately form the exposed skin, wool and hair (Forrest *et al.* 1985; Fleet 2002a; Fleet *et al.* 2004).

In contrast to medullated fibres, the occurrence of dark fibres in Merino sheep is of greater recognised importance and has attracted more investigation. Processing surveys reveal that fibres darkened by urine stain are most common though pigmented fibres can be just as important arising from inherent sources (Burbidge *et al.* 1991,1993; Mendoza and Maggiolo 1999) or as contaminants from external sources (e.g. rearing of coloured crossbred lambs – Fleet 1999b). The occurrence of pigmented fibres in white Merinos can take several macroscopic forms (Fleet 1998), including:

1. Recessive black patterns (each with variations in white spotting).
    - Badgerface (black ventrum and tan, light or white dorsum)
    - Reverse badgerface (tan, light or white belly to neck and under tail with black dorsum)
    - Self-colour (black often with white or grey patches but not sharply divided in dorsal/ventral manner)
    - Other patterns
2. Distinct random pigmented spots
    - Present at birth
    - Developing after birth
3. Diffuse and symmetrical located pigmented fibre remnants (present from early life and associated with the occurrence of isolated pigmented wool fibres in the fleece).
    - Halo-hair – especially back of neck
    - Spots, Speckling or patches of fibres on legs and/or face
    - Horn site fibres
    - Eye lash and ear fibres
4. Old-age black skin spots – developing pigmented fibre.

Medullated fibres

Medullation refers to the tract(s) of hollow cells that can be present in sheep fibres (Figures 4.2a, b and c). White fibres that are sufficiently medullated may appear paler (Figure 5.6) than the wool bulk after mill dying (Trollip *et al.* 1987; Hunter *et al.* 1990; Hunter *et al.* 1996; IWTO 1999; Tester 2004). Medullated fibres tend to be brittle and this feature may either assist or hinder removal during processing or mending (Hatcher *et al.* 1999; Tester 2004).

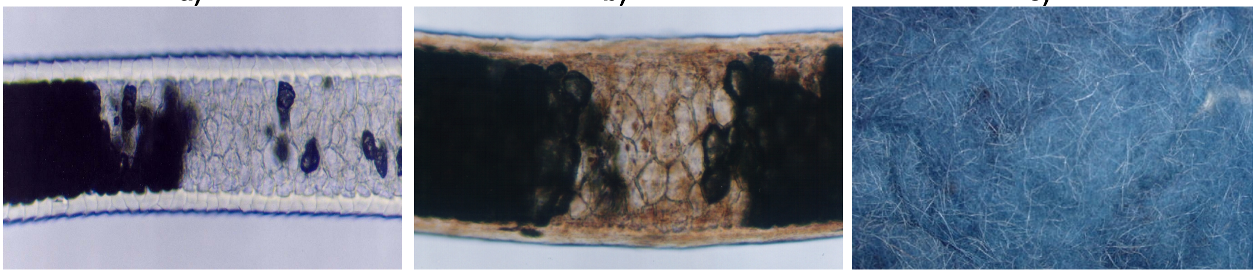

Figure 4.2: a) White kemp fibre with a continuous wide lattice medulla. On the right most of the medulla cells have apparently been filled with mounting medium while on the left most remain vacant. **b)** Pigmented kemp fibre with wide lattice medulla. **c)** Dyed Damara x Merino wool showing the white or pale kemp fibres (Malcolm Fleet, SARDI 2004).

The term "kemp" has been defined in different ways (Lang 1950; Wildman 1954; WSR 1954; Gallagher 1969; Wood 2000; Hatcher 2002) but to the manufacturing industry it broadly means fibres that are highly medullated which are most likely to cause problems. These can be short or long and seasonally shed or continuously growing shorn fibres. Kemp fibres tend to also be coarse (Hunter *et al.* 1990; Hunter *et al.* 1996; IWTO 1998; Fleet *et al.* 2001) and chalky-white (Hunter *et al.* 1990; IWTO 1998) and can be seen in the fleece when present in high levels. Based on the ASTM test method, a "kemp" fibre is distinguished from lesser medullated fibres when the medulla width exceeds 60% of the fibre diameter (ASTM 1996 cited by Lupton and Pfeiffer 1998).

Medullation does occur among the fibres produced by Merino sheep though the extent appears to be negligible relative to other breeds (Lang 1950). A survey (Gallagher 1969; Gallagher 1970) revealed an average incidence of medullated fibres of 1.1% though most of these fibres were of the fragmental type. Merino lambs were found to have a greater number of medullated fibres, as did the breech compared to the midside and neck sites, and this declined rapidly in the first month after birth (Gallagher 1969). It is not clear at this stage if any importance should be attached to birthcoat halo-hairs (Figure 4.3a) and long coarse hair seen on some older sheep (Figure 4.3b) in relation to occurrence of trace levels of inherent objectionable medullated fibres in Merino wool. The evidence available (Lang 1950; Gallagher 1969) suggests these fibres are usually not highly medullated though may contain such fragments.

Balasingam and Mahar (2005) report on the incidence of medullated fibres in a random sample (1%) of Australian greasy wool lots in 2004 found Merino fleece lots had an average of 5.8 medullated fibres per 10 g core sample (with a range of 0 – 452); skirtings or pieces lines an average of 30 (range 0 – 396); bellies lines an average of 55 (range 0 – 433); locks an average of 35 (range 1 – 406); and lines of lambs wool had an average of 133 medullated fibres per 10g of core wool (with range 1 – 572). Whereas, all samples from crossbred lines had an average of 137 medullated fibres/10g (range 0 – 576). Fleet *et al.* (2005) assessed wool from Merino lambs and compared it with that of wool from Damara crossbreds. Halo-hair score on newborn Merino lambs was not related to objectionable medullated fibre content, in the subsequent shorn lamb fleece, but is positively correlated with flat fibre content and the diameter of medullated fibres overall. Merino lamb wool had little objectionable medullated fibre compared to Damara crossbreds (ie. about ≤1 v. 100 objectionable per 10,000 fibre snippets).

There are a large number of sheep breeds present in Australia ranging from hair and Downs types that shed their fleece (e.g. Damara, Dorper), double-coated sheep with long and short kemp fibre that need to be shorn (e.g. Awassi), other carpet wool breeds, traditional longwool crossbred and Downs types, to Merino types (Hatcher 2002; AWEX 2004b). To some extent classifications of fibres (hair, wool, heterotype) can be associated with follicular type – primary follicles, original and derived secondary follicles (Ryder and Stephenson 1968 cited by Hatcher 2002) and differences in occurrence of objectionable medullated fibres can be related to ratios of these follicle types (Lyne and Hollis 1968) and with fibre diameter characteristics (Hunter *et al.* 1990; Hunter *et al.* 1996). While breeds producing wools with high fibre diameter tend also to have more medullated fibres (Lang 1950) these traits are not necessarily dependent (Scobie *et al.* 1998; Fleet and Bennie 2002). Table 4.4 shows the percentage of medullated fibres in lambs' wool of various breeds.

a) **b)**

Figure 4.3: a) Merino lamb showing high coverage of halo-hairs and **b)** adult Merino wool with coarse hairs protruding from the staple tips (Malcolm Fleet, SARDI 2004).

Table 4.1: Percentage of medullated fibres in 14 week old lamb wool of various breeds (Holst *et al.* 1997).

Percentage of medullated fibres in 14-week lamb wool of various breeds (Holst *et al.* 1997)	
Merino x Merino = 0.1%	Texel x Merino = 1.6%
Border Leicester x Merino = 0.4%	Poll Dorset x Border Leicester Merino = 0.5%
Poll Dorset x Merino = 0.2%	Texel x Border Leicester Merino = 5.8%
Percentage of medullated and (objectionable medullated) fibres in 7-month lambs wool (Fleet and Bennie 2002)	
Merino x Merino = 0.37% (0.001%)	Damara x Merino = 3.05% (0.78%)
Merino x Merino = 0.43% (0.000%)	Damara x Merino = 4.16% (1.36%)

4.2 Strategies to reduce or identify dark and medullated fibres

Recognised practices for controlling dark and medullated fibres on farm as well as the appropriate descriptions for branding greasy wool lots are included in the Code of Practice for Preparation of Australian Wool Clips. A checklist is provided as a reminder of the tasks required in preparation for and during shearing (AWEX 2004; 2006b; 2010).

Non-sheep fibrous contaminants

Simple cleanliness tasks are involved in avoiding exposure of sheep and wool to foreign fibres of non-sheep origin. Oversight on the farm to these details (e.g. leaving hay bale twine where sheep graze or are held; using fertiliser/seed bags to store or separate wool) is a continuing problem for the wool industry (Figure 4.4a and b). Hay bale twine contamination found per tonne of clean wool was about 3-fold higher than found in a previous survey 10 years earlier while the amount of fertiliser/seed bag contamination had more than halved (AWI 2003b).

Previously, jute and HDPE (high density polyethylene) wool pack materials were major contaminants found in mill surveys (Heintze 1994; AWI 2003b). Wool pack material can enter wool at several points, including routine operations, where packs are penetrated and damaged; e.g. pressing and core sampling (Abbott and Blanchonette 1998). Since 1998, procedures were introduced to replace jute and HDPE with wool packs made of nylon (accepts dye similar to wool) in Australia (AWEX 1997) and continuous polyethylene film in Uruguay (Mendoza and Maggiolo 1999).

A recent mill survey (AWI 2003b) found the weight of farm pack materials (made of jute or HDPE) per tonne of wool inspected has declined by 96% and the overall frequency of non-wool contaminants in the sample declined by 52%. Farm objects were the major source of the contamination with the most common items being hay bale twine, fertilizer bags and feathers.

a) b)

Figure 4.4: a) Black hay bale twine in top and woven fabric and **b)** white poly bag fibres in knitted fabric (Vern Gibbs PIRSA)

Dark and medullated fibres of sheep origin

In a wool producing flock, all sheep have the potential to produce wool darkened by urine while only some have a liability for pigmented fibre (Fleet 1996,1998). CSIRO studies have identified the on-farm factors that influence the risk of urine stain (Foulds 1989, Burbidge and McInnes 1994; Rottenbury *et al.* 1995). The main conclusions of this work are:

- Sale lot assessment of apparent skirting quality can be a poor indicator of the likely level of stain present.
- Fleece and skirtings from wethers are less likely to be contaminated by urine stain than for ewes.
- Mulesing (at least in wrinkly sheep) can reduce the amount of stain to about one sixth of that produced by untreated ewes.
- Fleece wool contained less stain than the pieces shed line.
- If the stain is present at shearing, it is difficult to eliminate it completely. Often, modified shearing and shed procedures did reduce the amount of stain but, usually, not enough to lower the level to within acceptable limits.
- Emphasis should be placed on removing stain through some form of crutching for ewes (Figure 4.5) and ringing for wethers (and rams) close to shearing. If this crutching occurs within 3-months of shearing there is low risk of contamination from this source ("Stain Free Procedure").

a) b)

Figure 4.5: Shows a) a urine-affected wool on the ewe and b) a crutched ewe (Malcolm Fleet, SARDI 2004).

The dark and medullated fibre risk (DMFR) scheme

In July 2004 a DMFR scheme was introduced for Australian Merino wools as part of IWTO test regulations. This acceptance by IWTO allows AWTA Ltd to include the assessed risk level (Figure 4.6) on AWTA Ltd Core Test Certificates and on AWEX Ltd sale catalogues. The DMFR scheme is a declaration made by woolgrowers within the National Wool Declaration regarding the risk of dark and/or medullated fibres present in Merino fleece and piece wool (AWEX 2010). The DMFR rating is assigned according to the decision tree in Figure 4.6.

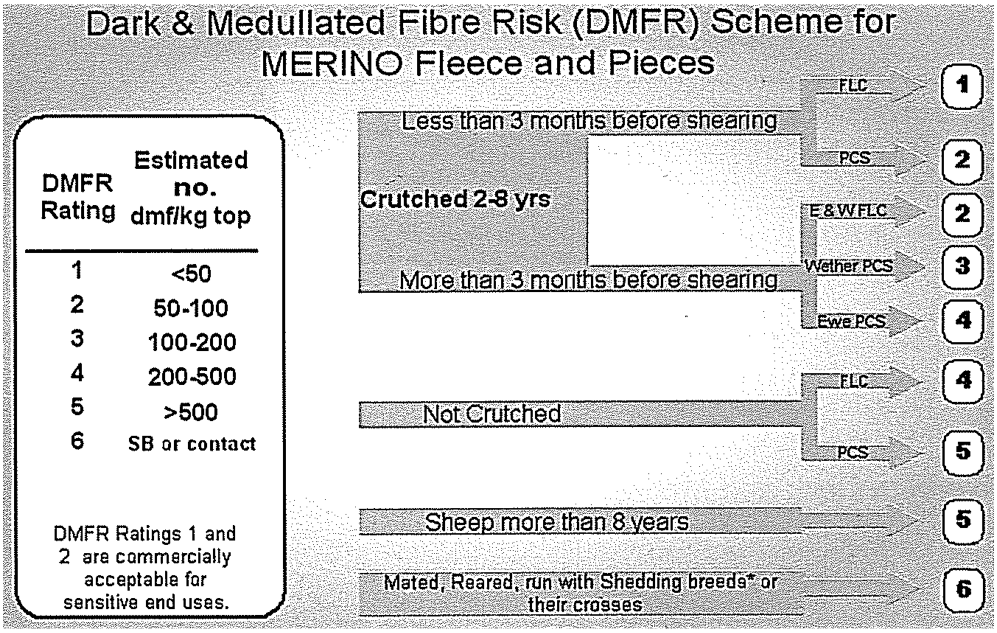

Figure 4.6: Decision tree for dark and medullated fibres (AWEX 2010).

The information for determining DMFR from the Wool classer's Specification or separate Woolgrower declaration form include (Hansford *et al.* 2003; Morgan 2003):

- WOOL TYPE (wether fleece, pieces, lambs, bellies, locks crutchings, stain etc)
- QUALIFIERS IN WOOL DESCRIPTION: AWEX ID qualifiers Y (pigment), P (kemp) or S (stain)
- CRUTCHING: none, Crutch/shear interval ≤ 3 months
- SEX: Ewes, wethers, rams
- CONTACT WITH EXOTICS: Mated, reared or run with “exotics/crosses”
- AGE: ≤1 year, 1-2 years, 2-8 years and > 8 years

The introduction of the DMFR scheme involves voluntary declarations. However, where the information is not provided then “Not Declared” will be indicated against DMFR limiting its acceptability for certain buyer's requirements. As with past additional measurements buyer acceptance and demonstrated price benefits will facilitate adoption. Demonstrated price benefits for low risk wool will also enhance commitment on-farm for the breeding and management required to qualify while development of measurement and trace-back with potential penalties will encourage compliance to required standards.

Genetic improvement

Observation of the many breeds of sheep reveals obvious differences in pigmentation and medullation (AWEX 2004) that must reflect genetic determinants. Single genes uniquely control some of these features while others have a more complicated genetic basis (Dolling 1970; Sponenberg *et al.* 1996; Dolling *et al.* 1996). For the most part we are not certain which genes are involved in sheep but for some features comparisons can be made with effects of characterised genes found in mice, humans and other livestock (Fleet 2002a). For example, Beraldi *et al.* (2006) has mapped a coat pigment dilution gene effect to sheep chromosome 2 where a likely candidate gene (tyrosinase-related protein-1) has also been mapped. This gene (TYRP1) is recognised for causing dilution of black to brown or more extreme types of hypopigmentation such as oculocutaneous albinism type 3 in humans and melanocyte death/fibre greying in mice. Interesting also, that this pigment dilution effect in the population of sheep studied is also associated with differences in body weight and survival. Fleet (1996; 1997) reported significant positive genetic correlations (based on a sample of 24 to 42 sires) between residual pigmentation on white sheep and birth or hogget weights in a Merino genetic resource flock as well as the links with risk of isolated pigmented fibres (see below).

The absence/minimisation of pigmentation and medullation is most relevant to the Merino types and breeders, through selection on phenotype, have achieved much. Even though the Merino has a reputation for relative freedom from pigmented and objectionable medullated fibres there remains scope for improvement. Unwanted pigmentation remains a continual reason for culling of some sheep and for occurrences of pigmented wool fibres in certain wool lots that are excessive (Burbidge *et al.* 1991).

Black sheep and random spots

Black lambs and random spots on lambs usually occur only at a low frequency in Merino flocks. While the occurrence of a black lamb indicates that both the sire and the ewe are carriers of the recessive gene responsible, the cause of lambs with distinct random pigmented spots is much less certain to explain. For the commercial wool producer the potential for transfer contamination from these sources is usually relatively low and prevented as soon as all affected sheep are separated and culled (Fleet 1996; Fleet *et al.* 1995a). The major problem is inconvenience caused and loss in value of coloured lambs and wool that on a national basis is important. For the ram breeder, occurrence of black lambs could signal an important increase in a recessive gene and the need to reverse the change.

Even though there is some degree of relationship between non-wool pigmentation and occurrence of black (Fleet *et al.* 1989) and random spot (Fleet 1999a) lambs the degree of overlap is large and this difference cannot be relied upon to prevent the problem. Furthermore, culling sheep for occurrence of any type of pigmentation may leave few individuals to assess on more economically important production characters (Fleet *et al.* 1989; Fleet 1999a). Table 4.2 shows that white sheep that are carriers of the genetic variation for recessive black (selfcolour) have slightly more black-grey pigmentation for bare-skin around the eyes, nose-lips and under-tail and in the hooves.

Brooker and Dolling (1969) report on various matings of black rams to white ewes, involving 566 white progeny (all carriers of recessive black) of which only 5 were classified as having a random/piebald spot (i.e. about 1%), 29 were black lambs (indicating about 10% of the ewes were carriers). Furthermore, from matings between white with random/piebald spot and black parents producing 2 black progeny and 111 white progeny (all carriers of recessive black) only 9 progeny (i.e. 8%) had a black random/piebald spot. These findings indicate there is little, if any, dependence of occurrences of random spots on white sheep that are carriers for recessive black. At present, the only mechanism available to ascertain a ram's status for recessive black is by progeny testing/occurrence of a black lamb. Unfortunately, the principle of simple Mendelian genetics cannot be reliably applied for testing pre-disposition to production of random spots (Brooker and Dolling 1969; Fleet *et al.* 1985). However, it is practical to identify via DNA paternity testing services the ram(s) responsible for black lambs in a syndicate-mated flock. Research underway by CSIRO/Sheep CRC with support from AWI may characterise DNA variation responsible for black lambs and produce a diagnostic test that could be used to specifically eliminate this genetic variation from ram breeding flocks or sale rams.

Table 4.2: White carriers for recessive black (A^{Wt}/A^{a}) had a little more black-grey skin and hoof pigment (Fleet *et al.* 1989).

Type of pigment	Genotype	No. sheep with level of black-grey pigment		
		Nil	**Minor**	**Distinct**
Skin around eyes	Non-carrier (A^{Wt}/A^{Wt})	2	72	3
	Carrier ($A^{Wt}t/A^{a}$)	1	68	35
Nose-lips skin	Non-carrier (A^{Wt}/A^{Wt})	40	37	0
	Carrier (A^{Wt}/A^{a})	38	63	3
Under-tail	Non-carrier ($A^{Wt}/A^{Wt}t$)	55	22	0
	Carrier (A^{Wt}/A^{a})	42	61	1
Hooves	Non-carrier ($A^{Wt}/A^{Wt}t$)	54	22	1
	Carrier (A^{Wt}/A^{a})	64	35	7

Isolated pigmented fibres

Some Merino sheep produce fleeces containing isolated pigmented wool fibres. As this fault is hidden in the fleece and difficult to measure, considerable effort was invested to find if relationships existed with visible pigmentation and to identify the most efficient indicators for selection (Fleet *et al.* 1989; Fleet and Smith 1990; Fleet *et al.* 1995a; Fleet 1996, 1997, 1998).

Using a Merino resource flock at Trangie Agricultural Centre (NSW) the heritability of various types of visible pigmentation and isolated pigmented fibres was estimated (Fleet *et al.* 1991b; Fleet 1996, 1997) and hypothetical culling manipulations undertaken on the data set to examine effects on isolated pigmented fibres in the hogget fleece, visible pigmentation and the main productive traits (Fleet *et al.* 1995a; Fleet 1996; Fleet 1997; Fleet *et al.* 1997). Figure 4.7 shows the levels of isolated pigmented fibres found in groups of hogget fleeces separated on the basis of 4 pigment culling criteria (Fleet *et al.* 1995a).

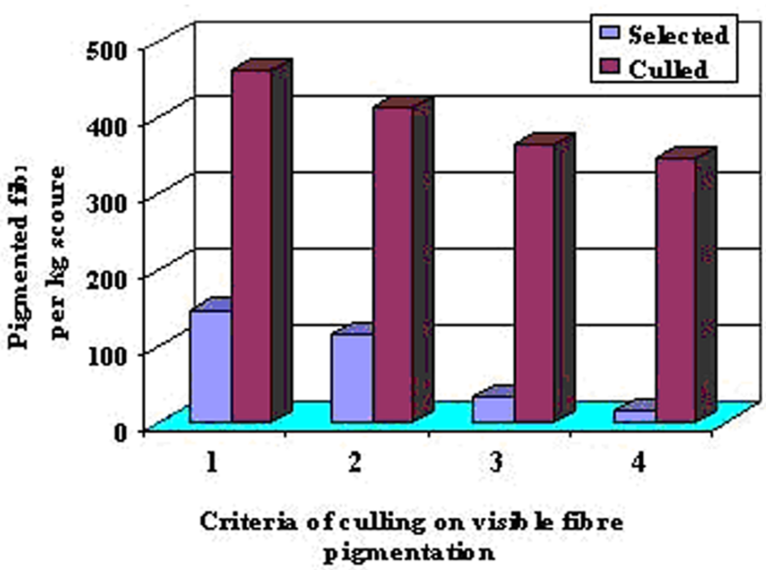

Figure 4.7: Isolated pigmented fibre concentration in culled and selected groups based on four criteria. Criteria 1 = Only those with pigmented birthcoat halo-hair pigment culled. Criteria 2 = Only fibre pigment visible on hoggets (excluding eye lashes). Criteria 3 = Fibre pigment visible on hoggets (including eye lashes). Criteria 4 = 3 above plus including pigmented fibres recorded on the lambs (Fleet *et al.* 1995b).

The results shown in Figure 4.7 indicate that separating sheep with visible fibre pigmentation (when present) can effectively reduce isolated pigmented fibres in hogget fleece wool. Since these types of visible fibre pigmentation also mainly had high heritabilities (Fleet 1996, 1997) the culling of affected sheep would be expected to reduce occurrences in future generations. Furthermore, such culling was demonstrated (Fleet *et al.* 1997) to not affect clean fleece weight, fibre diameter and body weight in the selected sheep as phenotypic correlations were all low (Fleet 1996; 1997).

Study of the inheritance of leg fibre pigmentation from affected and unaffected Merino sheep at Turretfield Research Centre (South Australia) provided data consistent with the proposal that an identifiable gene is involved in preventing this feature (as well as reducing other pigment types) in Merino sheep (Fleet 1994; Fleet *et al.* 1995b; Fleet 1996). Should this leg fibre pigmentation develop in a Merino flock then after careful sheep inspection (during early life – lamb to hogget) and culling all individuals affected with any trace, this feature can potentially be almost completely removed from the flock in a single generation.

New technology and novel options

Even though much can be achieved through selection on phenotype it is also clear that without gene specific selection or new genetic options for preventing pigmentation and objectionable medullation, these fibres will continue to arise and cause problems at least at low levels. Identifying and characterising useful or unwanted genes in this regard has the potential for complete elimination of one or more of these inherited sources. This research, at least for pigmentation, would be facilitated by the numerous Genomic achievements in mice, humans and other livestock (Fleet 2002a). Initial molecular approaches to pigmentation problems in the Merino have concentrated on recessive black (Parsons *et al.* 1999a,b) and this is being continued together with investigation of the random spot problem by CSIRO/Sheep CRC and AWI. Other pigment genes have recently been studied at the molecular genetics level in primitive breeds of sheep where pigmentation and colour patterns are maintained as part of the breed description (Vage *et al.* 2003; Beraldi *et al.* 2006). Similar opportunities for pigment/medullation gene mapping could arise in Merino x terminal sire crossbreeding flock situations.

4.3 Vegetable matter contamination

Vegetable fault (or vegetable matter - VM - contamination) refers to any particles of plant material present within greasy wool. When present, vegetable fault incurs a price penalty in the market place, because VM influences:

- the yield of clean, usable fibre
- the system by which the wool is to be processed (worsted or woollen)
- fibre loss and breakage during processing
- residual contaminants in the top.

The price discounts imposed depend on the amount and type of VM present. Table 4.3 outlines the types of VM contamination and the plants that fall into these categories. It is incorrect to assume that all VM-causing pasture species are "undesirable", as some valuable pasture species also contribute to VM fault, such as sub-clover and medics.

Table 4.3: Types of VM contamination (AWTA 1986).

Type	Description
B – Burr	Seed pods produced mainly by Medicago species eg Subterranean clover. Generally non-fibrous and relatively easy to remove
E – Seed	Fine grass seed material eg. Carrot seed (*Tragus australianus*), Dock (*Rumex spp.*) and Saffron Thistle (*Carthamus lanatus*)
S – Shive	Fibre-like seed material derived from a wide range of plant species often difficult to remove
F – Bogan Flee	Seed of *Calotis hispidula* a small, flea-shaped seed with several spreading awns.
N – Noogoora Burr	a hard, spine covered burr capable of causing damage to processing machinery due to its hardness. Also Ring Burr (*Sida platycalyx*) included in this category
T – Bathurst Burr	A hard spine-covered burr, more easily removed during processing compared to Noogoora Burr
M - Moit	All non-burr, non-seed plant material such as leaves, twigs and bark. Relatively easy to remove during processing.

Both the amount present and the type of VM contribute significantly to the price that will be paid for raw wool (see tables 4.4 and 4.5). The amount of VM directly influences the Clean Fibre Yield which can be obtained after processing the greasy wool, whilst the amount and type of VM affect the method, speed and cost of processing. Some types are inexpensive to remove from the wool, while others cause damage by breakages in machinery. Thin seeds such as shive may manage to go through the combing machine. This requires recombing and sometimes not even this prevents vegetable matter showing up in the finished cloth. In all cases VM causes some degree of entanglement and causes fibres to be broken during processing (Dawes 1973).

Moderate amounts of VM are removed by the carding and combing processes, but the only satisfactory method of removing excess VM is by the carbonisation process which destroys it with sulphuric acid. Carbonising is the process for removing VM from raw wool – especially very short, burry wools such as lambs, crutchings and locks. Therefore, processors prefer to purchase wool that is Free or Nearly Free (F/NF) from vegetable matter contamination.

Table 4.4: Discounts (c/kg) for VM fault in a range of fleece wool microns sold at auction January 2012 (AWEX report Northern Region 12 Jan 12).

VM%	18μm	19μm	20μm	21μm	23μm
1	0	0	0	0	0
2	-30	-5	+10	+10	0
3	-50	-40	-20	-20	-10
4	-90	-60	-50	-50	-40
5	-100	-85	-80	-60	-45
6	-110	-110	-110	-85	-70
8	-130	-130	-120	-110	na

Table 4.5: Discounts for VM type of fleece wool microns sold at auction 2012 (AWEX report Northern Region 12 Jan 12).

VM type	18μm	19μm	20μm	21μm	23μm
Seed E	0	0	0	0	0
Burr B	+4	+2	0	-2	+2
Shive S	-20	-15	-4	-2	-3
Moit M	-15	-3	-2	na	na
Bogan Flea F	na	na	na	na	na
Noog/Bath N/T	-10	-6	-2	-8	-7

NB. Discounts vary over time and when prices are high, discounts would normally be higher than in the Tables 4.10 and 4.11 and these discounts are also additive. For example, for a 20 micron wool with 5% VM of Moit and Burr would have a discount of 7.8% for VM.

4.4 Strategies to reduce VM fault

The amount and type of VM found in wool reflects the seasonal conditions and the district in which the wool was grown, as well as management practices on individual properties. Some VM types are confined to limited wool-growing areas, while other types are distributed throughout much of the sheep production zone of Australia.

VM problems are more common in wool from mixed farming and pastoral areas as these areas have a greater capacity to sustain plant species causing problems in wool. The high rainfall areas have less VM problems due to greater ground cover, more reliable and higher rainfall and higher stocking rates which tend to limit growth of some of the more problematic species.

For example, the study of Warr *et al.* (1979) of VM contamination across NSW showed that the major seed contaminant in all districts except the Western Division was Barley Grass, the latter region having Wire Grass and Spear Grass as the major seed types. The major burr types in the NW and CW slopes and plains were from Medicago species with the NW and CW slopes and plains having higher VM than the Tablelands and Southern areas of NSW. Burr contamination was the major VM component in NW and CW slopes and plains, whereas seed was the major component contributing to VM in Tablelands and Southern slopes environments while hard heads were a major component in the Riverina district only.

As the level of VM contamination and the main species causing this contamination vary from district to district, the opportunities for controlling VM contamination will therefore vary between districts. In some areas opportunities to reduce VM levels or types may be low due to the degree of VM contamination and VM type compared to the cost to reduce this contamination to low levels. In addition to the strategies discussed below, opportunities may also exist to manipulate VM fault via chemical control of problematic species and utilisation of crop residues for grazing during seeding periods.

Shearing time

Time of shearing has a major effect on the amount and type of vegetable fault present in the fleece, by influencing the length of wool carried during periods when these plants are a problem which is normally when they are seeding. In evaluating the options, a distinction must be made between annual and perennial pasture systems, given the differences between the two in pasture dynamics and time of seed set.

In a study conducted in Central NSW, Warr and Thompson (1976) demonstrated that shearing lambs in October reduced VM accumulation in the fleece compared to unshorn lambs, for all three species contributing to VM contamination (Table 4.6). The shorn lambs also showed less penetration of seeds into the skin compared to unshorn lambs, the latter group exhibiting an associated loss in live weight arising predominantly from reluctance to move through the mature pasture.

A larger study of Warr *et al.* (1979) considered 4 shearing times (summer, autumn, winter, spring) within each of the 7 main wool-growing districts of NSW. In this instance, shearing time was shown to only affect total VM fault in one of the 7 surveyed districts, this being the CW slopes and plains. A summer shearing gave lower VM compared to autumn and winter shearing times. For the other locations, the relative contribution of the burr and seed components changed at particular shearing times, but without affecting the total level of contamination. This study indicated that, at least within NSW, the benefits in terms of VM of changing shearing time, depend on the district in which the wool is grown, this being a reflection of regional differences in the dynamics of the pasture species.

Table 4.6: VM fault and seed penetration of skin in Merino and Crossbred lambs grazing seed infested pasture from October to December in Central Western NSW (Warr and Thompson 1976**).**

	Merino		**Crossbred**	
	Shorn	**Unshorn**	**Shorn**	**Unshorn**
Barley grass (%)	0.1	0.7	0.4	0.8
Storksbill (%)	0.1	1.0	0.6	3.1
Medic Burr (%)	1.7	23.2	0.6	16.9
Skin penetration (no. per 6cm2)	0.0	5.7	0.7	7.0

This is further demonstrated in the study by Ritchie (1992) comparing autumn and spring shearing in the cereal-sheep zone of WA. On pastures dominated by annual grass species (Figure 4.8) and on pastures comprising a mix of annual grasses and medics (Figure 4.9), an autumn shearing gave rise to a higher accumulation rate of VM in the fleece compared to a spring shearing.

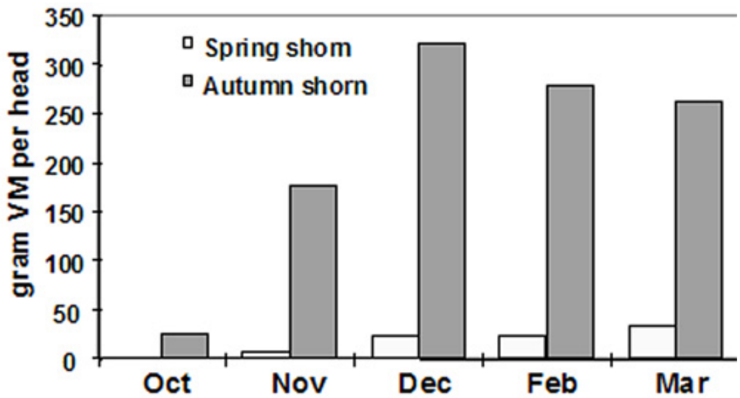

Figure 4.8: Accumulation of seed and shive in spring and autumn shorn Merino sheep grazing grass-dominant pastures over the spring-autumn period at Katanning, WA (Ritchie 1992**).**

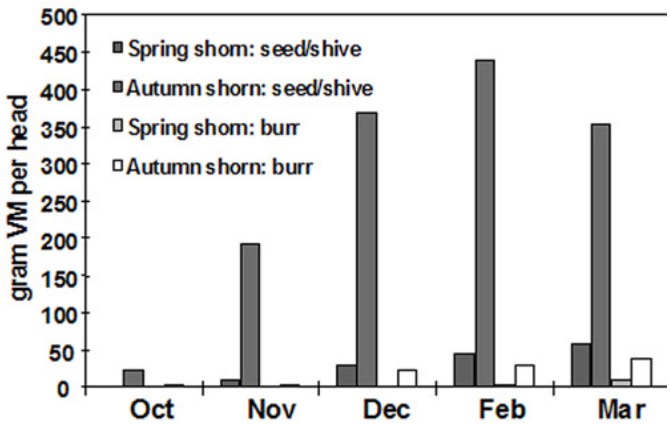

Figure 4.9: Accumulation of seed, shive and burr in spring and autumn shorn Merino sheep grazing mixed pastures over the spring-autumn period at Katanning, WA (Ritchie 1992).

Grazing management

Modification of botanical composition of a pasture by grazing can be achieved through:

- Heavy or light stocking densities
- Continual grazing of either sheep or cattle
- Changing the length and frequency of rests (for desirable species)
- Strategic grazing based on the stage of growth of the plant
- Hard grazing over the flowering period to reduce seed production of undesirable species
- Tactical cutting (fodder conservation or slashing)
- By allowing pastures to seed and regenerate.

Botanical composition is easier to manipulate by grazing management if the problematic species are annuals. The growth pattern of both the problem and desirable species need to be known to be able to determine the periods of weakness in the problem species when a desirable change in botanical composition can be obtained. This may involve the use of a herbicide to reduce the seed set of the less desirable plants (PROGRAZE®).

Stocking rate or grazing pressure in association with grazing management can also influence VM contamination by modifying the species composition of the pasture, and thus also the amount and/or type of vegetable fault present in the fleece. For example, at 2.04 wethers per hectare on natural pastures in Central West NSW (Brownlee 1973), the predominant pasture species were those associated with burr fault (Medicago spp) with the grass component (mainly Aristida and Stipa spp) being somewhat less. However, when grazed at 1.02 wethers per hectare, the contribution of Aristida to the pasture increased, whereas that associated with the Medicago spp decreased. While no results for VM fault were reported in this study, the change in botanical composition would suggest an associated change in the seed and burr components of the VM in the fleece.

The value of grazing pressure to modify botanical composition and possibly VM contamination does depend on the pastures species present and their relative competitiveness and responsiveness when being grazed. For example, when Whitespear Grass (a major source of seed contamination in Qld) is grazed by sheep, there is little effect on plant height and seedhead numbers. However, both attributes can be substantially reduced when grazed by cattle (Figure 4.10), such that sheep subsequently grazing on these pastures showed markedly reduced contamination arising from Whitespear Grass.

Some plants (especially annuals) only shed seed for a limited period and problems can be reduced by either deferring grazing these paddocks or creating some cleaner paddocks that can be grazed when seed is a problem. If possible do not graze paddocks with a high population of problem plant species but do not graze with sheep with a higher wool value such as hoggets or lambs.

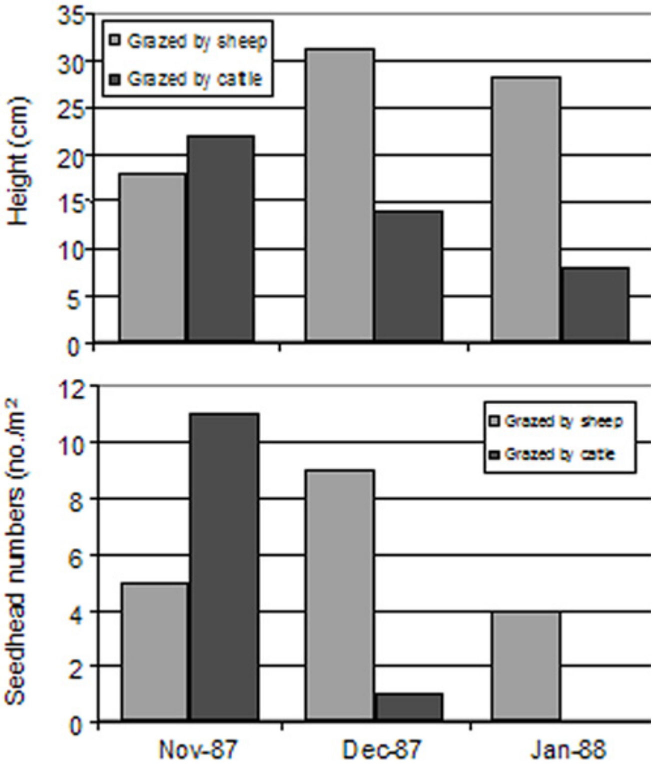

Figure 4.10: The effect of short-term grazing by cattle on the height and number of seedheads of Whitespear Grass present in Mitchell Grass pasture in SW Qld (Wilson and Simpson 1994).

Sheep coats

The use of coats or rugs on sheep is another potential strategy for reducing VM fault in the fleece. The value of this strategy does depend on the pasture species present, the total level of VM normally accumulated when rugs are not used and the improvements in wool value relative to the cost of using coats. The improvement in wool value will depend on fibre diameter, as there is more to gain if coats are used with fine wool rather than broader wool types. However, the "convention" is for medium and broader wool types to be run in those environments subject to higher levels of VM fault.

A trial conducted in Central West NSW (Hatcher *et al.* 2003) to consider the feasibility of running fine wool sheep in this environment found that sheep coats slightly reduced the VM content and increased the style on fine wool sheep. Table 4.7 shows the VM fault and VM particles in coated and uncoated sheep in a number of locations in South Eastern Australia (Abbott 1979).

Table 4.7: VM fault (%) and residual VM particles in wool top for rugged and unrugged sheep run together in a number of wool-growing regions (Abbott 1979).

Location	Rugged	VM%	VM particles per 100gm top
Birchip, Vic	Yes	0.4	4
	No	0.9	2
Wanbi, SA	Yes	4.1	90
	No	4.7	160
Sandalwood, SA	Yes	4.4	16
	No	9.7	45
Deniliquin, NSW	Yes	0.7	6
	No	2.5	20

Agronomic opportunities

Another potential field of research for addressing VM contamination is the development of less problematic cultivars of valuable pasture species. For example, Barrel medic is a valuable pasture species in many wool-growing areas, but it is also a problematic species in terms of VM contamination. There are, however, spineless cultivars of this pasture species. Brownlee and Denney (1985) demonstrated marked differences between cultivars of Barrel medic in their persistency under grazing, pod productivity and contribution to VM in the fleece (Table 4.8). This study included two spined cultivars - Akbar and Hannaford - and two spineless cultivars - Cyfield and Tornafield. Cyfield was similar to Hannaford in terms of persistency and productivity, but without contributing to VM contamination. Tornafield likewise did not contribute to VM contamination, but was not as productive or persistent as other cultivars.

These results suggest that there may be opportunity for developing cultivars of pasture species with a reduced capacity for being acquired in the fleece, while retaining their contribution to the feed base. Limited research appears to have been conducted in this field.

Table 4.8: The persistency, productivity and contribution to VM fault of barrel medic cultivars after 3 years of continuous grazing at 4 sheep per hectare at Condobolin, central NSW. These results refer to the last year of the experiment (Brownlee and Denney 1985).

Cultivar	Medic % in paddock	Total pod (kg/ha)	Medic burr fault (gm per gm greasy)	
			Skirtings	Bellies
Akbar	33	1580	10.1	11.1
Hannaford	52	2497	7.2	13.5
Cyfield	60	2900	0.0	0.0
Tornafield	30	1113	0.0	0.0

Readings

The following readings are available on web learning management systems:

1. Brownlee, H. 1973, 'Wool production, ground cover and botanical composition of pastures grazed by merino wethers in central western New South Wales. I. natural pasture', *Australian Journal of Experimental Agriculture; Animal Husbandry*, vol. 13, pp. 502-509.
2. Brownlee, H. and Denney, G.D. 1985, 'Evaluation of medics under continuous grazing with sheep in central western New South Wales', *Australian Journal of Experimental Agriculture*, vol. 25, pp. 311-319.
3. Fleet, M.R. and Bennie, M.J. 2002, 'A comparison of Damara crossbred and Merino lambs wool', *Animal Production in Australia,* vol. 24, pp. 69-72.
4. Hatcher, S., Atkins, K.D. and Thornberry, K.J. 2003, 'Sheep coats can economically improve the style of western fine wools', *Australian Journal of Experimental Agriculture,* vol. 43(1), pp. 53-59.
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