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Sheep Updates 2003

‘Pastures from space’ - an opportunity to increase the profitability of sheep production

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KEY MESSAGES

Producers can increase the profitability of their sheep enterprise by using satellite-based pasture information.

INTRODUCTION

The development of profitable and sustainable sheep grazing systems requires information on pasture availability, how animals respond to changes in pasture availability and what are the pasture conditions required to achieve target levels of intake and animal performance. CSIRO Livestock Industries in collaboration with the Western Australian Departments of Agriculture and Land Administration have developed a method of measuring both the biomass and growth rates of annual pastures using satellite images (1). This paper reports on the value to producers of satellite based feed on offer (FOO, kg DM/ha) and pasture growth rate (PGR, kg DM/ha/d) information delivered at the paddock level via a website (www.spatial.agric.wa.gov.au/foo) and e-mail.

AIM

To conduct an on-farm case study to test the proposition that wool-producers can increase the profitability of their sheep enterprises by using satellite-based pasture information.

METHODS

In 2001 Precision Sheep Production Producer Groups were set up to pilot test the delivery of satellite based FOOs and PGRs for paddocks on individual farms. The producers within these Groups were delivered, from August to September 2001 and from May to October 2002, predictions of PGRs weekly and FOOs monthly for each of the paddocks on their farms. Case studies were undertaken both in 2001 and 2002 to assess the value of the remote sensed pasture measurements (2), (3). The results of one case study are presented in this paper.

RESULTS AND DISCUSSION

Case study (management of wool production to forward contract and budget for silage production) - Richard Coole farms 5,500 ha spread over 6 farms between Frankland and Boyup Brook, approximately 400 km south of Perth. Approximately 40 per cent of the arable area is planted to crops and 35,400 DSE are run at a winter grazed stocking rate of 12.9 DSE/ha with an average annual rainfall of 600 to 700 mm. In 2001, Richard used satellite-sourced estimates of FOOs and PGRs to both manage wool production and increase pasture utilisation on the farm. In concert with the satellite based pasture technology, he used the ‘measure as you grow’ approach (4) to manage the wool production in two and four-tooth dry ewes to a predetermined fibre diameter, staple length and staple strength by restricting their intake in winter-spring. Because Richard was so confident that he had the tools available which would allow him to hit his target, he made the decision to forward sell 300 bales (a third of his clip) of 18 to 19 micron wool with a staple strength of around 30 N/ktex.

Through a combination of technologies Richard was able to meet his forward contracts and realised a profit of $50,000 over what he would have achieved if he had sold his wool into the spot market. The profit achieved through the forward selling of his wool does not take into account the extra profit achieved over and above his current grazing management, through the management of wool production during winter-spring. The surplus land that became available as a result of the more intensive grazing of dry ewes provided him with the option of fodder conservation. He used the weekly PGR and monthly FOO predictions to develop feed budgets for his livestock and to provide him with the information as to how much land he should lock up for silage production. He valued the 1,500 tonnes of silage produced from the surplus land at $150,000 (i.e. $100/tonne).

Richard also claimed that the provision of remote sensed PGR and FOO resulted in a labour saving by eliminating 1 day/week of the time needed to monitor pastures during the growing season. This saving in labour for a skilled person was valued at around $3,900 per year ($30,000 annual salary). In addition, the technology was used in the management of his five remote properties that resulted in a further labour saving to the enterprise. The technology provided him with additional time to spend on making strategic and tactical management decisions.

CONCLUSION

The provision of reliable, timely and accurate FOO and PGR information provides with the opportunity to improve the profitability of their sheep enterprise. The plan in 2003 is to undertake an economic analysis of the technology in order to quantify the resultant increase in profit that is achieved though its use. Cooperating producers will be asked to collect specific information associated with the use of the technology to enable a ‘with and without’ economic analysis to be conducted to determine the value of technology to their farming businesses. In addition, whole farm economic modelling will be undertaken to investigate the potential opportunities that the FOO and PGR information will offer producers in maximising profits on their farms.

KEY WORDS

satellite, pasture biomass, feed on offer, pasture growth rate, sheep

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Paper reviewed by: Dr Keith Croker, Senior Research Officer, Department of Agriculture and Andrew Peterson, Research Officer, Department of Agriculture

REFERENCES

Gherardi, S. and Oldham, C. (2003). The value proposition for remotely sensed estimates of feed on offer and pasture growth rate. Proceedings of the Joint Conference of GSV and GSNSW, 19-22.

House, R., Bilney, R., Ladyman, D, Oldham, C.M., Paganoni, B. and Yelland, M. (2002). Producing wool to budget using the ‘Measure as you grow’ approach - wool producers experience. *Proc. Aust. Soc. Anim. Prod.* 24: 101-4.

House, R. (2003). My experience with satellite predicted estimates of feed on offer and pasture growth rates. Proceedings of the Joint Conference of GSV and GSNSW, 23-25.

Kelly, R., Edirisinghe, A., Donald, G., Oldham, C. and Henry, D. (2003). Satellite based spatial information on pastures improves Australian sheep production. 1st European Conference on Precision Livestock Farming, 15-18 June (in press).

Curvature, and what is it worth?

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ABSTRACT

Curvature results have been made available by AWTA since July 2000 using the Laserscan instrument. The Wool Service Desk has analysed the Australian auction data which contains the curvature results and all other pre-sale measurements for the period July 2000 to December 2001.

Mean curvature for all Australian sale lots is 94.4 degrees per mm (°/mm). The range of curvature values for sale lots was 58°/mm to 167°/mm, with a standard deviation between sale lots of 11.4°/mm.

The curvature value decreases as the mean fibre diameter of the sale lot increases. Sale lots in the 17.5 to 18.4 µm range had mean curvature of 105°/mm and a SD of 10.7°/mm. For sale lots in the 23.5 to 24.4 µm range, curvature had a mean of 83°/mm and SD of 7.3°/mm.

Curvature results were not related to AWEx appraised style for sale lots broader than 22 µm, but increased with better style wool for finer lots.

The relationship between curvature and clean price was studied for fine Australian Merino fleece sale lots matching a consignment design which constrained diameter to ± 0.5 µm, staple length to between 75 and 95 mm, staple strength > 35 Nktex and VM content < 1.5%. The results for the individual characteristics are presented after these constraints were applied. The style of these sale lots did not vary with changes in curvature.

The clean price of these sale lots were examined when the consignment average diameter ranged from 17 to 22 µm. Estimates were made of the rate of change in clean price due to curvature changes. This slope is linear within the diameter class, and ranged from 12 cents per °/mm at 18 µm to 0.3 cents per °/mm for 22 µm.

KEY MESSAGES

The average curvature of Australian sale lots is 94 °/mm with a range from 58 to 116 °/mm. Curvature is higher in fine wool, and in fine wool of better style. Within a diameter class, adult fleece wool has higher curvature than weaner wool, and lambs wool has the lowest curvature.

For 18 µm sale lots chosen to match a standard processing consignment, auction price increases as curvature increases at a rate of 12 cents per °/mm. For consignments of higher diameter, the increase in price is lower and for consignments above 21 µm curvature does not alter price.

METHOD

Information was collected on each Australian sale lot that was offered at auction between July 2000 and December 2001. The information included core test results and staple measurements from AWTA. The measurement of fibre diameter using Laserscan provided curvature measurements, in addition to the fibre diameter statistics.

Test information was combined with other sale and appraisal information on the sale lot. The other information included regional information, AWEx appraisals, sale details and auction price. The AWEx ID was used to provide style information.

It is estimated that about 85% of all Australian wool production is sold through the auction system. Therefore it is assumed that the following results provide a reasonable and unbiased sample of the Australian wool clip.

A total of approximately 740,000 sale lots were used in the analysis.

Curvature classes refer to the median curvature ± 5°/mm.

The relationship between curvature and price was analysed by comparing the average price of lots assembled to a typical processing specification but with the added constraint of limits on curvature. The design for a typical consignment specification was made by constraining diameter to the target mean ± 0.5 µm, staple length between 75 and 95 mm, staple strength > 35 Nktex, vegetable matter < 1.5% for adult Merino fleece wool lots.

RESULTS

Summary statistics

The average curvature for all Australian sale lots offered at auction between July 2000 and December 2001 was 94.4°/mm. The SD of curvature between sale lots was 11.4°/mm. The majority of the sale lots are within the curvature range of 60 to 150°/mm.

Average curvature is related to the average fibre diameter in Australian auction sale lots. Table 1 shows curvature statistics for each diameter class between 17 and 27 µm. The curvature is reduced as diameter increases, and the curvature variation within the diameter class decreases as the diameter increases for diameter ≤ 23 µm.

Table 1. Average and SD of curvature within diameter classes for Australian auction sale lots

Diameter class	Number of sale lots	Average curvature	SD	Maximum curvature	Minimum curvature
17	32,242	108	10.0	149	80
18	86,293	105	10.7	150	75
19	129,914	101	10.1	144	61
20	140,415	95	8.3	147	71
21	127,746	91	7.1	167	68
22	93,104	88	6.8	130	64
23	56,484	85	6.9	129	64
24	32,444	83	7.3	152	62
25	18,227	82	8.0	130	60
26	12,089	82	8.1	138	60
27	10,633	82	7.3	132	58

Curvature and fibre diameter by breed

Table 2 shows the average curvature for the breed categories recognised in the AWEx ID wool types. As the AWEx ID makes a distinction between the Australian Superfine (AS) sale lots and the Merino sale lots (M), the results in Table 2 keep these two classes separate. The differences in curvature between Merino and superfine Merino suggests that style has a strong curvature component.

In the finer diameter classes, the superfine Merino has the highest average curvature, followed by the Merino. The Merino has a higher average curvature than the crossbreds in the 18 to 21 µm classes, but lower curvature over 22 µm. As expected the Downs breeds have a higher curvature than both the Merino and the crossbred at any diameter.

Table 2. Average curvature for Australian sale lots, using the AWEx ID to provide breed information, and AWTA test results for average diameter and curvature

Diameter class	17	18	19	20	21	22	23	24	25	26	27
Superfine Merino	117	116	113	110							
Merino	109	107	101	95	90	87	83	80	77	73	70
Cross-bred		96	95	95	91	90	88	87	85	83	81
Downs					108	94	95	92	97	97	95

Curvature and style for Merino fleece wool

Average curvature in Merino adult fleece wool changes with both mean fibre diameter and style. The style value is taken from the AWEx ID for Merino sale lots. The effect of changing these two characteristics together is shown in Table 3. As style improves towards style = 1, the average curvature increases within the diameter classes finer than 22 μm.

Curvature by Australian selling centres

Genetic and environmental differences in the types of wool from various regions of Australia can give rise to specification differences between the Australian wool selling centres. Average curvature results for each selling centre are presented in Table 4, together with the average fibre diameter.

Table 3. Average curvature for Australian Merino fleece sale lots by style and by diameter classes

Style	Diameter class										
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
1	124	125									
2	123	122	114	111							
3	116	113	109	102	95	88	84	75	77		
4	111	109	105	98	92	87	83	79	76	73	72
5	104	100	96	93	90	87	84	81	77	74	71
6	99	97	95	92	90	87	84	81	78	75	69
7	97	102	92	94	90	86	84	81	80	83	74

Table 4. Average curvature and fibre diameter by Australian selling centres

Selling centres	Number of sale lots	Average curvature	SD curvature	Average fibre diameter
Brisbane	47,483	92	8.7	20.8
Fremantle	134,969	92	8.5	20.5
Launceston	9,294	99	12.8	19.6
Melbourne	254,758	92	10.9	21.0
Newcastle	60,162	106	12.0	19.0
Sydney	232,925	96	11.5	20.5

High curvature results are evident in Newcastle and Launceston, but these are associated with a lower average fibre diameter. Therefore it does not seem reasonable to attribute curvature differences to the selling centres.

Curvature and fibre diameter for Merino fleece wool types

Changes in curvature are evident in the different Merino fleece types. Curvature results were assembled by fleece type (adult, weaners and lambs) using the AWEx ID. These categories represent fleeces from animals of different ages. As the AS and M classifications both refer to adult fleece wool, they have been combined in the results shown in Table 5.

Table 5. Curvature for Australian Merino fleece sale lots, sold between July 2000 and December 2001

Diameter class	17	18	19	20	21	22	23	24	25	26	27
Adult	111	108	102	95	90	87	83	80	77	73	70
Weaner	106	100	95	91	89	86	84	83	86	83	83
Lambs	99	94	90	87	84	83	84	89	86	81	-

The highest average curvature results are in the adult fleece category, especially in the finer diameters below 21 μm. The average curvature for wool less than 22 μm is lower within a given diameter for weaners and for lambs.

Curvature and clean price

The relationship between curvature and clean price was explored using a typical consignment specification. For an 18 µm consignment assembled using sale lots offered between September and November 2001, average characteristics are given in Table 6.

Sale period September to November 2001 was selected for convenience in order to remove any significant average price trends over the period of the analysis.

Table 6. Average raw wool characteristics of 18 µm selections of Australian Merino fleece sale lots of differing curvatures, sold between September and November 2001

Curvature class	80	90	100	110	120	130	140
Curvature (°/mm)	84	91	100	109	118	127	137
Average clean price (cents)	1103	1199	1397	1558	1677	1819	1804
Number of sale lots	6	152	675	1400	754	99	4
Staple length (mm)	85	84	84	82	80	79	78
Staple strength (N/ktex)	39	42	46	47	47	47	46
Vegetable matter content (%)	0.7	0.9	0.8	0.8	0.8	0.8	0.8
Schlumberger dry yield (%)	72	72	77	77	76	75	73
Fibre diameter (Laserscan, µm)	18.2	18.1	18.1	18.0	18.0	17.9	17.9

Table 6 shows clean price increasing with increasing curvature for the 18 µm consignment design. There is a 700 cents/kg price increase as the curvature class increases from 80 to 140°/mm. There is very little change in average staple length, strength, vegetable matter content, yield or diameter across the full range of curvature classes.

The preceding analysis was then expanded to include all months between July 2000 and December 2001. The clean price versus curvature relationships for each month are plotted in Figure 1. The slope of clean price on curvature is similar for all months, suggesting that the relationship between curvature and clean price holds over a wide range of average market prices. The average slope is 12 cents per °/mm (SE = 1.1) for the 18 µm consignment design.

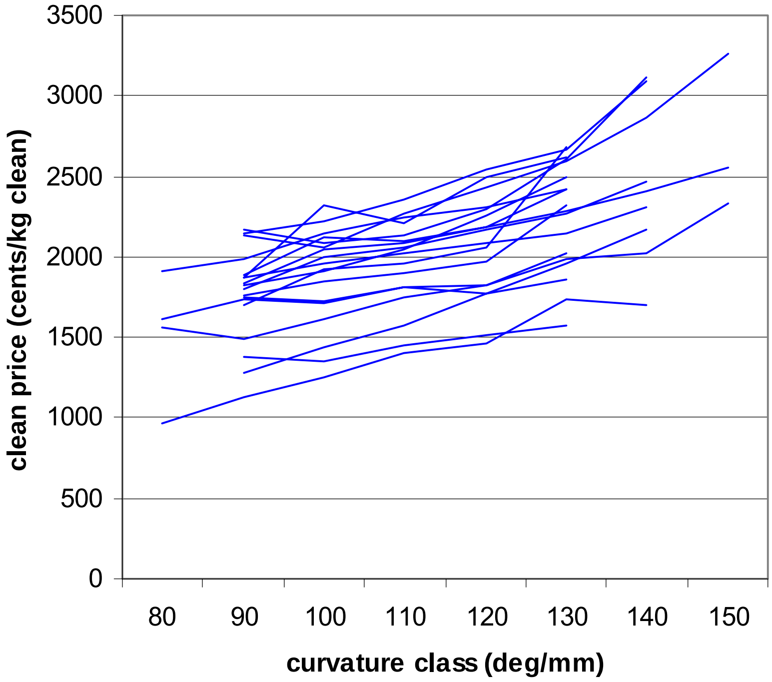


Figure 1. Average clean price versus curvature class for 18 µm sale lots chosen as suitable for a typical consignment specification. The individual lines are for the months from July 2000 through December 2001.

This consignment design includes sale lots over the diameter range of 17.5 to 18.6 µm. Part of the average slope result could be due to differences in average diameter across the curvature classes. It is possible to validate the above result for the 18 µm consignment design by examining the curvature/price relationship for only those sale lots which have a diameter of precisely 18.0 µm. The average results for those sale lots at each curvature step are shown in Figure 2. The slope of clean price on curvature is 12.2 cents per °/mm, which agrees with the 12 cent result for the 18 µm consignment.

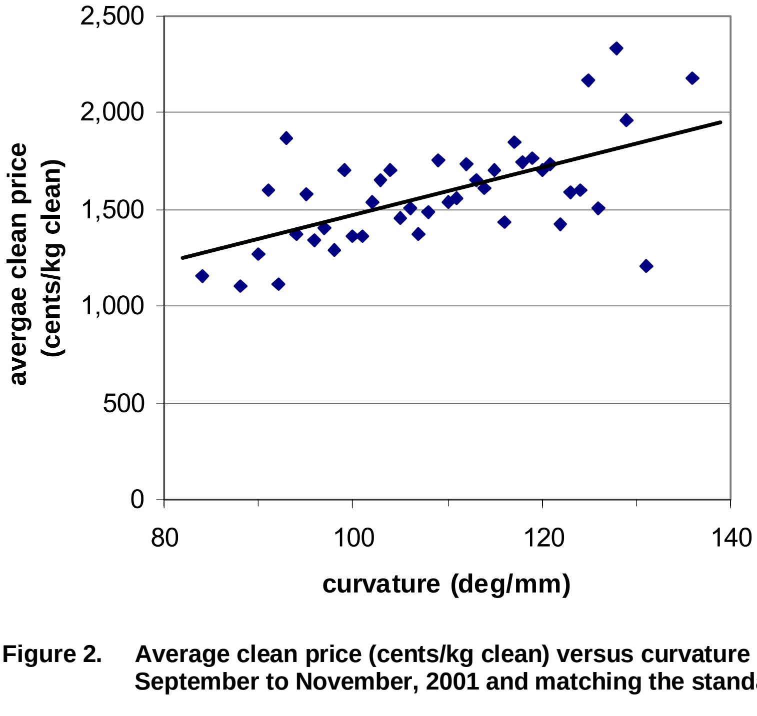


Figure 2. Average clean price (cents/kg clean) versus curvature (°/mm) for 18.0 µm sale lots offered during September to November, 2001 and matching the standard contract specifications.

The analysis for the 18 μm consignment design was repeated for consignments with average diameters from 17 to 22 μm. The price-curvature relationship (slope) for each diameter class are presented in Table 7.

Table 7. Average across months (July 2000 to December 2001) of the slope from the clean price versus curvature linear regression by μm. [For example, the 11.8 value in this table for the slope on 18 μm consignments is the average of the slopes for all the lines in Figure 2.].

Average diameter for consignment design	(μm)	17	18	19	20	21	22
Average slope for clean price on curvature	(cents per °/mm)	12.8	11.8	5.4	3.5	0.6	0.3
SE between months	(cents per °/mm)	1.7	1.1	0.5	0.5	0.1	0.1

Table 7 shows the average slope of clean price on curvature falling as diameter increases. The SE also decreases as the number of sale lots increases and the average clean price is lower, and the overall range of prices decreases.

DISCUSSION

Curvature and other raw wool attributes

The analysis of curvature shows that it is related to other raw wool characteristics, and can change between wool types. However curvature does not appear to be able to replace any of the measured (such as diameter) or appraised (such as style) characteristics because the variance of curvature within these classes is high. This is seen in the use of curvature in the delivery of Elite wools in combination with diameter as part of the initial selection criteria for raw wool. It is also interesting that the Elite wools are identified on the basis of low curvature for a given diameter, whereas the style results (Table 3) show high styled wool with high curvature. Curvature therefore has the ability of being sought in the high and low ranges for any given diameter.

Initial use of curvature by industry will most probably be as an additional specification in the raw wool which would impact on the quality of end-product or efficiency of processing intermediate products.

Curvature and clean auction price

There is considerable industry discussion about the benefits of curvature in processing and on end-product quality. If these benefits are recognised by the processors, then some preference for curvature in raw wool, possibly through the association of curvature, style and crimp, should be evident in the auction prices.

An examination of auction prices was undertaken for the 18 μm wool selections that were defined above. Average price increased as the curvature increased. This would suggest that there is an increase in demand for high curvature fine wool and there is no increase in demand for low curvature in fine wool.

The results show that the relationship is stable over the time period analysed. The common regression result of 12 cents per °/mm for the 18 μm consignment design is present across periods despite the average price varying between months. This suggests that the price/curvature relationship is not a short term anomaly, nor is it dependent on higher demand levels for fine and superfine wool.

This price-curvature analysis was expanded to other diameter classes between 17 and 22 μm. The results show that the relationship is not constant across the 17 to 22 μm range. The analysis shows that the high curvature premium is greatest at low diameter and negligible above 20 μm.

The results presented in this paper are from the first 18 months of the measurements being available on Australian sale lots. Therefore the results are representative of a short term cross section of the Australian supply. In this period the total supply is at the lowest level in over 10 years, and any increase in weight will have the potential to change the balance of wool types reaching the auction market, and the distribution of curvature results within the expanded supply.

CONCLUSION

The curvature of Australian sale lots has been described in detail. Changes in curvature have been associated with changes in breed within the Australian clip. Within Merino sale lots, curvature changes with diameter and style, reaching maximum average curvatures for very fine, high styled Merino sale lots.

Auction price rises with increasing curvature for low diameter sale lots. At higher diameters (over 20 μm), clean price is independent of curvature.

KEY WORDS

wool, auction price, curvature of sale lots

Is selection of ewe hogget replacement on measurement profitable?

Johan Greeff, Department of Agriculture of Western Australia, Katanning

KEY MESSAGES

Selecting Merino ewe replacements on measurement may result in economic losses.

Ewe replacements should be selected on an index that combines both fleece weight and fibre diameter.

Reproductive performance of the ewe flock is a critical factor in the profitability of selecting ewe replacements.

INTRODUCTION

Measurement technology such as the OFDA2000 and Fleecescan that measure fibre diameter of individual fleeces in the shearing shed makes it possible to identify the most profitable animals for replacement purposes. This is possible since fleece weight and fibre diameter are repeatable traits. Animals that produce more wool and/or finer wool at hogget age will tend to produce more and/or finer wool at later ages. But as the relationship between fleece weight and fibre diameter is negative, it is important to find out when selecting replacement animals on fibre diameter alone or on an economic index that includes fleece weight, will be profitable.

The key issues affecting whether measurement to select replacements is profitable are:

- average fleece weight of the flock;
- average fibre diameter of the flock;
- proportion of animals available to cull.

METHOD

To assess the impact of each of these factors, and combinations of these factors, we have developed a simple simulation model. This model, which describes a flock of 1000 breeding ewes with five age groups (that is, a hogget, two, three, four and a five year age group), was used to determine the effect of fibre diameter, fleece weight and different culling rates on profitability.

Five different culling rates (0, 10, 20, 30, 40 and 50 per cent) were assumed to establish the effect of different numbers of replacement hogget ewes available.

The average fleece price was calculated from sale lots sold in the 1998/1999 selling season with no discounts for tender wool, high vegetable matter or low yield. This approach was taken as we were interested in the dollar value of the genetic merit of the animal, as opposed to environmental aspects.

A measurement cost of $1.15 per fleece was used and a discount rate of five per cent was assumed. The cumulative net present value (NPV) of the benefits/losses over the lifetime of the animals selected was calculated over a 10 year period.

Two selection options were simulated:

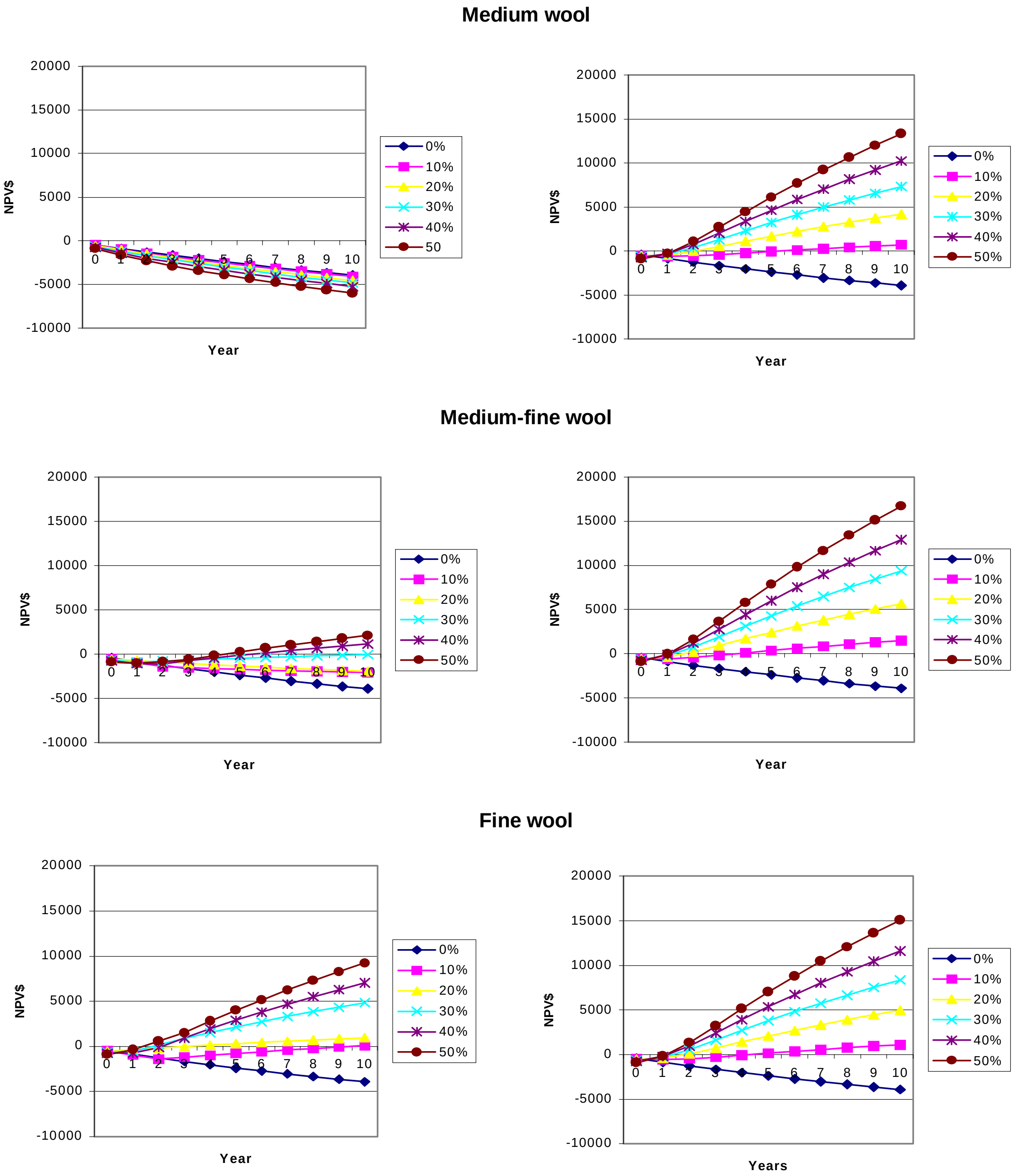
- Selecting replacement hogget ewes on fibre diameter only; and
- Selecting replacement hogget ewes on a dollar index value that is based on the average wool price multiplied by the amount of wool produced.

Different scenarios were compared for a medium, medium-fine and a fine wool group. The performance of the groups was assumed to be as shown in Table 1. A yield of 70 per cent was assumed in all cases.

Table 1. The assumed values of fibre diameter and fleece weight for three flocks fine, medium fine and medium fibre diameter

Group	Fibre diameter (µm)		Greasy fleece weight (kg)	
	Hogget	Mature	Hogget	Mature
Medium	19.5	22.5	5.5	6.0
Medium-fine	18.0	21.0	4.5	5.0
Fine	17.0	20.0	3.5	4.0

RESULTS



Selecting on fibre diameter only. **Selecting on a $ index value.**

Figure 1. Effect of different culling rates and wool genotypes (medium, medium-fine, fine) on profitability.

In the case of the medium wool group, selecting replacement animals on fibre diameter only resulted in a positive cumulative NPV. However, for the fine wool group, a small positive cumulative NPV occurred when selecting 20 per cent of available animals.

In all micron groups, selection on the basis of a dollar index resulted in positive NPVs regardless of culling level, and the higher the culling rate, the greater the return on investment.

CONCLUSION

The key points as a result of our simulations are:

- Measuring fleeces for fibre diameter only can result in losses and may therefore not be a profitable activity. This depends on the average fibre diameter of the flock. It would only be profitable to select replacement ewes on fibre diameter in fine wool flocks.
- Selecting ewe replacements on an index that combines both fleece weight and fibre diameter is more profitable than selecting on fibre diameter alone.
- Flocks that have more ewes available for replacement because of higher fertility and survival rates, will benefit more from culling on measurement than flocks with lower reproduction rates. It may not be profitable to use measurement in flocks that can cull less than 30 per cent of the available replacement hoggets.

Careful consideration needs to be given to the place of measurement in animal selection and preparation of lines for marketing. In some cases, the use of measurement can result in losses.

KEY WORDS

OFDA2000, Fleecescan, fleece testing, measurement, economics

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Paper reviewed by: Andrew Peterson, Department of Agriculture, Western Australia

REFERENCES

Greeff, J.C. (2001). Department of Agriculture Western Australia Farmnote 100/2001.

Optimising the nutrition/grazing management of ewe flocks

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KEY MESSAGES

The results from the 2001 lambing in the Lifetime Wool Project strongly suggest that there is enormous potential, in medium-to-high rainfall areas, to increase pasture utilisation and wool production by breeding ewes without penalising lambing and weaning percentages, or lifetime performances of the resulting progeny.

INTRODUCTION

In Mediterranean climates in Australia, the seasonal fluctuations in available pastures generally mean that at some stage during pregnancy a grazing ewe will become undernourished. This is particularly true for autumn lambing where ewes are pregnant over summer.

The level of feed intake by ewes during mid and/or late pregnancy can influence wool production and quality, lamb birth weight and survival, the level of secondary follicle initiation and development in the fetus (fetal programming). Therefore, the lifetime quality and quantity of wool produced by the progeny can be influenced by the nutrition of the ewes.

The current recommended ‘industry best practice’ is to lamb in late winter/early spring so that early lactation coincides with the onset of the spring flush of pasture growth, and to manage ewes to maintain body condition score three throughout pregnancy. However, there is no information available describing the cost:benefit of different amounts of annual pastures, during late pregnancy and lactation, on the productivity of the ewe and its progeny. The Lifetime Wool Project jointly funded by the WA Department of Agriculture and DPI Victoria has set out to rectify this deficiency.

AIM

To develop, demonstrate and communicate practical grazing management guidelines that enable woolgrowers across southern Australia to increase lifetime production of wool per hectare from ewes and their progeny by 20 per cent, without compromising wool quality or the environment, by 2007.

METHODS

Plot-scale experiments were started during 2001 on specialist wool producing properties near Coleraine, Victoria and Kendenup, Western Australia. At each site, ewes were joined in condition score 2.5 to 3.0 and then were fed to either maintain condition or lose a condition score by day 90 of pregnancy. From day 90 of pregnancy until the lambs were weaned, the ewes were allocated to grazing treatments where Feed on Offer (FOO) was maintained at different amounts: 800, 1100, 1400, 2000, and 3000 kg DM/ha. The experiment was repeated over three years from 2001 to 2003, with the last year still in progress.

RESULTS AND DISCUSSION

The amounts of green FOO can be managed to achieve production targets by adjusting stock numbers based on regular assessments of FOO, anticipated pasture growth rates and estimates of pasture intake.

Preliminary results of the two experiments show there were significant differences in pasture growth rates between sites, seasons and years. Grazing to maintain FOO at 1000 kg DM/ha, or below, during winter-spring reduced pasture production by more than 20 per cent at both sites during 2001. However, significantly higher pasture utilisation occurred on the lower grazing treatments, ranging from 60% to 90% utilisation for the 3000 to 800 kg DM/ha treatments, respectively.

The preliminary results suggest that there is enormous potential, in med-high rainfall areas, to increase pasture utilisation and wool production from breeding ewes, without penalising lamb weaning percentages or lifetime performance of the progeny. The flexible grazing management used to maintain FOO at 2000 kg DM/ha during winter/spring more than doubled the district average stocking rates at both the Western Australian and Victorian sites. Below this level of FOO there are adverse effects on ewe and progeny performances, but these critical thresholds are still being defined.

The effect of FOO during late pregnancy or lactation on the performance of lambs is clear. At both sites, the highest level of nutrition increased the clean fleece weight of the 2001 progeny at their hogget shearing by about 300 g and decreased the fibre diameter by about 0.3 microns compared to the lowest level of nutrition. However, there were subtle variations in the levels of nutrition at which the detrimental effects on clean fleece weights and fibre diameter occurred.

Ewes grazing amounts of FOO less than 2000 kg DM/ha during late pregnancy and lactation had reduced liveweight at their next joining. This resulted in lower conception and twinning rates the following autumn, but the critical thresholds are still being defined. As expected, ewes fed to lose liveweight and condition during early and mid-pregnancy produced about 0.3 kg less fleece wool that was 0.5 to 0.9 micron finer. However, the level of ewe nutrition did not effect their faecal worm egg counts, or lamb birth weights, lamb mortality or progeny faecal worm egg counts at either site.

The different FOO treatments achieved significant differences in ewe liveweight changes during late pregnancy and lactation. However, there were differences in the responses of the ewes to the same quantity of FOO at the two sites. In Victoria, the ewes lost less weight on the low levels of FOO compared to Western Australia and the reverse appeared to happen at the highest levels of FOO. The current explanation for this difference is believed to involve two factors. The pastures in Victoria had a much higher proportion of grass compared to the sub-clover dominant pastures in Western Australia. Hence, the grassy pastures in Victoria may have been taller and more available at low levels of FOO compared with Western Australia. Conversely, at high levels of FOO the pasture height difference would not affect the ability of the ewes to eat but the higher digestibility of the clover dominant pastures may be responsible for the better response in liveweight. However, as the final recommendations from the Lifetime Wool Project must be able to be applied to all pastures across the Mediterranean environment of Australia, direct measurements of feed intake by the ewes have been made in late pregnancy and twice during lactation. These measurements will be used to adjust for estimated intake in grazing management support systems such as GrazFeed®.

CONCLUSION

The preliminary results from this work suggest that there is enormous potential, in med-high rainfall areas, to increase pasture utilisation and the subsequent wool production from breeding ewes, without penalising lamb weaning percentages or the lifetime performance of their progeny.

KEY WORDS

life time, optimal nutrition, ewes, wool production, fetal programming, feed on offer

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Paper reviewed by: Drs Keith Croker and Stephen Gherardi, Senior Research Officers, Department of Agriculture

How do we produce wool for next-to-skin wear?

Andrew Peterson, Department of Agriculture Western Australia

KEY MESSAGES

Wool comfort is defined as the degree to which a garment can be worn next to the skin without any discomfort. Only a small proportion of wool garments are worn close to the skin. Next to skin comfort is primarily determined by the mean fibre diameter of the garment. Of secondary importance is the type of garment (knitted or woven), the fibre diameter distribution, and the fibre diameter at the ends of the fibres.

INTRODUCTION

Wool comfort is important when garments are worn close to the skin as broad fibres can cause irritation to the skin. Wool comfort should not be confused with other properties such as fabric weight and softness which tend to be subjectively measured by touch. The comfort of wool garments next to the skin is normally assessed with a wearer trial by determining the percentage of people that find the garment comfortable to wear. Knowledge now exists on what wool types are needed to create highly comfortable fabrics.

REVIEW

A mechanism for skin irritation has been proposed by CSIRO and DAWA research has been undertaken to understand what fibre properties are important in determining wool comfort. All fabrics have fibres that make contact with the skin at some point. If these fibres do not bend easily, they will be more likely to stimulate pain receptors in the skin (Figure 1).

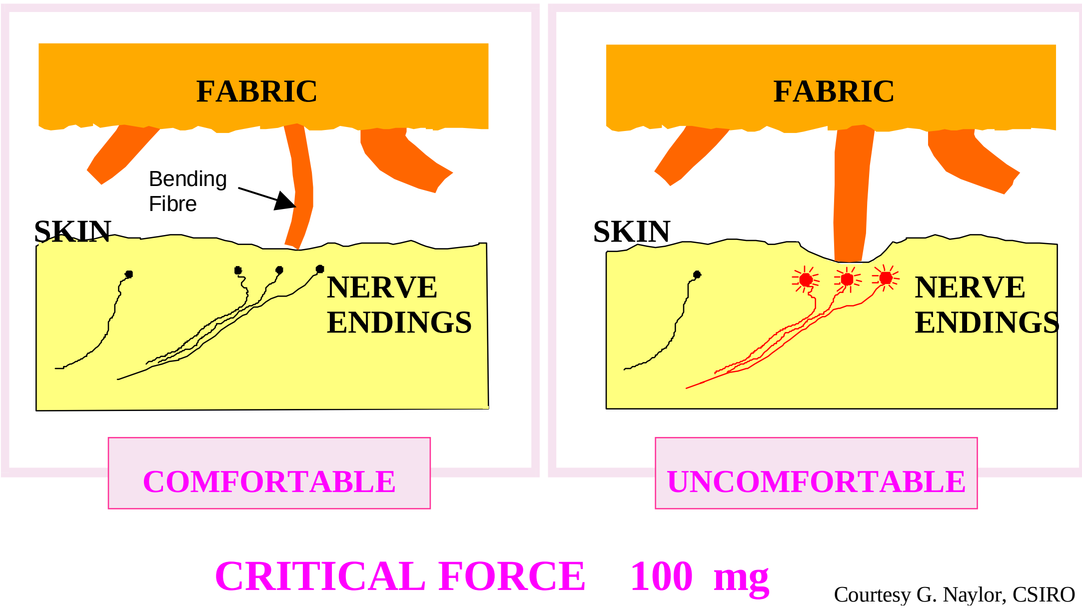

Figure 1. The mechanism that causes fabric prickliness.

Mean fibre diameter

The mean fibre diameter is a major determinant of wool comfort. Finer fibres will bend easier when pressed against the skin. By having a larger proportion of fine fibres in the garment, there will be less skin nerve receptors stimulated and hence the garment will feel more comfortable. It is difficult to determine a specific MFD value at which all garments feel comfortable. Other fabric and fibre properties will alter this value. However, it can be safe to say that most people find a lightweight knitted garment less than 19 microns to be comfortable.

Comfort factor

The comfort factor is defined as the percentage of fibres less than 30 microns. A similar measurement is Coarse Edge Micron (microns above the mean where the broadest 5% of fibres are found). The comfort factor is a function of mean fibre diameter and the width of the fibre diameter distribution (standard deviation). It is difficult to state what comfort factor value is required to manufacture a highly comfortable fabric. However, a garment with a comfort factor of 100% (no fibres greater than 30 microns) will almost always be comfortable next to the skin. Wool top with this specification would be rare in wools with a MFD of more than 19 microns.

Fabric type

An obvious factor is the type of woven or knitted fabric and the way it is finished. For the same given MFD and Comfort Factor, knitted fabrics tend to be more comfortable than woven fabrics. The distance between the outer surface fibres and the inner weave structure affects the ease at which fibre can bend when pressed next to the skin. The fibres in closely cropped woven fabrics will be more resistant to bending (and hence less comfortable) than loose knitted fabrics or woollen knitwear. Furthermore, certain fabrics present more fibre ends to the skin per square centimetre of fabric. Some knitted fabrics achieve the same level of skin comfort as an equivalent plain woven fabric that is made from 3 µm finer wool [1].

Fine ends

It has been shown that the shape of the fibre diameter profile of wool staples is sometimes preserved in the same wool fibres after processing to top. Wool staples with a distinct narrowing in fibre diameter at the tip and base will tend to produce wool tops with slightly finer ends. These types of diameter profiles are commonly found in autumn in mediterranean environments, and in spring in the NZ high country. Because the fibres are finest at their ends, there tends to be less skin irritation when garments made from fine ends wool are worn next to the skin [2]. The fine ends can be measured on fleeces as well as wool top enabling garment manufacturers to source the most comfortable wool without having to use exclusively superfine wool. Processing lots with fibre ends 1.5 µm less than the mean fibre diameter of the top have been produced using single fleece selection of fine ends wool. Finer fine ends may be possible with specially selected fleeces.

CONCLUSION

Much is known about the raw wool properties that affect fabric comfort. This knowledge is now being enhanced by a research project initiated by the Department of Agriculture WA and Australian Wool Innovations. This project aims to identify the best next-to-skin wear garments and then determine the raw wool requirements for producing these garments (reverse engineering). The results of this project will be available next year.

KEY WORDS

fabric comfort, prickle, skin, fine ends

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Paper reviewed by: John Stanton, Department of Agriculture, Western Australia

REFERENCES

Naylor, G.R.S. and Phillips, D.G. (1996). Top-Tech, CSIRO, Geelong.

Naylor, G.R.S. (2002). *Wool Tech. Sheep Breed.*, 50(4): 698-704.

Sheep Updates 2003

Measuring fibre contamination post farm gate

Peter Sommerville, Corporate Development Manager, AWTA Ltd

KEY MESSAGES

The provision of a measurement of pigmented or medullated fibre content that can be used post farm gate is not practicable in every instance. However, until relatively recently, contamination of farm lots with pigmented and medullated fibres has been less of an issue in Australia than in other wool producing countries.

Historically the major source of dark fibre contamination in Australian adult merino wools is from urine stained fibres, with pigmented fibres being of secondary importance. This has changed with the introduction during the 1990s of meat-producing breeds of sheep with highly pigmented and/or medullated wool onto traditional merino wool producing enterprises. It has been demonstrated in some instances that contamination of the merino wool produced by these enterprises is now occurring, and this has generated an impetus to develop a post farm gate measurement system.

Fortunately, in such cases, due to the mechanism by which contamination occurs, such a measurement is possible using existing technology, albeit at considerable cost. Research is currently underway into optical, image analysis and other chemico-physico technologies to reduce the cost. In parallel to this work an effort is being made to implement a dark fibre risk scheme to provide better information post farm gate concerning the risk of contamination of merino wool that has always existed.

This presentation provides an update of the current situation.

OVERVIEW

The purpose of this presentation is to outline the present and future possibilities for measuring contamination by medullated and pigmented fibres post farm gate. The presentation reviews the available literature on this topic, outlines the technology that is currently available, and points to future technologies currently under consideration. In also draws attention to the serious limitations of post farm measurement systems.

BACKGROUND

Due to the efforts of studs and commercial wool growers to reduce objectionable fibre contamination, through animal selection, culling and clip preparation, Australian wool is conspicuously free of coloured fibres compared to wool of many other countries, and commands a premium because of this[7].

Coloured fibres may be either naturally pigmented fibres (black fibres) or fibres stained by urine. Pigmented fibres will always likely occur in some sheep, no matter how well bred, because the genes that produce them cannot be totally eliminated by traditional breeding techniques. Apart from the occasional ‘black sheep’ the expression of pigmented fibres may occur via small patches of such fibres on white sheep[11]. These often become more prevalent on older sheep[4].

Alternatively, pigmented fibres in wool may occur through contamination from coloured sheep running within a white mob[5] or by poor shed hygiene.

Historically, urine stain has been seen as the most significant source of coloured fibres in Australian wool[2]. Urine stained fibres almost always occur because of unsatisfactory crutching or the failure to crutch at all. Removal of urine stained fibres during skirting and classing is extremely difficult.

Spinners or weavers may specify levels of around 10-20 pigmented fibres per 100 grams of wool top (even less for some uses) before discounts (or claims) apply[7]. In the original greasy wool this corresponds to as few as 3-4 staples of stained or coloured fibres per bale. **Given that the sources of coloured fibres are normally patchy, it is difficult if not impossible to provide a reliable test of sale lots of greasy wool for such low levels of contamination. The major difficulty is obtaining an appropriate sample.**

The CSIRO Dark Fibre Detector (left) uses balanced illumination from above and below a thinly spread sample constrained between two glass plates to make objectionable fibres more visible. The SiroCLEAR™ technology (right) is an on-line optical sensing device that detects and removes contamination from undyed yarns.

In the early 1980s CSIRO developed an instrument, the Dark Fibre Detector, which can be used for routinely monitoring levels of dark fibre contamination in wool tops[1]. In principle this instrument can and has been used for examination of scoured and carded samples of greasy wool, but the sampling difficulties preclude its routine use for testing for contamination from pigmented fibres. Furthermore it is a very tedious labour intensive procedure, which means for routine testing of greasy wool it is very expensive.

CSIRO subsequently developed additional technology, SiroCLEAR™, an optical sensing device for examining yarns when they are wound from a bobbin onto a cone. It offers processors dramatic cost reductions in coloured contaminant detection and removal from undyed yarn in winding, and is capable of removing rust stains, black fibres, dirty fibres, vegetable material, strands of baling twine, and packing material residues.

The Dark Fibre Detector can therefore alert a processor that there is a problem in a particular top. The SiroCLEAR provides a spinner with a system for ameliorating a problem. In general neither is useful in preventing the problem in the first place.

Contamination of merino wool by imported non-merino breeds can occur by contact with the rams during mating, contact with the lambs and by running the breeds together.

EXISTING PREVENTATIVE MEASURES

Due to the inherent difficulties in sampling and testing greasy wool for contamination of sale lots by objectionable fibres, Australia has taken the approach of attempting to minimise this by emphasising on-farm management techniques rather than relying upon a presale test. These techniques were incorporated in the former Australian Wool Corporation's *'Code of Practice for Wool Preparation'*, and are maintained in AWEX's rules.

CONTAMINATION FROM IMPORTED NON-MERINO BREEDS

Over the past four years there has been an increasingly vigorous debate within the Australian Wool Industry about the risk of contamination of sale lots of merino wool by 'objectionable fibres' arising from the introduction of sheep breeds such as Damara, Dorper, Karukul, and Awassi. Farmers were encouraged to introduce these sheep during the 1980s[3] and some did so throughout the 1990s[15] because they believed that they could improve the economic performance of their businesses.

Research has shown that contamination of merino wool by exotic sheep or their crossbred offspring can occur via three mechanisms[9,10,11,12,14,16,17,18]:

- Contact of the ewes with the exotic rams during mating.
- Contact of the ewes with their offspring following such matings; and
- Penning coloured sheep and white sheep together close to shearing.

Contamination is unlikely if merinos are allowed to graze in paddocks previously grazed by exotic sheep, or in paddocks adjacent to exotic sheep[15].

The Australian Wool Exchange (AWEX) has introduced variations to clip preparation and marketing procedures that reinforce the risk of wool contamination in such situations. AWEX's Woolclasser Development Program, recently completed, has very actively promoted these changes to all of Australia's registered classers. Indeed, AWEX requires identification of potentially affected lots in all auction sale catalogues, via the addition of a Y suffix to the description of the wool.

There is evidence to suggest that such contamination can be effectively managed[9,10,11,13,14,17] on-farm. However, there is also evidence that such attempts at management are not always successful[16,18].

Furthermore, there have already been examples of commercial sale lots of wool being contaminated and causing substantial problems to processors.

MEASURING CONTAMINATION FROM IMPORTED NON-MERINO BREEDS

It has been shown that contamination from non-merino breeds, by the pathways indicated above, results in the contamination being relatively uniformly distributed over the contaminated fleeces. Further AWTA Ltd and the South Australian Research & Development Institute (SARDI) have demonstrated that a Test Method based on the CSIRO Dark Fibre Detector can be used to screen for the presence or absence of such contamination with a detection level that is sufficient to meet commercial requirements[16].

However, although this equipment is relatively inexpensive (AUD8000) the Test Method is highly labour intensive, requiring approximately five man-hours per test, which means that each test costs AUD150 (+GST). If every lot were to be routinely monitored then the cost would be much higher, due the physical space required. Despite this, as an interim measure, AWTA Ltd is providing a simplified screening service based on the Dark Fibre Detector, so that growers have a testing option if they require it. Meanwhile, the Company is employing its own resources and also collaborating with other researchers in an effort to develop a more cost effective test. Furthermore Australian Wool Innovation is also funding research by three other independent research groups to develop more efficient technologies.

However, because of the mechanisms via which contamination occurs, contamination from non-merino breeds is a special case. **It is most unlikely that any improvements to the current technology or new technologies arising from the research now under way will provide a catch-all measurement system for all instances of objectionable fibre contamination.**

IMPROVED MEASUREMENT SYSTEMS

A number of possibilities for technically improved and more efficient measurement of medullated and pigmented fibre contamination post farm gate are currently being considered. In general terms these involve:

- improving the efficiency of the existing dark fibre detector by making the contaminating fibres more visible in a larger mass of fibre than is currently possible;
- applying image analysis to identify and count objectionable fibres in washed core samples;
- using High Pressure Liquid Chromatography to measure the chemicals that cause pigmentation;
- adapting the principles embodied in the Dark Fibre Detector and the CSIRO SiroCLEAR to measure contamination in washed and carded core samples that have been semi-processed.

The first of these approaches is the most likely candidate for a significant improvement in the measurement technology in the short term. The remaining concepts are more long term.

TOWARDS A MORE HOLISTIC APPROACH

An improved post farm gate measurement system will not adequately address the entire problem of objectionable fibre contamination. It can only address the special case of contamination arising from contact with introduced non-merino breeds. Due to the inherent sampling difficulties no measurement system is likely to be capable of detecting of urine stain, or pigmented or medullated fibres that are naturally grown by merino sheep, with a commercially acceptable reliability. The industry therefore requires a more holistic approach. Ideally this will incorporate:

- on-farm management systems to minimise the risk of contamination from any source;
- systems for quantifying the level of risk of contamination given that the appropriate management system is followed;
- a low cost presale test for potential contamination arising from the special case of contamination from non-merino breeds;
- technology to quantify contamination of tops; and
- technology to remove any contamination from yarns.

Fortunately much of what is required is already in place, able to be put in place relatively quickly, or made available after some development effort.

On-farm management systems

On-farm management systems for minimising contamination from urine stain or pigmented fibres grown by merino sheep are already well established, with a demonstrated track record of success. On-farm systems for managing contamination by exotic sheep are not as well established, and some additional work is required to fully develop these. SARDI, the NSW Department of Agriculture and the Queensland DPI already have considerable expertise in this area and are already working actively to improve these systems. Any improvement in the measurement systems will assist progress in this area.

Dark fibre risk assessment

A system for quantifying dark fibre risk was developed by CSIRO during the 1980s[6, 8]. This did not incorporate risks associated with contamination from exotic sheep, but once practicable on-farm management systems are delineated this should prove to be a relatively simple task. The system does rely on wool growers providing correct information about their animal husbandry and wool management practices, but it is not simply a Vendor Declaration system, as has been reported in some of the Australian media. It is more than that.

The Federation of Australian Wool Exporters (FAWO) has taken on board a recommendation from AWTA Ltd that implementation of a Dark Fibre Risk analysis system, which does require industry cooperation, should be pursued. FAWO have made an application for funding from AWI to employ a professional for a fixed period to extend the risk analysis system to include contamination from exotic breeds and to define the information collection systems that will be required. This project has been approved and is currently underway.

Measurement post farm gate

AWTA Ltd has already implemented a presale screening service for contamination from exotic sheep based on the CSIRO Dark Fibre Detector. A promising adaptation of this technology to decrease the cost of the test for pigmented and urine stained fibres, as well as medullated fibres, has been identified and is being further developed, with reasonable prospects for its implementation within the short term. Any other technologies that arise from the research being funded by AWI may afford further improvements in the longer term.

In process detection and removal of contaminating fibres

The CSIRO Dark Fibre Detector technology already provides a capability for top makers and combers to quantify contamination in their tops. Any developments on the raw wool side will ultimately provide benefits here as well.

Technology to remove contamination from yarns, SiroCLEAR, already exists and can be used by top makers, combers and spinners for further quality control.

The extent to which the processors need to rely on measurements on tops and yarns will ultimately be dictated by the levels of contamination that occur in all the greasy wool supplied to them. The key element in reducing their risk is a reliable Dark Fibre Risk Assessment system. Australia has an opportunity to even more definitively differentiate the quality of its wool from that of its competitors by implementing such a system.

KEY WORDS

contamination, dark fibre, exotic breeds, measurement

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BIBLIOGRAPHY

[1]Foulds, R.A. *'Preparation and Dark Fibre Contamination'*, Seminar Proceedings: Clip Preparation Research, CSIRO Division of Textile Physics & Australian Wool Corporation (Research & Development), April 1983.

[2]Foulds, R.A., Wong, P. and Andrews, M.W. *'Dark Fibres and their Economic Importance'*, Wool Technology & Sheep Breeding, 32(2): 1984.

[3]Fisher, B.S. and Gooden, J.M. *'An economic and technical assessment of the establishment of an Australian fat-tail sheep industry'*, Research Report 10. Department of Agricultural Economics, University of Sydney, 1986.

[4]Fleet, M.R. *'Pigmented Fibres in White Wool'*, Wool Technology & Sheep Breeding, 33(1): 1986.

[5]Fleet, M.R., Stafford, J.E., Dawson, K.A. and Dolling, C.H.S. *'Contamination of white wool by melanin-pigmented fibres when pigmented and white sheep graze together'*, Australian Journal of Experimental Agriculture, 26: 159-163, 1986.

[6]Foulds, R.A. *'Dark Fibre Contamination in Wool - Its Prediction and Ramifications'*, Seminar Proceedings: Technical Feasibility of Sale by Description, CSIRO Division of Textile Physics, July 1988.

[7]Teasdale, D.C. *'The Wool Handbook: the A to Z of Fibre to Top'*, 1988 (revised 1995).

[8]Burbidge, A. and McInnes, C.B. *'Dark Fibre Risk and Prediction, Seminar Proceedings: Specification of Australian Wool and Its Implications for Marketing and Processing'*, CSIRO Division of Wool Technology and the International Wool Secretariat, November 1994.

[9]Hatcher, S., Foulds, R.A., Lightfoot, R.J. and Purvis, I.W. *'The relative wool contamination potential of Awassi and black Merino sheep when penned together with white Merinos'*, Australian Journal of Experimental Agriculture, 39: 519-528, 1999.

[10]Hatcher, S., Lightfoot, R.J. and Purvis, I.W. *'Mating Awassi rams to Merino ewes causes an initial level of fibre contamination which decreases to an insignificant level eight weeks post-mating'*, Australian Journal of Experimental Agriculture, 40: 363-369, 2000.

[11]Fleet, M.R. *'Dark Fibre Control in Sheep and Wool'*, PIRSA/SARDI Fact Sheet Agdex 437/30, South Australian Research & Development Institute, Turretfield Research Centre, Rosedale SA 5350, July 2000 © PIRSA/SARDI.

[12]*'Wool Contamination - Pigmented and heavily medullated fibres'*, PIRSA/SARDI Fact Sheet Agdex 437/85, Malcolm Fleet, South Australian Research & Development Institute, Turretfield Research Centre, Rosedale SA 5350, October 2000.

[13]Hatcher, S., Lightfoot, R.J. and Purvis, I.W. *'Previous Awassi grazing on a paddock or grazing in the same or adjoining paddock, does not cause fibre contamination of fleeces of Merino sheep'*, Australian Journal of Experimental Agriculture, 40: 379-385, 2000.

[14]Hatcher, S., Lightfoot, R.J. and Purvis, I.W. *'Transfer of contaminant lamb fibres to their dam's fleece, and loss within four weeks of weaning'*, Australian Journal of Experimental Agriculture, 40: 371-378, 2000.

[15]Douglas, S.A.S. *'Exotic Sheep Breeds in Australia - a Status Report'*, AWTA Ltd Fact Sheet 16, January 2001.

[16]Fleet, M.R., Mahar T.J. and Denney S.I. *'The detection of pigmented and medullated fibre in core samples of commercial sale lots from Merino ewes mated to Damara fat-tail rams'*, Report CTF 02, Commercial Technology Forum, Nice Meeting, November 2001.

[17]Hatcher, S. *'Fibre Medullation, Marketing and Management'*, NSW Agriculture, 2002.

[18]Fleet, M.R., Mahar, T.J. and Turk, J.A. '*Merino Crossbreeding and Objectionable Sheep Fibres: The Problem and Potential Solution'*, Paper 41, Wool Industry Science and Technology Conference, October 2002, Hamilton, Victoria, Australia.
