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Australian Wool Innovation 2004 Global Survey of Dark and Medullated Fibres

By

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SUMMARY

This report summarises the results from the Australian Wool Innovation 2004 Global Dark and Medullated Fibre (DMF) Survey. The aims were to:

- Assess levels of DMF contamination in 689 wool consignments processed in 14 collaborating mills (3 in Europe, 9 in Asia and 2 in Australia) over approximately 6 months production during 2004.
- Identify whether there were detectable changes in the levels of dark fibre (DF) contamination in processed Australian wool, for the period 1999 to 2004, using data from 3 mills in Australia, Asia and Europe. The data included information on batch size, date of processing, raw wool characteristics, origin of raw wool, wool type and top parameters (including DF).

Based on results from both the 2004 DMF data and the historical data, it was found that:

- The majority of consignments of Australian Merino fleece wool are suited to sensitive end uses (both white/pastel and dark coloured end-products). Other Australian Merino wool types can be included in sensitive end-use batches if carefully selected, for example, if Australian Merino Dark and Medullated Fibre Risk (DMFR) Scheme used (see Appendix 1).
- Although there was variation between countries, the measured levels of DMF contamination generally increased with increasing content of wool from countries/regions other than Australia.
- In 7 of the 14 collaborating mills, DF contamination was due to dyed fibre in the top. In some cases, aspects of mill maintenance and performance may need to be addressed.
- Australian consignments had lower levels of non-wool contamination compared with wool sourced from other countries.
- There was no detectable increase in the levels of DF contamination in processed Australian wool for the period 1999 to 2004 for the three mills that provided historical data. These results suggest that DMF contamination associated with exotic sheep breeds is isolated in occurrence. The use of the DMFR Scheme would assist buyers when sourcing wools for sensitive end-uses.

It was concluded that:

- The Australian Merino clip's reputation for being well specified and free from DMF is justified.
- The DMFR Scheme (Appendix 1) may assist with the construction of sensitive end use batches.

- The results show that in comparison to wool from other countries, the high reputation of Australian Merino wool is justified.
- It is recommended that Australia continue its efforts to maintain and/or improve this reputation through industry initiatives such as the Dark and Medullated Fibre Risk Scheme, the Dark and Medullated Fibre Test and new research and extension aimed at better understanding issues related to DMF contamination. Further work is required to develop better methods for expressing levels of DMF contamination using descriptive statistics.

This Global Survey provides benchmark data on the current (2004) and past (1999-2004) DMF content of Australian Merino wool. Thus, it will now be possible to monitor any changes to the status of the Australian clip as well as assess the success of initiatives aimed at maintaining Australia's reputation for clean, white wool. It is recommended that this survey be repeated on an on-going basis.

INTRODUCTION

Both dark and medullated fibres (DMF) cause problems for the manufacturer (Foulds *et al.* 1984). A single dark fibre (DF) in white/pastel fabric shows as a thin dark line or as a dark smudge. In coloured fabrics, medullated fibres (MF) give a different, often white, appearance when dyed. As a commercial rule of thumb, the limit for white/pastel end uses is less than 100 dark fibres per kilogram (df/kg) top, with lower limits for ultra-high quality (less than 50 df/kg). It is thought that similar limits apply to MF in tops.

The Australian wool clip, especially of Merino origin, has a high reputation for cleanliness in terms of its low DF and MF content. Recently, there have been claims of increased DMF contamination of the Australian clip (Tester 2002; Steger 2004), especially related to the introduction of exotic sheep breeds to meet the requirements of the live sheep trade. Contamination can occur through the transfer of DMF from exotic breeds or their crosses to the Merino. Prior to the development of the Dark and Medullated Fibre Risk (DMFR) Scheme (Hansford and Industry Working Group 2003), a comprehensive report summarised issues related to the DMF content of the Australian clip (Hansford 2003).

Responding to industry feedback, Australian wool growers, through Australian Wool Innovation (AWI) funding, have recently initiated a number of projects aimed at maintaining the reputation of Australian Merino wool. Such initiatives include the introduction of the DMFR Scheme, development of a low cost, automated technique for DMF testing (eg. AWTA Ltd 2004a and b; Balasingam and Mahar 2005); and further research and extension related to DMF contamination. AWI's 2004 Global Dark and Medullated Fibre Survey has quantified the levels of DMF to enable these initiatives to be monitored over time.

This paper summarises results from the 2004 Global Dark and Medullated Fibre Survey that sought to:

- Provide an up-to-date assessment of the levels of DMF contamination in consignments of Australian wool being processed around the globe (Part 1).
- Identify whether there were any changes in the levels of DF contamination in processed Australian wool over the period 1999 – 2004 (Part 2).

A condition of conduct of this survey was that the identity of each mill was kept strictly confidential, and for that reason, no mills are identified in this paper.

MATERIALS AND METHODS

PART 1

The current levels of DMF were determined using a dataset comprising 789 consignments supplied by 14 participating mills (3 in Europe, 9 in Asia and 2 in Australia) over approximately 6 months production during 2004. CSIRO Textile and Fibre Technology (CSIRO) DMF tests were conducted on each batch. The results thus provide the first estimate of the MF content of commercial consignments. It is important to note that the data supplied was not the same for all mills and this was taken into consideration by reporting the number of consignments for each statistic.

The CSIRO DMF tests involved microscopic inspection of fibres extracted from tops. Coloured fibres (CF) comprised CSIRO Colour Reference Levels 4 and 5 and brown/black fibres (BF) comprised Reference Levels 6, 7 and 8. These categories (CF+BF) were combined to provide the total DF content. All DF fibres were examined under a microscope to determine if their source was urine-stain,

pigmentation or dye. Medullation (MF) of the top samples was measured using a microscope. If the area under examination showed 50% or more of medullation, it was considered to be medullated. The full length of the fibre was not examined; however, if medullation was present, each fibre was scanned up and down for a short distance. Non-wool contamination comprised fibres, for example, polypropylene, polyethylene, HDPE (eg. baling twine, farm packs, mill packs etc.) sourced on-farm or in the mill itself.

PART 2

Three mills from Europe, Asia and Australia provided historical data for batches processed between 1999 and 2004. The data for each consignment included the size and date of processing, raw wool characteristics, origin of raw wool, wool type and expected and actual top parameters, including DF.

The historical case studies aimed to determine relationships between DF content and the following:

- Changes over time,
- Raw wool parameters, eg. mean fibre diameter (MFD),
- Wool category, eg. fleece, piece, belly, lambs and prem wool, and
- Country of origin of wool.

The historical data differed between mills; with Mill A being the most comprehensive allowing analyses of all the factors listed above. For succinctness, Mill A analyses are presented for all factors, with Mill B (Asia) and Mill C (Australia) analyses only presented for changes in DF over time. It is important to note; however, that the analyses produced for these two mills produced comparable results.

EXPRESSION OF DMF CONTAMINATION LEVELS

A characteristic of DMF measurements is that the levels of contamination across samples is generally heavily skewed; the majority of samples have low levels of contamination (e.g. less than 100 contaminant fibres/kg), whereas a small number have extremely high levels (e.g. greater than 1000 contaminant fibres/kg). This affects the utility of descriptive statistics which assume a normal distribution of values (e.g. mean and standard deviation). For example, for the 331 consignments comprising Australian fleece wool less than 24 µm in MFD (AUST FLC), the average DF content ranged from 0 – 1870 df/kg, with a mean of 35 df/kg and a standard deviation of 153 df/kg (see Table 5).

It is suggested that further work be conducted to determine the best methods for expressing levels of contamination as well statistical or descriptive differences between them. For the purposes of this report, in addition to standard descriptive statistics, (viz. mean, standard deviation (Std Dev), maximum value (Max), minimum value (Min) and range in values), the actual DF and MF values were converted to Dark Fibre Risk (DFR) and Medullated Fibre Risk (MFR) with the Fibre Risk values equivalent to: FR 1 ≈ <50; FR 2 ≈ 50 – 100; FR 3 ≈ 100 – 200; FR 4 ≈ 200 – 500; and FR 5 ≈ >500 dmf/kg.

RESULTS AND DISCUSSION

PART 1

Analyses for All Mills

2004 DMF Dataset

The 2004 DMF dataset included information such as the size and date of processing, raw wool characteristics, origin of raw wool, wool type and expected and actual top parameters (including DF); however, this data varied between mills. In these analyses, the database comprises the results from 14 mills, with DMF testing conducting by CSIRO. The aim of Part 1 was to evaluate the following:

- DMF content and mean fibre diameter,
- Levels of medullation and dark fibre, and
- The source of DF contamination (viz. urine-stain, pigmentation or dyed fibres).

From a total of 789 consignments from 14 mills, the following 3 datasets were extracted:

- Consignments comprising 100% Australian wool (n = 696), hereafter called AUST.
- A subset of 100% Australian wool (n = 331), less than 24 µm in diameter and fleece wool only, hereafter called AUST FLC.
- A dataset comprising batches sourced from other countries (n = 93), hereafter called OTHER. ***Note:*** OTHER batches may contain up to 50% Australian wool.

Tables 1 (AUST), 2 (AUST FLC) and 3 (OTHER) present the standard statistics related to consignment construction and top parameters. The statistics for each parameter are based on the number of consignments detailed in the right hand column (No. Cons), reflecting the fact that mill records provided for each consignment did not always include all parameters listed in Tables 1 to 3.

Table 1 Basic statistics for AUST consignments

Parameters	Mean	Std Dev	Max	Min	Range	No. Cons
Greasy Weight (tonnes)	37	31	332	6	326	554
Number of Bales (n)	246	187	1117	33	1084	420
% Australian Wool	100	0	100	100	0	696
% Fleece Wool	87	24	100	0	100	655
% Pieces Wool	7	13	72	0	72	655
% Bellies	3	7	45	0	45	655
% Lambs	3	7	54	0	54	655
% Other	1	3	61	0	61	655
Diameter (µm)	20.9	2.2	31.3	16.5	14.8	696
Hauteur (mm)	74	7	100	49	51	694
Expected Mill DF (df/kg)	290	672	6200	20	6180	157

Table 2 Basic statistics for AUST FLC consignments

Parameters	Mean	Std Dev	Max	Min	Range	No. Cons
Greasy Weight (tonnes)	28	20	201	7	194	238
Number of Bales (n)	217	153	1117	58	1059	97
% Australian Wool	100	0	100	100	0	331
% Fleece Wool	100	0	100	100	0	331
Diameter (µm)	20.7	1.6	23.5	16.5	7.0	331
Hauteur (mm)	76	6	97	58	39	331
Expected Mill DF (df/kg)	46	17	100	20	80	25

Table 3 Basic statistics for OTHER consignments

Parameters	Mean	Std Dev	Max	Min	Range	No. Cons
Greasy Weight (tonnes)	70	29	147	14	133	93
Number of Bales (n)	364	154	815	95	720	93
% Australian Wool	60	28	99	0	99	93
% Fleece Wool	66	28	100	0	100	93
% Pieces Wool	18	21	77	0	77	93
% Bellies	6	13	62	0	62	93
% Lambs	5	11	57	0	57	93
% Other	5	6	27	0	27	93
Diameter (µm)	21.9	3.8	36.6	16.2	20.4	93
Hauteur (mm)	72	8	90	54	36	93
Expected Mill DF (df/kg)	1800	4364	19990	30	19960	63

- The construction of AUST was primarily fleece wools with an average of 87%, against 66% fleece wool content for OTHER.
- For MFD, for AUST the mean and max (20.9 µm and 31.3µm, respectively) were lower than OTHER (mean = 21.9 µm and max = 36.6 µm). AUST FLC was 20.7 µm and max 23.5 µm.
- The average Hauteur for AUST FLC (76 mm) was slightly longer than AUST (74 mm), which was slightly longer than OTHER (72 mm).
- Although based on limited data, the expected DF content was much lower for AUST FLC and AUST compared to OTHER (viz. average 46, 290 and 1800 df/kg, respectively). This indicates that buyers and processors have high expectations of Australian wool in terms of low levels of DF contamination.

The DMF parameters measured by CSIRO, reported as number/kg top, are presented below in Table 4 (AUST), Table 5 (AUST FLC) and Table 6 (OTHER). The actual DF and MF values were converted to the DFR and MFR with the Ratings equivalent to: FR 1 ≈ <50; FR 2 ≈ 50 – 100; FR 3 ≈ 100 – 200; FR 4 ≈ 200 – 500; and FR 5 ≈ >500 dmf/kg.

Table 4 Statistics for top DMF parameters measured by CSIRO for AUST (n = 696)

Parameter	Mean	Std Dev	Max	Min
Medullated Fibres (mf/kg)	162	804	11050	0
Medullated Fibre Risk (Scale 1-5)	1.4	1.1	5	1
CF Lev 4 & 5 (cf/kg)	6	31	670	0
BF Lev 6, 7 & 8 (bf/kg)	154	1577	29450	0
DF Lev 4, 5, 6, 7, 8 (df/kg)	160	1581	29450	0
Dark Fibre Risk (Scale 1-5)	1.5	1.0	5	1
DF urine stain (df/kg)	106	1200	28570	0
DF pigment (df/kg)	42	673	17680	0
DF dyed fibre (df/kg)	13	100	1780	0
Non-wool contaminants (number/kg)	12	43	720	0

Table 5 Statistics for top DMF parameters measured by CSIRO for AUST FLC (n = 331)

Parameters	Mean	Std Dev	Max	Min
Medullated Fibres (mf/kg)	36	220	3820	0
Medullated Fibre Risk (Scale 1-5)	1.2	0.6	5	1
CF Lev 4 & 5 (cf/kg)	2	10	90	0
BF Lev 6, 7 & 8 (bf/kg)	33	149	1870	0
DF Lev 4, 5, 6, 7, 8 (df/kg)	35	153	1870	0
Dark Fibre Risk (Scale 1-5)	1.2	0.6	5	1
DF urine stain (df/kg)	12	38	530	0
DF pigment (df/kg)	7	24	290	0
DF dyed fibre (df/kg)	16	128	1780	0
Non-wool contamination	13	49	720	0

Table 6 Statistics for top DMF parameters measured by CSIRO for OTHER (n = 93)

Parameter	Mean	Std Dev	Max	Min
Medullated Fibres (mf/kg)	2282	6724	39420	0
Medullated Fibre Risk (Scale 1-5)	2.7	1.7	5	1
CF Lev 4 & 5 (cf/kg)	375	1370	10150	0
BF Lev 6, 7 & 8 (bf/kg)	1785	5325	30450	0
DF Lev 4, 5, 6, 7, 8 (df/kg)	2160	6519	40600	0
Dark Fibre Risk (Scale 1-5)	2.4	1.6	5	1
DF urine stain (df/kg)	1902	6380	40600	0
DF pigment (df/kg)	207	892	8310	0
DF dyed fibre (df/kg)	4	22	180	0
Non-wool contaminants (number/kg)	57	265	2050	0

- The mean MF content was lower and its distribution (Std Dev) narrower for AUST FLC compared with AUST and OTHER (viz. 36 ± 220; 162 ± 801 and 2282 ± 6724 mf/kg, respectively). Caution is required when interpreting these results as the tests conducted by CSIRO are not the same as, for example, those conducted by AWTA Ltd where the aim is to measure objectionable medullation (Balasingam 2005).
- The mean MFR values for AUST FLC, AUST and OTHER were 1.2, 1.4 and 2.7, respectively.
- For DF values, the mean was lower and the distribution narrower for AUST FLC compared with AUST and OTHER (viz. 35 ± 153; 160 ± 1581 and 2160 ± 6519 df/kg, respectively).
- The mean DFR values for AUST FLC, AUST and OTHER were 1.2, 1.5 and 2.4, respectively.
- For AUST and OTHER, urine-stain was the dominant source of DF contamination. For OTHER, urine stained fibres were 10 times more common than pigmented fibres, whereas for AUST they were only 2½ times. This highlights the large influence urine stain has on DF contamination, regardless of country of origin of the wool or the breed of the sheep.
- Dyed fibre contributed to the total DF content of all 3 datasets. In the reduced subset of Australian fleece wool (AUST FLC), dyed fibre contributed more to DF contamination than did urine stain or pigmentation.
- There were nearly 5 times as many non-wool contaminants in batches containing wool from other countries viz. 57/kg for OTHER and approximately 12/kg for both AUST and AUST FLC.

The DMF and non-wool contamination values obtained by CSIRO testing demonstrate the cleanliness of the Australian wool clip compared to wool from other origins.

Dark Fibre Content and Mean Fibre Diameter

To assess the relationship between DF content and MFD, the DF content for each batch was converted to its DFR Rating. Tables 7 (AUST), 8 (AUST FLC) and 9 (OTHER) present the percentage of consignments with DFR Ratings 1 to 5.

Table 7 Proportion of DFR Ratings (1 to 5) for AUST batches for four MFD groups

MFD Group (µm)	No. Cons.	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
<20.0	274	82	10	5	1	2
20.0 - 23.9	381	79	9	8	2	2
24.0 - 28.0	26	38	12	15	19	15
>28.0	15	13	13	13	20	40
AUST	**696**	**53**	**11**	**10**	**11**	**15**

Table 8 Proportion of DFR Ratings (1 to 5) for AUST FLC batches for two MFD groups

MFD Group (µm)	No. Cons.	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
<20.0	121	93	4	2	1	0
20.0 - 23.9	210	86	7	4	1	2
AUST FLC	**331**	**90**	**5**	**3**	**1**	**1**

Table 9 Proportion of DFR Ratings (1 to 5) for OTHER batches for four MFD groups

MFD Group (µm)	No. Cons.	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
<20.0	26	62	12	12	4	11
20.0 - 23.9	54	43	20	11	4	22
24.0 - 28.0	6	17	50	0	17	17
>28.0	7	14	14	14	14	50
OTHER	**93**	**34**	**24**	**9**	**10**	**25**

- For all MFD groups, AUST had 64% with DFR Ratings of 1 or 2 (<100 df/kg) and OTHER 58%.
- For Merino MFD groups (<24 µm), 81% of AUST and 53% for OTHER met ultra-sensitive end use criteria (<50 df/kg or DFR Rating 1). For AUST FLC, the proportion was 90%.
- For wools less than 24 µm, if the requirement is <100 df/kg (DFR Ratings 1 and 2), 95% of AUST FLC, 90% of AUST and 69% of OTHER batches would meet this.
- For non-Merino categories (>24 µm), AUST had 38% and OTHER 48% with DFR Ratings 1 and 2. This may be partly explained in that OTHER batches primarily comprised fleece and pieces, while AUST contained batches with a high proportion of lambs and some unknown wool types.

Medullated Fibre Content and Mean Fibre Diameter

To assess the relationship between MF content and MFD, the MF content for each batch was converted to its MFR Rating. Tables 10 (AUST), 11 (AUST FLC) and 12 (OTHER) present the percentage of consignments with MFR Ratings 1 to 5.

Table 10 Proportion of MFR Ratings (1 to 5) for AUST batches for four MFD groups

MFD Group (µm)	No. Cons.	% MFR 1	% MFR 2	% MFR 3	% MFR 4	% MFR 5
<20.0	274	88	4	6	2	0
20.0 - 23.9	381	82	8	5	3	2
24.0 - 28.0	26	31	4	8	4	54
>28.0	15	7	0	7	20	66
AUST	**696**	**52**	**4**	**7**	**7**	**31**

Table 11 Proportion of MFR Ratings (1 to 5) for AUST FLC batches for two MFD groups

MFD Group (µm)	No. Cons.	% MFR 1	% MFR 2	% MFR 3	% MFR 4	% MFR 5
<20.0	121	94	3	2	0	0
20.0 - 23.9	210	85	8	3	2	1
AUST FLC	**331**	**90**	**6**	**3**	**1**	**1**

Table 12 Proportion of MFR Ratings (1 to 5) for OTHER batches for four MFD groups

MFD Group (µm)	No. Cons.	% MFR 1	% MFR 2	% MFR 3	% MFR 4	% MFR 5
<20.0	26	65	8	8	11	8
20.0 - 23.9	54	43	11	9	7	30
24.0 - 28.0	6	33	0	0	17	50
>28.0	7	0	0	14	14	71
OTHER	**93**	**35**	**5**	**8**	**12**	**40**

- For all MFD groups, AUST had 56% with MFR Ratings of 1 or 2 (<100 df/kg) and OTHER 40%.
- For Merino MFD groups (<24 µm), 85% of AUST and 54% for OTHER met ultra-sensitive end use criteria (<50 df/kg or DFR Rating 1). For AUST FLC, the proportion was 90%.
- For wools less than 24 µm, if the requirement is <100 mf/kg (MFR Ratings 1 and 2), 95% of AUST FLC, 91% of AUST and 64% of OTHER batches would meet this.
- For wools >24 µm (non-Merino diameter), OTHER had 17% and AUST had 21% of batches suited to sensitive end uses (MFR Ratings 1 or 2). These values demonstrate the association between MF content and MFD.

Origin of Dark Fibre Contamination in Australian Merino Fleece Wool

To further examine the DF content of Australian Merino wool, the following analysis was conducted on Australian fleece wools <24 µm, thus minimising the influence of non-Merino breeds and wool type. For AUST FLC, Table 13 presents CSIRO results for DF classified as urine-stained, pigmented or dyed.

Table 13 For DFR Ratings (1 to 5), DF classified as urine-stained, pigmented or dyed

Dark Fibre Risk Rating	Statistic	Number of dark fibres/kilogram top			
		Urine-stain	Pigment	Dyed	Total
DFR Rating 1 (<50 df/kg) (n = 293, 90% of total)	**Mean**	5	4	2	11
	Std Dev	13	11	9	17
	Max	50	50	50	50
	Min	0	0	0	0
DRF Rating 2 (50-100 df/kg) (n = 20, 6% of total)	**Mean**	42	24	9	74
	Std Dev	32	31	19	12
	Max	90	80	60	100
	Min	0	0	0	60
DFR Rating 3 (100-200 df/kg) (n = 12, 3.6% of total)	**Mean**	77	27	32	136
	Std Dev	58	37	53	19
	Max	180	90	150	180
	Min	0	0	0	110
DFR Rating 4 (200-500 df/kg) (n = 3, 0.9% of total)	**Mean**	37	150	153	340
	Std Dev	35	145	200	98
	Max	70	290	380	420
	Min	0	0	0	230
DFR Rating 5 (>500 df/kg) (n = 3, 0.9% total)	**Mean**	213	0	1223	1437
	Std Dev	275	0	623	742
	Max	530	0	1780	1870
	Min	30	0	550	580

For AUST FLC, the number of batches with DFR Ratings 4 and 5 was low (3 each out of 331), demonstrating the overall cleanliness of Australian Merino fleece wool. Examination of the source of DF for each DFR Rating showed:

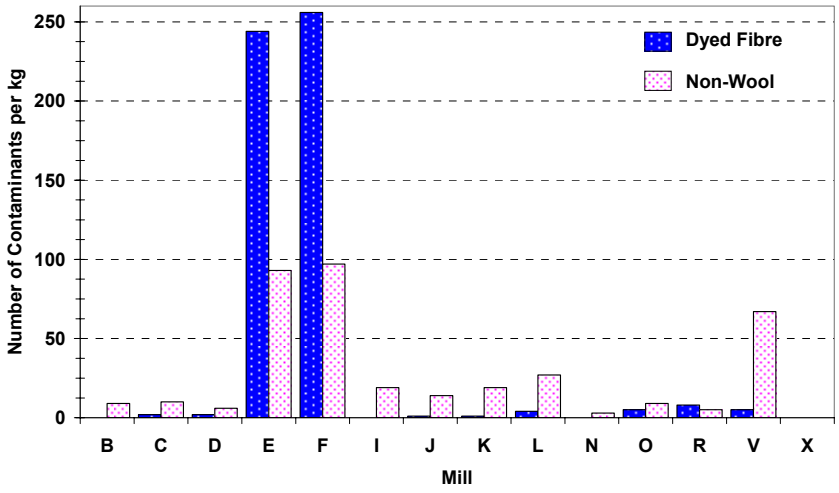
- DFR Rating 1: Urine-stain, pigment and dye contributed to the DF contamination in this group. In separate batches, all 3 forms contributed up to 50 df/kg top.
- DFR Rating 2: All 3 forms of contamination contributed up to 100 df/kg top.
- DFR Rating 3: All 3 forms of contamination contributed up to 200 df/kg top.
- DRF Rating 4: All 3 forms of contamination contributed up to 500 df/kg. Individually, urine stain was the least significant and dyed fibres the most significant.
- DRF Rating 5: Only urine stain (1 batch) and dyed fibres (2 batches) contributed over 500 df/kg. Pigmentation did not contribute to the total contamination.

A previous study (Burbidge *et al.* 1993) found urine stain was the more common source of DF contamination of Australian consignments compared to pigmentation. This survey adds to this information by examining DF contamination in terms of urine stained, pigmented and dyed fibres. Of the 14 mills involved in the survey, half the batches contained DF of dyed wool origin, some with very high levels. Although it is not known if these tops were destined for white or pastel end uses, it is clear that topmakers need to maintain high standards of mill cleanliness to avoid issues of cross-contamination.

Non-Wool and Dyed Fibre Contamination of Database

To assess the general cleanliness of the 14 mills involved in the survey, the average numbers of dyed fibres and non-wool contaminants were plotted for each mill (see Figure 1).

Figure 1 **2004 global survey database (n = 789), average non-wool and dyed fibre (contaminants/kg) for 14 global processing mills**



The data show that for Mills E and F, the levels of both dyed fibre and non-wool contamination are high compared to the other mills. In these circumstances, all aspects of mill maintenance and performance may need to be addressed. ***Note:*** as part of this survey, each mill will receive a confidential report advising them of the status of their mill with respect to all forms of contamination.

PART 2

Analyses for Mill A

Mill A Dataset

The historical dataset supplied by the single mill (Mill A) covered 5 years from September 1999 to Jun 2004 and detailed 1092 consignments processed for one customer. Two datasets were extracted:

- Mill A consignments comprising 100% Australian wool (n = 125), hereafter called 100% AUST.
- Both fine and coarse consignments were removed so this dataset has the same range in top MFD as the 100% Australian wool consignments (n = 360), hereafter called OTHER. These consignments had a maximum Australian wool content of 50%.

Note: Mill A uses the following criteria: Colour Ref Level 4 = light, 5/6 = medium and 7/8 = dark. Dark fibres are greater than 15mm in length, while coloured fibres must have a “darker section” that is greater than 15mm in length.

Tables 14 (100% AUST) and 15 (OTHER) present the standard statistics related to consignment construction and top parameters.

Table 14 Statistics for Mill A consignments - 100% AUST (n = 125)

Parameters	Mean	Std Dev	Max	Min	Range
Greasy Weight (tonnes)	119	52	265	4	261
Number of Bales (n)	655	277	1478	22	1456
% Additional Measurement	91	20	100	0	100
% Fleece Wool	86	28	100	0	100
% Pieces Wool	6	16	78	0	78
% Bellies+Lambs+Prem	9	17	100	0	100
Diameter (µm)	22.2	1.1	25.4	19.1	6.3
Hauteur (mm)	77	7	87	56	31
Dark Fibre (df/kg)	69	95	570	20	550

Table 15 Statistics for Mill A consignments – OTHER (n = 360)

Parameters	Mean	Std Dev	Max	Min	Range
Greasy Weight (tonnes)	91	43	306	9	296
Number of Bales (n)	404	197	1397	45	1352
% Australian Wool	23	18	50	0	50
% Additional Measurement	28	20	100	0	360
% Fleece Wool	55	37	100	0	100
% Pieces Wool	31	34	100	0	100
% Bellies+Lambs+Prem	13	23	100	0	100
Diameter (µm)	21.6	1.5	25.2	19.4	5.8
Hauteur (mm)	71	7	99	53	46
Dark Fibre (df/kg)	1134	2020	12960	0	12960

- The Australian wool content of OTHER consignments ranged from 0 to 100%; with an average Australian content of 23%.
- 100% AUST averaged 91% Additionally Measured (AM), whereas OTHER was considerably lower at 28% AM. This confirms that Australian wool is highly specified.
- 100% AUST contained, on average, higher proportions of fleece wool compared to OTHER (86% c.f. 55%), and lower proportions of pieces, bellies, lambs and prem wool.
- For MFD, the average values were similar for OTHER compared to 100% AUST. There were differences in the average Hauteur with 100% AUST longer (77 mm) c.f. OTHER (71 mm).
- There were large differences in mean and distribution statistics for the DF content of 100% AUST compared to OTHER consignments. Both mean and distribution parameters were considerably lower for 100% AUST (viz. 69 $\pm$ 95 df/kg c.f. 1134 $\pm$ 2020 df/kg).
- Additionally, the maximum DF content for any 100% AUST consignment was 570 df/kg compared with an extreme value of 12,960 df/kg for OTHER.

Additional analyses of the datasets allowed the DF content to be examined in terms of: mean fibre diameter, time, wool type and country of origin. As the range in DF between batches was zero to 12,960 df/kg top, to facilitate the analyses, the actual DF content (df/kg) was converted DFR Rating. The Ratings are equivalent to the following: DFR 1 ≈ <50; DFR 2 ≈ 50 – 100; DFR 3 ≈ 100 – 200; DFR 4 ≈ 200 – 500; and DFR 5 ≈ >500 df/kg top.

Dark Fibre Content and Mean Fibre Diameter

Tables 16 and 17 present for 3 diameter groups for 100% AUST and OTHER respectively, the percentage of consignments with DFR Ratings of 1 to 5 and the average DF levels.

Table 16 Proportion of DFR Ratings (1 to 5) and average DF content for 100% AUST for three MFD groups

MFD Group (µm)	No. Cons (% Tot)	Av df/kg	% DFR 1 (Av df/kg)	% DFR 2 (Av df/kg)	% DFR 3 (Av df/kg)	% DFR 4 (Av df/kg)	% DFR 5 (Av df/kg)
<21.1	22	70	68 (31)	9 (75)	18 (170)	5 (240)	0
21.1-23.0	70	80	76 (37)	11 (68)	3 (155)	6 (295)	4 (547)
>23.0	33	46	79 (36)	18 (75)	3 (140)	0	0
100% AUST	**125**	**65**	**74 (35)**	**13 (73)**	**8 (155)**	**4 (268)**	**1 (547)**

Table 17 Proportion of DFR Ratings (1 to 5) and average DF content for OTHER for three MFD groups

MFD Group (µm)	No. Cons (% Tot)	Av df/kg	% DFR 1 (Av df/kg)	% DFR 2 (Av df/kg)	% DFR 3 (Av df/kg)	% DFR 4 (Av df/kg)	% DFR 5 (Av df/kg)
<21.1	141	443	21 (37)	30 (76)	9 (145)	7 (341)	32 (1173)
21.1-23.0	155	1580	4 (38)	9 (83)	5 (149)	14 (379)	69 (2189)
>23.0	64	1576	6 (28)	11 (73)	22 (156)	27 (336)	34 (4198)
OTHER	**360**	**1134**	**10 (34)**	**17 (77)**	**12 (150)**	**16 (352)**	**45 (2520)**

- OTHER had 27% of consignments with <100 df/kg (DFR Ratings 1 and 2) compared to 87% for 100% AUST. For 100% AUST wool there was no increase in DF content with diameter; however, OTHER had higher levels for batches greater than 21 µm.
- The DFR Rating 5 consignments for 100% AUST had an average 547 df/kg compared with 2520 df/kg for OTHER. These differences are likely due to the inherent low levels of pigmentation in Australian Merino wool and the attention to clip preparation paid by Australian growers.

Dark Fibre Content of Consignments over Time

Mill A (Europe)

Table 18 (100% AUST) and Table 19 (OTHER) show the percentage of consignments with DFR Ratings of 1 to 5 for ten time periods of approximately six months each over 5 years (Sep 1999 to Jun 2004).

Table 18 Proportion of DFR Ratings (1 to 5) for 100% AUST measured over 10 time periods. Change in proportion of 100% AUST consignments processed over time is shown

Time Period	No. Cons	Av df/kg	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
Sep–Dec 1999	8	58	88	0	12	0	0
Jan–Jun 2000	7	156	29	43	0	14	14
Jul–Dec 2000	27	50	81	15	0	4	0
Jan–Jun 2001	22	46	82	14	5	0	0
Jul–Dec 2001	23	75	78	4	13	0	4
Sep 99–Dec 01	**87**	**77**	**72**	**15**	**6**	**4**	**4**
Jan–Jun 2002	9	62	67	11	22	0	0
Jul–Dec 2002	9	132	56	22	0	11	11
Jan–Jun 2003	7	37	100	0	0	0	0
Jul–Dec 2003	10	67	80	10	0	10	0
Jan–Jun 2004	3	120	33	33	0	33	0
Jan 02–Jun 04	**38**	**80**	**67**	**15**	**4**	**11**	**2**
Sep 99–Jun 04	**125**	**69**	**69**	**15**	**5**	**7**	**3**

Table 19 Proportion of DFR Ratings (1 to 5) for OTHER measured over 10 time periods

Time Period	No. Cons	Av df/kg	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
Sep–Dec 1999	9	888	0	22	11	22	44
Jan–Jun 2000	55	692	11	18	13	15	44
Jul–Dec 2000	29	686	3	3	10	14	69
Jan–Jun 2001	41	740	24	17	7	5	46
Jul–Dec 2001	19	912	5	11	5	5	74
Sep 99–Dec 01	**153**	**784**	**9**	**14**	**9**	**12**	**55**
Jan–Jun 2002	33	738	6	12	18	27	36
Jul–Dec 2002	36	2416	8	14	6	3	69
Jan–Jun 2003	60	1055	20	23	12	13	32
Jul–Dec 2003	31	1888	3	6	0	32	56
Jan–Jun 2004	47	1310	9	32	11	9	40
Jan 02–Jun 04	**207**	**1481**	**9**	**17**	**11**	**17**	**47**
Sep 99–Jun 04	**360**	**1134**	**9**	**16**	**9**	**15**	**51**

- For Period 1 (Sep 1999 to Jun 2002), the proportion of 100% AUST with <100 df/kg top averaged 87%, while those with >500 df/kg averaged 4%. For Period 2 (Jul 2002 to Jun 2004), the proportion with <100 df/kg decreased slightly (87% to 82%) as did those with >500 df/kg top (4% to 2%). These two changes effected a 7% increase for 200-500 df/kg (DFR Rating 4).
- For Period 1, the proportion of OTHER with <100 df/kg top averaged 23%, increasing a little to 26% for Period 2. This was countered by a decrease in Ratings 4 and 5 (viz. 67% c.f. 64%).
- Over the 5 year time frame, 100% AUST had more batches suited to ultra-sensitive end uses (<50 df/kg) with 69% compared to OTHER with 9%. And, for DRF Ratings 1 and 2 (<100 df/kg), 100% AUST had considerably more suitable batches (84%) than OTHER (25%).
- Conversely, for DRF Rating 5 (>500 df/kg), 100% AUST was 3% compared with OTHER at 51%.
- From Period 1 to Period 2, the DF content for 100% AUST batches remained constant (average 77 c.f. 80 df/kg). In contrast, the DF content for OTHER doubled from 784 to 1481 df/kg.
- For OTHER, wool type and country/region may help explain the DF content increase over time.

Mill B (Asia)

The Mill B dataset of 366 batches comprised mostly Australian fleece and piece wool with a MFD of 18.8 µm (range 12.8 – 29.5 µm). Table 20 shows the percentage of Mill B consignments with DFR Ratings of 1 to 5 for seven time periods of approximately six months each over 3½ years (Jan 2000 to May 2003).

Table 20 Proportion of DFR Ratings (1 to 5) for Mill B measured over seven time periods

Time Period	No. Cons	Av df/kg	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
Jan–Jun 2000	44	6	98	2	0	0	0
Jul–Dec 2000	73	50	95	3	1	0	1
Jan–Jun 2001	66	8	97	3	0	0	0
Jul–Dec 2001	60	12	95	5	0	0	0
Jan 00–Dec 01	**243**	**19**	**96**	**3**	**0.25 (140)**	**0**	**0.25**
Jan–Jun 2002	39	5	97	3	0	0	0
Jul–Dec 2002	42	19	95	0	2	1 (300)	0
Jan–May 2003	42	4	100	0	0	0	0
Jan 02–May 03	**123**	**9**	**97**	**1**	**0.67**	**0.33**	**0**
Jan 00–May 03	**366**	**17**	**97**	**2.3**	**0.4**	**0.15**	**0.15**

- For the 3½ year timeframe from Jan 2000 - Dec 2001 to Jan 2002 - May 2003, there was no observable change in the DF content of Mill B batches (mean 19 c.f. 9 df/kg, respectively).
- On average, 97% of batches were DFR Rating 1 (<50 df/kg) and 2% were DFR Rating 2 (50-100 df/kg). These low DF levels are consistent with the company policy of buying mainly fleece wools, with the addition of small proportions of high quality pieces (eg. broken).

Mill C (Australia)

The Mill C dataset of 130 batches comprised mostly Australian wool of all types with a MFD of 21.1 µm (range 17.6 – 29.1 µm). Table 21 shows the percentage of Mill C consignments with DFR Ratings of 1 to 5 for seven time periods of approximately six months each over 3½ years (Feb 2000 to May 2003).

Table 21 Proportion of DFR Ratings (1 to 5) for Mill C measured over seven time periods

Time Period	No. Cons	Av df/kg	% DFR 1	% DFR 2	% DFR 3	% DFR 4	% DFR 5
Feb–Jun 2000	7	240	71	0	0	14	14
Jul–Dec 2000	4	63	50	25	25	0	0
Jan–Jun 2001	10	36	90	0	10	0	0
Jul–Dec 2001	22	39	86	5	5	5	0
Feb 00–Dec 01	**43**	**95**	**74**	**8**	**10**	**5**	**4**
Jan–Jun 2002	28	59	61	18	18	4	0
Jul–Dec 2002	37	80	57	14	19	11	0
Jan–May 2003	22	105	55	18	14	9	5
Jan 02–May 03	**87**	**81**	**58**	**17**	**17**	**8**	**2**
Feb 00–May 03	**130**	**77**	**67**	**11**	**13**	**6**	**3**

- For Period 1 the proportion of batches with a DF content <100 df/kg top (DFR Ratings 1 and 2) averaged 82% compared to 75% for Period 2. This decrease in sensitive end use wools was countered by a slight increase in DFR Rating 3 wools. However, in terms of average DF content, there was no observable change for Mill C batches (mean 95 c.f. 81 df/kg, respectively).
- The higher levels of DF for Mill C compared with Mill B are likely due to the high use of fleece and piece wool by Mill B.

These statistics from the three mills highlight the consistent cleanliness of Australian Merino wools compared with that from other countries/regions. On average, the Australian clip's DF content has not changed over the last five years. While industry has reported instances of increased contamination of Australian wool occurring as a result of the introduction of exotic breeds of sheep, these results suggest that any such contamination is an isolated occurrence. To identify such wools when constructing sensitive end use consignments, it is suggested that buyers utilise wools with a DMFR Rating.

Dark Fibre Content for Different Wool Types over Time

Tables 22 (100% AUST) and 23 (OTHER) present for ten time periods of approximately six months each (September 1999 to Jun 2004), the average percentage of each wool type in the consignments. The wool types were: Fleece (Flc), Pieces (Pcs), Bellies (Bls), Lambs (Lms) and Prem-shorn wool (Prem).

Table 22 Proportion of each wool type for 100% AUST measured over 10 time periods

Time Period	No. Cons	Av df/kg	% Flc	% Pcs	% Bls	% Lms	% Prem
Sep–Dec	8	58	79	7	3	2	9
Jan–Jun 2000	7	156	51	14	14	1	20
Jul–Dec 2000	27	50	93	3	1	0	3
Jan–Jun 2001	22	46	99	1	0	0	0
Jul–Dec 2001	23	75	90	7	3	0	0
Sep 99–Dec	**87**	**77**	**82**	**6**	**4**	**1**	**6**
Jan–Jun 2002	9	62	70	15	7	1	7
Jul–Dec 2002	9	132	73	4	15	0	8
Jan–Jun 2003	7	37	87	0	0	0	13
Jul–Dec 2003	10	67	85	5	0	0	10
Jan–Jun 2004	3	120	61	27	0	0	12
Jan 02–Jun	**38**	**80**	**75**	**10**	**4**	**0**	**10**
Sep 99–Jun	**125**	**69**	**79**	**8**	**4**	**0**	**8**

Table 23 Proportion of each wool type for OTHER measured over 10 time periods

Time Period	No. Cons	Av df/kg	% Flc	% Pcs	% Bls	% Lms	% Prem
Sep–Dec 1999	9	888	40	53	3	0	5
Jan–Jun 2000	55	692	51	44	3	0	1
Jul–Dec 2000	29	686	32	63	4	1	1
Jan–Jun 2001	41	740	63	31	6	0	0
Jul–Dec 2001	19	912	44	39	15	1	0
Sep 99–Dec	**153**	**784**	**46**	**46**	**6**	**1**	**1**
Jan–Jun 2002	33	738	65	21	10	2	1
Jul–Dec 2002	36	2416	48	18	31	1	2
Jan–Jun 2003	60	1055	70	17	9	2	2
Jul–Dec 2003	31	1888	31	46	20	1	2
Jan–Jun 2004	47	1310	72	15	10	0	3
Jan 02–Jun	**207**	**1481**	**57**	**23**	**16**	**1**	**2**
Sep 99–Jun	**360**	**1134**	**55**	**31**	**11**	**1**	**1**

- From Period 1 to Period, for 100% AUST, the blend structure changed a little with the proportion of fleece wool declining from 82 to 75%, with a corresponding increase in piece and prem wool.
- For 100% AUST, the highest levels of DF were related to higher proportions of pieces and bellies. Conversely, the lowest DF levels were generally associated with a high content of fleece wool and lower content of pieces and bellies.
- For OTHER, the makeup of the blends changed from Period 1 to Period 2 with the proportion of piece wool declining while fleece wool and bellies increased slightly.
- For OTHER, the highest average DF content corresponded to Jul – Dec 2002 when the proportion of fleece and pieces was lower while bellies and lambs wool was higher. There was no clear pattern with respect to the role of wool type in determining the lower levels of DF contamination.

These results indicate that for Australian Merino wool, the DF content is closely related to the wool type used in the blend. As the proportion of fleece wool declines, with an associated increase in pieces and bellies, there is a greater risk of DF contamination. Use of the Australian Merino DMFR Rating Scheme can provide information to buyers to aid their purchasing decisions. The Ratings (see Appendix 1), which are based on objective information provided by the wool grower, differentiates fleece and piece lines in terms of their potential for DMF contamination (Hansford and Industry Working Group 2003).

The results for OTHER did not show any strong association between the changes in DF content over time and wool type. It is therefore thought that country of origin of wool (through sheep breed) may influence the increased DF content from Period 1 to Period 2. This is examined in the next section.

Dark Fibre Content for Wool from Different Countries/Regions of Origin

The effect of country/region of origin on the DF content of batches was examined graphically using the entire database (1092 batches) with DF content plotted against country/region. The graphs for the countries/regions of origin are as follows:

- Australia (Figure 2), New Zealand (Figure 3), South Africa (Figure 4), South America (Figure 5), USA (Figure 6) and Europe (Figure 7).

  Note: South America comprises wool from Argentina, Uruguay, Chile and Falkland Islands. Europe comprises wool from Germany, Russia, Hungary, Romania, United Kingdom and France.

The trends indicated by these graphs were:

- Australia – as the proportion of Australian wool increased, the DF content decreased.
- New Zealand – the DF content decreased for batches with >80% New Zealand wool, however, the DF values exceeded those for equivalent Australian batches.
- South Africa – there were no consignments with a high proportion of South African wool.
- South America – these consignments often had a high DF content.
- USA – batches often contained excessive levels of DF. This was demonstrated by the DF content of 100% USA batches.
- Europe – wool from Europe generally contained excessive levels of DF, as evidenced by the high DF content of 100% European consignments.

Figure 2 Dark fibre content (df/kg) of consignments with >50% Australian content

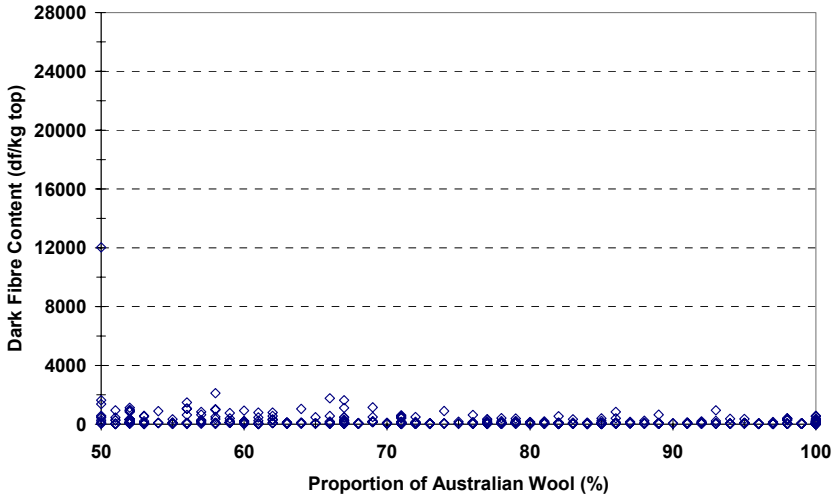


Figure 3 Dark fibre content (df/kg) of consignments with >50% New Zealand content

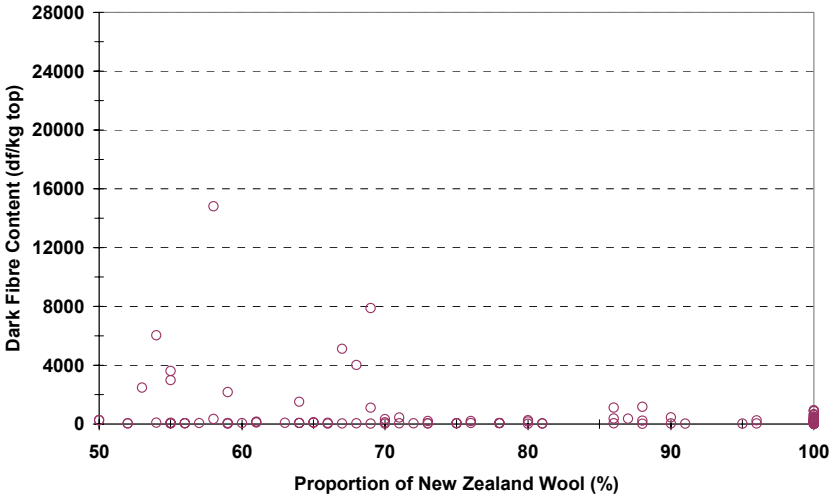


Figure 4 Dark fibre content (df/kg) of consignments with >50% South African content

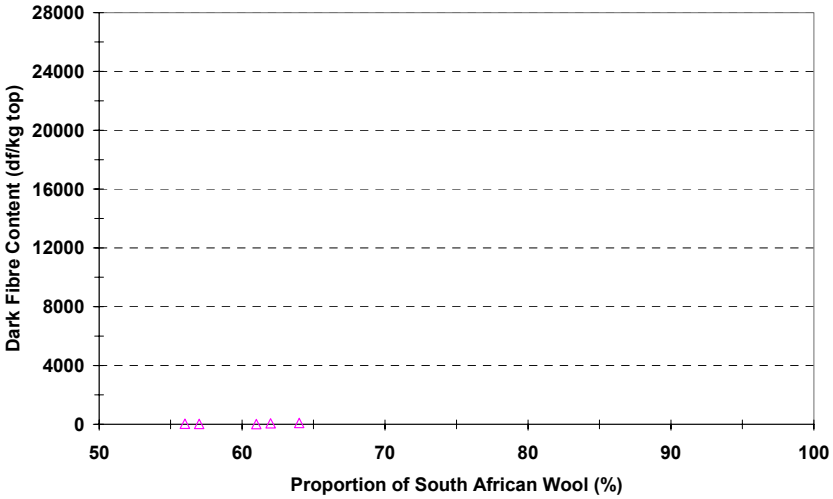


Figure 5 Dark fibre content (df/kg) of consignments with >50% South American content

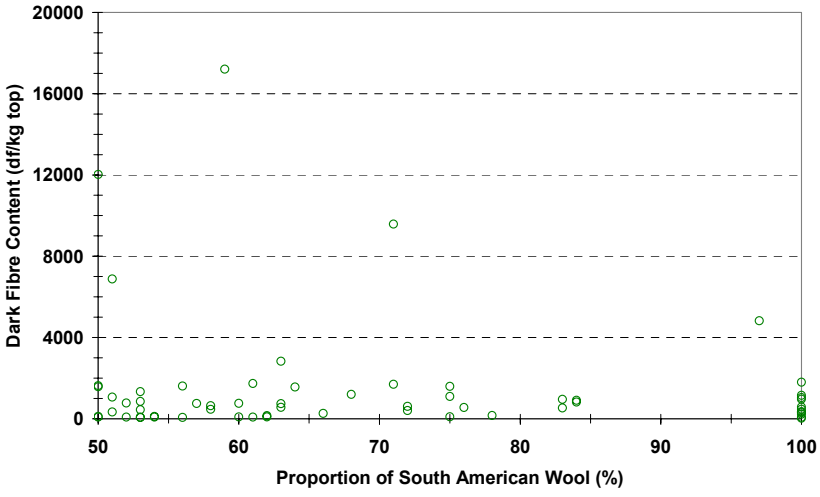


Figure 6 **Dark fibre content (df/kg) of consignments with >50% United States content**

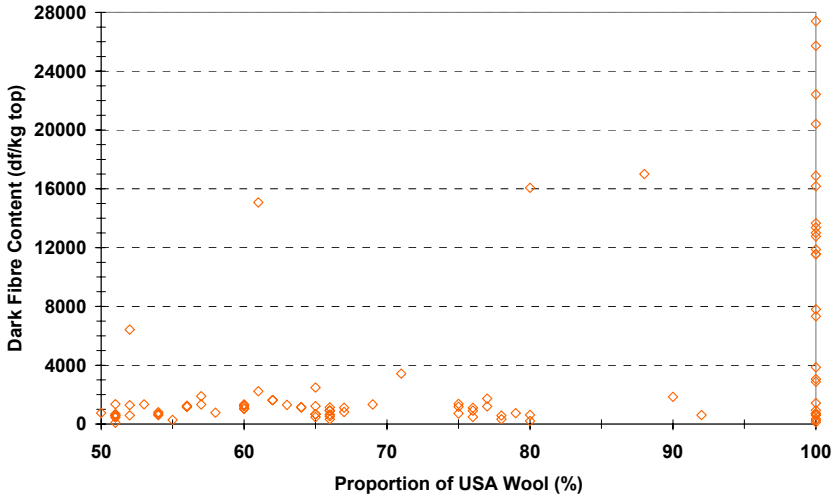
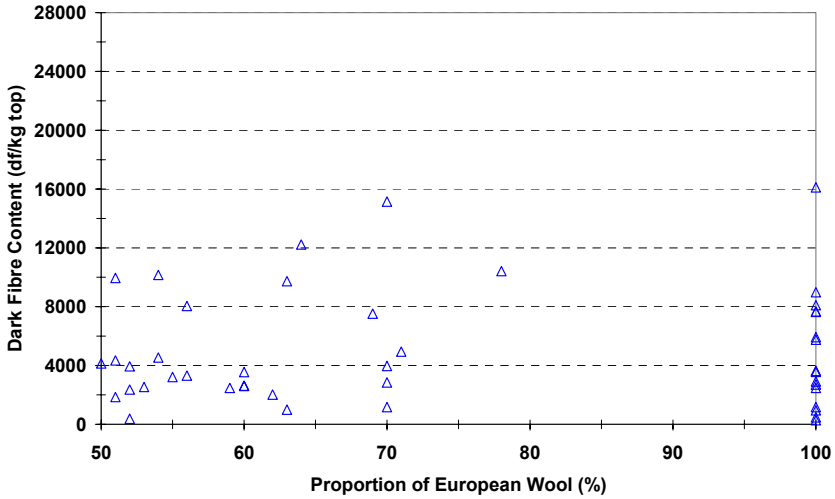


Figure 7 **Dark fibre content (df/kg) of consignments with >50% European content**



To further assess the DF content relative to country/region of origin, DFR Ratings were determined for batches where the percentage of wool from each country/region was greater than 75% (Table 24). ***Note:*** There were no consignments comprising greater than 75% South African wool.

Table 24 **For batches with >75% content for each country/region of origin, the proportion of consignments with DFR Ratings 1 to 5 and average df/kg top**

>75% Content	No. Cons.	Av df/kg	% DFR 1 (Av df/kg)	% DFR 2 (Av df/kg)	% DFR 3 (Av df/kg)	% DFR 4 (Av df/kg)	% DFR 5 (Av df/kg)
Australia	357	85	60 (37)	24 (75)	7 (145)	6 (315)	2 (656)
New Zealand	92	205	30 (34)	16 (75)	21 (146)	24 (321)	9 (871)
South Africa	0	–	–	–	–	–	–
South America	23	761	4 (30)	4 (70)	9 (170)	30 (321)	52 (1234)
United States	41	7096	–	–	5 (160)	10 (350)	85 (8263)
Europe	18	5131	–	–	–	11 (375)	89 (4890)
All	**531**	**2656**	**(34)**	**(73)**	**(155)**	**(336)**	**(3183)**

When considering DRF Ratings 1 and 2, the following trends were determined:

- Australia had the highest percentage of batches (84%) with a DFR Rating of 1 or 2, followed by New Zealand (46%) and South America (8%). Both USA and Europe had no consignments with a DFR Rating of 1 or 2.

Examination of DRF Ratings 3 and 4 (combined) and DFR Rating 5, revealed the following trends:

- Australia - 13% of batches with DFR Ratings 3/4; and 2% with DRF Rating 5
- New Zealand - 45% of batches with DFR Ratings 3/4; and 9% with DFR Rating 5.
- South America - 39% of batches with DFR Ratings 3/4; and 52% with DFR Rating 5.
- USA - 15% of batches with DFR Ratings 3/4; and 85% with DFR of 5.
- Europe - 11% of batches with DFR Ratings of 3/4; and 89% with a DFR of 5.

These analyses clearly show that in terms of meeting commercially sensitive end use requirements (<100 df/kg top), wool from Australia was the most suitable. To complete a sensitive end use consignment, wool from other countries/regions may be included; however, caution is required to ensure such wool is carefully vetted, for example, Merino fleece wool might be specified.

To examine changes in country/region of origin of wool over time, Table 25 (OTHER) presents for ten time periods (September 1999 to Jun 2004) of approximately six months each, the average percentage of wool sourced from the six countries/regions of origin.

Table 25 For OTHER, proportion of each country/region of origin over 10 time periods

Time Period	No. Cons	Av df/kg	AUST %	NZ %	South Africa %	South Amer %	USA %	Europe %
Sep–Dec 1999	9	888	14	25	3	37	22	0
Jan–Jun 2000	55	692	11	31	1	35	22	0
Jul–Dec 2000	29	686	19	12	0	33	36	0
Jan–Jun 2001	41	740	23	35	0	22	20	0
Jul–Dec 2001	19	912	32	13	0	15	41	0
Sep 99–Dec 01	**153**	**784**	**20**	**23**	**1**	**28**	**28**	**0**
Jan–Jun 2002	33	738	29	26	1	17	13	13
Jul–Dec 2002	36	2416	33	9	2	12	16	28
Jan–Jun 2003	60	1055	32	16	11	28	7	6
Jul–Dec 2003	31	1888	20	2	2	15	37	24
Jan–Jun 2004	47	1310	20	19	16	24	13	9
Jan 02–Jun 04	**207**	**1481**	**37**	**14**	**6**	**19**	**17**	**16**
Sep 99–Jun 04	**360**	**1134**	**23**	**20**	**5**	**24**	**20**	**8**

- Between Period 1 and Period 2, there were differences in the proportion of wool originating from all six countries/regions of origin. However, the most noticeable change was that no wool from Europe was used in Period 1, but the proportion increased to 16% in Period 2.
- Although wool from USA was found to be similar to wool from Europe in terms of its high proportion of DFR 3, 4 and 5 wools; from Period 1 to period 2, the use of USA wool declined from 28% to 17%.
- Therefore, it is suggested that for this dataset that the greater use of wool from Europe from Period 1 to Period 2, contributed to the increased levels of DF contamination.

Actual Dark Fibre compared with Expected Dark Fibre

To approximate problems that might arise in meeting a spinner's limit for DF content, Mill A's expected DF content was compared with the actual measured DF content. Table 26 shows for 100% AUST and OTHER:

- The proportion of all consignments where the actual DF content was greater than or equal to (≥) the expected DF content. That is, they did not meet the mill's expectation, and
- The proportion of consignments with expected values less than or equal to (≤) 100 df/kg where actual DF content was greater than or equal to the expected DF content. That is, they did not meet the mill's expectation.

Table 26 Actual DF content versus expected DF content - proportion of batches that did not meet the mill's expectations

Sub-set of BWK data	No. Cons.	*All Expected DF values* Proportion Batches where Actual ≥ Expected DF	No. Cons.	*Expected values ≤100 df/kg* Proportion Batches where Actual ≥ Expected DF
100% AUST	125	3% (n=4)	83	3% (n=3)
OTHER	360	43% (n=153)	55	18% (n=10)

- When all the data is considered, compared to 100% AUST, OTHER had considerably more batches that did not meet the mill's expected DF content (viz. 43% c.f. 3%).
- For batches expected to have a DF content <100 df/kg, the subjective estimates for OTHER improved from 43% to 18%. This result was not surprising as a mill would take more care to ensure that these batches met the spinner's specification.
- The results highlight the reliability of Australian wool in meeting white/pastel specifications, with only 3% of 100% AUST wools not meeting expectations compared to 18% for batches containing wool from other countries. For ≤100 df/kg consignments, the maximum differences between actual and expected DF content were 300 df/kg for BWK MFD and 130 df/kg for 100% AUST.
- It may be possible to reduce the 3% error rate in Australian wools not meeting a processor's DF expectation to zero with 100% uptake of the DMFR Scheme.

CONCLUSIONS

This report summarises the results from Australian Wool Innovation's 2004 Global Dark and Medullated Fibre (DMF) Survey. The main aims were to:

- Assess levels of DMF contamination in 689 wool consignments processed in 14 collaborating mills (3 in Europe, 9 in Asia and 2 in Australia) over approximately 6 months production during 2004 (Part 1).
- Identify whether there were detectable changes in the levels of dark fibre (DF) contamination in processed Australian wool for the period 1999 to 2004 using the data from three mills in Australia, Asia and Europe. The data included information on batch size, date of processing, raw wool parameters, origin of raw wool, wool type and top parameters, including DF (Part 2).

The results, based on analyses of both 2004 DMF and historical data, showed that:

- The majority of consignments of Australian Merino wool are suited to sensitive end uses (white/pastel and dark coloured end uses). If fleece wool is used, there is a greater likelihood of meeting ultra-sensitive end uses.
- For 100% Australian consignments, as the proportion of non-fleece wool increased, so did the risk of contamination. However, this risk was much lower than that for wool sourced from other countries.

- Although there was variation between countries; generally as the content of wool from countries/regions other than Australia increased, so did the measured levels of DMF contamination.
- In 7 of the 14 collaborating mills, some DF contamination was due to dyed fibre in the top. In a few cases, aspects of mill maintenance and performance may need to be addressed.
- Australian consignments had lower levels of non-wool contamination compared with wool sourced from other countries.
- There was no detectable increase in the levels of DF contamination in processed Australian wool for the period 1999 to 2004 for the three mills that provided historical data.

It was concluded that:

- The good reputation of the Australian Merino wool clip for freedom from DMF is justified, as overall; it can reliably supply wool that meets sensitive end use requirements.
- The Australian Merino DMFR Scheme can be used to help construct batches suited to sensitive end uses, thus further reducing the risk of contamination by either DF or MF.

The results show that in comparison to wool from other countries, the high reputation of Australian Merino wool is justified. It is recommended that Australia continue its efforts to maintain and/or improve this reputation through industry initiatives such as the Dark and Medullated Fibre Risk Scheme, the Dark and Medullated Fibre Test and new research/extension to improve the understanding of issues related DMF contamination. Further work is required to develop better methods for expressing levels of DMF contamination using descriptive statistics.

This Global Survey provides benchmark data on the current (2004) and past (1999-2004) DMF content of Australian Merino wool. Thus, it will now be possible to monitor any changes to the status of the Australian clip as well as assess the success of initiatives aimed at maintaining Australia's reputation for clean, white wool. It is recommended that this survey be repeated on an on-going basis.

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APPENDIX 1