The Precision of Dark and Medullated Fibre Testing of Noil

By

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SUMMARY

The benzyl alcohol test for dark and medullated fibres, developed by AWTA/AWI/CSIRO, was used to estimate the levels of dark and medullated fibres in noil. Variance estimates have been used to estimate the precision of a dark and medullated fibre test at different levels.

Samples used in this study were generated from an earlier trial reported to IWTO, by placing Merino ewes in controlled contact with Damara crossbred lambs. Processing lots generated from this material were converted to top, with all the waste generated during processing being collected for later analysis.

Confidence limits for the measurement of dark and medullated fibre from the front-box noil using the benzyl alcohol method were measured and form the basis of this report.

Analysis of the variance components within the noil measurements showed that the confidence limits of the measurement result increased linearly with the level of dark or medullated fibres. Furthermore, at low dark fibre levels the between-subsample variance was greater than that for between-operator variance while at high levels the between-subsample variance was smaller than that for between-operator.

INTRODUCTION

Worsted combing has three distinct functions to perform: to remove short ‘wool’ fibres below a predetermined length; to straighten and make the retained long ‘wool’ fibres lie as parallel as possible; and to remove foreign impurities, such as burrs, straw, shives, kemps, neps and dust (Wetzold & von Bergen, 1970). Noil is a valuable by-product of combing and is usually sold by worsted manufacturers to woollen yarn spinners who use them as a component in the production of woollen yarns. As in worsted manufacture, the presence of dark and/or medullated fibres can limit the flexibility of end-use or result in mending costs of woollen products (Appleyard & Perkins, 1965; Hatcher, 2002).

A previous report (Fleet *et al.* 2006) confirmed that a recently developed benzyl alcohol DMF test (AWTA et al., 2004) had potential for the identification of dark and medullated fibre in core and top samples. This report investigates the application of the benzyl alcohol test for measurement of noil, for which no specific IWTO standard method exists. Between-operator and between-subsample variance components are estimated. Confidence Limits are reported for the measurement of two (2) x 5g sub-samples by two (2) operators.

MATERIALS AND METHODS

The materials and methods for this body of work have previously been reported (Fleet et al., 2006). Consequently a brief summary is provided here. The sample set comprised of ten (10) lots generated by the South Australian Research and Development Institute (SARDI) through the introduction of different controlled levels of contact between Merino and Damara animals, as summarised in Table 1.

Table 1: Summary of the wools samples.

Sample	Expected contamination Level	Merino	Ram contact	Cross-bred lambs contact	When shorn (particulars)
1 & 2	Low	Ewes	Merino	No	8 months (end of mating)
3 & 4	Low	Ewes	Damara	No	8 months (end of mating)
5 & 6	Medium	Ewes	No	Yes	8 months (3.5 mths after weaning)
7 & 8	High	Ewes	No	Yes	7.5 months (day after weaning)
9 & 10	High	Lambs	No	Yes	7 months

Using Draft TM-13-01, individual fleece measurements were performed to determine the initial level of contamination. Samples were processed in order of increasing levels of dark and medullated fibre contamination by CSIRO-TFT in Geelong.

A single pass on a NCS PB29 comb with the ratch set at 34mm was undertaken for all batches. All by-products of the top-making process were collected. The front-box noil is the focus of this report.

Sampling Noil

The benzyl alcohol based DMF test, developed by AWI, AWTA and CSIRO (AWTA *et al*. 2004), was used to measure the number of dark and medullated fibres in noil. A single layer of noil was arranged on a flat surface. A 3 x 4-hole sampling board was placed over the noil, and sufficient material sampled through each hole until a 5g sub-sample had been obtained (approximately 0.4g per hole). The sampling board was repositioned and sufficient 5g sub-samples taken until there were 4 x 5g sub-samples per sample. A total of 3 x 20g samples of noil for each lot are reported (Figure 1). Due to the homogenous nature of the noil, it was not Shirley Analysed prior to sampling, so it retained some vegetable fault. The minimum dark or medullated fibre length to be measured was increased from 3mm (core sample) to 10mm (top and noil) to comply with specifications set out in current IWTO Methods for detection of Dark Fibres in tops (IWTO-55-99 and Draft TM-13-01 both of which specify a minimum dark fibre length of 10mm).

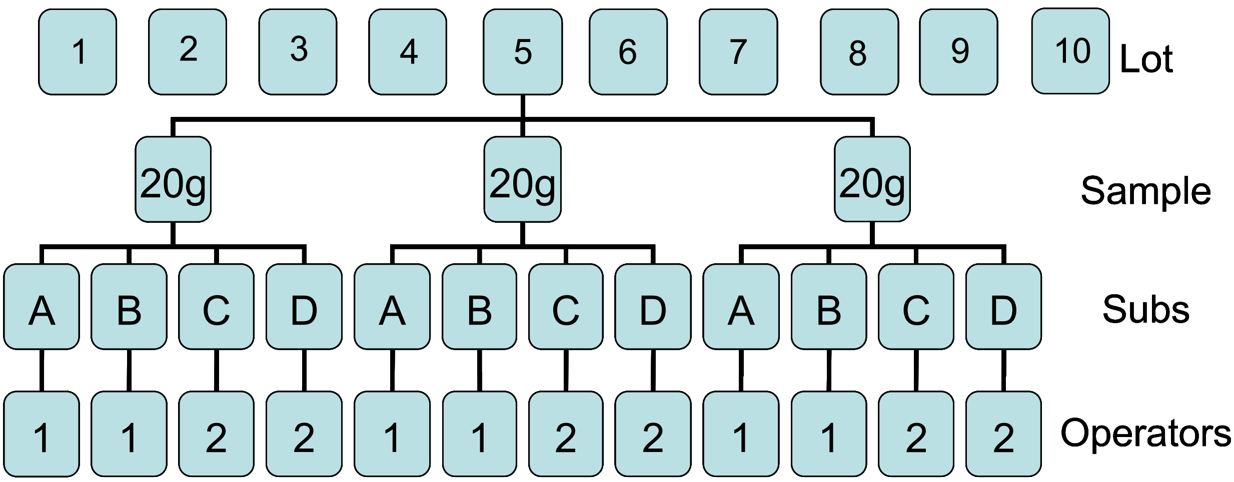

Figure 1: Schematic diagram showing the measurement of noil for dark and medullated fibre

In order to generate variance estimates for the measurement of noil, four (4) operators each measured the four (4) sub-samples for each of the ten (10) sale lots. Operators measured the slides independently, so that the between operator variance could be established, along with a between sub-sample variance estimate.

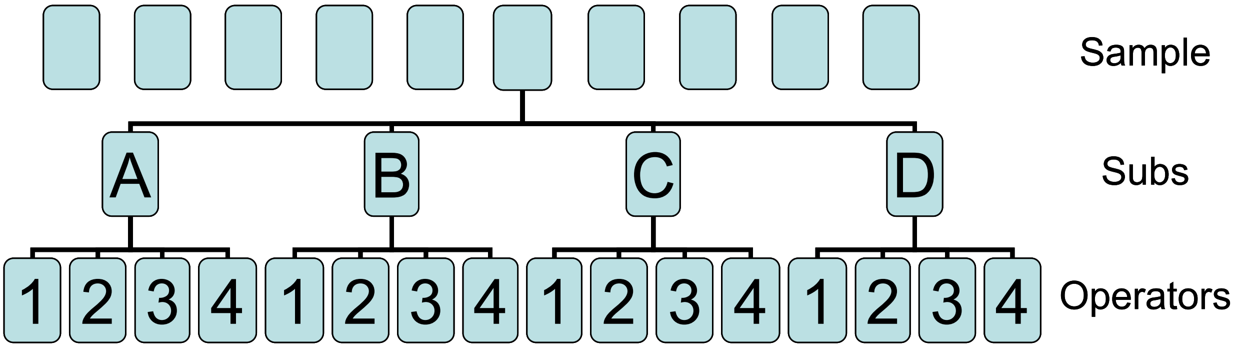

Figure 2: Schematic diagram showing the method for estimating the between-subsample and between-operator variance for dark and medullated fibre.

Statistics

The model under investigation was:

$$Y_{fibre} = S_i + O_j + E_{ij}$$

where Y_{fibre} was the mean dark or medullated fibre value for a give sample, S_i is the effect of the ith sub-sample and O_j is the effect of the jth operator.

For each of the ten (10) noil samples, a two-way analysis of variance without replication was used to determine the between operator, and between sub-sample variance estimates.

RESULTS AND DISCUSSION

Variance estimates for the measurement of dark and medullated fibre within noil

The between-subsample and between-operator variance estimates have been generated for the measurement of Dark fibre (Table 2) and Medullated fibre (Table 3) in noil using the Benzyl alcohol method previously described in AWTA *et al.* 2004. As expected, the noil contained a large amount of fine vegetable matter making it relatively difficult to identify dark and medullated fibres. In agreement with IWTO-0-01, the between-subsample and between-operator variance estimates were directly related to the average level of contaminant fibre within the sample. These values are illustrated in Figures 3 and 4, which show an exponential relationship between the mean dark or medullated fibre count for a 5g sub-sample and the components of variance.

Table 2: Between-subsample and between-operator variance estimates of the measurement of dark fibre in the noil. Note: Dark fibres values are per 5g sub-sample, and samples are presented in ascending order of Dark Fibres/5g.

Lot No	Average Dark Fibres /5g	Variance		Stand. Dev.	
		σ^2_{sub}	σ^2_{op}	σ_{sub}	σ_{op}
1	1.3	1.7	0.5	1.3	0.7
3	1.3	2.2	0.7	1.5	0.8
2	1.8	6.1	1.1	2.5	1.0
4	2.3	1.5	0.7	1.2	0.9
5	21.6	38.9	72.4	6.2	8.5
10	27.8	113.5	172.9	10.7	13.2
6	32.8	102.9	133.6	10.1	11.6
9	34.6	80.8	251.0	9.0	15.8
7	76.0	896.0	530.3	29.9	23.0
8	118.1	993.6	1617.8	31.5	40.2
Average	**31.8**	**223.7**	**278.1**	**10.4**	**11.6**

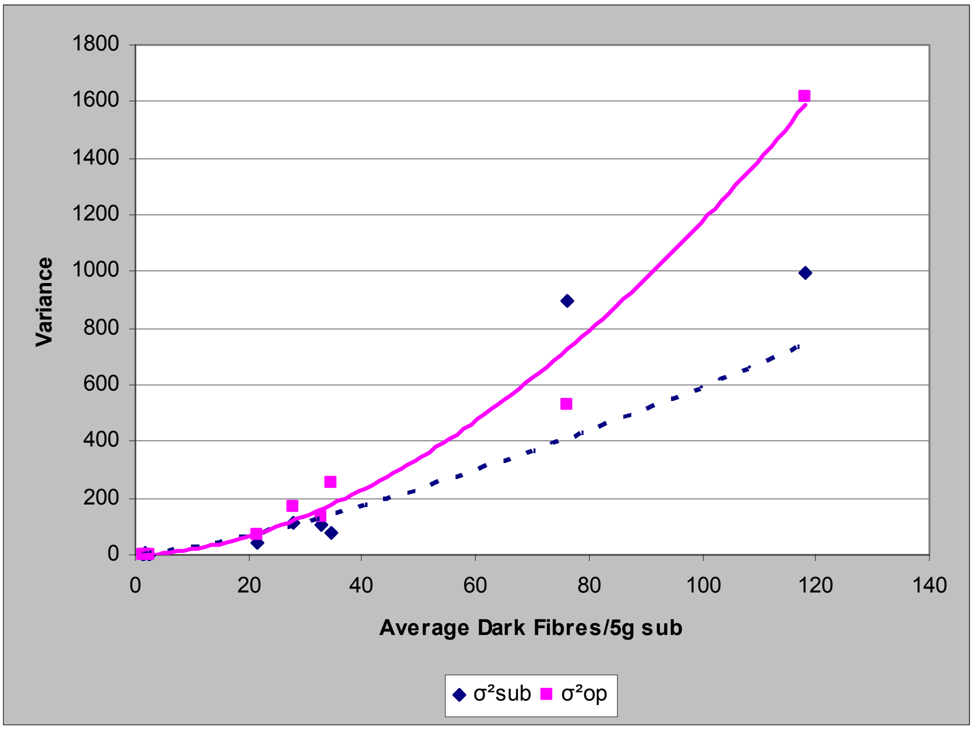

Figure 3: Relationship between the variance estimates for dark fibres in a 5g sub-sample, and the average dark fibre values for 5g sub-samples.

Table 3: Between-subsample and between-operator variance estimates of the measurement of medullated fibre in the noil. Note: Medullated fibres values are per 5g sub-sample, and samples are presented in ascending order of Medullated Fibres/5g.

Lot No	Average Med. Fibres/5g	Variance		Stand. Dev.	
		σ^2_{sub}	σ^2_{op}	σ_{sub}	σ_{op}
3	0.9	0.6	0.5	0.8	0.7
4	1.4	2.4	4.3	1.5	2.1
1	1.8	8.9	6.4	3.0	2.5
2	1.9	5.1	4.8	2.3	2.2
5	3.3	6.1	15.7	2.5	4.0
6	3.7	10.2	19.8	3.2	4.4
9	18.9	226.1	123.0	15.0	11.1
10	21.8	329.7	301.6	18.2	17.4
8	25.1	85.7	373.1	9.3	19.3
7	28.3	651.0	616.6	25.5	24.8
Average	**10.7**	**132.6**	**146.6**	**8.1**	**8.8**

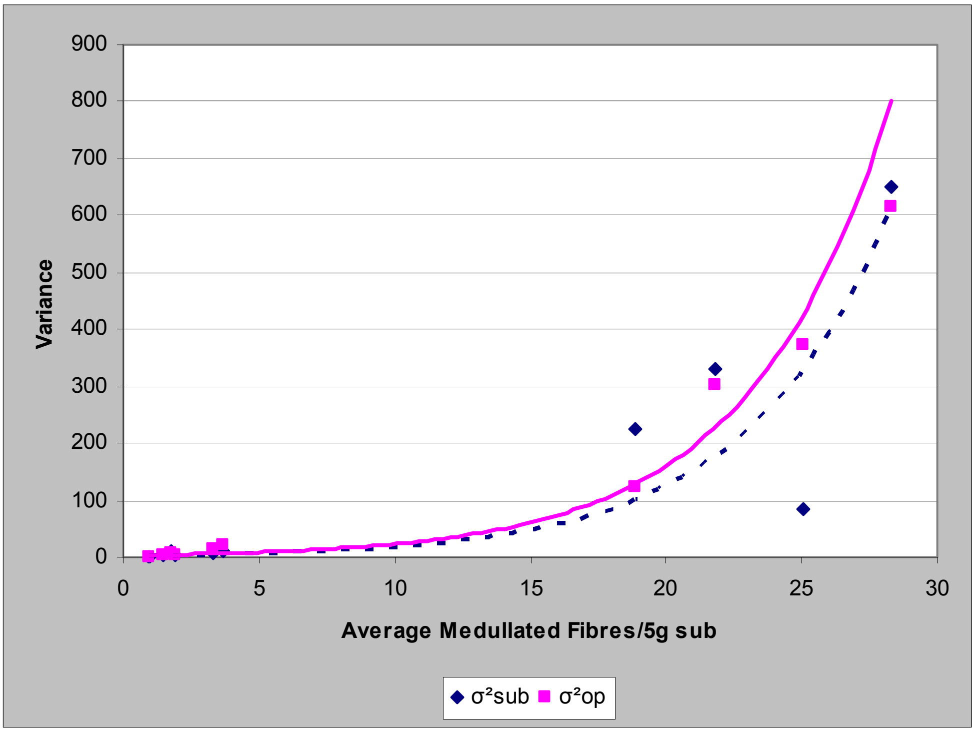

Figure 4: Relationship between the variance estimates for medullated fibres in a 5g sub-sample, and the average medullated fibre values for 5g sub-samples.

Tables 2 and 3 show that when the dark or medullated fibre content is relatively low (lots 1 to 4), the between-subsample variance was higher than variation due to the operator. In contrast, when dark or medullated fibre content was moderate to high (lots 5 to 10), the between-operator variance exceeded the between-subsample variance in most cases. After extensive evaluation of Draft TM IWTO-13-01, Burbidge *et al.* (1994) showed that human detection and appraisal was a major limitation for quantification of dark or medullated fibres within a sample.

Figures 4 and 6 show the relationship between the mean dark or medullated fibre count per 5g, and the standard deviation of fibre count, as reported in Tables 3 and 4. The expectation was that the relationship between the standard deviation and the mean would more closely approach a linear relationship, as described in IWTO-0-01.

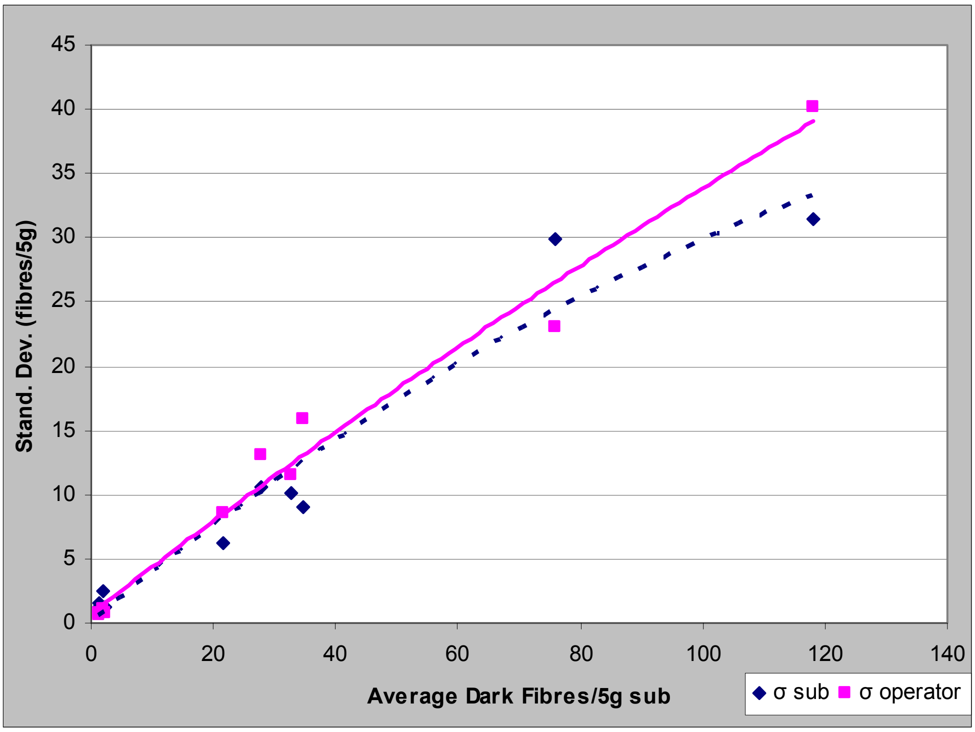

Figure 5: Relationship between the standard deviation for dark fibres in a 5g sub-sample, and the average dark fibre values for 5g sub-samples.

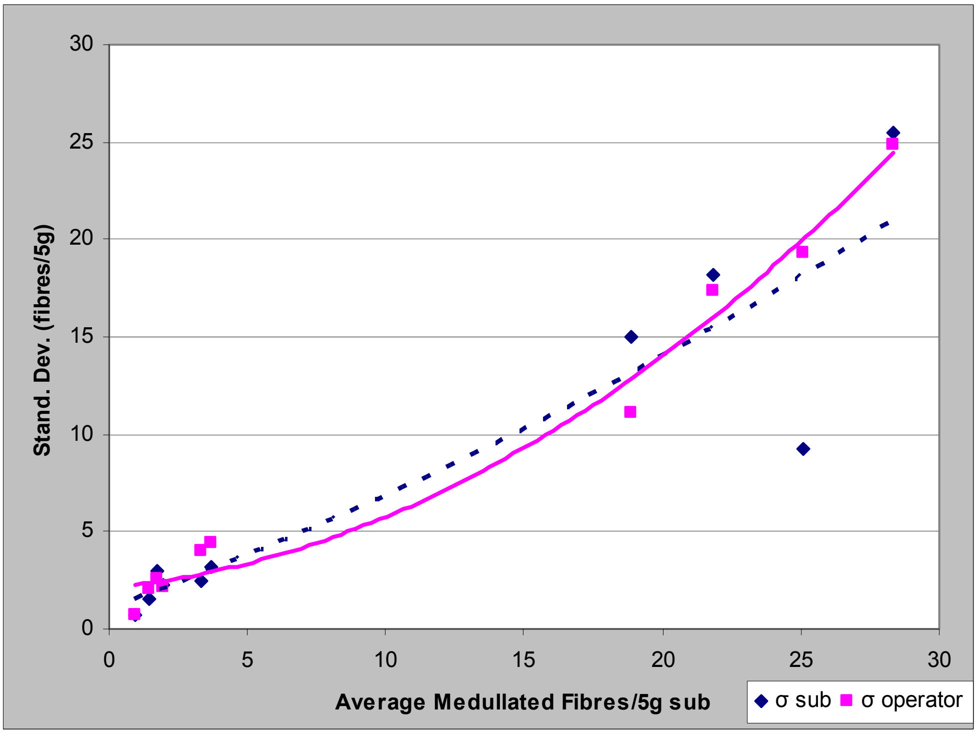

Figure 6: Relationship between the standard deviation for medullated fibres in a 5g sub-sample, and the average medullated fibre values for 5g sub-samples.

Precision Estimates for the Measurement of Dark and Medullated Fibre in Noil

The variance estimates reported in Tables 2 and 3 were used to estimate the precision of a measurement when two (2) operators each measure two (2) sub-samples per sample. The Confidence Limit for the measurement increased with the average number of dark or medullated fibres. Table 4 shows the estimated precision for the measurement of dark and medullated fibre in noil, using the Benzyl alcohol method. The 95% confidence limit was calculated as:

$$95\%CL = 1.96 \times \sqrt{\left(\frac{\sigma_{sub}^2}{4}\right) + \left(\frac{\sigma_{op}^2}{2}\right)}$$

Table 4: Precision estimates for 2 operators measuring 2 x 5g sub-samples, for dark and/or medullated fibre. Precision is quoted as fibres/10g

Sample	Average df/10g	CL ±df/10g	Average mf/10g	CL ±mf/10g
1	2.5	1.6	3.5	4.6
2	3.6	2.8	3.9	3.7
3	2.5	1.8	1.9	1.2
4	4.6	1.7	2.9	3.2
5	43.3	13.3	6.6	6.0
6	65.6	18.9	7.4	6.9
7	152.0	43.3	56.6	42.5
8	236.3	63.7	50.1	28.3
9	69.3	23.7	37.8	21.3
10	55.6	21.0	43.6	29.9

Figures 7 and 8 show the Confidence Limits for dark and medullated fibre respectively, when 2 operators each measure 2 sub-samples each. Tables 5 and 6 show the indicative precision for dark and medullated fibre in noil, as calculated using the regression equations for Figures 7 and 8.

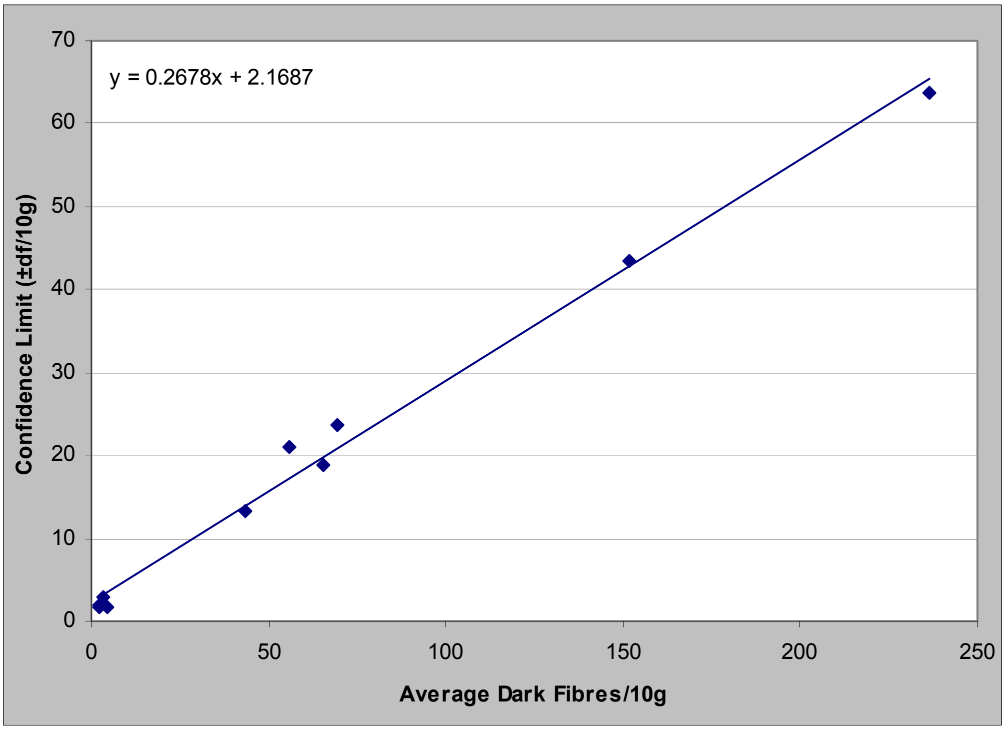

Figure 7: Confidence limits for dark fibres/10g using the Benzyl alcohol method, and 2 operators each measuring 2 sub-samples of 5g.

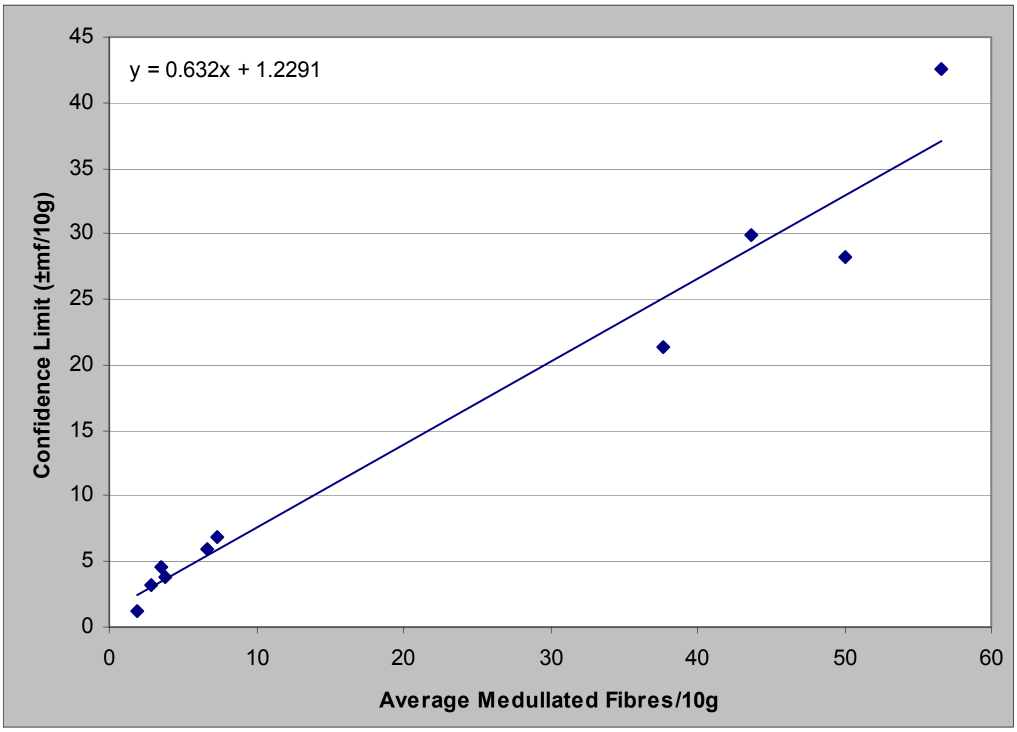

Figure 8: Confidence limits for medullated fibres/10g using the Benzyl alcohol method, and 2 operators each measuring 2 sub-samples of 5g.

Table 5: Estimates of the Indicative Confidence Limit for dark fibres/10g using the Benzyl alcohol method, and 2 operators each measuring 2 sub-samples of 5g.

Dark Fibres/10g	Confidence Limit (±df/10g)
10	4.8
25	8.9
50	15.6
100	28.9
150	42.3
200	55.7

Table 6: Estimates of the Indicative Confidence Limit for medullated fibres/10g using the Benzyl alcohol method, and 2 operators each measuring 2 sub-samples of 5g.

Medullated Fibres/10g	Confidence Limit (±mf/10g)
10	7.5
20	13.9
30	20.2
40	26.5
50	32.8
60	39.1

CONCLUSION

For low levels of dark fibre contamination (10 df/10g), the precision was estimated as ±4.8df/10g. Alternatively, at high level of dark fibre contamination (50df/10g), the precision was estimated as ±15.6df/10g. At low levels of dark fibre (<10df/10g), the confidence limit was somewhat questionable, due to the level of variation in the measurement of this point.

The results for medullated fibre appear similar to those for dark fibre; at low levels of medullated fibre (10mf/10g), the confidence limit was ±7.5mf/10g. Alternatively, at high levels of medullated fibre (50mf/10g), the confidence limit was 32.8mf/10g.

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REFERENCES

Appleyard, H.M. and Adele Perkin, M.E. (1965). *Identification of short animal fibres appearing as contaminants in wool cloth*. J. Textile Inst., 56, T45-48.

AWTA Ltd, CSIRO and AWI (2004) Development of an improved test for detection of dark and medullated fibres in presale core samples. IWTO, T&S Committee, Shanghai, Report RWG 5. www.awta.com.au/Publications/Research_Papers/Wool_Contamination.htm (2006).

Burbidge, A., McInnes, C.B., Brown, G.H., Foulds, R.A. and Stephens, L. (1994). Inter-laboratory trial to evaluate IWTO(E)-13-88(E). IWTO, T&S Committee, New Delhi, Report No. 22

DRAFT TM-13-01 EA. {Formerly IWTO(E)-13-88} Counting of Coloured Fibres in Tops by the Balanced Illumination Method

Fleet, M.R., Alaya-ay, A. and Mahar, T.J. (2006). Relationship between greasy and processed dark fibre contamination from Damara crossbred lambs in Merino wool. IWTO T&S Committee, Cairo Meeting Report CTF 2. pp 1-12.

Hatcher, S. (2002). Fibre medullation, micron, marketing and management. In: Proceedings of a Symposium on African and Middle East meat sheep breeds. Cowra Show Society, Cowra NSW (http://www.awta.com.au/Publications/Research_Papers/Wool_Contamination.htm).

IWTO-55-99. Method of Automatic Counting & Classifying Cleanliness Faults in Tops using the Optalyser Instrument.

IWTO-0-01. Procedures for the Development, Review, Progression or Relegation of IWTO Test Methods and Draft Test Methods.

Wetzold, W.W and von Bergen, W. (1970). Worsted topmaking. In: 'Wool Handbook'. Edit. W. Von Bergen (Interscience; New York) pp 255-333.