The following pages include practical information that the Sheep CRC has developed from the scientific research carried out during 2007–2014.

It is intended as a source of information to help the Sheep Industry put into practice some of these new ideas.
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Knitted wool fabrics can have soft handle but still prickle

By David Tester, Sheep CRC

Key points
- Wool fabric softness and next-to-skin comfort are poorly related characteristics.
- A move away from using subjectively measured softness to indicate next-to-skin comfort is required.

Introduction

Processors and wearers still often judge the comfort of lightweight wool knitwear by squeezing the fabric to gauge how ‘soft’ it is, believing a softer feel or ‘handle’ will provide an excellent wearing experience and not prickle or irritate the skin. However, Sheep CRC research has shown this relationship to be unreliable.

Reliance on this relationship means that uncomfortable wool knitwear is being produced and sold, which continues to reinforce the notion that wool is a prickly fibre.

New objective testing devices for comfort and handle provide the opportunity to ensure all wool garments are fit for purpose and positively reinforce the exceptional comfort properties of wool.

How are fabric handle and comfort measured?

Handle describes the feel or softness of a fabric and is mainly influenced by fabric weight, thickness and density; there is little effect from the mean fibre diameter of the wool.

The Sheep CRC has developed and commercialised the Wool HandleMeter, a device that measures the softness of a finished fabric by the force required to push the fabric through a nozzle in the instrument. Handle is quite different from how comfortable the fabric will be when it is worn next to the skin.

Comfort (or the level of prickle) is measured with a different device, the Wool ComfortMeter (also developed by the Sheep CRC). The device primarily measures the resistance to bending of the fibre ends protruding from the fabric.

Comfort is strongly related to mean fibre diameter, with wools having an average fibre diameter of less than 18 microns being very comfortable, and as the wool becomes broader, it becomes less comfortable.
How are fabric handle and comfort related?

The objective measurement of both handle and comfort on fabrics, with the two Sheep CRC developed meters, demonstrated that fabric softness and prickle are two unrelated fabric attributes.

Figure 1 shows the measured relationship between the level of prickle and the softness of each knitted fabric from the wearer trials. There is a broad scatter of results showing four extremes: soft handle/high prickle; soft handle/low prickle; hard handle/high prickle; hard handle/low prickle, as well as combinations in between.

If the industry-accepted relationship was true then the graph should have the points concentrated in a band from top left (hard handle and high prickle rating) to the bottom right (very soft handle and no prickle).

However, the graph shows no strong relationship between the fabric softness and the wearer assessed prickle rating. Some of the softest fabrics (values above 7) are also the fabrics with the lowest prickle rating; these fabrics conform to the general industry understanding. However, there are fabrics that are still very soft (values above 6.5) that have quite high prickle ratings. Similarly, there are fabrics with very low prickle ratings (values less than 2) that are not very soft.

The introduction and widespread use of the Wool ComfortMeter and the Wool HandleMeter will replace the subjective appraisal of fabric comfort and softness with accurate, objective measures of the prickle propensity and the softness of wool fabric or garments.

Take home messages

- Knitters (sourcing yarns) and garment makers and retailers (sourcing fabrics) can assure comfort directly using objective measurement with the Wool ComfortMeter, rather than indirect subjective assessment of comfort based on the softness of the yarn and fabric.
- Knitters, garment makers and retailers can achieve the combination of comfort and handle to meet all retail and consumer requirements by specifying desired values and limits from tests using the Wool ComfortMeter and Wool HandleMeter.
- Wool producers should be prepared for increased future demand for high comfort ultrafine wools, but current production of good quality fine wool is available to meet the immediate needs.
Figure 1. Measures of prickle and softness for selected knitted wool fabrics.

Further information

- The Wool ComfortMeter: www.woolcomfortmeter.com.au
- The Wool HandleMeter: www.woolhandlemeter.com.au

Acknowledgements

Research team: Bruce McGregor and Maryam Naebe (Deakin University); Henry Wang and Trevor Mahar (AWTA); John Stanton, Sara Pieruzzini and Jane Speijers (DAFWA); Geoff Naylor, David Fox and Don Ramsay (CSIRO); David Tester (Sheep CRC).
‘Wool Comfort Factor’ does not predict garment comfort

By David Tester, Sheep CRC

Key points

- The Wool Comfort Factor test has limited value in predicting final garment comfort.
- Fabric and garment comfort can be predicted by testing yarns with the Wool ComfortMeter.
- Wools less than 18 microns should be chosen for next-to-skin wear.

Introduction

Until recently, the spinner and knitter have had no direct measure of the potential for their products to be suitable for next-to-skin applications. Early stage processors had one measurement to indicate the comfort potential for wool: the ‘Wool Comfort Factor’, however, Sheep CRC research has shown this measure of fibre diameter distribution poorly predicts whether knitted fabric made from wool is likely to prickle.

The opportunity for an accurate comfort measurement on raw wool or yarn would offer more certainty for spinners, knitters and garment makers producing next-to-skin apparel.

Can raw wool or yarn measurements indicate fabric comfort?

The Wool Comfort Factor test is carried out on raw wool or wool top during the measurement of the mean fibre diameter. The Wool Comfort Factor is the proportion of the measured fibre snippets that are less than 30 microns in diameter.

The Sheep CRC tested the comfort of wool fabrics (using wearer trials) and compared these with their Wool Comfort Factor results to see their relationship. Figure 1 shows that finished garments made from wool with a Wool Comfort Factor above 99.5% were associated with a Wearer Prickle Rating of less than 2 (prickle is below a threshold detection value). However, when wools with Wool Comfort Factors below 99.5% were used they were associated with a wide variety of wearer prickle ratings from 2 to nearly 4.
As such, the Wool Comfort Factor test has limited value in predicting the final garment comfort.

Fortunately, the Sheep CRC has extended the application of the Wool ComfortMeter (initially developed to test wool fabrics) to be able to measure yarn and from the yarn values to predict the potential fabric values.

This has extended the application of the measurement from knitters and retailers to also include spinners that wish to predict the comfort of fabric based on their yarn. The advantage of the test occurring earlier in the supply chain is that it saves the cost and time associated with preparing the fabric sample for testing and can be done prior to spinning the whole consignment. Alternatively, finished yarns can be tested to determine their predicted next-to-skin comfort and therefore their suitability for lightweight knitwear.

Sheep CRC research has shown that by choosing raw wools with a mean fibre diameter of less than 18 microns was the first step in ensuring the fabrics would be comfortable for next-to-skin wear.

Figure 1. Mid-side sample test showing a Wool Comfort Factor result.

Figure 2. Wool ComfortMeter.
Take home messages

- Early stage processors should identify the end-product and ensure consignments of wool destined for spinners of yarn for next-to-skin knitwear are below a mean fibre diameter of 18 microns, rather than use the Wool Comfort Factor test as an indicator of fabric comfort.
- Spinners can prepare a yarn sample and test this with the Wool ComfortMeter to gain an early determination of the suitability of yarns for next-to-skin applications.
- Wool producers already supply suitable wool for immediate needs, but the new technology and the expected demand increase for lightweight knitwear may require greater production in the ultrafine range.

Further information

- www.woolcomfortandhandle.com

Acknowledgements

John Stanton, Sara Pieruzzini and Jane Speijers (DAFWA); Bruce McGregor and Maryam Naebe (Deakin University); David Tester (Sheep CRC).
Wools of 18 microns and finer provide next-to-skin comfort

By David Tester, Sheep CRC

Key points
- Fibre diameter is the single most important wool characteristic affecting comfort in knitted fabrics.
- Wool with a mean fibre diameter under 18 microns guarantees comfort.
- A move away from commonly used 18–19 micron wools is required.

Introduction

Some consumers still perceive wool as too itchy and uncomfortable for next-to-skin wear because many garments are made from raw wool not ideal for this purpose.

Unfortunately, spinners and knitters have had no direct measure of next-to-skin comfort and have relied on older research suggesting wool up to 19 microns would provide comfort, however, negative consumer feedback continues to cast doubt on the accuracy of this specification.

Providing objectively measured incentive to use finer wools in next-to-skin applications should improve both the performance of wool as well as increase demand for finer wools in this growing product category.

How can comfort be measured?

The Sheep CRC has developed a measurement device, the Wool ComfortMeter, which provides the most accurate prediction of the prickle propensity of knitted wool fabric. The Wool ComfortMeter results were validated with a series of wearer trials with garments worn under controlled conditions to determine their comfort.

An average wearer prickle rating of 2 was found to be the threshold under which garments were considered comfortable for next-to-skin wear. An average wearer prickle rating of 4 was associated with extreme discomfort by many wearers. While a number of factors were found to influence comfort, fibre diameter was, by far, the most important.

All knitted fabrics in the trial made from wools finer than 18 microns were rated less than 2. Most, but not all, garments made from wool above 18 microns were above 2, which meant that on average a level of prickle could be detected.
Wool above 18 microns provides variable results and the likelihood of greater levels of prickle increases as the average fibre diameter increases, however, some fabrics in this category are suitable for next-to-skin wear and can be identified by testing with the Wool ComfortMeter. The Wool ComfortMeter is now for sale through AWTA and their global distributors with a commercial service being offered by test houses in China, England and Australia.

What other factors affect comfort?

For wools above 18 microns the effects of spinning, knitting and finishing have a significant influence on the final fabric performance, with some of these wools able to achieve a desirable comfort level.

Raw wool specifications or processing that reduces the average fibre length in the yarn is likely to make the prickle performance worse; with shorter fibres there are more fibre ends in the yarn. Processing that reduces the average fibre length of the fibres protruding from the fabric is also likely to make prickle worse because shorter fibres prickle more as they do not bend as easily as longer fibres.

The second most important factor for predicting the average wearer prickle rating of lightweight knitted fabrics is the count of the yarn. Fabrics with finer yarns produced more comfortable garments but the effect is only 5% of that of mean fibre diameter.
**Take home messages**

- Spinners and knitters aiming to guarantee next-to-skin comfort in knitted fabrics should use raw wool of 18 microns or finer.
- Knitters can use the Wool ComfortMeter to test fabrics made from wools to see whether they will provide suitable wearer comfort.
- Wool producers should be prepared for higher demand for wools of 18 microns or finer in the future, although current production is likely to meet short-term demand.

**Further information**

- The Wool ComfortMeter: www.woolcomfortmeter.com.au

**Acknowledgements**

Research team: Bruce McGregor and Maryam Naebe (Deakin University); John Stanton, Sara Pieruzzini and Jane Speijers (DAFWA); Geoff Naylor, David Fox and Don Ramsay (CSIRO); David Tester (Sheep CRC).
Staple strength—use genetics to make real progress

By Sue Hatcher, NSW DPI

Key points
- Staple strength is important in determining the value of your clip.
- Controlling staple strength by on-farm management techniques is difficult.
- An appropriate breeding strategy allows staple strength and other key price drivers of your wool to be improved.

Introduction
Along with staple length (SL) and fibre diameter (FD), staple strength (SS) is an important predictor of hauteur, coefficient of variation of hauteur and romaine, which are key early stage processing performance parameters. Therefore, it is not surprising that staple strength is consistently second only to fibre diameter as a major determinant of the value of raw wool. In general, wool that measures 35 N/ktex is considered ‘sound’ and this figure is used as the benchmark for reporting staple strength premiums and discounts. Historically, the premiums and discounts applied to wools of varying staple strength are considerably greater for fine wools compared to medium wools. Objective measurement of staple strength was developed to provide an indication of potential fibre breakage during early stage processing, specifically for testing sale lots of wool.

What influences staple strength?
Wool staples consist of many hundreds of single wool fibres and the measured strength in Newtons/kilotex (N/ktex) of a staple is controlled by four different biological components:
- variation in fibre diameter along fibres
- variation in fibre diameter between fibres
- follicle shutdown
- intrinsic fibre strength

However, it is the variation in the fibre diameter along a wool fibre and variation in fibre diameter between fibres within the staple that have the biggest impact on staple strength.
Pregnancy and lactation can have a significant impact on staple strength with reductions of up to 45% reported for ewes raising twins compared to dry sheep. Reproduction data of the Sheep CRC Information Nucleus Flock (INF) ewe progeny, first joined at 19–21 months of age, indicate that dry ewes had the highest staple strength, followed by single-bearing ewes, while twin-bearing and lambed-and-lost ewes were not different to each other (Table 1).

<table>
<thead>
<tr>
<th>Mean (N/ktex)</th>
<th>Pregnancy Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td>All INF ewes</td>
<td>35.0</td>
</tr>
<tr>
<td>Ultrafine/Superfine</td>
<td>36.1</td>
</tr>
<tr>
<td>Fine/Fine-Medium</td>
<td>36.0</td>
</tr>
<tr>
<td>Medium Strong</td>
<td>34.2</td>
</tr>
</tbody>
</table>

Figure 1. Staple strength is a major determinant of wool value.

How can environmental differences in staple strength be managed?

Previous research found that live weight could be used as a proxy for changes in the fibre diameter profile, therefore, minimising live weight variation over a full year should reduce variability in wool growth, fibre diameter variability and hence, staple strength. However, these strategies are not always effective, results varied between autumn- and spring-shorn wools and with the age of the animal, its sex and pregnancy status.

The genetics of staple strength

Given the large impact of the environment and the variable responses to on-farm strategies to manage staple strength, genetic improvement of the trait is an important approach to generate long-term improvements. The heritability of yearling staple strength (YSS; 11 months) is 0.23 while that of adult staple strength (ASS; 23 months) is 0.25; both would be classified as moderately heritable traits.
Staple strength, however, is only one of a suite of wool quality traits that impact on the price paid for wool, so selection decisions must be made on the full array of traits that impact on Merino enterprise profitability. It is, therefore, important to take into account the genetic relationships with other traits including live weight, wool production and both visual and measured wool quality, shown in Table 2.

It is important to note that breeding objectives that aim to improve the various visual wool quality traits, live weight, wool production, fibre curvature, mid-breaks and brightness will produce correlated increases in staple strength, although of a low magnitude. However, the high unfavourable genetic correlation between fibre diameter and staple strength means that breeding objectives that aim to reduce fibre diameter will lead to lower staple strength unless some selection pressure is placed on staple strength. For this reason, it is recommended that commercial producers aiming to reduce the fibre diameter of their wool clip should purchase rams with a higher Yearling Staple Strength (YSS) ASBV (preferably above zero).

Table 2. Genetic correlations* between staple strength, visual wool quality traits, off-shears live weight and wool production and measured wool quality traits (2008–2012 INF shearings).

<table>
<thead>
<tr>
<th>Visual Wool Quality Scores</th>
<th>YSS</th>
<th>ASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td></td>
<td>Neg</td>
</tr>
<tr>
<td>Character</td>
<td>–0.32 ✓</td>
<td>–0.22 ✓</td>
</tr>
<tr>
<td>Dust</td>
<td>–0.37 ✓</td>
<td>–0.21 ✓</td>
</tr>
<tr>
<td>Weathering</td>
<td>–0.36 ✓</td>
<td>–0.33 ✓</td>
</tr>
<tr>
<td>Fleece rot</td>
<td>–0.22 ✓</td>
<td>Neg</td>
</tr>
<tr>
<td>Staple structure</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Handle</td>
<td>–0.25 ✓</td>
<td>Neg</td>
</tr>
<tr>
<td><strong>Live weight and wool production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-Shears Live Weight</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Greasy Fleece Weight</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Yield</td>
<td>0.45 ✓</td>
<td>0.36 ✓</td>
</tr>
<tr>
<td>Clean Fleece Weight</td>
<td>0.28 ✓</td>
<td>Neg</td>
</tr>
<tr>
<td><strong>Measured wool quality</strong></td>
<td>YSS</td>
<td>ASS</td>
</tr>
<tr>
<td>Fibre Diameter</td>
<td>0.36</td>
<td>0.54</td>
</tr>
<tr>
<td>Fibre Diameter Standard Deviation</td>
<td>–0.42 ✓</td>
<td>–0.29 ✓</td>
</tr>
<tr>
<td>Coefficient of Variation of Fibre Diameter</td>
<td>–0.70 ✓</td>
<td>–0.61 ✓</td>
</tr>
<tr>
<td>Curvature</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Resistance to Compression</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Staple Length</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Mid-breaks</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>Brightness (Y)</td>
<td>0.37 ✓</td>
<td>Neg</td>
</tr>
<tr>
<td>Yellowness (Y–Z)</td>
<td>Neg</td>
<td><strong>0.68</strong></td>
</tr>
</tbody>
</table>

* Neg = Negligible correlations (<0.2), low correlations (0.2–0.4) are in normal text, medium correlations (0.4–0.6) are in bold text and high correlations (>0.6) are shaded. ✓ indicates a favourable genetic relationship.
Take home messages

- Staple strength is a measurement of a material property and unlike other wool production and quality traits has no single, simple biological basis. This contributes to the large differences in phenotypic expression of the trait, which makes on-farm management to improve staple strength problematic.
- Genetic improvement of staple strength is an important means to produce long-term improvements in staple strength. For commercial producers, selection of sires with a positive staple strength ASBV, while also choosing a lower FD ASBV can generate simultaneous decreases in fibre diameter and improvements in staple strength and overcome the unfavourable genetic correlation between these two traits.
- Coefficient of variation of fibre diameter can be reliably used as an alternative selection criterion for staple strength when selecting replacement animals to enter either the breeding flock or wool growing mob in a self-replacing Merino enterprise.

Further information

- Sheep Genetics  www.sheepgenetics.com.au
- NSW DPI  www.dpi.nsw.gov.au
- AWI  www.wool.com

Acknowledgements

Research team: Sue Hatcher and James Preston (NSW DPI)

We acknowledge the dedicated team of scientists and technical staff at each of the eight Information Nucleus Flock sites who are responsible for management of each of the flocks and implementation of the comprehensive sampling, assessment and measurement protocols.
Implications of wool measurement systems for producers

Philip Attard, Gostwyck, NSW

The ability of the Wool ComfortMeter and HandleMeter to provide objective information to the supply chain will create clear product differentiation for the next-to-skin trade and the opportunity for price premiums for ultrafine and superfine Merino wools for producers like Philip Attard of Gostwyck Merino.

About Philip Attard

Philip Attard is a businessman who operates the superfine and ultrafine wool enterprise at Gostwyck, in the New England Tablelands of NSW.

Mr Attard’s business experience includes building successful information technology enterprises, holding senior executive roles in sales, marketing, strategic planning and general management, with firms in Europe, North America, Asia and Australia. He is a Director of Graziers Investment Company and Chair of the Sheep Genetics Advisory Committee.

Mr Attard is now focusing his attention on the family business, Gostwyck Merino, which produces ultra-fine and super-fine Merino wool for the next-to-skin trade.

“We want to make sure that the quality of Gostwyck Merino is always comfortable next-to-skin,” he said.

“Growth in demand for superfine and ultrafine Merino can only come by expanding wool’s use in the next-to-skin market and that means dealing with wool’s reputation for being itchy or prickly next-to-skin.

“Having the Wool ComfortMeter available to retailers means that they can be absolutely certain through an independent source that our product is comfortable next-to-skin.

“As a result they will gain confidence in our brand and they will have confidence in the wools that we are producing.”
The Wool ComfortMeter quantifies how comfort levels improve with finer micron wools all the way down to 13.5 micron, creating a clear product differentiation and the opportunity for price premiums for superfine and ultrafine wools for next-to-skin applications.

Take home messages

- The wool industry needs to constantly sell the quality of pure superfine and ultrafine Merino as being totally comfortable.
- To create new demand for next-to-skin wool garments, industry must tackle consumer perceptions of wool as prickly.
- The Wool ComfortMeter and Wool HandleMeter demonstrate that if manufacturers and retailers wish to produce and market a superior next-to-skin product they must invest in a supply chain that uses pure superfine and ultrafine Merino wool.

Further information

Detailed fact sheets on the Wool ComfortMeter and Wool HandleMeter technology and how they benefit different areas of the wool supply chain, are available at www.woolcomfortandhandle.com.

- Companies wishing to test fabrics should contact AWTA, textiles@awta.com.au, or call +61 (03) 9371 2400.
- www.gostwyck.com
Implications of wool measurement systems for retailers

Natalie Skubel, Country Road

The objective data on offer from the Wool ComfortMeter and HandleMeter will provide garment retailers like Country Road the quality assurance system they need to ensure the wool garments are of a consistent standard that meets customer expectations for quality and comfort.

About Natalie Skubel

Natalie Skubel is the General Manager of Sourcing at Country Road, one of Australia’s leading fashion retailers and an early participant in the Sheep CRC’s research into the objective measurement of wool comfort and handle.

The Wool ComfortMeter counts the number of fibres protruding from a fabric that could cause wearer discomfort, and then accurately predicts a consumer’s response—crucial information for next-to-skin fabric manufacturers.

Wool ‘handle’ had traditionally been measured subjectively by judges, who often had differing views on a fabric’s smoothness, softness, hairiness, tightness and perceived weight. The Wool HandleMeter overcomes this with objective data.

Ms Skubel believes the Wool ComfortMeter and HandleMeter will assist her business in managing consistency of quality across seasons, as well as reducing the complexity of the buying process.

“The garment hand feel is the result of extensive product development in yarn and garment finishing,” she said. “Once established, the same high-quality hand feel must be maintained for garments season after season—it is vital for encouraging consumers to re-purchase garments.”

Ms Skubel said the biggest factor that impacts the quality of garments on the shop floor is the spinning process, and what the knitter then does to that yarn when producing garments out of it.
“There are some really important applications for both these tools at the back-end of the product development process and we see a particular benefit in the finishing and final processing of the woollen material,” she said.

“That objective data from these tools enables us to consistently replicate the kind of comfort, handle and hand feel that we want to deliver to our customers.”

Take home messages

● Wool comfort and handle are critical to the process of fabric selection and garment design.
● The Wool ComfortMeter and Wool HandleMeter allow retailers to set strict specifications and source fabric and garments of a consistent standard.
● The technology provides retailers and brands with a means of differentiating their next-to-skin Merino wool products, enhancing consumer trust and increasing their willingness to pay a premium for Australian wool.

Further information

Detailed fact sheets on the Wool ComfortMeter and Wool HandleMeter technology and how they benefit different areas of the wool supply chain, are available at www.woolcomfortandhandle.com.

● www.sheepcrc.org.au
● www.countryroad.com.au