

**INTERNATIONAL WOOL TEXTILE ORGANISATION****TECHNOLOGY & STANDARDS COMMITTEE****ISTANBUL MEETING**

Raw Wool Group

November 2003

Chairman: A.C. BOTES (South Africa)

Report No: RWG 7

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The Development of a Quantified Risk Factor for the Presence of Dark and/or Medullated Fibres in Australian Merino Wool

By

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**SUMMARY**

Contamination of the Australian Merino clip has traditionally been associated with dark fibres originating from urine-stain and isolated pigmentation found in the fleece.

Over the last two decades, non-specialist woolgrowers introduced to Australia meat breeds often called exotics<sup>a</sup> to meet the preferences of the live sheep trade. These breeds are crossed with Merinos to increase the number of exotics and to produce fat lambs. Contamination has resulted from the transfer of dark and/or medullated fibres from exotic breeds to Merinos, usually at mating and later when rearing an exotic cross lamb. Recent claims based on medullated fibre contamination of fabric have led to industry concern that the high reputation of the Australian clip may be affected.

An objective Pre-Sale Test is preferred. A manual, non-certified test based on a core-sample is offered by the Australian Wool Testing Authority Ltd, but due to high labour costs, the test is expensive and uptake low. Research, funded by Australian Wool Innovation, is underway to provide a more automated system; however, any development is a few years from commercialisation.

To address this situation, the Federation of Australian Wool Organisations, with funding from Australian Wool Innovation, initiated a project aimed at the introduction of a voluntary vendor (woolgrower) declaration for the risk of dark and/or medullated fibre contamination. To oversee the project and ensure its industry focus, a Working Group comprising representatives of all industry sectors was formed.

The project was founded on previous research, primarily by CSIRO and South Australian Department of Agriculture, who identified the major factors contributing to dark fibre contamination of Merino wool. This work ultimately resulted in a prediction scheme for urine-stained and/or isolated pigmented fibre. This CSIRO Dark Fibre Risk Scheme, which was validated by processing trials, calculated the "Risk" that a particular sale lot would meet the requirements of the white/pastel trade.

This paper reports on the development of a Dark and Medullated Fibre Risk (DMFR). The scheme is primarily based CSIRO's Dark Fibre Risk Tree with additional information included on the contamination risk posed by contact with exotic breeds. The results of validation trials, conducted to provide a basis for any refinement to the scheme and to provide a sampling regime for possible future random testing, are presented.

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<sup>a</sup> For the purposes of this report, "exotic" refers to sheep breeds that shed pigmented and/or medullated fibres and are allocated an AWEX Risk Rating of 5. Currently, these breeds are Awassi, Damara, Dorper, Karakul and Wiltshire Horn. Note: The Wiltshire is used for carpet-wool production, not as a meat breed.

It is proposed that the DMFR be a scale from 1 to 5, with Risk Levels 1 and 2 most suitable for sensitive end-uses. The objective information required for the calculation of the DMFR for Merinos includes wool types and description, sex, age, crutching, crutch/shear interval and mated to, reared or run with exotic sheep (or their crosses). The information would be collected on the Classer's Specification or separate declaration form and the DMFR calculated at a central computer prior to reporting on test certificates and in auction catalogues.

With International Wool Textile Organisation and Australian Wool Exchange endorsement, this "Risk" will be reported on Test Certificates and in sale catalogues. The declaration will provide white wool producers with the opportunity to identify their product as such; while buyers/processors will have objective information on the potential risk of contamination.

## **INTRODUCTION**

This project was initiated in response to on-going concern by members of the Federation of Australian Wool Organisations (FAWO)<sup>b</sup> over contamination of the Australian wool clip by dark and/or medullated fibres. The commitment of the entire Australian wool industry to this project is demonstrated by the close participation of the project's Industry Working Group. Indeed, the project is unique in that since its inception, this Group has provided regular input to ensure that all industry-based issues are considered.

The Working Group comprises: John Gubbins (Wool Producers), Michael Jackson (Australian Wool Testing Authority Ltd), Jonathan Lillie (Private Treaty Wool Merchants of Australia), John O'Connor (National Council of Wool Selling Brokers of Australia), Peter Morgan (FAWO), Lindsay Spencer (Australian Wool Exchange) and George Waldthausen (Australian Wool Innovation).

Australian Wool Innovation provided funding as one of its initiatives to address issues of contamination.

Woolclassers/woolgrowers are urged to declare lots that contain dark fibre by using a "Y" qualifier in the description. However, there is no method to declare the risk of dark and/or medullated fibres as negligible. To protect the Australian Merino clips' reputation, tools are required to control/manage the risk of unwanted delivery of dark and/or medullated fibres. Equally, white wool Merino producers would like the opportunity to identify their product as such.

The prediction of dark fibre contamination was proffered by CSIRO in 1988, with its principles later utilised in wool quality schemes (eg. Clipcare, Dalcare). Thus, FAWO proposed that a voluntary vendor declaration for the risk of dark and/or medullated fibre contamination of Merino wool be investigated, and if viable, reported in sale catalogues and test certificates.

A Dark and/or Medullated Fibre Risk (DMFR) scheme would provide: (i) an interim approach pending a low cost Pre-Sale Test and (ii) on-going information on the risk of urine-stain and pigmentation.

This Report documents the primary activities required for the development of a DMFR scheme, namely:

- Review CSIRO Dark Fibre Risk Tree.
- Update CSIRO Dark Fibre Risk Tree to include contamination risk related to exotic breeds.
- Develop practical methods that allow growers to declare information to determine a DMFR and transfer it to broker/private treaty merchant and test house.
- Conduct and analyse objective tests on sale lots covering a range of Risk categories to validate the scheme and to develop a sampling regime for possible future random testing.

On the basis of these activities, a recommendation will be made to IWTO to recognise the DMFR scheme for Australian Merino wool within its Core Test Regulations and thus allow it to be reported on Test Certificates. The Australian Wool Exchange will subsequently be approached to facilitate the inclusion of DMFR in sale catalogues.

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<sup>b</sup> The Federation of Australian Wool Organisations (FAWO) is the Australian National Committee of IWTO.

## **BACKGROUND**

### **DARK AND/OR MEDULLATED FIBRE CONTAMINATION**

#### ***The Problem***

Dark fibre contamination causes problems for the manufacturer<sup>1</sup>. A single dark fibre in a white or pastel fabric will appear as a thin dark line if lying on the yarn surface, or a dark smudge if within the yarn structure. To rectify this situation after weaving involves manual removal (picking) of individual dark fibres or, if the fault levels and thus picking costs are too high, the fabric may be dyed to a darker shade.

The problem of medullated fibre contamination is converse to that of dark fibres<sup>2</sup>. In fabrics that are coloured, medullated fibres give a different appearance when dyed. This problem is more pronounced as the depth of colour of the fabric increases. The least noticeable effects are in pastel shades. If a fabric is already dyed a dark shade, then picking is the only remedial action. However, if the contamination is detected prior to dyeing, a processor may be able to rectify the problem by changing the colour/shade of the fabric or using the wool in a fancy yarn<sup>3</sup>.

Picking of dark or medullated fibres is not undertaken when it is uneconomic or if the process damages the appearance of the fabric<sup>1</sup>. If contamination in a fabric is too high, then compensation for financial loss is claimed on the spinner, who subsequently makes a claim on the topmaker. Such claims range from total replacement cost of the fabric to a share of the picking costs to remedy the problem.

As a rule of thumb<sup>1,4</sup>, the commercial limit for dark fibre contamination in tops destined for a white/pastel end-use is 100 dark fibres per kilogram (df/kg) with lower levels required for ultra-high quality products. One hundred df/kg equates to approximately three dark fibres per running metre of fabric. Limits are not usually applied to medullated fibre contamination in wool. Without research or commercial clarification, it is therefore assumed that limits for medullation are similar to dark fibres (ie. 100 contaminant fibres/kg).

#### ***The Source***

Wool permanently stained through exposure to urine is well recognised<sup>5</sup>. Urine-stained fibres vary in colour from pale yellow to very dark brown; however, generally only brown fibres with a CSIRO Colour Reference Value darker than Level 4 are intolerable in knitted or woven fabric<sup>1</sup>. This variation in colour is largely due to the length of exposure to urine. Urine-stained fibres are uniformly discoloured, though fibre tips are often darker due to longer exposure. The factors contributing to the occurrence and magnitude of urine-stain contamination have been summarised<sup>1,6,7,8</sup>. The primary determinant is the sex of the sheep in conjunction with flock management factors.

Pigmentation is caused by a naturally occurring protein, melanin, which is produced by cells called melanocytes<sup>9</sup>. These are usually found along the epidermal/dermal border, the outer root sheaths and in the bulbs of hair follicles. From these sites, melanin granules are passed into adjoining keratinocyte cells, which subsequently develop into dead layers of skin or into wool or hair fibres. Due to the granular nature of melanin, the colour of a pigmented fibre is usually not uniform along its length.

Since the early 1980s, research aimed at further understanding fibre pigmentation in Australian Merinos has been conducted, with these findings summarised by Fleet in 1985<sup>9</sup> and 2000<sup>10</sup>. In general, due to traditional selection against all types of pigmentation, its occurrence is considered low.

The coat of the wild sheep typically had two layers, a coarse outer coat and a fine woolly undercoat that shed in spring, and for camouflage purposes, it was black, brown grey and/or white in colour<sup>11</sup>. To a greater or lesser extent, sheep breeds today have some of the features of wild sheep, depending on their habitats and the selective breeding imposed by man. The Merino is considered the most highly developed breed as it grows wool continuously, with pigmentation and hair generally not tolerated. If present, these contaminants are more often found on the points, or as discrete isolate fibres or staples. Medullated fibres originating from Merino fleeces are not a recognised source of contamination, possibly because of breakage and loss during early stage processing.

In Australia, the last decade has seen increased production of exotic breeds for meat production, with the rams of these sheep often crossed with Merino ewes to more rapidly increase flock numbers<sup>12,13</sup>. Thus, the transfer of pigmented and/or medullated fibres from exotic fleece to Merino fleece presents a new concern regarding contamination. In Australia, exotic breeds that shed contaminant fibres are allocated an AWEX Risk Rating of 5<sup>14</sup>. Currently these are: Awassi, Damara, Dorper, Karakul and Wiltshire Horn.

### ***Pre-Sale Testing***

Identification of dark fibre contamination in a lot prior to sale would give a buyer the opportunity to purchase wools suited to their proposed end-use. In this way, wools destined for white or pastel end-uses could be contamination free or nearly free. Although AWTA Ltd offers a manual non-certified test (conducted according to in-house standards) for the measurement of dark fibres in a core sample<sup>15,16</sup>, Pre-Sale Testing for dark fibres of urine-stain and pigmentation origin is not reliable because:

- only a very small quantity of dark fibres is required to produce a recognised fault; that is, approximately 4 staples in 1 bale or 10 g per tonne of wool, and
- its distribution is non-random; that is, it generally occurs as discrete clumps within a fleece/bale, thus making core or staple sampling unrepresentative.

Despite the lack of a Pre-Sale Test, processors often specify a limit for dark fibre contamination (eg. <100 dark fibres/kilogram for white or pastel end-uses). Therefore, in order to meet a spinner or weaver's dark fibre limit, buyers/topmakers are reliant on their knowledge of the source and extent of dark fibre contamination for specific categories of wool. Note, it is not common for a processing specification to include a limit for medullation<sup>11</sup>.

The dispersion of pigmented and/or medullated fibres in the fleeces of exotic breed sheep or Merinos in contact exotic breeds or their crosses is random, thus core sampling provides a more representative sample. However, due to the manual nature of the non-certified test<sup>15,16</sup>, routine testing of sale lots is currently uneconomic. Given these circumstances, the buyer is dependent on the accuracy of the information obtained from the grower and/or woolclasser during wool classing (eg. the AWEX Code of Practice advocates that a "Y" suffix be marked on the bale if the sheep have been in contact with exotic breeds (Risk Rating 5) or if ewes have reared exotic crossbred lambs within the wool growth period<sup>14</sup>).

### ***Voluntary Vendor Declaration for Contamination Risk***

It is apparent that methods to clearly identify contamination by dark and/or medullated fibres prior to sale are not likely in the foreseeable future (for discrete contaminants such as urine-stain and isolated pigmentation) or are a few years from commercialisation (for pigmentation and medullation resulting from contact with exotics). Therefore, it is essential that other mechanisms be investigated to provide:

- growers with the opportunity to promote their clip(s) as having a low risk of contamination, and
- buyers and/or topmakers with objective information on the potential risk of contamination of a sale lot by dark and/or medullated fibres.

Thus, FAWO proposed that a voluntary vendor declaration for the risk of dark and/or medullated fibre contamination of Merino wool be investigated, and if viable, reported in sale catalogues and test certificates.

The risk scheme is based on the CSIRO concept of a stained and pigmented fibre risk factor for Merinos (Dark Fibre Risk Scheme)<sup>6</sup>, but extends it to include the dark and/or medullated fibre risk incurred when Merino sheep come in contact with "exotic" sheep or their crosses. This contact is principally through joining and the rearing of crossbred offspring.

It is hoped that the implementation of a vendor declaration for dark and/or medullated fibre risk will eventually result in market signals that will particularly benefit the producers of white Merino wool of low contamination risk.

## **MATERIALS AND METHODS**

### **INTERPRETATION OF CSIRO DARK FIBRE RISK SCHEME**

#### ***CSIRO Dark Fibre Risk Tree***

Following extensive research conducted during the 1980s, a predictive method of determining the risk of dark fibre contamination was proposed by CSIRO Division of Wool Technology in 1988<sup>6</sup>. Research to validate the underlying assumptions of the Dark Fibre Risk Scheme (DFRS) was subsequently conducted and reported to industry<sup>17,18,19</sup>.

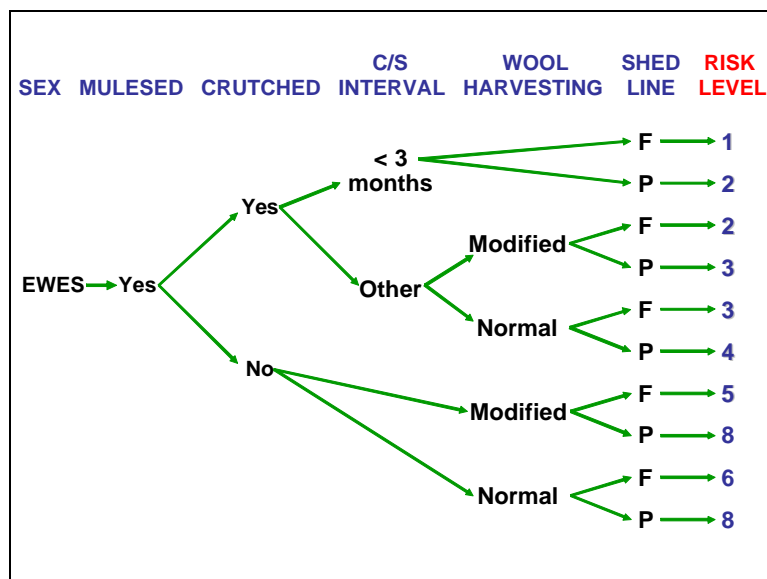
This scheme utilised knowledge of the factors that influence the risk of dark fibre contamination of urine-stain or isolated pigmentation origin. This knowledge was used to formulate questions for the DFRS (see Table 1). Care was taken to ensure that all questions could be answered with objective information obtained at the time of shearing<sup>6</sup>. Although the concept was never implemented commercially, it was positively received by the wool industry.

**Table 1 Factors in the original Dark Fibre Risk Scheme<sup>6</sup>, the type of dark fibre contamination and options for each branch point**

Factor	Type	Option 1	Option 2
<b>Breed</b>	Pigment	Merino	XBred & Comeback
<b>Age</b>	Pigment	Adult Sheep	Lms, Wnr, Hgt
<b>Age</b>	Pigment	<6 years old	>6 years old
<b>Sex</b>	Urine-Stain	Wether	Ewe
<b>Mulesing</b>	Urine-Stain	Yes	No
<b>Crutching</b>	Urine-Stain	Yes	No
<b>Crutch/Shear Interval</b>	Urine-Stain	=3 months	>3 months
<b>Harvesting</b>	Urine-Stain	Modified Shearing	Normal Shearing
<b>Wool Type</b>	Urine Stain	Fleece	Pieces

The DFRS uses a decision tree that involves a series of questions with a number of potential answers, that is, branch points. Follow-on questions “branch” in response to the reply. This process is continued until all relevant factors have been considered, with the “Risk” then calculated. Utilising some of the factors listed in Table 1, Figure 1 demonstrates how the decision tree and the Risk Scale might work in the case of urine-stain for ewes.

**Figure 1 A section of the original Dark Fibre Risk Tree showing the branches used for urine-stain control in ewes (Source: Foulds 1988<sup>6</sup>)**



The DFRS assumed a benchmark level of 100 df/kg top<sup>1,4</sup>. That is, if dark fibre levels are below this level, the wool is deemed suitable for the white or pastel trade. It was originally anticipated that eight (8) Risk Levels would be derived from DFRS. In these circumstances, Risk Levels 1 and 2 would be below this benchmark; Level 3 would be just above and Levels 4 to 8 progressively higher.

**Validation of Dark Fibre Risk Scheme**

It should be noted that it is rare for a top to have zero dark fibres. Australian Merino wool generally has a background level of contamination of <100 df/kg top. This is because, despite careful breeding, isolated pigmented fibres may occur. Equally, the best stain-prevention procedures may not eliminate all urine-stained fibres. For Merinos, contamination above this background level is usually caused by urine-stain.

Validation compares the “Risk” predicted using the DFRS with actual dark fibre test results measured on tops of known origin. Sale lots individually selected to evaluate the influence of specific factors on dark fibre contamination and commercial consignments where the component sale lots were known<sup>17,18,19</sup> were used. For these studies, dark fibres were colour graded as medium or dark according to IWTO DTM-13-01<sup>20</sup>, as these criteria are equivalent to commercial fault levels. The results of these processing validation trials are summarised as follows:

**Breed** Little information is available on the dark fibre risk presented by non-Merino breeds. Of 101 individual sale lots processed to top, two were Corriedale, one fleece and one pieces. They contained a total dark fibre count of 747 and 1451 df/kg, respectively, with the majority of the dark fibres being pigmented. These results were consistent with an evaluation of four commercial Crossbred consignments, two fleece wool and two lambs wool. These results reinforce the commercial practice of avoiding wool from non-Merino breeds if a top suitable for the white or pastel trade is required.

**Age (Adults)** Due to exposure of the skin to the sun, the occurrence of pigmented spots generally increases with age (non-congenital pigmentation). Recent studies<sup>21</sup>, have found that age-related pigmentation increases most dramatically after a sheep reaches 6 years of age. However, they need to be quite old, >8.5 years, before a significant number of spots develop. Except in pastoral areas, most sheep are culled before they reach this age.

**Age (Young Sheep)** Congenital pigmentation is the primary cause of dark fibre contamination in young sheep; however, it usually diminishes as they become adults. Sale lots from young sheep grouped into three ages ( $\leq 1$ , 1-2 and  $>2$  years) and two wool categories (fleece and pieces) were processed to top (Table 2). Higher counts for pieces are likely due to more pigmentation occurring on a sheep’s points.

Note, the values in Table 2 represent pigmented fibres only, thus any urine-stained fibres would increase the total dark fibre contamination of wool from these sheep.

**Table 2 Relationship between mean pigmented fibre levels (df/kg top) and age, n=161 lots (Source: Burbidge and McInnes 1994<sup>19</sup>)**

Category	£1 yr (df/kg)	1-2 yrs (df/kg)	>2 yrs (df/kg)
Flc	204	44	23
Pcs	251	91	57

The wool from sheep  $\leq 1$  year old clearly presents a much higher pigmented fibre risk than the wool from older sheep. The data presented in Table 2 is for pigmented fibres only; therefore, taking into account potential contamination from urine-stained fibres, it was felt that wool from 1-2 year old sheep may be a borderline risk for the white/pastel trade benchmark level of 100 df/kg, whereas the dark fibre risk for wool from sheep  $>2$  years would still meet this benchmark.

As this allocation of a dark fibre risk to sheep 1-2 years of age is marginal, additional information is required to confirm these age effects.

**Sex** The relative levels of dark fibre contamination for Merino ewes and wethers were established using data where the underlying sheep husbandry practices were the same. These practices were mulesing, with a crutch/shear interval greater than 3 months. Table 3 presents sale lot data that compares the stain and pigment levels for fleece and piece lines of wool from ewes and wethers.

**Table 3 Mean dark fibre content (df/kg) of ewe and wether sale lots for different wool categories (Source: Burbidge and McInnes 1994<sup>19</sup>)**

Sex	Category	Stain (df/kg)	Pigment	Total DF
Wethers	Flc	43	29	72
	Pcs	115	20	135
Ewes	Flc	55	17	72
	Pcs	267	106	373

The data show that ewes have higher levels of urine-stained fibres, particularly in the piece lines. The lower levels of contamination for wethers are due to the removal of pizzle stain with the belly wool. Pigmentation levels are similar for ewe and wether fleece wool.

**Crutching and Crutch/Shear Interval** Un-crutched sheep have the potential to produce high levels of stain. A supplementary consideration is the crutch/shear interval, where fibres stained by urine for less than 3 months would not be sufficiently dark to cause a visible fault. Batches sourced to compare the stain levels related to crutching (Table 4) indicated a dramatic rise in urine-stained fibres as sheep are crutched  $\leq 3$  months before shearing, crutched  $>3$  months before shearing, or not crutched at all.

**Table 4** Urine-stain content (df/kg) of fleece and piece sale lots with crutch/shear interval  $\leq 3$  months or  $>3$  months or not crutched (Source: Burbidge and McInnes 1994<sup>19</sup>)

Category	$\leq 3$ months	$> 3$ months	Not Crutched
FLC	15	70	302
PCS	11	251	2366

**Mulesing** Foulds<sup>6</sup> reported that at least for wrinkly sheep, mulesing reduced urine stain by about one sixth compared with unmulesed ewes. However, no specific trial data was available to validate the influence of mulesing on dark fibre levels, particularly urine-stain.

**Modified Shearing** Modified shearing was initially included as a factor influencing the risk of dark fibre contamination<sup>6</sup>. Preliminary data from two sale lots prepared using this technique revealed low levels of urine-stain; however, modified shearing did not gain popularity amongst shearers and/or woolgrowers.

**Wool Type** Data presented in Tables 2, 3 and 4 indicate a significantly higher level of urine stain in piece lines compared with fleece lines. To a lesser extent, the same trend was observed between the pigmentation levels for fleece and pieces. Table 5, shows the contamination levels of 111 commercial consignments comprising both individual wool categories and blends. Wool categories are reported in order of highest to lowest contribution to the blend.

In order of increasing levels of contamination by urine-stain, wool categories are ranked as follows: Fleece, Pieces, Bellies and Stain. Similarly, in order of increasing levels of contamination by pigmentation, the wool categories are ranked: Fleece, Pieces, Weaner, Lambs and Crossbred.

**Table 5** Relative incidence (df/kg) of urine-stained and pigmented fibres in Australian consignments (Source: Burbidge *et al.* 1993<sup>18</sup>)

Wool Type	No. Cons.	Number dark fibres per kilogram (df/kg)		
		Stain	Pigment	Total Stn+Pig
Flc	34	53	37	90
Pcs	12	247	65	312
Flc/Pcs	19	48	36	84
Flc/Pcs/Lms	2	146	731	877
Pcs/Bls	13	1,051	120	1,171
Pcs/Lms/Bls	2	1,212	597	1819
Bls/Stn/Pcs	1	58,461	0	58,461
Flc/Wnr	13	69	25	94
Wnr/Flc	3	126	126	252
XB	4	196	1,919	2,115
Flc/Mx	8	32	24	56

To summarise, when CSIRO's dark fibre research program ceased in the mid-1990s, the factors that validation trials determined were important in terms of estimating the dark fibre risk were: wool type, breed, age, sex, crutching, and crutch/shear interval.

### **Determination of Dark Fibre Risk Levels**

In 1994, CSIRO revised the number of risk levels in the DFRS<sup>19</sup> because it over-estimated the number of dark fibres in fleece and piece lines. It was confirmed that sale lots with Risk Levels between 5 and 8 had a very high probability of the dark fibre count exceeding 100 per kg. A five level scale was proposed. Based on data from 161 Merino sale lots, the probability that a sale lot would be under the 100 df/kg top benchmark was calculated for each Risk Level (see Table 6).

**Table 6** For each Risk Level, the mean df/kg and percentage of lots with  $\geq 100$  df/kg (Source: Burbidge and McInnes, 1994<sup>19</sup>)

Risk Level	No. Lots	Mean df/kg	% Sale Lots	95% CL
1	5	43	100	0.54
2	35	72	77	0.62
3	56	112	68	0.56
4	35	254	43	0.28
5	30	802	20	0.09

The 95% Confidence Limit (CL) value means that a lot chosen at random from within a Risk Level will have a particular probability of its dark fibre content being  $< 100$  df/kg. This interpretation of "Risk" is complex. Thus it is proposed that each Risk Level derived using the DRFS could equate to an estimated dark fibre value (or range).

### DERIVATION OF DARK AND/OR MEDULLATED FIBRE RISK

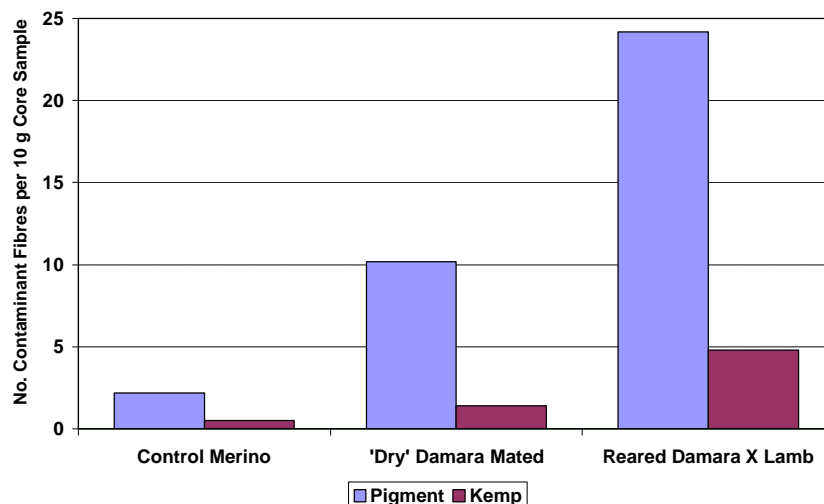
#### *Pigmented and Medullated Fibre Contamination of Merino Wool*

In Australian Merino wool, the inherent level of medullation is very low and historically, has not caused commercial contamination faults. Research to date suggests that the primary factors influencing commercially significant levels of pigmented and/or medullated fibres in Merino wool relates to contact between Merinos and exotic breeds or their crosses, the length and closeness of contact and the time between the contact and shearing<sup>11,22,23,24</sup>. Note, in this work results are based on non-standard measurements made on greasy or scoured samples making extrapolation to commercial fault levels in top (ie. dark fibres/kg top) difficult.

The most relevant data is that presented by Fleet *et al.* at a FAWO seminar in 2002<sup>25</sup>, where pigmented and kemp (medullated) fibres were counted in cored, scoured wool samples from Merino ewes exposed to Damaras (see Table 7 and Figure 2).

**Table 7** Pigmented and medullated contamination (fibres/10 g core sample) for Merino ewes raising Damara Cross lambs at weaning and 3½ months later (Source: Fleet *et al.* 2002<sup>25</sup>)

Contact between Merino Ewes & Damara Cross Lambs	Pigment Fibre >3mm	Pigment Fibre >10mm	Pigment Fibre >25mm	White Kemp >10mm
At Weaning (4.5 mths wool growth)	113	50	25	6
3.5 mths Post Weaning (8 mths wool growth)	21	10	4	0.3

**Figure 2** Pigmented and medullated contamination (fibres/10 g core sample) for Merino ewes: dry, mated to Damaras and rearing Damara cross lambs (Source: Fleet *et al.* 2002<sup>25</sup>)

The results in Table 7 and Figure 2 indicate that pigmented and medullated fibre contamination is related to the length of exposure of Merinos to exotics (in this case Damaras) and the time between mating and shearing. The levels of contamination were extremely high, even for ewes that were mated to Damaras but did not rear a lamb.

### ***Updating the Dark Fibre Risk Scheme for Contact with Exotics***

Some data has been presented that indicates that the numbers of pigmented and/or medullated contaminants may reduce once Merino and exotic sheep have been separated. However, to maintain the high reputation of Australian Merino wool, it is important to err on the side of caution when determining the risk. It is proposed that all Merinos that have any contact with exotics or their crosses, (through mating, rearing a lamb or running in the same paddock); will generate the highest Risk level.

This dark and/or medullated fibre risk is relevant to contact with exotic breeds only, although it is recognised that other non-Merino breeds may also pose a contamination risk. However, as little research data is available on these non-Merino breeds, a Risk for dark and/or medullated fibre contamination will only be applicable to Merinos.

If dark and/or medullated fibre contamination occurs due to contact between Merinos and exotics or their crosses, the wool is not suited to either the white/pastel trade (due to pigmentation) or darker coloured end-uses (due to medullation). For this reason, plus simplicity in terms of receiving and subsequently reporting the information, only one combined dark and/or medullated fibre risk scheme is proposed.

### ***Dark and/or Medullated Fibre Risk (DMFR) Scheme***

Based on the risk factors utilised in the dark fibre risk scheme together with information on whether there has been contact between the Merinos and exotic breeds, a Dark and/or Medullated Fibre Risk (DMFR) scheme has been devised. Factors have only been included in the DMFR Scheme if supporting research is available.

The number of medullated fibres required to produce a commercial fault has not been established; however, it might be expected to be similar to that for dark fibres (ie. 100 df/kg). Thus, it is practical that the benchmark contamination level for both dark and medullated fibres be 100 contaminant fibres/kg.

A scale of 1 to 5 was retained for the DMFR scheme as a zero contamination value is extremely rare due to background levels of contamination. Risk Levels 1 and 2 are most suitable for sensitive end-uses.

### ***Interpretation of Dark and/or Medullated Fibre Risk Levels***

CSIRO research papers<sup>6,17,18,19</sup> provide examples of Risk Levels for specific wool types along with breeding, husbandry and wool harvesting practices. Based on a review of this research, Table 8 presents proposed “cut-off points” for each Risk Level based on estimated numbers of dark and/or medullated fibres/kg (dmf/kg) top. In the future, these “cut-off points” may be validated through topmaking trials or as a result of industry experience with the DMFR scheme.

Note, it is important that the wool industry recognises that the values presented in Table 8 are intended as a guide only.

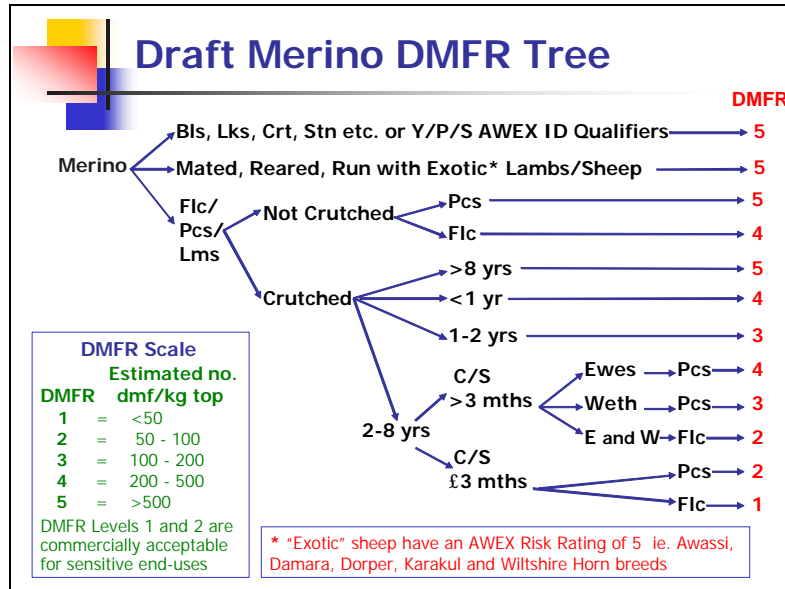
**Table 8** Estimated range in dmf/kg top for each DMFR Level

<b>Risk</b>	<b>Estimated No. dmf/kg</b>
<b>1</b>	<50
<b>2</b>	50-100
<b>3</b>	100-200
<b>4</b>	200-500
<b>5</b>	>500

**Dark and/or Medullated Fibre Risk Tree**

A draft DMFR scheme, depicted as a “risk tree” in Figure 3, was developed prior to commencing validation trials. Note, amendment to this draft DMFR scheme was made on the basis of the results of these validation trials, as explained in subsequent sections of this report. Further refinement and improvement may be possible as more information comes to hand.

**Figure 3 Draft Dark and/or Medullated Fibre Risk Tree**



**VOLUNTARY VENDOR DECLARATION FOR DMFR**

**Information for Determination of DMFR**

Table 9 summarises the information that is required to calculate a DMFR and the type of contamination associated with each factor.

**Table 9 Information to determine DMFR and the main type of contaminant involved**

Factor	Main Type of Contaminant
<b>WOOL TYPE:</b> eg. BLS, LKS, CRS, STN	Urine-Stain
<b>QUALIFIERS IN WOOL DESCRIPTION:</b> AWEX ID qualifiers Y, P or S	Pigment/Medullation
<b>MAIN WOOL TYPES:</b> FLC, PCS, LMS	Urine-Stain/Pigment
<b>SEX:</b> Ewes, Wethers, Rams	Urine-Stain
<b>AGE:</b> ≤1 year (=12 mths), 1-2 years (13-24 mths), >8 years	Pigment
2-8 years	Urine-Stain
<b>CRUTCHING:</b> None, Crutch/Shear Interval ≤3 months or >3months	Urine-Stain
<b>CONTACT with EXOTICS:</b> Mated, reared or run with exotics/crosses	Pigment/Medullation

**Collection of DMFR Information**

It is necessary that the collection of data for the determination of DMFR is as simple as possible; otherwise, its uptake by woolgrowers is likely to be low. A voluntary system is envisaged, whereby growers record the required information either on a Classer’s Specification form or on a separate DMFR Woolgrower Declaration form. The declaration *per se* is signed by the grower at shearing; with the data subsequently transmitted to a central database and the Risk calculated. It is proposed that if a grower chooses not to declare the DMFR, this will also reported in the catalogue and on test certificates.

Note, the data collection proformas also facilitate a voluntary declaration on chemical use by the woolgrower; however, currently there is no means for this information to be transferred to the buyer.



### **Data Capture and Transmission and Determination of DMFR**

Discussions have been held with Australian wool industry companies/organisations that potentially will be involved in various aspects of DMFR data capture and transmission, the calculation of the Risk Level and its publication in sale catalogues and on test certificates. It has been agreed that for consistency, the DMFR will be calculated at a central location. As with the production of the test certificate, AWTA Ltd was nominated as the organisation most appropriate for this role. In addition, a request has been forwarded to the (Australian) Wool Industry Electronic Data Processing Users Group (WIEDPUG) asking that proposals related to the transmission requirements for DMFR be presented to WIEDPUG with a proposed implementation date of July 2004.

## **VALIDATION TRIALS**

### **Dark and/or Medullated Fibre Test**

Top testing results are reported as the number of dark fibres per kg top, with 100 df/kg considered the benchmark level for white or pastel end-uses. For medullation, a benchmark similar to that for dark fibre contamination is considered appropriate (viz. <100 dark and/or medullated fibres/kg top).

By comparison, the manual AWTA Ltd tests are made on 2 x 10 g samples of cored, scoured wool<sup>15,16</sup>. Individual contaminant fibres are measured, with a maximum of 100 dark or medullated fibres counted per 10 g sample. The results for dark and medullated fibres are currently reported as four categories: none detected, 1-5, 5-10 and >10 fibres per 10 g sample. Note, this reporting system may change as new research data becomes available.

The purpose of a core sample test is to detect commercially significant contaminant fibres, not ones that do not cause problems for the manufacturer. Thus, the threshold for the measurement of dark and/or medullated fibres is relevant<sup>26</sup>. To date no standard medullated fibre threshold or scale has been developed. The difficulty is that the visibility of a contaminant medullated fibre is strongly influenced by the diameter of the fibre as well as the level (or percentage) of the fibre diameter that is medullated. Indeed, it affects both dark and medullated fibre measurement since coarser fibres stand out more as contaminants than finer fibres of the same level of darkness (in light coloured fabrics) or level of medullation (in dark coloured fabrics).

Some Australian processing mills arbitrarily set 60% medullation within a fibre as the threshold. This means that in order for a fibre to be "counted", its medulla must comprise at least 60% of the total fibre diameter for a length of 3 mm. To assist its operators in conducting dark and/or medullated fibre screening tests, AWTA Ltd established an in-house Reference Scale for medullated fibres similar to the CSIRO Dark Fibre Reference Scale used to grade the darkness levels<sup>20,27</sup>. Thus, only fibres with a continuous medullation of 60% or more are reported, even though its operators can detect fibres with low levels of medullation (ie. medulla <20% of fibre diameter).

The AWTA Ltd tests form the basis of validation trials for the DMFR scheme. It is important to note that as this test is relatively new, the interpretation of results requires caution. Certainly, there is only scant knowledge of both inherent and foreign (exotic breeds) medullation in Australian Merino wool, particularly the behavior of the fibres of different origin during processing (breakage and loss). This has implications for the relationships between medullation measured in greasy wool compared with that measured in top and/or fabric.

### **Validation Trials for DMFR**

The trials were conducted for two primary purposes:

- To validate the DMFR scheme and provide a basis for refinement.
- To develop a statistically valid sampling regime for possible future random testing.

For the purposes of this report, the validation trials provide an opportunity to compare the Risk Levels determined for specific sale lots using the DMFR scheme against the results of testing conducted on cored, scoured wool samples. Although these validation trials provide valuable information, it is important to note that IT IS NOT POSSIBLE to directly compare the results of the validation trials with the result of testing on top. This is because:

- A core sample is not suitable for all forms of contamination, ie. it is not representative for urine-stain and isolated pigmentation.
- The fibres in core sample are approximately 2 cm in length. Therefore, both dark and medullated fibre contamination may be visually different compared to the full length fibres in top.
- The fibres in a top sample have been subjected to carding and combing. No objective information exists that determines the fibre breakage and loss during these processes. This is particularly the case for medullated fibres, which are generally more brittle than wool fibres.

Hence, it is not valid to simply convert the core sample results (reported as dmf/10 g sample) to those of top (reported as df/kg top). Despite these limitations, the validation trials are considered important in order to further understand both the Risk Scheme and results that testing core samples might produce.

The trials were based on approximately 200 AWTA Ltd dark and/or medullated fibre tests conducted on keeper samples<sup>15,16</sup>. They were conducted in two parts:

- Part A.** Tests on Merino wool that has been in contact with “exotic” sheep, ie. breeds given an AWEX Risk Rating of 5 (currently Awassi, Damara, Dorper, Karakul and Wiltshire Horn).
- Part B.** Tests on Merino wool covering a range of DMFR values sourced from sheep that have not been in contact with exotic breeds.

### ***Collection and Testing of Samples for Validation Trials***

Woolgrowers who were prepared to complete a questionnaire detailing their Merino sale lots (eg. wool type, description, sex, age, crutching history) as well as any contact with exotic breeds or their crosses (eg. how the contact occurred) participated in the validation trials.

Keeper samples of the nominated lots were sourced from all Australian states, with AWTA Ltd testing conducted in laboratories in New South Wales, Victoria and Western Australia. The test results were provided as individual measurements (number dark and medullated fibres/10 g sample).

### ***Part A Analyses – Merino Wool in Contact with Exotics***

#### **Raw Wool Parameters**

The mean, standard deviation, maximum, minimum and range in raw wool parameters for the Part A dataset demonstrates that a wide variety of Merino wool types were considered (Table 10). Note, these sale lots are mainly fleece wools (89 fleece and 2 piece lines). The raw wool parameters presented are: mean fibre diameter (MFD), co-efficient of variation of diameter (CVD), vegetable matter content (VM), IWTO scoured yield (Scd Yld), staple length (SL), co-efficient of variation of staple length (CVL), staple strength (SS) and percentage of mid-breaks (Mid).

**Table 10 Raw wool parameters of Merino wools used in Part A validation trials**

<b>Statistic</b>	<b>MFD (µm)</b>	<b>CVD (%)</b>	<b>VM (%)</b>	<b>Scd Yld (%)</b>	<b>SL (mm)</b>	<b>CVL (%)</b>	<b>SS (N/ktex)</b>	<b>Mid (%)</b>
<b>Mean</b>	21.2	22.8	1.3	66.1	82	17	37	52
<b>SD</b>	1.3	1.4	1.3	5.3	14	3	11	18
<b>Min</b>	18.5	19.7	0.2	50.6	51	9	19	7
<b>Max</b>	24.0	26.2	9.7	78.0	129	30	70	87
<b>Range</b>	5.5	6.5	9.5	27.4	78	21	51	80
<b>Count</b>	87	87	87	87	71	71	69	69

#### **Mode of Contact**

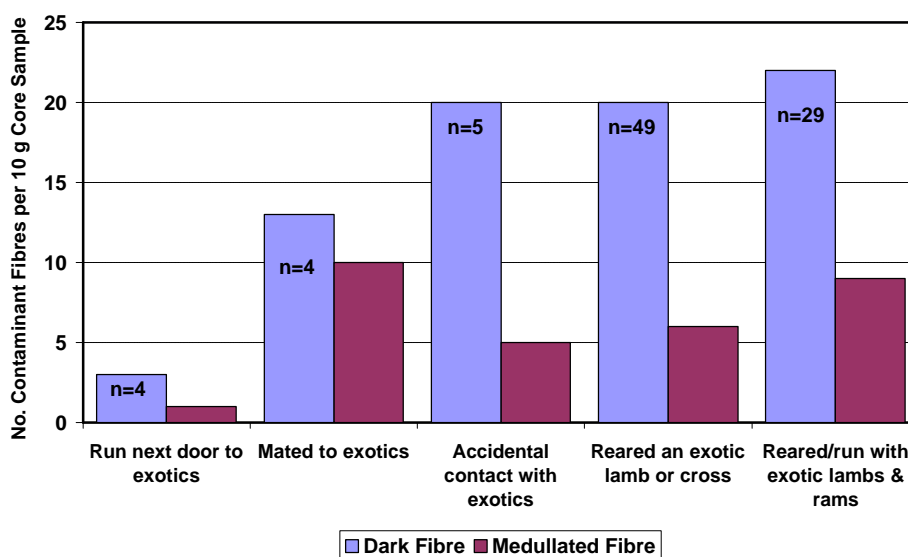
Four different modes of contact between Merinos and exotic breeds or their crosses were assessed in the validation trials, viz. mated to exotics, reared an exotic cross lamb, reared an exotic cross lamb and ran with an exotic rams, and accidentally ran with an exotic (eg. exotic sheep jumped into paddock with Merinos). In addition, a fifth group involved Merinos that had no direct contact with exotics but were run in paddocks next to exotics or their crosses.

The results are shown in Table 11 and Figure 6.

**Table 11 Basic statistics for Part A – Contact with Exotics. Dark and medullated fibres (no. fibres/10 g) for sale lots representative of different modes of contact with exotics**

Description of Contact	No.	Dark Fibre				Medullated Fibre			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Mated to Exotic Rams	4	13	7	6	21	10	10	1	20
Reared Exotic Cross Lamb	49	20	21	4	100	6	14	1	100
Reared Exotic Cross Lamb and run with Exotic Rams	29	22	21	6	96	9	8	2	32
Accidentally run with Exotic	5	20	21	8	56	5	4	2	11
Run in paddock next to Exotic	4	3	3	0	7	1	1	0	3

**Figure 6 Mean results for Part A – Contact with Exotics. Dark and medullated fibres (no. fibres/10 g) for sale lots representative of different modes of contact with exotics**



These results show that all forms of direct contact between Merinos and exotics or their crosses present a very high risk of dark and/or medullated fibre contamination and justify the allocation of a DMFR of 5 to such wools. For the Merinos run next door to exotics, there was no perceptible increase in dark and/or medullated fibre contamination above that caused by urine stain and/or pigmentation. Thus, these Merinos would be allocated a DMFR based on husbandry and management factors (the sale lots in this trial have a DMFR of 2 or 3).

It is worth noting that the AWTA Ltd dark and/or medullated fibre tests only count to a maximum of 100 contaminant fibres/10 g sample. Thus for some of these sale lots, the total dark and/or medullated contamination may be much higher.

**Exotic Breeds**

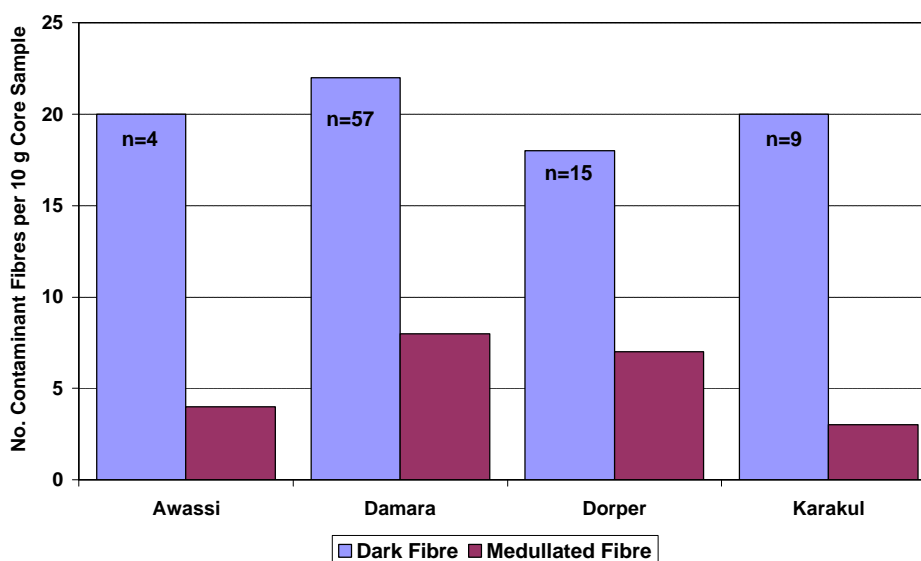
Of the five exotic breeds allocated an AWEX Risk Rating of 5, validation trial samples were only available for four, viz. Awassi, Karakul, Damara and Dorper. These four breeds were specifically imported to Australia for sheep meat production and are commonly crossed with Merinos. There were only a few sale lots where contact with Awassi and Karakul breeds occurred, as Merinos are often only used to build sheep numbers as the producers move towards purebred exotic flocks. No trial samples were available for contact with Wiltshire Horns, which is not surprising as this breed is used for specialist carpet wool production and is not generally crossed with Merinos. Note, all four forms of direct contact between Merinos and exotics (described above) are included in this analysis.

The results are presented in Table 12 and Figure 7.

**Table 12 Basic statistics for Part A – Contact with Exotics. Dark and medullated fibres (no. fibres/10 g) for sale lots representative of contact with different exotic breeds**

Exotic Breed	No.	Dark Fibre				Medullated Fibre			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Awassi	4	20	24	8	56	4	5	1	11
Damara	57	22	20	6	100	8	14	1	100
Dorper	15	18	24	4	93	7	6	2	20
Karakul	9	20	17	4	58	3	2	1	7

**Figure 7 Mean results for Part A – Contact with Exotics. Dark and medullated fibres (no. fibres/10 g) for sale lots representative of contact with different exotic breeds**



It is clear that direct contact between all four exotic breeds and Merinos present a strong risk of contamination by both dark and/or medullated fibres. Although the number of Awassi and Karakul samples tested was small (4 and 9 samples, respectively), this interpretation is considered valid, particularly when the maximum contamination values are taken into account.

From this analysis, there is no evidence to suggest that any of the nominated exotic breeds (AWEX Risk Rating 5) should be excluded from the DMFR scheme, and that all Merino wool that has been in direct contact with these breeds or their crosses should all be allocated a DMFR of 5.

### **Part B Analyses – Merino Wool Covering a Range of DMFR Values**

The validation trials also looked at dark and/or medullated fibre measurements made on Merino wools grown without any contact with exotic sheep and representing a range of DMFR values. The analyses were aimed at evaluating significant trends. As mentioned, caution is required when interpreting these results because, for example, core sampling does not necessarily provide a representative sample of urine-stained or isolated pigmented fibres.

That said, the analyses were viewed with interest, particularly those related to the age of the sheep. In this case, it is hypothesised that pigmentation and medullation of congenital origin (birth coat of young sheep) may be more evenly spread over the fleece compared to that of non-congenital origin (age spots of old sheep). And hence, the sampling method would be representative.

### **Raw Wool Parameters for Part B Dataset**

The raw wool parameters (MFD, CVD, Scd Yld, Curv, CF, SL, CVL, SS, Mid) for the wools used in Part B (see Table 13) are little different to those used in Part A of the validation trials; however, the dataset includes sale lots with finer MFDs (lowest 16.3 µm). This is not unexpected, as specialist fine-wool growers are unlikely to cross their Merinos with exotic breeds.

**Table 13 Raw wool parameters of Merino wools used in Part B validation trials**

Statistic	MFD (µm)	CVD (%)	VM (%)	Scd Yld (%)	SL (mm)	CVL (%)	SS (N/ktex)	Mid (%)
Mean	19.3	22.8	1.5	66.5	82	17	33	56
SD	1.8	1.8	1.5	7.4	13	4	8	20
Min	16.3	18.8	0.2	51.4	45	10	14	9
Max	23.8	27.9	11.9	82.4	112	28	50	92
Range	7.5	9.1	11.7	31.0	67	18	36	83
Count	99	99	99	99	87	87	82	82

**Dark and/or Medullated Fibre Risk (DMFR)**

The DMFR was determined for each sale lot using the DMFR Tree depicted in Figure 3. Based on 99 sale lots, Table 14 provides a statistical summary of the dark and medullated fibre counts for each DMFR, while Figure 8 presents the mean results. This analysis showed the general trend that as the DMFR factor increases, so does the mean and maximum value.

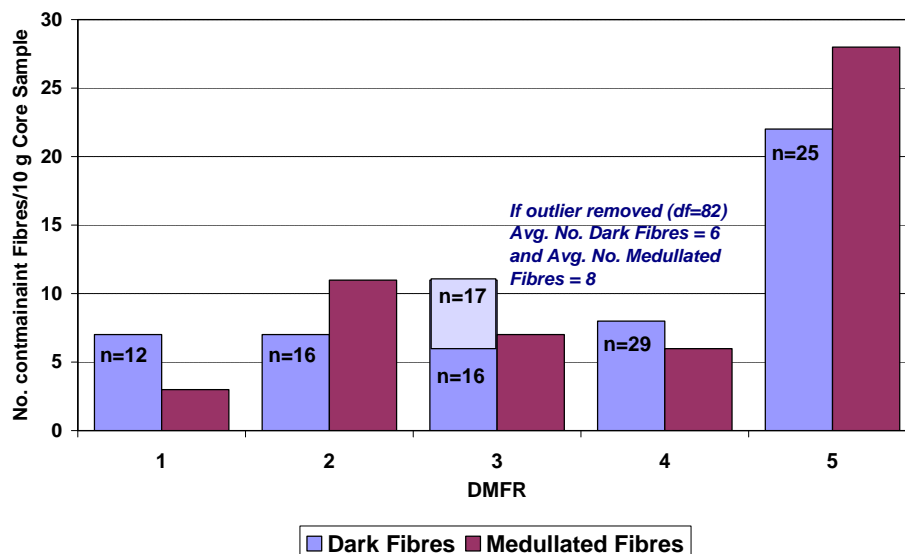
Critical to the interpretation of these results is the role of outliers. As an example, the last row of Table 14 (also see Figure 9) shows DMFR 3 after the removal of one outlier result (sale lot with 82 df/10 g). The removal of only one lot dramatically changes how such results might be interpreted.

**Table 14 Basic statistics for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for the five DMFR values**

DMFR	No. Lots	Dark Fibre				Medullated Fibre			
		Mean	SD	Min	Max	Mean	SD	Min	Max
1	12	7	2	3	10	3	2	1	6
2	16	7	4	1	18	11	19	0	69
3	17	11	19	0	82	7	9	0	29
4	29	8	5	2	26	6	6	0	20
5	25	22	24	3	100	28	29	0	100
3*	16	6	4	0	17	8	9	0	29

\* DMFR 3 dataset after removal of one sale lot with outlier dark fibre value of 82 df/10 g.

**Figure 8 Mean results for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for the five DMFR values**



Dark and/or medullated fibre tests are relatively new and trials similar to those reported here have not previously been undertaken. As mentioned, fibre diameter and length are known to impact on the subjective assessment of both dark and medullated fibres<sup>26</sup>. However, little is known about the appearance of medullated fibres of Merino origin compared to those of exotic origin or their behaviour during both early and late-stage processing (dyeing).

The inherent medullation found in Merino wool is not considered a commercial problem. This may be because Merino kemp fibres are generally short and brittle and may be removed during processing. Therefore, the fibre counts presented in Table 15 do not cause concern. That said, research is required to understand the relationship between tests conducted on core samples with those subsequently conducted on top.

The fact that these validation trial results showed a general trend for higher dark and medullated fibre counts as the DMFR increases, lends support to the DMFR Scheme.

**Wool Type**

Wool type is one of the most important parameters determining the dark and/or medullated fibre content of Merino wool. The dark and medullated fibre test results for 99 sale lots comprising six different wool types are presented in Table 15 and Figure 9.

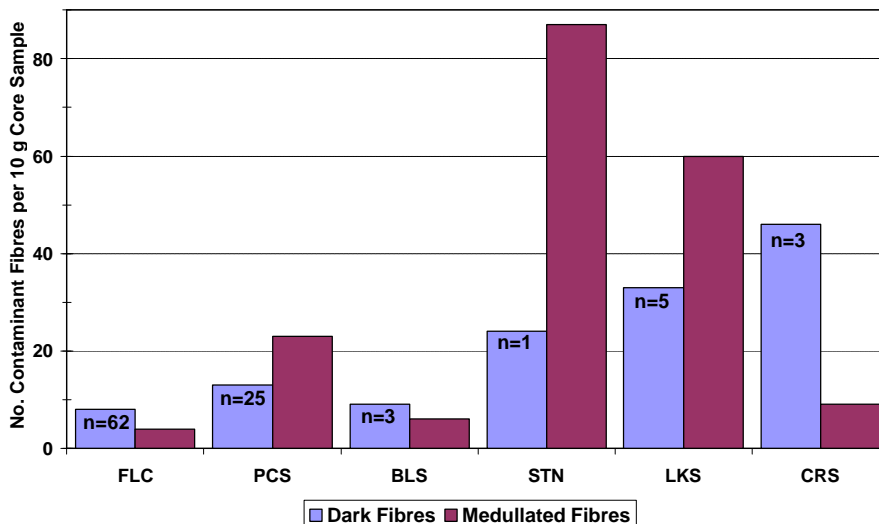
The data indicates that dark and/or medullated fibre counts for fleece and piece lines is low compared to stain, locks and crutchings. These findings are in agreement with previous processing research<sup>18,19</sup> and support the allocation of a DMFR of 5 to these latter three wool types. The results for bellies were inconclusive; however, as only three lots were tested, a DMFR of 5 is still considered applicable.

**Table 15 Basic statistics for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for the five DMFR values for six wool types**

Wool Type	No. Lots	Dark Fibre				Medullated Fibre			
		Avg	SD	Min	Max	Avg	SD	Min	Max
FLC	62	8	10	0	82*	4	4	0	21
PCS	25	13	8	1	32	23	19	0	69
BLS	3	9	3	7	12	6	3	4	9
STN	1	24	-	-	-	87	-	-	-
LKS	5	33	38	8	100	60	28	30	100
CRS	3	76	42	3	87	9	7	1	15

\*One sale lot with outlier dark fibre value of 82 df/10 g core sample

**Figure 9 Mean results for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for six wool types**



For some wool types it seems that Merinos without contact with exotics (Table 15) had similar mean medullated fibre counts to those Merinos that did have contact with exotics (Table 11). However, it is important that appropriate comparisons are made. The lots in Table 11 (contact with exotics) are primarily fleece wools (98% of total lots) and should be compared to the fleece wool results in Table 15. When this comparison is made, as expected, the mean and maximum medullated fibre values in Table 11 (contact with exotics) are higher than the mean and maximum values for the fleece wools shown in Table 15 (no contact with exotics).

**Age**

Fleece lines (n=54) were separated into three groups on the basis of age, viz. =1 year old, 1-2 years of age and 2-8 years of age. Note, no sale lots from sheep >8 years old were available for these trials.

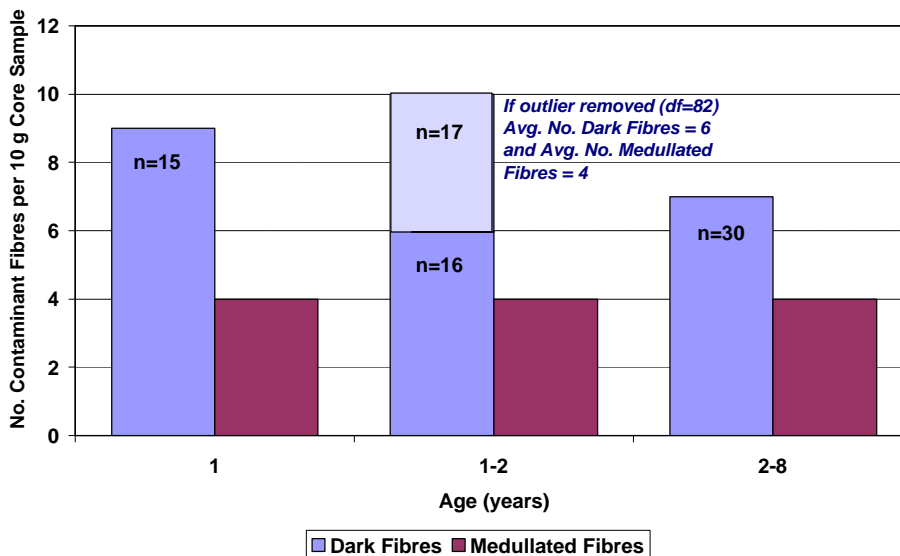
As with previous analyses, the data presented in Table 16 are affected by one sale lot containing 82 df/10 g sample. Hence, this outlier was removed, with the revised dataset presented in the last line of Table 16. From the statistical results in Table 16 and the mean values in Figure 10, it appears there is little difference between the dark and/or medullated fibre levels in the age groups 1-2 and 2-8 years.

**Table 16 Basic statistics for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for three age groups**

Age in Years	No. Lots	Dark Fibre				Medullated Fibre			
		Avg	SD	Min	Max	Avg	SD	Min	Max
=1	15	9	6	2	26	4	4	0	14
1-2	17	10	19	0	82	4	5	0	21
2-8	22	7	3	3	17	4	3	0	15
1-2*	16	6	3	0	13	4	5	0	21

\* Age 1-2 dataset after removal of one sale lot with outlier dark fibre value of 82 df/10 g.

**Figure 10 Mean results for Part B – No contact with exotics. Dark and medullated fibres (no. fibres/10 g) for three age groups**



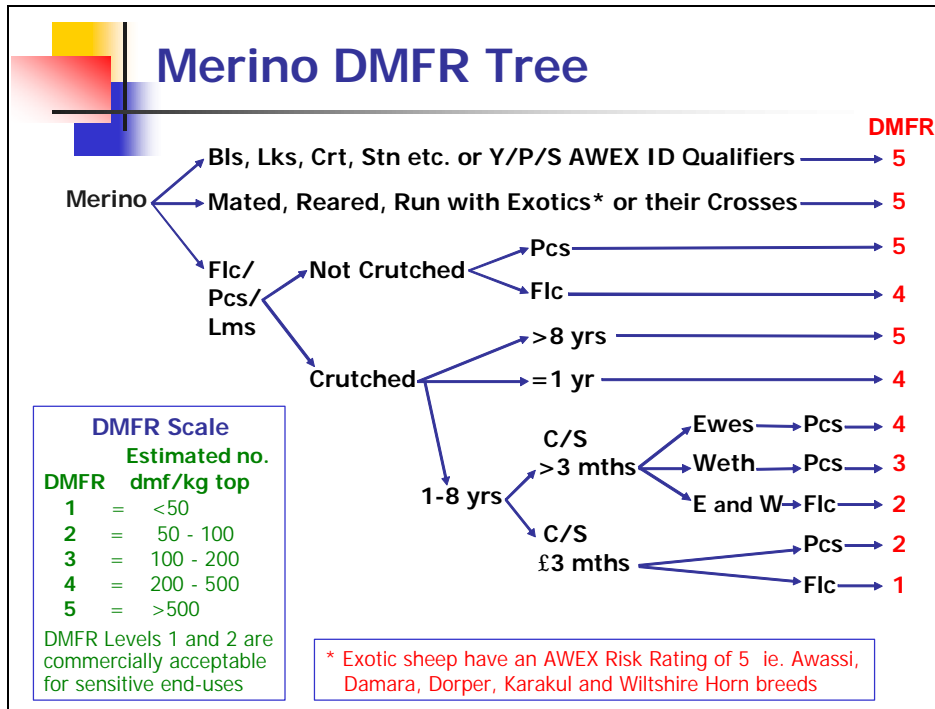
Previous research by Burbidge and McInnes<sup>19</sup> showed that the wool from young sheep =1 year old had a high risk of pigmentation whereas the wool from 1-2 year old sheep was borderline and that for sheep older than 2 years, the contamination risk was even lower.

By comparison, the results of these validation trials show very little difference in the dark and medullated fibre counts for sheep aged 1-2 years compared to those aged 2-8 years. If sheep aged 1-2 years were combined with the 2-8 year age group, their DMFR would be determined by criteria related to the sex of the sheep, crutching and the crutch/shear interval, which are probably more important factors in determining the risk.

**Refinement of the Dark and/or Medullated Fibre Risk Scheme**

On the basis of the results of the validation trials, one modification was made to the draft DMFR scheme. This change relates to the age category 1-2 years, which in terms of dark and medullated fibre levels were similar to the 2-8 year age group. This modification is supported by previous processing research where there was very little difference between these age groups. The final DMFR tree is presented as Figure 11.

**Figure 11 Dark and/or Medullated Fibre Risk Tree**



**CONCLUSIONS**

The introduction of the DMFR scheme for Australian Merino wool is a positive step for the wool industry because:

- It provides an opportunity for Australian Merino woolgrowers to promote their wool as being white.
- It provides buyers/topmakers with objective information to help manage the risk of the unwanted delivery of dark and/or medullated fibre contamination.
- It should eventually result in market signals that will particularly benefit the producers of white Merino wool of low contamination risk.

As a result of this evaluation, recommendations are made to recognise the DMFR scheme for Australian Merino wool within the Core Test Regulations and thus allow inclusion on Test Certificates (see Appendix 1). Subsequently, the Australian Wool Exchange will be approached to facilitate inclusion of the DMFR in sale catalogues.

**Basic Principles of Dark and/or Medullated Fibre Risk**

The following points summarise the basic principles of the proposed DMFR scheme:

- DMFR is applicable to Merinos or Australian Superfine breeds only (AWEX Code of Practice<sup>14</sup>, Breed Risk Rating 1).
- For determination of DMFR, specific breeds have been defined as “exotics” (AWEX Code of Practice<sup>14</sup>, Breed Risk Rating 5).

- Factors required for the calculation of a Merino DMFR include:
  - Sheep mated to, reared or run with exotic breeds or their crosses
  - Wool Type (eg. F1c, Pcs, Bls, Lks, Crs etc.)
  - AWEX ID Wool Description Qualifiers for dark and medullated fibres (Y, P or S)
  - Sex
  - Age
  - Crutched/Not Crutched
  - If Crutched, was it within 3 months of shearing
- Scale 1 – 5. Estimated top contamination values derived for DMFR Levels are:
  - 1 = <50 contaminant fibres/kg
  - 2 = 50 - 100 contaminant fibres/kg
  - 3 = 100 - 200 contaminant fibres/kg
  - 4 = 200 - 500 contaminant fibres/kg
  - 5 = >500 contaminant fibres/kg
- DMFR Levels 1 and 2 are most suited to sensitive end-uses.
- Same benchmark criteria (ie. 100 contaminant fibres/kg) used for dark and medullated fibres.
- No differentiation is made between contamination by dark and/or medullated fibres:
  - urine-stain and isolated pigmented fibre of Merino origin will cause problems for white and pastel trade, and
  - pigmented and medullated fibres of non-Merino origin (eg. exotics) will cause problems for white/pastel trade as well as dark coloured end-uses.
- Tests performed on core samples do not produce results that are directly comparable to the fibre counts made on top (or fabric). Thus, caution is required when interpreting data.
  - Tests performed on core samples will not satisfactorily measure contamination caused by urine-stain or isolated pigmentation. Thus, DMFR is a long-term strategy to give the Merino industry a mechanism to address this form of dark fibre contamination.
  - Tests performed on core samples are applicable to the measurement of contamination caused by contact of Merinos with shedding, pigmented and/or medullated breeds. Thus, the main uptake will be by producers running both Merinos and exotic breeds.

### ***Implementation of Dark and/or Medullated Fibre Risk***

If the recommendation to include the DMFR in the Core Test Regulations is accepted by IWTO, the following issues are relevant to implementation:

- DMFR is for use in Australia for Merinos and Merinos in contact with shedding, pigmented and/or medullated breeds, and as such, the declaration is for Merino producers only. The Test Certificate and sale catalogue will identify Merino wool growers who choose not to make a DMFR declaration. For example, ND (Not Declared) could be reported.
- For Combined Core-Test Certificates, the DMFR could be reported for each lot, if available.
- DMFR cannot be applied to objectively matched lots, interlots or bulk classed wools as their history is not known.
- A DMFR declaration made at the time of sheep trading, for use by the new owner at shearing, would complement the DMFR scheme.

Note, other declarations, for example, wool preparation category are currently reported on IWTO Test Certificates and in sale catalogues. The introduction of DMFR is proposed on a similar basis.

## **ACKNOWLEDGEMENTS**

Australian Wool Innovation provided funding for this project. The authors wish to thank staff of AWTA Ltd for their contributions, particularly the Sampling Managers who co-ordinated the validation trials. Appreciation is also extended to staff of Australian wool brokers for their assistance in sourcing samples.

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## **APPENDIX 1**

### **RECOMMENDATIONS**

Giving consideration to the background research presented in this report; it is recommended that a new regulation relating to the inclusion of a Dark and/or Medullated Fibre Risk (DMFR) be included in Sections 1.4, 2.1 and 2.2 of the IWTO Test Regulations. The following additions/changes are proposed:

#### **1.4 Regulations Relating to IWTO Test Certificates**

1.4.8 Where a National Committee has determined a method for categorising the risk of dark and/or medullated fibre contamination in Merino wool; based on information declared by the seller, the test house shall report on the test certificate either the Risk Level or that no declaration has been made.

The National Committee must obtain IWTO approval of the method used to assign the Risk.

The nature of the declaration shall be determined by the National Committee of the country in which the Test House is situated.

If the declaration for a lot is found to be incorrect, any IWTO Certificate shall be reissued by the Test House if correct information is available, or the dark and/or medullated fibre risk otherwise cancelled.

- 1.4.89 Where the test is being conducted in conjunction with grab sampling, the grab sample shall be taken prior to weighing for the core test. However, up to 1% of the nett greasy weight may be drawn from the lot after such bale weighing (e.g. for appraisal purposes), provided that such wool is drawn at random and that its weight is recorded by a party who is independent of the seller. (The Test House staff or accredited representatives of the Test House may be recognised for this purpose). A record of this weight shall be sent to the Test House, who will record it on the Test Certificate which must be recalculated and reissued to take account of the wool removed. If the weight of such samples exceeds 1% of the weight of the delivery at the time of core sampling, the Core Test Certificate(s) will become invalid.
- 1.4.910 The recalculation of IWTO approved yields shall be laid down in Section 3.0.
- 1.4.911 The Certificate shall show necessary test and identification information as laid down in Section 4.0.

## 2.0 FORMATS OF IWTO TEST CERTIFICATES

### 2.1 General

The Raw Wool Certification Sub-committee concluded that it was not feasible for Test Houses to adopt identical formats for their certificates, due principally to the differing requirements of national selling regulations affecting Test Certificates.

Nevertheless, it was agreed that the users of IWTO Certificates would be assisted by the Test Houses adopting Certificate formats which are standardised with respect to location and sequence of identifying details, sampling data and test results. In this regard it is recommended that, from the top to the bottom of the Certificate, the sequence of information appearing on an IWTO Certificate should be:

- First Section:** Contains Certification identification details in the following order:
- Test House letterhead (including name, address, logos, etc.)
  - Certificate identity (including the Title of the Certificate, the Test House's Test Number and the official IWTO Specification Code Number, eg. , IWTO 190; the date of issue may appear in this Section
  - The Wool Preparation Category symbol or number
  - The Dark and/or Medullated Fibre Risk (if applicable)

### 2.2 Format of IWTO Test Certificate

This Certificate applies to tests carried out in accordance with IWTO-19 and/or IWTO-28, IWTO-12 or IWTO-47 using core sampling and calculation procedures as specified in the IWTO Core Test Regulations.

The recommended format for IWTO Test Certificates is given below. Certificates should also provide the details in the order given from top to bottom of the certificate.

- First Section:** "Certificate Identification" (Title not required on Certificate). This section must contain the following details:
- Test House letterhead (including name, address, logos, etc.)
  - The title "IWTO Test Certificate"
  - Unique Certificate Identification Code
  - Test Method used to obtain the results: i.e. IWTO-19 and/or IWTO-28, IWTO-12 or IWTO-47
  - The Wool Preparation Category symbol or number
  - The Dark and/or Medullated Fibre Risk (if applicable)