Australian Cashmere Research Workshop Proceedings 2004

Proceedings Australian Cashmere Workshop
Newcastle 7th May 2004

By Andrew James
Australian Cashmere Growers Association

April 2005

RIRDC Web-only publication no W05/041
RIRDC Project No WS034-16
## Contents

**R&D FOR THE AUSTRALIAN CASHMERE INDUSTRY** ........................................ 4  
Peter McInnes ........................................................................................................ 4  

**Investigation into the Basis of Down Production in Cashmere Goats and its Improvement by Genetic Means.** ............................................................... 8  
R.J.Browne and R.G.Pearce .................................................................................. 8  

**Cashmere production in Mongolia** ................................................................. 19  
Bolormaa Sunduimijid ........................................................................................... 19  

**Breeding for worm resistance in Cashmere goats.** ...................................... 24  
Steve Walkden-Brown, Muyiwa Olayemi and ..................................................... 24  
Julius Van Der Werf .............................................................................................. 24  

**National evaluation of sires for the production of quality Cashmere** .......... 33  
Steve J. Gray, John T.B. Milton and Graeme B. Martin ................................. 33  

**What Fibre Properties Are Important In Processing Cashmere On The Worsted System?** ................................................................. 35  
Martin Prins ......................................................................................................... 35  

**Cashmere benchmarking shows industry has the potential to increase fleece value by 35%** ................................................................. 42  
Bruce McGregor ................................................................................................. 42  

**You've got to be attractive to sell: a commercial view of the cashmere industry** ................................................................. 48  
Stephen Chaffey and Bruce McGregor ............................................................... 48
R&D FOR THE AUSTRALIAN CASHMERE INDUSTRY
Peter McInnes

Rural Industries Research and Development Corporation, www.rirdc.gov.au
Email: mcinnes2@comstech.com

Abstract
The Australian Cashmere Industry provides levies that contribute to R&D undertaken through the Australian government Rural Industries R&D Corporation (RIRDC). The R&D is administrated through a sub-program (RNF) that covers rare natural animal fibres and has a total budget of $240,000 for 2003/2004. Four cashmere projects are being funded in 2003/2004 and are in line with a five year plan developed by industry and RIRDC. Some past and present projects will be addressed in other papers at the Workshop. The future direction of RNF includes more R&D with potential commercial outcomes and projects with industry to increase productivity and production.

Media Summary
The Australian Cashmere Industry with the Rural Industries R&D Corporation are undertaking R&D to increase the productivity and production of cashmere fibre.

Key Words
Cashmere; R&D; Funding; Outputs; Future.

About RIRDC
The RIRDC administers part of the Australian government national research priorities by fostering the development of new rural industries – both prospective and emerging, managing R&D investments for some established industries and also addressing strategic cross-sectoral issues facing the rural sector (RIRDC Corporate Plan 2003-2008). The Corporation which was established by the Primary Industries and Development Act 1989 is administered by a Board that is mainly selected by industry and has a Chairperson selected by the Australian government. The functions and every-day operations of RIRDC is from Canberra. There are 18 full time staff and some part-time research managers such as myself.

Funding of RIRDC
The total revenue for the Corporation which comes from federal government ($14.6m), levies ($3.6m) and external contributions were $22.4m in 2002/2003 and the total expenditure was $22.0m of which $17.9, was spent directly for R&D (RIRDC Annual Report 2002/2003). The balance is spent on Corporation’s salaries etc and supplier expenses including program communication and co-ordination costs.

R&D Operational Structure 2003/2004
A brief outline of the operational structure is given in Table 1.
Table 1. Operational structure in RIRDC (2003/2004)

<table>
<thead>
<tr>
<th>Program 1</th>
<th>New and Emerging Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub Programs (7) include</td>
<td></td>
</tr>
<tr>
<td>• Rare Natural Animal Fibres</td>
<td></td>
</tr>
<tr>
<td>Others for example</td>
<td></td>
</tr>
<tr>
<td>• New Plant Products</td>
<td></td>
</tr>
<tr>
<td>• New Animal Products</td>
<td></td>
</tr>
<tr>
<td>• Food Integrity and Biosecurity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Program 2</th>
<th>Established Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub Programs (8) includes for example</td>
<td></td>
</tr>
<tr>
<td>• Rice</td>
<td></td>
</tr>
<tr>
<td>• Horses</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Program 3</th>
<th>Sustainable Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub Programs (4) includes</td>
<td></td>
</tr>
<tr>
<td>• Agroforestry</td>
<td></td>
</tr>
<tr>
<td>• Organics</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Program 4</th>
<th>Capacity Building and Competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub Programs (3) include</td>
<td></td>
</tr>
<tr>
<td>• Food Integrity and Biosecurity</td>
<td></td>
</tr>
</tbody>
</table>

Funding Rare Natural Animal Fibres Sub-Program RNF
The RNF Sub-Program (subsequently referred to as program) can incorporate cashmere, mohair, alpaca fibre, camel hair and other rare fibre projects (RIRDC Annual Operational Plan 2003-2004). The goat (mohair and cashmere) provided $40,000 in 2002/2003 from statutory levies based on value of fibre production. On average cashmere provides these days about one third of the total levies collected.

The total budget for R&D has also a voluntary contribution from the Alpaca industry of $20,000. The rest of funding comes from the Australian government. The total budget or expenditure of recent years is in Table 2.

Table 2. Funding of the Rare Natural Fibres Program

<table>
<thead>
<tr>
<th>Year</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004/2005</td>
<td>265,000</td>
</tr>
<tr>
<td>2003/2004</td>
<td>240,000</td>
</tr>
<tr>
<td>2002/2003</td>
<td>215,000</td>
</tr>
<tr>
<td>2001/2002</td>
<td>215,000</td>
</tr>
<tr>
<td>2000/2001</td>
<td>190,000</td>
</tr>
<tr>
<td>1999/2000</td>
<td>180,000</td>
</tr>
</tbody>
</table>

Expenditure for Cashmere
The number of projects and expenditure (or budget) for Cashmere projects in recent years is given in Table 3.
Table 3. Expenditure (or budget) for the Cashmere Industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Projects</th>
<th>Value ($)</th>
<th>Other Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004/2005</td>
<td>4</td>
<td>36,500</td>
<td></td>
</tr>
<tr>
<td>2003/2004</td>
<td>4</td>
<td>27,800</td>
<td>5,000</td>
</tr>
<tr>
<td>2002/2003</td>
<td>4</td>
<td>44,950</td>
<td>2,500</td>
</tr>
<tr>
<td>2001/2002</td>
<td>1</td>
<td>16,000</td>
<td>900</td>
</tr>
<tr>
<td>2000/2001</td>
<td>3</td>
<td>27,675</td>
<td>5,000</td>
</tr>
<tr>
<td>1999/2000</td>
<td>2</td>
<td>32,900</td>
<td>2,500</td>
</tr>
</tbody>
</table>

R&D Plan
A five year R&D Plan for the program is developed every five years by RIRDC, the industry associations and the Program’s Advisory Committee. The latter includes two representatives nominated by the Australian Cashmere Growers Association Dr Andrew James and Noel Waters. The present plan (RIRDC Rare Natural Animal Fibres Program 2003-2008) has three goals –

Goal 1 – Develop New Opportunities
Goal 2 – Stimulate Industry Partnerships and Adoption
Goal 3 – Increase Competitiveness, Capability and Capacity

Annual Operational Plan
In August of each year the RIRDC calls for R&D proposals for funding in the following financial year (RIRDC Research Priorities 2004-2005). These proposals are considered by the Advisory Committee and full submissions are invited from those judged worthy of funding. By May a final decision is given to the organisation submitting the project. Some projects such as a breeding/genetic objective might be for a period of 5 to 6 years. Others can be as short as one year.

Notable Outcomes
A list of titles of reports published during the last five years are included in Table 4. Many of the reports will be referred to other addresses

Table 4. Titles of published reports

<table>
<thead>
<tr>
<th>Titles of published reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Cashmere – Attributes and Processing</td>
</tr>
<tr>
<td>Down production on Cashmere Goats</td>
</tr>
<tr>
<td>Increased Production of Mohair and Cashmere</td>
</tr>
<tr>
<td>Innovative Processing of Rare Natural Fibres</td>
</tr>
<tr>
<td>Nutrition of Goats during droughts</td>
</tr>
<tr>
<td>Palatability and Potential Toxicity of Australian Weeds to Goats</td>
</tr>
<tr>
<td>Properties and Performance of Goat Fibre</td>
</tr>
<tr>
<td>Water quality and Provision for goats</td>
</tr>
</tbody>
</table>

Future Direction
In Table 5 future directions are given for RNF
Table 5. Future Direction for RNF

- Towards Commercialisation
- Industry Partnership
- Overseas Linkages
- Value Adding
- Improving Genetics
- Greater production per animal
- Finer Fibre
- Facilitating Optimal Marketing
- Move livestock producers diversifying into RNF
- Support for industry priorities for R&D

References
RIRDC Corporate Plan 2003-2004
RIRDC Annual Report 2002-2003
RIRDC Annual Operational Plan 2003-2004
R&D Plan – RIRDC Rare Natural Animal Fibres Program 2003-2008
RIRDC Priorities 2004-2005

These publications are available from www.rirdc.gov.au
Investigation into the Basis of Down Production in Cashmere Goats and its Improvement by Genetic Means.

R.J.Browne and R.G.Pearce

*The following paper prepared for the ACGA May 2004 Research Workshop is made up of extracts from this recently released report.*


A hardcopy has been printed - 101pp, includes a CD-ROM, Pub No. 04/027. The CD contains all the research data, many extra charts, a simple breeders database program etc

Report No: R04-027 - Post Weight: 0.30 kg, Price $26.00 posted.  

Once there - go to New and Emerging Industries/ Rare Natural Animal Fibres /2004

**Background**

**The basic restriction on sustained growth of the Australian Cashmere Industry is economic and the primary economic restriction is 'production per head'**.

The opportunity to combine, the selection of superior animals with a controlled environment and some lateral thinking on the consequences of production observations, led to the formulation of this research project.

A group of 120 females and 3 males were selected and the females introduced into controlled environment conditions in Sept. 1997. The project, which commenced in 1998, ran for three years, with a further two years required to analyse the results and produce the report. It was understood at the start of the project that the fibre populations under investigation would be influenced by the level of health and feed intake of the project animals over their growth period. Considerable steps were taken to keep the animals in good health and to match their ration to their dietary requirements.

The project set out to dissect an individuals observed down production into contributing parts; then for each component, to suggest a model for genetic inheritance, a partial model, or a statement that no such model could be found. The project has now been completed and a final report published. The Report has some elements of a specialist review and some elements of original work. The authors believe it to be the most complete work, yet published, on ‘Inherited Down Production’ in goats.
There has been ample discussion by Australian authors, and others, on the macro components affecting down quality and down quantity. A full review of these papers finds no reference to the concept “that taken individually, contributory components to observed annual down production may have a fairly simple form of genetic inheritance.”

At the opposite end of the spectrum major advances have been made in recent times in the understanding and mapping of the molecular mechanisms that govern inheritance. There is little reference to the practical application of this information to the improvement of Down production. This report starts to build the bridge between these two pillars of knowledge.

**Genomic Research**

Every cell of an organism has a "Genome" - a set of chromosomes containing the heritable genetic material that directs its development. The genetic material of chromosomes is DNA.

A study of these Genome databases highlights the surprisingly high level of common genes with similar functions in widely disparate organisms. This all leads to the belief that the species of the world evolved from a common molecular base by a series of molecular changes and combinations of their DNA. The historic classification of the biological kingdom into taxonomic groups has produced a “tree of life”. The current genomic studies are correcting and reinforcing this concept. The study of the pattern of molecular evolution presumes that like species have developed from a common base and that their path of evolution and the relative timing of any split can be determined by a study of their genome.

On this basis it is presumed that the goat and the sheep are closely related species and that both have evolved from the “bovid” (cattle) group. Goats and sheep have a very high proportion of their genomes in common. Any study of the breeds within each species will demonstrate that there are many sheep that look like goats and many goats that look like sheep. Goats and sheep are so closely related that hybrids of the two are known to exist.

It seems very likely indeed that the commercial improvement of the Cashmere goat will follow that of the Merino sheep.

It is important for the reader to learn to think about genetic topics at a genomic level. A study of genomic data for the Family Bovidae, which includes cattle, sheep and goats, illustrates this point. As explained sheep and goats are so closely related they will hybridize - yet sheep (*Ovis aries*) have 54 chromosomes while goats and cattle have 60. At a first glance sheep and goats would appear to be quite unrelated. Both have much the same DNA material, but it is arranged in quite a different way. It is the DNA nucleotide segments (genes) that are important, not the arrangement (chromosomes).

**Taxonomy**

Older literature may refer to several species of goat. It is now accepted that all goats belong to the one species - *Capra hircus*. The project animals strictly belong to “The
Australian Goat” a recognised child breed (strain) of the species. All the goats have a common genome with different minor variations that give them their ‘Breed’ features.

A close look at a Cashmere fleece
Commercially, Cashmere Down is the primary interest and increasing Down production the primary goal. The report however looks at Fleece Production as a whole. Cashmere Down is just one of the components of the total fleece. It is just as important to understand the genetic manipulation of Guardhair (which has commercial implications), as it is to understand the genetic influences that might increase Cashmere Down production.

The report will demonstrate that there are a number of contributing fibre populations that could turn up in a commercially acceptable cashmere fleece. Commercial acceptability is a function of the overall effect of the combination (is the product saleable?), which is as much a function of ‘quantity present’, as it is of type.

The complex interaction of the components of fleece production is best understood by examining the final proposition and then working back through the supporting details.

The investigation suggests it is useful to think of a goats fleece cover in terms of human clothing. When the Creator first dressed the Cashmere goat against the rigours of a harsh climate, he started with a nice warm neck-to-knee under garment of pure fine cashmere and a neck-to-knee ‘coverall’ of hair. To this he added optional dress – varying from goat to goat - an additional under-garment, and perhaps an additional hair garment, a waist coat, trousers, a bib, a neck scarf. In places, for extra protection, he added some hairy patches, and for some goats, a tough neck-to knee overcoat of long hair. All these articles of clothing seem to be represented by a nearly equivalent fleece component. They are not worn as one substituting for the other, but as true articles of clothing - one overlaying the other. Some goats wear many items of clothing – others just a few. An ideal Cashmere goat would have just two, the primary neck-to-knee under garment of pure fine cashmere and the ‘coverall’ of hair. Such an animal (if it exists) would be rare.
The primary underclothing is generally made of cashmere. Secondary underclothing may be made of longer, stronger cashmere or straighter mohair like fibres.

The waist coat is typically any “non-hair” fibre. In the Authors experience the waist coat is never made of a finer material than the trousers.

The trousers are thought to be the exception to the rule. They are NOT an overlying fibre population, but an area free of overlays that allows full expression of the underlying populations.

Just like people – the goat wears extra clothing in winter and may remove some items (typically underclothing) in the summer.

**Garbs and garblets**
Of the fibre populations under consideration there seem to be two types – those covering the whole body (with, perhaps, the exception of the extremities) and those which are regional.
It is proposed by this report, that all identifiable populations be named, to facilitate their common identification and further investigation. The ‘whole-body’ populations have been termed ‘garbs’. The regional populations termed ‘garblets’. Naming individual garblets is easy, and in most cases is self descriptive. Naming garbs is more complex, and a naming convention for all populations, that allows for variation in allelic performance at a population locus, has been proposed and used.

**Garbs**
It is proposed garbs exist for all types of fibre. At the time of writing three have been defined, two down garbs and one hair garb, and there is evidence to suggest a second hair garb. There may be others.

The AAgarb (overall coat of long, medium or short guardhair) is described and an example of its inheritance given. Fibre Draw and Ofdagram results suggest a second
overall hair garb the BBgarb may exist. The inheritance and interaction of the hair
gars are still to be delineated. In the sheep, and the South African and Texan Mohair
goat, it seems that the hair garbs have been genetically ‘switched off’. No evidence
was found of a similar switch in the Cashmere goat.

The ZZgarb (classic cashmere fibre) is discussed together with comments on its
operation.

The YYgarb (the likely origin of mohair) is also discussed together with the role it
plays in Cashmere, Cashgora and Mohair fleeces.

Evidence of the existence of, at least, the three named garbs is compelling. They can
be seen on a fibre diameter histogram manipulated in the right way (the Ofdagram)
and they can be seen in the Fibre Draw of the few animals where the populations do
not overlap.

**The Ofdagram**
The garbs were studied in detail using a new technique (developed during this project)
to enhance and depict the previously “under-used” data available from OFDA fibre
measurement devices. This technique was called an “Ofdagram”. On-farm
Ofdagrams would be useful in defining more precisely the fleece characteristics of
breeding animals – particularly bucks, where you often have a large choice, of
seemingly similar animals. A “How-to” kit was developed for on-farm use.

Fig: 4.2/1 is a traditional, full range Histogram. Its main purpose is to give an
overview and to show clearly the distribution of the down population.

Figure 4.2/3 is the same fleece sample viewed as an Ofdagram. This gives a much
better understanding of the “Non-down” components of the fleece.

The plot represents the relative contribution of each “Micron Step” to total fleece
weight. Strictly this plot is based on Fibre Area. As it can be assumed that the
“Minicored” fibres used for OFDA measurement are all of the same length, this plot
can be considered as Fibre Volume against Diameter. Assuming further that the
Specific Gravity of Down and Guardhair fibres are similar, this plot can be considered
as fibre weight against diameter for the full fleece.

It is an obvious deduction that the “other fibres” include at least one population of
guard hair. A close examination of the charts suggests that “guardhair” could itself be
a composite population. **How many “non-down” populations can you see?**

**Back to Garbs**
It is possible that there are additional garb populations to the three mentioned. A
study of Ofdagrams based on a mid-side fleece sample taken from project animals,
deliberately selected to cover a range of “high producing” fleece types, (including
Strong Cashmere and “Downey Cashgora”) proved inconclusive. The eye suggests
the possibility of additional garbs, but their existence was unable to be proven
mathematically, despite a considerable effort in this regard.
A parallel interaction of “garbs” is presumed to operate in sheep with the ZZgarb being the dominant influence in the Superfine/Extrafine Merino, and the (ZZgarb + YYgarb) being the basis of the Peppin Merino. It is presumed that the Lincoln sheep is the equivalent to the Mohair goat and is an extreme development of the YYgarb. The AAgarb in goats seems to have been eliminated in most wool growing sheep.

Fig:4.2/1 A Plot of Fibre Count against Diameter, for the Diameter Range 1 – 175 micron
Garblets
Garblets are regional patches of fleece that overlay the main garbs. The major garblets in the cashmere goat have been identified and named. The naming convention adopted was that of an article of clothing that might be worn in a similar manner.

The naming of a garblet indicated whether it refers to down (DD\(\text{name}\)), mohair (MM\(\text{name}\)) or hair (HH\(\text{name}\)). For example MMbib refers to an “overlay”, sleek, shiny, fibre population that covers the front of the goat running from just under the chin to the brisket.

The project studied in detail a number of the hair garblets. These seem capable of independent inheritance and some suggested mechanisms were proposed. It is not known, at this time, whether a DD and/or MM companion garblet exists for each identified hair garblet. This seems unlikely. A great deal of work remains to define precisely garblets and their interaction.

The proposed model of garbs and garblets goes some way to explaining the development of the merino sheep from its primitive form, and the effectively kemp-free mohair goat.

“The proof of the pudding is in the eating!”

Table 5.1/1 shows an example of the potential for rapid genetic progress that comes with the manipulation of single locus characters. The buck Z124 removed (in one generation) the BackMane garblet, the Bib garblet and the Britch garblet from a significant proportion of its progeny. Buck Z124, a high yielding buck with very little guard hair, was mated to does that had been
randomly selected for the characters under consideration. The estimate of character frequency for the dam group is for the group from which they came – not the dams themselves. It is approximate only.

<table>
<thead>
<tr>
<th>Character</th>
<th>Dam Group observed Frequency %</th>
<th>Progeny Group observed Frequency %</th>
<th>Expected Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Back Mane K-</td>
<td>15%</td>
<td>47%</td>
<td>43%</td>
</tr>
<tr>
<td>No HHbib Bb-</td>
<td>9%</td>
<td>29%</td>
<td>39%</td>
</tr>
<tr>
<td>No HHbritch Bh-</td>
<td>47%</td>
<td>76%</td>
<td>65%</td>
</tr>
</tbody>
</table>

The EXPECTED FREQUENCY is the expected progeny result assuming the characters recorded in the table are all recessive characters, in a simple dominant/recessive relationship. It further assumes the Buck Z124 was a homozygous recessive for all characters in the table and was mated to a dam group with the character frequency listed in the table.

**A KEY TO INCREASING DOWN PRODUCTION**

For a given mfd and a given fibre density per unit skin area – ‘Growth Rate’ (down fibre produced/unit time) is the fundamental component of down production.

Between animals ‘Down Growth Rate’ and Down Mean Fibre Diameter are independently inherited traits that do not seem to be correlated in any way.

- For a given mfd ‘Down Growth Rate’ is easily measured as ‘Change in Length’.

- It should be possible to select for fast growing, long down while holding mfd constant. The measured growth rate in the best project animals was up to 3 times the growth rate of better feral animals.

*This fact has major implications for the industry.*

Given the commercial reality that it is important to hold the mfd of fleece within certain limits – the only practical options for increasing clean down production are to produce more fibres per unit area of skin, or to increase down length which requires increasing fibre growth rate (length/unit time).
Fig 4.1/8: Plots the length of 3 months down growth (representative of Growth Rate) for the ‘Long’ end of the fibre draw, against the mean fibre diameter of the sub-sample. The 85 animal pairs are then aligned in order of decreasing MFD. As sampled at 5/4/1998

Within Animal Comparisons
All project fibre draw results, without exception, show that within the down components of an individual animal fleece there is a direct relationship between the fibre length and the mean fibre diameter of the sub-sample under consideration. As the down gets longer the mfd increases.

This is a well known fact and novice breeders typically fall into the trap of thinking a “longer fleece is a stronger fleece”. This is not actually the case!

Coping with what seems a contradiction

To better understand the apparent conflicts in the ‘down length (growth rate) / mfd relationships’ … consider the analogy of two pine plantations, both with the same ‘genetic potential’. Within each, there is a range of trees. Consider one growing on poor soil and one growing on good soil. There is a relationship between height and diameter within a plantation, governed by a set of ‘within plantation’ genetic rules.

Between plantations, it is the soil fertility that governs the growth rate and height and this has nothing to do with the ‘within plantation genetic’ rules.

This is an imperfect analogy, because the natural systems under consideration are driven by different fundamental mechanisms, but it serves to illustrate that height/diameter relationships can be controlled by more than one mechanism.
Isn’t hindsight a wonderful thing!

The Production Plateau
The first requirement for genetic production gains in any endeavour is the existence of individuals with superior performance in the characters under consideration. The wider the genetic variance the greater the potential gains. We started with a great resource.

Major phenotypic gains have been made in Australian Cashmere breeding herds over the last 25 years by classing and selection. There is no doubt that much of the original gain in performance was made by selection. Some actual genetic gains were made by a few discerning stud breeders. Some adopted the population genetics approach. A Group Breeding scheme was established to spearhead gains and feed improved bucks and does back to the contributing herds. This failed to deliver an economic result and was abandoned. For the majority of breeders, the gains made by selection were simply ‘fixed’ in perpetuity by their breeding programs. Growers quickly reached a production plateau and stayed there.

Manipulation using quantitative population genetics is a ‘shotgun’ approach. This report proposes that any rapid and economic genetic manipulation of the fleece components first requires an understanding of the factors involved. Up to now, the great majority of research in this area has concentrated on quantitative population genetics and the identification and manipulation of ‘multiple character’ variance. This should deliver positive gains, but over a very long period of time – a luxury the industry cannot afford. There has been a focus on important components like down weight, mean fibre diameter and down length. There has been equal focus on some much less tangible and composite aspects of cashmere down production, like yield and total fleece weight.

A lot of time and effort has gone into establishing the heritability and genetic correlations of the end products, rather than that of the producing components.

“And they left the industry in droves!”

By the mid 1990’s, for economic reasons, a large number of breeders had left the industry or changed to goat meat production, using the newly imported Boer Goat.
The tragedy of this was that so much of the initial variance captured by earlier selection was lost. However what is left tends to be “the cream of the cream”.

There is no doubt the industry needs some real genetic progress
The authors see the report of this project as a first step. It is the Authors belief that the general concepts proposed in this report will stand the test of time.

Successful genetic manipulation requires:

- Identification of the individual genetic components involved.
- Some idea of their mode of inheritance.
- A series of breeding goals.
- A plan to get there.
A word of warning!
The information derived from this project will likely allow the breeder to rapidly reduce, or even eliminate, the protective guardhair covering from the goat. The authors have no doubt this is possible and some of the project animals came close to this goal. The management implications of this are considerable in un-shedded flocks.

The hair plays a role in protecting the cashmere from the environmental elements, (the type of hair is an important dehairing consideration). Hair helps prevent cotting, the collection of vegetable matter and ultra-violet degradation. These problems were solved in the modern wool growing sheep by increasing the grease content of the “down” to a level of about 30%. However at the fine end of the merino clip, (in the Cashmere micron range) to get the best fibre price, sheep are either rugged or run under the ‘Sharlea’ (shedded) system. With Ultra Fine Merino they do both.

In addition, high yielding animals growing large amounts of cashmere, with very little hair seem more sensitive to post-shearing stress. In a pastoral environment, without some form of shedding or rugging, off-shears losses with this type of animal will be high.

This said – the lighter the guardhair loading, the easier the commercial dehairing process, and the better and longer the dehaired produce. Both are prime commercial considerations. For most breeders, hair coverage on paddock reared goats, will be a compromise dependant on grazing conditions.

I only wish we knew all this 25 years ago – such is life!
Cashmere production in Mongolia
Bolormaa Sunduimijid

Animal Science, The University of New England; Email: bsunduim@pobox.une.edu.au

**Introduction**

Mongolia is a very important producer of cashmere in the world, second only to China and produces annually about 3,000 tons. Cashmere is the third highest earner of export dollars after copper and gold. In the year 2000 livestock industries accounted for 32% of the NGP. Natural pastures of the country occupy over 90% of the country’s territory. Herders have kept goats among Mongolian pastoral livestock since ancient times for meat, milk, hide and fibre production. The Livestock industry in Mongolia is still fundamentally nomadic. Keeping livestock in Mongolia is particularly challenging due to the extreme climatic conditions and the effect this has on pastures. Traditional knowledge of care and breeding of animals has been lost due to collectivisation during the communist era in Mongolia. Today approximately 100 000 herder families care for 25,307,800 head of livestock in Mongolia. Average flock size is 500 and it is up to 2000 heads mixed with goats and sheep.

**Geography and climate**

Mongolia is a country located between Russia and China with an area of 1,565,000km² inhabited by 2.5 million people. In 2003 there were 25.3 million head of livestock made up of 10.6 million goats, 10.7 million sheep, 1.78 million cattle, 1.96 million horses and 255,600 camels. The average temperature during the winter is -30 to -35°C and during summer is +30 to 35°C. The autumn and spring seasons are strongly windy. Hence, climate is the major determinant of the success of livestock production. In 1999 there were 33.5 million head of livestock; however this was decreased by 9.4 million at the end of 2002 due to drought and the heavy snowfalls that followed for 3 years.

**Social History**

The Mongolian pastoral culture used to be truly nomadic up until 1921 when Mongolia fell under Russian influence and became a socialist state. For centuries nomadic pastoralists have inhabited Mongolian huge steppe land, moving their herds of livestock to different seasonal pastures searching for fresh grass and water. Livestock belonging to nomadic cultures were more like wildlife populations than domesticated animals in other cultures. All the families gave their livestock to the government under social collectivization movement in the 1940s and 1950s. When the Russians finally pulled out in 1990, the collective herds quickly privatized. Two significant things changed. Firstly, the herders’ safety net disappeared. Secondly, their true nomadic culture disappeared in favour of one that revolved around fixed base social services. In Mongolia, all land is State owned. Herders have historic right to use broad areas that technically supersede the rights of the newer, and less experienced herders. Traditionally, herders keep goats with sheep with a ratio 1:3 due to environment condition and grazing methods. After privatisation of the livestock its composition and herd structure has changed significantly. At the moment this ratio equals one to one due to the increase of cashmere price.

**Mongolian goat characteristics and breeds**

At present, 10.6 million goats are distributed throughout Mongolia. Mongolian goats are robust and vigorous with fine cashmere fibre, and are well adapted to the harsh environment of a dry climate, bare mountain rocks and hill pastures. They are feed all year around and can resist difficult weather and various diseases. The cashmere yield in mature bucks is 250-350 grams, in mature females 250-320 grams. The cashmere fibre diameter in female goats 13.7-14.1 µ, in castrated males and bucks 14-16 µ. About 40-50% of all cashmere grows on the sides of the body and 28-35% on the back and croup areas. The same length of cashmere and
hair fibre can be found around the ears and upper parts of the neck. But hair fibres in croup and hindquarters are longer and those on the upper parts of the body longer by 3-4 cm (fineness 70-90 µ) than down fibres in these areas.

Mongolia has two main goat gene pools such as native Mongolian breed and crossbred goats. Within the native Mongolian breed there are found some distinct strains, like Bayandelger, Ulgii red, Erchim black, Buural and Zalaajinst white. The indigenous animals have cashmere of the desired fineness, varying in combed down yield, with various colours of both guard hair and cashmere (Table 1). A mass crossing of native goats with Pri Don (imported from Russia in 1954) and Gorno Altai breeds (imported from Russia in 1970s) aimed at increasing the cashmere production of Mongolian goats, took place in The Gobi and Altai regions. In consequences of these crossbreeding, at least three of these derivates have been given breed status like Gobi Gurvan Saikhan (1971), Mountain Brown breed (1991) and Unjuul breed group. These animals are very variable and yield large quantities of course cashmere (17-22 microns) (Table 1).

**Table 1. Characteristics of Mongolian Cashmere goat breeds**

<table>
<thead>
<tr>
<th>I. Mongolian native breed</th>
<th>Body Color</th>
<th>Autumn live weight (kg)</th>
<th>Cashmere yield</th>
<th>Cashmere diameter</th>
<th>Cashmere color</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bayandelger</strong></td>
<td>Red, redish and dark brown</td>
<td>59-61</td>
<td>300-330</td>
<td>12-15</td>
<td>Bright grey</td>
<td>Suckbaatar province: eastern region</td>
</tr>
<tr>
<td>Adult males</td>
<td>34-36</td>
<td>240-250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year old males</td>
<td>45-47</td>
<td>340</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td>31-32</td>
<td>240-250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Erchim black</strong></td>
<td>Predominantly black</td>
<td>58</td>
<td>350</td>
<td>13.9-14.7</td>
<td>Grey</td>
<td>Khuvsgul province: Northern area</td>
</tr>
<tr>
<td>Adult males</td>
<td>37</td>
<td>250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year old males</td>
<td>45</td>
<td>285</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td>35</td>
<td>230</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ulgii red</strong></td>
<td>Strongly red</td>
<td>56 (80)</td>
<td>340-450</td>
<td>14-16</td>
<td>Bright grey</td>
<td>Uvs province: Western region</td>
</tr>
<tr>
<td>Adult males</td>
<td>44 (58)</td>
<td>320-360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year old males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Buural</strong></td>
<td>Black associated with partial white and rose-reddish stripes on the head and legs</td>
<td>53</td>
<td>350</td>
<td>14-16</td>
<td>Dominantly grey white</td>
<td>Zavkhan province: North western region</td>
</tr>
<tr>
<td>Adult males</td>
<td>37</td>
<td>360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year old males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Zalaajinst white</strong></td>
<td>White</td>
<td>58</td>
<td>377</td>
<td>15.0-16.5</td>
<td>White</td>
<td>Bayankhongor province: South western area</td>
</tr>
<tr>
<td>Adult males</td>
<td>40</td>
<td>287</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 year old males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### II. Crossbred goats

<table>
<thead>
<tr>
<th>Gobi Gurvan saikhan</th>
<th>Adult males</th>
<th>Black</th>
<th>55</th>
<th>600-800 (1400)</th>
<th>16-19</th>
<th>Dark and brown</th>
<th>Umnu gobi province: South region</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 year old males</td>
<td></td>
<td></td>
<td></td>
<td>320-350 (1000)</td>
<td></td>
<td>+intermediate fibre 18-22%</td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>400-500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>320-350</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mountain Brown</th>
<th>Adult males</th>
<th>Black and black brown</th>
<th>61-63</th>
<th>470</th>
<th>17-20</th>
<th>Brown</th>
<th>Bayan-Ulgii province: Western region</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 year old males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female yearlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

G. Luikart and colleagues suggested that goats and other farm animals have multiple maternal origins with possible centre of origin in Asia. According to their phylogenetic study, there were revealed three highly divergent goat mtDNA lineages, and goat populations are less genetically structured than cattle populations. They explained the weaker genetic structure probably results from more intercontinental transportation of goats than of cattle. Mongolian goats are found among the all three lineages. Another study of genetic study in Mongolian goats based on microsatellite marker suggested that Mongolian goat populations did not significantly differentiate each other. Thus, the low degree of genetic diversity among Mongolian goats may be explained by the consequences of breeding improvement program implemented during social system.

### Production systems

#### Natural resources

Natural pasture of the country occupy over 90% of the country’s total territory, which accounts by 147.6 million of ha and 5% of them high mountain pastures, 64.5% are steppe pastures, 25.3% are desert pastures and 4.9% are other types of pastures. The pasture yield is low and varies from 0.9-0.5 c/ha depending on the zone and area of their development. Due to the lack of water supply a part of pastures is not used at all and remain to be natural parks. For example, 44% of pasture sections are not used in the Eastern Mongolia.

Maximum yield of grasses occurs in August. But 70-80 % of this yield is maintained in autumn, 48-59% in winter and only 30-40 % in spring. Goats are grazed on the last year’s dried grasses for 180-200 days. It means that the previous year’s dry pasture serves as the main feed resources for goats two times longer than fresh grasses. During this period, nutritional value decreases by 2-3 fold and protein content by 3-4 fold. While grazed on poor quality pasture in cold and windy winter-spring time the goats lose weight, as they are not able to acquire adequate nutrition from pasture. They therefore are heavily reliant on their accumulated body fat.

#### Management systems

The harsh climate of Mongolia, with great fluctuations of hot and cold and variation of yield and nutrient value of pasture grasses require herders to use pastures in accordance with the seasons. Herders prefer to graze goats in distant pastures according to the preliminarily determined timetable for rotated use of pasture within 10-15 km around the camp during the summer time. In autumn when grasses dry up or wither find pastures with green and nutritious grasses. Herders prefer to have a light tent for living because it is easy to put up with frequent moving over in autumn for searching for good pasture. From late September when grasses begin to dry up, herders move frequently. They usually prefer to graze goats in ravines, where grass is still dense and nutritious. Grazing areas in the autumn months usually
are within 3 km of the camp. Herders move to the winter camp at the beginning of December, and they choose their winter shelter for goats on the south part of mountain or hill, in other words in full sunlight.

After coming to the winter camp, herders keep goats in a fence built by stones or thick dung until the real cold comes, and they keep their animals in a shelter only after the genuine cold has come. It helps goats to withstand the cold temperature and prevent mange, louse, moth etc., and protects bedding from being wet. It is important to prevent bedding in the shelter from being frozen because frozen bedding leads to abortions.

In spring herders move into new area with good pasture, water supply and good wind protection. Herders usually move to the spring camp at the end of February before mass kidding occurs. After harsh winter time, when spring comes, many animals, particularly, pregnant goats are feeling exhausted and cannot give the birth. Throughout century-old herding practices, Mongolian herders have developed a wealth of techniques of making home-made feed using various types of raw materials and locally-available sources for the nursing of exhausted animals and supplementation of herds.

**Cashmere harvesting**

The cashmere harvesting period starts at the end of March when goats naturally shed the cashmere, and it continues till the beginning of June. Cashmere goats are hand combed using different types of combs, whereas the crossbred goats in Gobi region are shorn by scissors. The combing technique is as the following: For combed fleece the proportion of clean cashmere to guard hair usually is being 75% to 25% respectively. Herders avoid combing goats after June because a high proportion of guard hair can be included into fleece.

**Mating seasons and mating systems**

The normal sexual cycle of pastoral goats begins in July and the persistent period of physiological activity begins after the spring kidding. The optimal period for goat breeding is between mid September and the end of October in High mountainous and Khangai zones, throughout October in the steppe zone and from the end of October and to the end of November in the Gobi zone. Fertilization rates of first and repeated mating are 70 to 80% and 15 to 25% respectively.

Collective herders or breeding organisation use the free mating, controlling mating and group mating systems. Recently, it started to use marking harness in breeding systems in Mongolia, which is fixed to the buck is used for generating true information on the future selection of the best bucks and making precise records of the mating campaign and productive parameters. During social system and after that, the artificial insemination have successfully used for faster improvement of breed quality and productivity of goat herds, especially, for crossbreeding aims.

**Infectious diseases and treatments**

Common diseases like diarrhea and septic arthritis in kids, pneumonia, sore mouth and contagious agalactia occur among goat flocks. Anthelmintics available in Mongolia include ivermectin and fenbendazole. The most common type of prevention and treatment for external parasites in goats is dipping in an insecticide bath. Injectable and oral ivermectin are effective against biting lice and insecticide powders are available to treat individual goats. Plants such as juniperus sabin and artemisia and the ash of dung have been reported in the Mongolian literature as good repellents for lice. These plant powders and ash can be sprinkled on the litter of goat pens.

**Current Breeding systems**

Almost all (but not all) herders keep livestock including goats for self subsistence not for breeding purposes. Therefore keeping records is not a high priority. The structure of goat
flock comprises of 25% of castrated male goats, 75% of female goats aged between 2-7 years and kids.

The breeding program relies on precise information on selection criteria. The climate dramatically influence in livestock product yield. For example, a female may produce 400g greasy cashmere in a good year and only 70g if winter has been extremely cold and dry. Therefore it is difficult to get a precise estimation of genetic parameters.

**Cashmere marketing and its problems**

After combing goats, herders usually go to the nearest town and sell their cashmere to traders. Herders want to by to whom tell higher price. Traders tell their price according to fleece quality and the proportion of guard hair. This year, 2004, is good year for Mongolian goat breeders because the cashmere price is being up to US$ 45. Some of cashmere buyers go out to the herders, and provide food and other everyday necessities as a type of loan. When combing season comes the buyers come with a lorry to take their cashmere. Unfortunately, the cashgora of crossbred goats is sold at a much lower price; usually 4-5 times lower than native goat cashmere. Therefore, the herders in Gobi region go to the border town of China and sell their cashmere for good price. An annual cashmere exhibition is held among the Gobi regions, and representatives of cashmere processing factories, breeding units, and herders attend where sale of cashmere is negotiated.

Most cashmere goes to Chinese traders as raw cashmere. There are several cashmere processing factories in Mongolia, which produce soft and warm clothes made from cashmere and export to USA and some European countries. Some of cashmere is washed and de-haired in a cashmere processing factory and exported to USA.

Mongolia has a history of producing high quality cashmere but this has been damaged by several decades of cross breeding with the Russian Don breed in the most areas of Mongolia which has increased fibre diameter. Quality has also declined due to the tendency to raise more castrated male goats with the goal of obtaining increased yields but this has been at the expense of increased fibre diameter as well. In addition, Chinese buyers have been paying the same price for poor and high quality cashmere in recent years. Paying the same regardless of quality encourages herders to be concerned only with quantity of cashmere while disregarding quality.

**Conclusion**

Mongolia is the second largest producer of cashmere in the world. We have a huge genetic resource. To ensure survival of livestock, it is important to follow the traditional methods of pasture use. The deterioration of fibre diameter is the main controversial issue in Mongolia. To improve cashmere quality, it is essential to solve problems associated with the measurements of clean cashmere weight and diameter. It is also important to develop well organized breeding programs based on modern breeding methods combined with long traditional knowledge. One of the major limitations to implementing strategies for the improvement of the cashmere industry is the lack of funding. Providing the training programs and seminars for herder’s is essential to expand knowledge of breeding techniques and the market economy enabling them to improve cashmere production.

**References**


Breeding for worm resistance in Cashmere goats.
Steve Walkden-Brown, Muyiwa Olayemi and Julius Van Der Werf

Animal Science, School of Rural Science and Agriculture, University of New England, Armidale, NSW 2351. http://sciences.une.edu.au/srsag/ Email swalkden@une.edu.au

Abstract
This paper summarises the results of the first two years complete Cashmere goat data from an ongoing research project investigating the genetics of resistance to gastrointestinal nematode infection in Cashmere and Angora goats. Heritability of faecal worm egg count (WEC) varies with age of kids and type of infection. Heritability was highest (0.22±0.13) at 5 months of age during natural challenge. Heritability estimates for specific antibody responses to nematode infection were low (0.01-0.13) while those for packed cell volume (0.09-0.68) and blood eosinophil count (0.03-0.83) were much higher, albeit accuracies were low. Phenotypic correlations between these variables were generally low. Phenotypic correlations between these traits and live weight, while also generally low, were such that a better immune response was associated with higher weights. Heritability estimates for production traits are also presented. In the first year of the project kids were orally vaccinated with irradiated larvae of Trichostrongylus colubriformis (black scour worm) at 1 and 2 months of age but this had no effect on parasite resistance traits so was not continued. Heritability estimates for WEC are broadly consistent with other estimates in goats and sheep and suggest that selection for reduced WEC at 5 months of age would result in a gradual reduction in WEC over time. Detailed recommendations await full analysis of the complete data set.

Media summary
Preliminary results of an ongoing research project indicate that breeding Cashmere goats for resistance to gastrointestinal nematode or “worm” infections is feasible through selection based on worm egg counts.

Key Words
Goat, nematode, genetic resistance, breeding, parasite control

Introduction
Gastro-intestinal nematodiasis (GIN) is a major health problem of grazing goats word-wide and the major health problem of Australian Cashmere and Angora herds (Chevis, 1980; Thompson and Blisset, 1990, Sangster, 1990, Adams 1995). Indeed, in wet coastal areas the problem often precludes successful fibre goat production. Control of GIN has relied primarily on use of anthelmintic chemical, an approach that has resulted in the development of widespread anthelmintic resistance in nematode populations in goats (Mwamachi et al., 1995; Veale, 2002; Mortensen et al., 2003). The problem of anthelmintic resistance in small ruminants is increasingly driving worm control towards an “integrated parasite management” management approach which integrates a range of chemical and non-chemical control methods (Walkden-Brown et al., 2004). Selection for genetic resistance to worms in the host population is one such strategy.
The sheep industry has made considerable progress in describing the genetic component of host resistance to GIN and incorporating this trait in selection indices (Woolaston and Baker, 1996). The goat industry lags behind sheep in this regard. While between-breed differences in genetic resistance to helminths have been widely reported (Preston and Allonby, 1978; Richard et al., 1990; Pralomkarn et al., 1997; Baker et al., 1998), publications on within-breed variation in genetic resistance to nematode infection in non-fibre producing goats (Mandonnet et al., 2001; Morris et al., 1997), and fibre goats (Vagenas et al., 2002) have only appeared recently. Taken as a whole these studies suggest that it is possible to make genetic progress for resistance to worm infection by within breed selection on faecal worm egg count (WEC). However none of these reports are for Australian fibre goats and, despite the presence of good estimates of genetic parameters for production traits in these animals, there is a notable lack of information on disease resistance traits, particularly GIN. This paper describes the early results, in Cashmere goats, of RIRDC project UNE-69A “Breeding for helminth resistance in fibre goats”. The main objectives of the project are to:

Obtain genetic parameter estimates (eg. heritability) for resistance to *Trichostrongylus colubriformis* (Tc, black scour worm) in Cashmere and Angora goats;

Determine the extent of phenotypic and genetic relationships between worm resistance and production traits; and

Investigate the use of indicator traits other than worm egg count (WEC) as a marker of resistance.

The paper will review progress in each of these areas and outline future future work.

Methods
Location and management
The Cashmere component of the study took place on the property ‘Romani’ which is located near Barraba in Northern NSW (30.4°S, 150.6°E). Annual rainfall is about 800mm with mild summer dominance. A total of 1165 does was mated to 15 sires during 2000 and 2001 as shown in Table 1. Data from later kid drops is still being collected or awaiting analysis.

<table>
<thead>
<tr>
<th>Class of animal</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of new sires</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Total number of sires</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total number of dams</td>
<td>547</td>
<td>618</td>
</tr>
<tr>
<td>Average number of dams/sire</td>
<td>61</td>
<td>69</td>
</tr>
<tr>
<td>Range of dam/sire</td>
<td>56-65</td>
<td>66-78</td>
</tr>
<tr>
<td>Number of progeny born*</td>
<td>253</td>
<td>295</td>
</tr>
<tr>
<td>Number of weaned progeny (5 months)*</td>
<td>246</td>
<td>281</td>
</tr>
</tbody>
</table>

* Number of female kids only. Male kids were sold for capretto at a young age and were not included in the study.

After single-sire joining does were randomly allocated to different management groups such that all sires were represented in all management groups. Does then kidded and reared their kids in these management groups. Mating was in mid-March,
kidding from mid-August, marking in October and weaning generally in late December or January. Identification of dams occurred at marking, leaving the possibility of some cross mothering. Shearing occurred annually in June-July.

Measurements
Worm egg count in faeces (WEC) was recorded for each kid at 3 months and 5 months of age following natural infection from the pastures (natural challenge). Following the 5-month sample, kids were treated with an effective anthelmintic and a week later challenged with 10,000 infective larvae of Tc (artificial challenge). WEC was measured 4 and 5 weeks after this challenge (6.25 and 6.5 month WECs respectively). Larval differentiation to genus level was performed for each WEC. In year 1 only half of the kids were “vaccinated” orally at 1 and 2 months of age with 5,000 and 14,000 irradiated larvae of Tc to determine whether this would aid the detection of resistant animals.

Liveweight was measured at 3, 5, 6.5, 10 and 22 months of age. The last 2 measurements were at annual shearing.

Fleece data was collected from the 1st 2 shearings (11 and 22 months of age). Individual fleeces were weighed, sub-sampled and analysed for yield, down weight, diameter, medullation and kemp at UNE using an OFDA100 as described by Petersen and Gherhadi (1996). Fleece traits measured were greasy fleece weight (FW), Cashmere diameter (CD), hair diameter (HD), Cashmere yield (CY) and Cashmere weight (CW).

Blood samples were collected concurrently with the 3, 5, 6.25 and 6.5 month WECs. The haematological variables eosinophil count (EOS) and packed cell volume (PCV) were determined using a Cell-Dyn 3500 automated haematology analyser. Plasma was then separated and stored for later determination of levels of specific antibody (IgG) directed against Tc larval antigens (AB).

Data analysis
Data for the two years were pooled together for statistical analysis. The effects of vaccination with irradiated larvae vaccination were tested in the first year only.

The data distributions of WEC, EOS and Ab were skewed so data were transformed appropriately to normalise their distributions. The WEC data were cube root-transformed WEC (CWEC). Exploratory data analysis and testing of fixed effects were performed using S-PLUS® software (MathSoft, 1999) Effects fitted were Sire, Birth type, Management group, Year and their significant first-order interactions. Estimates of heritability for all the traits were obtained fitting sire as a random effect in a mixed model and by univariate analysis of ASREML (Gilmour, 1999) fitting the all significant fixed effects. Phenotypic correlations were estimated for all traits from bivariate analyses of ASREML. The phenotypic correlations were expressed as the ratio of the residual covariance and variance components between the traits. A significance level of P<0.05 is used throughout. Where means of transformed variables are presented, back-transformed least square means are used. The results of the genetic analysis are drawn from Olayemi (2004).
Results

**Worm egg counts**
Back transformed least square means for WEC at 3, 5, 6.25 and 6.5 months were 313, 1003, 1711 and 1749 eggs/g faeces respectively. At 3 and 5 months *Haemonchus contortus* (Hc, Barber’s pole worm) predominated with significant Tc also present in 2001/02 (40-50%). At 6.25 and 6.5 months, following artificial challenge with Tc, this species predominated (>92%). The effect of sire was only significant (P<0.05) at 5 months (range 597-1533 epg), although it approached significance at 6.25 and 6.5 months. There was a highly significant effect of management group (ie paddock) at each sampling, with the differences being greatest for the WECs due to natural challenge (eg, range of WEC from 462-2477 for different management groups at 5 months). There was a significant effect of birth type at 3 months only (263 v 368 epg for singles v twins). Liveweight fitted as a covariate did not account for a significant proportion of variation in WEC at any time.

Phenotypic correlations between WEC at different ages were low within infection cycles (0.33 and 0.21 respectively for natural and artificial infections) and very low (<0.1) between infection cycles, indicating relatively low repeatability of the trait. Heritability estimates for WEC were low to moderate, being 0.03±0.06, 0.22±0.13, 0.12±0.09 and 0.13±0.09 for WEC at 3, 5, 6.25 and 6.5 months respectively.

**Other potential resistance indicator traits**
Based on year 1 data only, vaccination with irradiated Tc larvae had no effect on WEC, PCV, AB or EOS in Cashmere goats.

Least square means for PCV (%) at 2, 3, 5 and 6.5 months were 29.0, 23.8, 23.9 and 25.9 respectively. There was a highly significant effect of sire at 3, 5 and 6.5 months (p<0.001) with sire means ranging from 23.3 to 28.6 at 6 months. The effects of birth type and management group were significant at 2 and 3 months only. Liveweight had a significant effect on PCV at 3 and 5 months only. Heritability estimates for PCV increased over time, being 0.09±0.12, 0.39±0.18, 0.63±0.24 and 0.68±0.25 at 2, 3, 5 and 6.5 months respectively.

Least square means for specific Ab (Ab, arbitrary units) at 2, 3, 5 and 6.5 months were 513, 468, 934 and 2582 respectively showing the pronounced effect of artificial challenge with Tc. AB levels were significantly affected by sire at 3 months, and by birth type at 3 and 5 months. Management group had a highly significant effect on AB at all times, while there was a significant effect of liveweight at ages 3 and 5. Heritability estimates for loge(10+AB) were low, being 0.13±0.14, 0.1±0.09, 0.04±0.06 and 0.01±0.05 at 2, 3, 5 and 6.5 months respectively.

Least square means for blood eosinophil counts (EOS, 10^6/L) at 2, 3, 5 and 6.5 months were 120, 115, 193 and 182 respectively showing a gradual increase over time with little effect of artificial challenge with Tc. EOS was markedly influenced by sire (P<0.001) at all times of measurement (range 99-334 x 10^6/L at 6 months). It was also significantly influenced by management group at all times (range 124-289 x 10^6/L at 6 months). Twins had significantly higher EOS at 3 and 5 months than single kids. Heritability estimates for EOS were 0.83±0.39, 0.3±0.15, 0.44±0.19 and 0.32±0.16 at 2, 3, 5 and 6.5 months respectively.
Phenotypic relationship between WEC and potential indicator traits
Phenotypic correlations between WEC and the other potential indicator traits were low at all ages. Correlations between WEC and PCV were low and of variable direction (-0.14, 0.12 and 0 at 3, 5 and 6.5 months respectively). Correlations between WEC and EOS were similarly low (-0.06, 0.02 and -0.03 at 3, 5 and 6.5 months respectively). Correlations between WEC and AB were very low but positive (0.04, 0.04 and 0.01 at 3, 5 and 6.5 months respectively). Correlations between EOS and AB were low but consistently positive (0.10 to 0.13) but associations between these variables and PCV were very weak (range 0 to -0.07).

Production traits
Liveweight (LW) increased steadily from 7.1kg at 1 month of age to 33.4kg at 22 months of age. Sire progeny groups did not differ significantly in LW at any age. Single kids were significantly heavier than twins at all ages up to 10 months. The effect of management group was significant up to 5 months of age but not thereafter. Heritability estimates for liveweight were surprisingly low, being 0.10±0.08, 0.07±0.07, 0.17±0.11, 0 and 0.08±0.17 at 3, 5, 6, 10 and 22 months respectively.

Summary statistics for fleece traits are presented in Table 2.

<table>
<thead>
<tr>
<th>Traits and age</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live weight, kg</td>
<td>296</td>
<td>24.5</td>
<td>2.91</td>
<td>16–32.5</td>
</tr>
<tr>
<td>Fleece weight, g</td>
<td>291</td>
<td>317</td>
<td>47.67</td>
<td>211–498</td>
</tr>
<tr>
<td>Cashmere weight, g</td>
<td>288</td>
<td>84</td>
<td>26.15</td>
<td>31.6–243.2</td>
</tr>
<tr>
<td>Cashmere mean diameter, μm</td>
<td>296</td>
<td>13.0</td>
<td>1.17</td>
<td>10.1–15.7</td>
</tr>
<tr>
<td>Cashmere yield, %</td>
<td>296</td>
<td>26</td>
<td>7</td>
<td>12–49</td>
</tr>
<tr>
<td>Hair diameter, μm</td>
<td>296</td>
<td>76.2</td>
<td>6.25</td>
<td>54–93.6</td>
</tr>
<tr>
<td>22 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live weight, kg</td>
<td>129</td>
<td>33.4</td>
<td>4.43</td>
<td>24.5–49</td>
</tr>
<tr>
<td>Fleece weight, g</td>
<td>125</td>
<td>396</td>
<td>74.96</td>
<td>260–790</td>
</tr>
<tr>
<td>Cashmere weight, g</td>
<td>123</td>
<td>121.2</td>
<td>48.83</td>
<td>0–276</td>
</tr>
<tr>
<td>Cashmere mean diameter, μm</td>
<td>126</td>
<td>14.2</td>
<td>1.07</td>
<td>11.8–17.69</td>
</tr>
<tr>
<td>Cashmere yield, %</td>
<td>126</td>
<td>30</td>
<td>10</td>
<td>14–54</td>
</tr>
<tr>
<td>Hair diameter, μm</td>
<td>126</td>
<td>81.7</td>
<td>7.53</td>
<td>64.3–119</td>
</tr>
</tbody>
</table>

There were few significant effects on fleece variables. Sire had a significant effect only on hair diameter at 10 months and fleece weight at 22 months (p<0.01). Birth type, management group and year had no significant effect at either shearing. Heritability estimates and phenotypic correlations amongst fleece traits are presented in Table 3.

Phenotypic relationships between liveweight and resistance indicator traits.
There was a low but consistently negative phenotypic correlation between WEC and LW, ranging from -0.13 to -0.02. The relationship was stronger at 3 and 5 months of age than at 6.25 and 6.5 months. PCV was positively related to LW with phenotypic
correlations up to 0.20. The relationship was stronger at 2 and 3 months than at 5 and 6.5 months. AB was positively and weakly correlated with LW (0.07 to 0.20) at 3, 5 and 6.5 months but negatively correlated at 2 months (-0.1). EOS was weakly but negatively correlated with LW at 3 and 6.5 months (-0.07 and -0.11 respectively) but correlations were weakly positive at 2 and 5 months (0.08 and 0.03 respectively).

Table 3. Heritability estimates ± s. e. (on the diagonal) and phenotypic correlations for production traits.

<table>
<thead>
<tr>
<th>Traits</th>
<th>LW</th>
<th>FW</th>
<th>CW</th>
<th>CY</th>
<th>CD</th>
<th>HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>10month shearing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LW</td>
<td>0.11 ±</td>
<td>0.23</td>
<td>0.09</td>
<td>-0.04</td>
<td>0.23</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.13 ±</td>
<td>0.58</td>
<td>0.11</td>
<td>0.08</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>0.09 ±</td>
<td>0.11</td>
<td>0.86</td>
<td>0.29</td>
<td>-0.29</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>0.11 ±</td>
<td>0.11</td>
<td>0.33</td>
<td>0.11</td>
<td>-0.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.56±0.26</td>
<td>0.42 ±</td>
<td>0.22</td>
</tr>
<tr>
<td>22month shearing</td>
<td>0.080</td>
<td>0.39</td>
<td>0.29</td>
<td>0.17</td>
<td>0.33</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>±0.17</td>
<td>0.83 ±</td>
<td>0.65</td>
<td>0.25</td>
<td>0.44</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>0.46</td>
<td>0.32 ±</td>
<td>0.28</td>
<td>0.89</td>
<td>0.54</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>0.16 ±</td>
<td>0.20</td>
<td>0.42</td>
<td>0.23</td>
<td>0.35 ±</td>
<td>0.36</td>
</tr>
</tbody>
</table>

LW = live weight, CD = cashmere diameter, HD = hair diameter, CW = cashmere weight, CY = cashmere yield and FW = fleece weight.

Discussion and conclusions

These data are preliminary and the inclusion of additional animals from kid drops in 2002-2004 will improve the accuracy of the genetic parameter estimates (Table 4). The use of DNA tests to verify pedigrees retrospectively to 2001 will also contribute to this. Comparison of the results in Cashmere goats with the data on Angora goats studied in the same project will also serve to reinforce major findings.
Table 4 Effect of record number on the standard error of estimates of heritability for true heritability of 0.1 and 0.3 (Falconer and Mackay, 1996).

<table>
<thead>
<tr>
<th>No. of records</th>
<th>True heritability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>0.18</td>
</tr>
<tr>
<td>500</td>
<td>0.08</td>
</tr>
<tr>
<td>1000</td>
<td>0.06</td>
</tr>
<tr>
<td>5000</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Heritability of WEC.
The heritability estimate for WEC at 5 months of 0.22±0.13 is broadly consistent with other published studies in goats and slightly higher than the 0.17±0.02 for a single WEC reported in Scottish Cashmere goats (Vagenas et al., 2000). They suggest selection for low WEC is feasible. However measurements at other times in the current experiment produced lower h² values indicating the importance of defining optimum conditions for WEC determination. These h² values in Cashmere goats are somewhat lower than most published of h² values for WEC in sheep (range 0.03 to 0.63, most between 0.2 and 0.4).

Use of alternative resistance indicator traits.
To be considered as an alternative to WEC, other indicator traits should ideally be easily measured, highly heritable and be closely correlated with resistance. PCV and EOS had h² estimates that were considerably higher and more consistent that those for WEC, but had low phenotypic correlations with WEC. On the other hand PCV had equal or stronger phenotypic correlations with the production trait LW, than did WEC. The ultimate utility of these alternative traits is difficult to ascertain without information on the genetic correlations between the various traits.

Heritability of production traits
Heritability estimates for FW and CD were within the range of other published estimates (Pattie and Restall, 1989; Summer and Bingham, 1993; Vagenas et al., 2002) but h² estimates for other fleece traits and LW tended to be lower than other published estimates.

Utility of oral vaccination as a worm control measure
The data from this experiment provide no support for this, and it was discontinued after the first year of the project.

The project is providing useful information on the genetics of worm-resistance in Australian Cashmere goats, and unique information for goats on the relationships between WEC, antibody responses, eosinophil counts and packed cell volume. When full data records are available for all kid drops and pedigrees are verified with DNA tests a second, larger and more complete data analysis will be performed and will more clearly answer the original questions posed in the project objectives.

Acknowledgements
The project is funded by RIRDC (Project UNE-69A) for which we are grateful. We thank Tony and Judy Brown, owners of “Romani” for their unflagging support of the project despite the imposition it has been on their normal operations. Thanks are also
due to Neil Baillie and Dominic Niemeyer for their technical assistance and Dr Leo Le Jambre for collaboration on parasitological aspects.

References

Falconer DS, Mackay TFC (1996) 'Introduction to quantitative genetics.' (Longman Group Ltd: London)
Science, University of Sydney.’ (Ed. KG Thompson) pp. 269-273. (Post-graduate committee in Veterinary Science, University of Sydney, Sydney.)


National evaluation of sires for the production of quality Cashmere

Steve J. Gray, John T.B. Milton and Graeme B. Martin

School of Animal Biology, www.animals.uwa.edu.au/home/faculty_staff, Faculty of Natural and Agricultural Sciences, The University of Western Australia, Crawley 6009. Email: alandale@cyllene.uwa.edu.au

Abstract
The Australian cashmere industry produces too little cashmere of the quality sought by processors to be viable. This issue was identified by the Australian Cashmere Growers Association (ACGA) who articulated the need to identify superior genetics. Towards this end, we will rank sires using estimated breeding values (EBVs) so that superior genetics are identified for dissemination across the country. Producers will be able to access this information from a web site to make informed choices when planning the genetic improvement of their herds. Because this project is based on genetics, the benefits will flow to the whole Australian industry for many years.

Media summary
Australia produces too little cashmere therefore the industry wants sires ranked on genetic worth and presented on a web site so producers can plan their breeding programs.

Keywords:
Goat, EBV (Estimated Breeding Value), Sire evaluation

Introduction
Australian Cashmere production has remained stagnant in recent times while its counterpart in the wool industry, the superfine wool sector of the market, has enjoyed success with increased production of quality wool. Cashmere producers need to emulate this by increasing the production of cashmere with the qualities specified by manufacturers. This will lead to increased demand that, in turn, will directly benefit the entire industry.

This issue led the ACGA to focus on the identification of superior genetics as a first step towards restoring the Australian cashmere industry to a pre-eminent position as a supplier of elite cashmere to the world. This can be done by determining the genetic worth of sires independently of environmental effects for important cashmere traits. This produces an “estimated breeding value” (EBV) for important traits for each sire that can be used to rank the sires and promote the dissemination of superior genes across Australia. Because this project is based on genetic improvement, the benefits will accumulate and continue to flow to the whole Australian industry for many years into the future.

Methodology
The project will be based on the cashmere does that have been retained at Allandale Farm (The University of WA) since 1998, after the termination of the RIRDC project UWA-27A (Increasing the production of mohair and cashmere sought by processors). These relatively homogeneous does provide an ideal breeding flock for genetic evaluation of cashmere sires from all over Australia.

The traits to be measured will be decided upon in consultation with the ACGA and the processors. These traits will be measured in the progeny for each sire and that sire’s genetic
worth for each trait will be calculated as an EBV that will be used to rank the sire. Up to 20 sires identified by the ACGA will form the basis of this sire evaluation program that will be conducted over five years. The number of does available for mating will limit the evaluation to 6 sires in the first year and 5 in subsequent years (one sire from Year 1 will be retained as a “link sire” to validate comparisons across years). Semen will be collected from each sire and used to inseminate the does. The does will be assigned among the sires based upon the does’ cashmere production records. After Year 3, the does and bucks born to the earlier matings will become available as a source of superior animals that will be made available to the industry.

The data will be analysed by Dr Mark Henryon, a geneticist currently employed by the Danish Government in their world-class agricultural genetics department. Dr Henryon is a graduate of UWA and has worked with other members of the UWA School of Animal Biology in analysing data on other breeding programs.

Communication of the results will occur in two ways: First, the data collected from the previous year will be analysed then presented directly to members of ACGA at their annual general meeting; Second, a web page will be developed that will show all relevant EBVs.

**Conclusion**

To foster production of more quality cashmere, we will identify superior sires across the nation for important cashmere production traits by central progeny evaluation. The main outcome will be a list of EBVs for sires on a web page. Cashmere producers from anywhere in Australia will be able to select amongst these sires ranked on objectively measured performance traits to plan their breeding programs.
What Fibre Properties Are Important In Processing Cashmere On The Worsted System?

Martin Prins

CSIRO Textile & Fibre Technology, Belmont, Victoria; www.tft.csiro.au; Email martin.prins@csiro.au

Abstract
In order to predict the processing performance of wool consignments during topmaking, prediction formulae known as TEAM were developed. The important fibre properties used in the prediction formulae are described and how experiences in wool processing may guide Australian cashmere growers in providing fibre suitable for the worsted system. Opportunities are suggested to investigate improvements to the fibre properties of Australian cashmere and its subsequent processing performance to enhance its premium position for worsted yarn production.

Media Summary
The experience gained by the wool worsted industry in the use of processing prediction formulae may assist Australian cashmere growers to enhance the marketability of Australian cashmere.

Key Words
Cashmere, TEAM, topmaking, worsted

Introduction
McGregor (2002) reported that dehaired Australian cashmere is longer and finer than cashmere sourced from the origins traditionally used for worsted processing. His data also showed that Australian cashmere has superior fibre strength and extensibility. These superior attributes place Australian cashmere in the premium position for worsted yarn production.

In the manufacture of wool yarns, two major production routes are used: woollen or worsted as shown in Figure 1. The more important production route is worsted, the first stage of which is topmaking. Topmaking is a term used to describe the series of processes (including carding, gilling and combing) used to convert scoured wool into an aligned sliver. In both routes, the first operation in the process of aligning the fibres for spinning is carding, an operation, which also removes a large amount of any remaining vegetable matter in the wool. Over 70% of fine apparel wool is processed on the worsted system and most of the remainder, including shorter wool and short fibre waste from the worsted system, is processed on the woollen system.

In order to predict the processing performance of wool consignments during topmaking, prediction formulae known as TEAM (TEAM 1985; TEAM-2 1988) were developed – Trials Evaluating Additional Measurement. The formulae can be used to predict the waste generated in combing, commonly referred to as noil or Romaine, and the mean fibre length (Hauteur) and fibre length distribution (coefficient of variation of Hauteur or CVH) of the resulting top. Not only is it useful for the processor to know how a wool consignment will behave in topmaking, but also it can benefit the woolgrower to understand how on-farm management practices and environment influence marketability, selection and clip preparation. It is
perhaps timely at this workshop to outline these important fibre properties and how they may guide Australian cashmere growers in producing fibre suitable for the worsted system.

Figure 1. Comparison of the Worsted and Woollen Processing Routes
What Are the Key Fibre Properties Affecting Topmaking?
The TEAM-2 formulae are as follows:

\[ H = 0.52SL + 0.47SS + 0.95D - 0.19MBC - 0.45VM - 3.5 \]
\[ CVH = 0.12SL - 0.41SS - 0.35D + 0.20MBC + 49.9 \]
\[ R = -0.11SL - 0.14SS - 0.35D + 0.94VM + 27.7 \]

Where:
- \( H \) = Hauteur (mm);
- \( CVH \) = Coefficient of variation of Hauteur (%);
- \( R \) = Romaine (%);
- \( SL \) = staple length (mm);
- \( SS \) = staple strength (Newtons per kilotex or N/ktex);
- \( D \) = fibre diameter (micrometres or \( \mu m \));
- \( MBC \) = percentage mid-breaks, corrected;
- \( VM \) = percentage vegetable matter base.

The constants in each formula are meant to be considered as adjustable to reflect the performance of individual mills.

Although not all the TEAM-2 formulae variables may be applicable to cashmere, brief comments will be made on them in regard to the experiences with wool. The TEAM report (TEAM, 1985) found that in general, diameter (D), staple length (SL), staple strength (SS) and vegetable matter base (VM) are the most significant raw wool characteristics affecting fibre length in the top and the waste (noil) generated during combing. The relative importance of each raw wool characteristic, or group of characteristics, is different for individual mills, and appears dependent on the range of wools processed. McGregor (2001) has also commented on the effect of processor on cashmere fibre attributes and noted that this includes:

- the differences due to fibre processed as a result of selection or purchase decisions and
- differences in processing between processors.

Mill or processor effects may be related to issues such as the commercial approach to processing, the type and age of machinery, machine settings, moisture and lubricant regimes, and processing environment.

Fibre Diameter
For wool, fibre diameter remains relatively constant from raw wool to top, with the AWTA (TEAM-3 Steering Committee, 2003) reporting that for the consignments tested the mean fibre diameter of the top was on average 0.24 micron coarser than the mean fibre diameter of the greasy wool. For cashmere, the dehaired fibre must be considered the raw fibre for topmaking. It may be conjectured, that from this point, the mean fibre diameter of cashmere will also not change significantly during topmaking.

In regard to processing performance, the TEAM-2 formulae predict that as fibre diameter decreases, fibre length in the top decreases and combing noil increases. It is well established in the worsted industry that finer wool, with its less rigid fibres, produce more fibre entanglements (neps) and combing noil than coarser wool (Prins and Robinson, 1996). In order to minimise the development of neps, processing parameters may need to be altered, starting from the scouring process. Currently the ACGA has most, if not all, of its cashmere clip scoured at CSIRO. The cashmere sent to CSIRO for scouring has not been dehaired. Thus the bulk of it is coarse guard hair. However, in order to minimise the entanglement of the fine
cashmere fibre, the scouring conditions are those typically used for ultra-fine merino wool, that is, the scouring action is gentler than that used for coarser fibre.

While on the subject of scouring, there would appear to be potential to investigate the possibility of full or partial dehairing prior to scouring. The cost of scouring is based on the total weight of fibre, not just the down. We at CSIRO believe that there is potential to reduce scouring costs if a relatively inexpensive greasy dehairing technique could be developed.

The TEAM-2 formulae do not take into account the fibre diameter distribution (coefficient of variation of fibre diameter or CVD), only the average fibre diameter of the consignment. Although there is still debate about the significance of CVD (Lamb, 2000; TEAM-3 Steering Committee, 2003), it has been suggested that a higher CVD is detrimental to achieving longer fibre length in the top (Hauteur). Additionally, it was reported at a recent IWTO meeting (TEAM-3 Steering Committee, 2003) that the inclusion of CVD, and coefficient of variation of staple length, can result in a small improvement in the prediction of Hauteur. Although it may be expected that the efficacy of cashmere dehairing will have an influence on the resultant average fibre diameter and its distribution (CVD) the effect this will have on the fibre length in the top will need to be established.

Although the influence in topmaking is still being debated, Lamb and Yang (1997 & 1998) have shown that when spinning worsted yarns at the spinning limit, CVD can influence spinning performance and yarn quality. They have reported that +5 units of CVD is equivalent to +1µm for spinning performance and yarn properties. The implication for cashmere is much the same as that for wool; when spinning fine worsted yarns, low CVD can improve spinning performance and yarn quality.

Staple Length
For the 453 consignments measured for the TEAM-3 trials (TEAM-3 Steering Committee, 2003), the staple lengths ranged from 71 mm to 104 mm, for an average of 86 mm. In unpublished data from a survey of two year old does across a number of Australian properties, McGregor has recorded cashmere staple fibre lengths ranging from 70 mm to 125 mm, lengths that are not unlike wool. In his Quality Attributes of Cashmere paper (McGregor, 2001) he has also reported that the length after carding of dehaired cashmere from new origins was around 25 mm with maximum fibre length measurements being between 30 mm to 35 mm. However, dehaired cashmere also contains a large proportion of short fibre. In another study (McGregor & Postle, 2004), it was reported that an experimental Australian cashmere top achieved a fibre length of 42 mm Hauteur from a length after carding cashmere measurement of 29 mm. This was achieved after most of the short fibre was removed during combing resulting in a noil level of 16.5%. Comment was also made that a 50 mm Hauteur may have been achievable but that the resultant noil may have been as high as 50%. Although machinery adjustments can be made to a certain extent, traditional worsted processing equipment is primarily designed to process long staple wool. As a consequence, processing fibres that are significantly shorter than typical wool fibre lengths can result in higher losses in processing. For cashmere fibre, therefore, the dehairing process should be viewed as an integral part of topmaking as the fibre breakage occurring during this process will have a significant bearing on the resulting fibre length in the top and the waste generated during topmaking.

Currently for Australian cashmere, dehairing and the following woollen or worsted processing steps are completely separate operations. The dehairing operation in Australia involves a carding operation at the output of the main dehairing section. It would be interesting to investigate the potential to link dehairing directly, particularly with worsted carding, to ascertain the effect on the resultant fibre length in the top. Would this result in less wastage in topmaking and longer fibre length in the top?
Staple Strength and Mid Break

The staple strength test measures the force to break a staple which is held at either end by jaws. Although it has been shown that this measurement has its limitations, staple strength is still a commercial means of relating the physical properties of wool to its topmaking performance. Hansford (1996) and Adam et al. (2000) observed that the variance of diameter along the length of fibres of a staple for sound and tender wools is important in determining the strength of greasy wool. Hansford showed in her studies that diameter profiles of staples measure the genetic response of sheep to the environmental and/or physiological conditions. That is, the changes in diameter reflect the sheep’s response to the quality and quantity of feed available, as well as whether it is pregnant, lactating, or whether it has disease. Hansford also showed that the response of individual sheep to the prevailing environmental conditions is quite varied. This within flock variation is a result of the genetic or inherent ability of each sheep to produce wool. These large variations in wool growth between sheep subsequently lead to the large differences in staple strength within a flock.

Time of shearing can also be important in managing the position of fibre diameter reduction along the staple. Hansford (1996) has reported that time of shearing can influence fibre length in top. Shearing when the lowest points in fibre diameter are near the ends of the staples was shown to result in the longest fibre length in the top.

For the cashmere grower, the goat’s response to environmental conditions will have the greatest impact on the fibre length after dehairing, irrespective of whether the fibre is destined for the worsted or woollen system. If the majority of fibre diameter reduction, and hence the point of weakness, is toward the middle of the fibre staple, then a shorter cashmere fibre length after dehairing is likely to result. Until data for Australian cashmere is available, it will be difficult to determine to what extent environmental and physiological conditions and on-farm management practices, such as time of shearing, will have on staple strength and position of break, and subsequently the length of cashmere fibre in top.

Vegetable Matter

A significant fraction of combing waste (noil) arises from fibre entanglements, vegetable matter and fibre attached to vegetable matter. The card is efficient in removing burr, but not as efficient in removing seed, therefore seed generally has a greater impact on combing waste. It has been suggested by Lamb (2000) that seed contributes about three times as much noil as burr.

What effect vegetable matter in cashmere has on topmaking is not clear. The dehairing process in Australia not only removes the guard hair, but also significantly reduces the amount of vegetable matter. However, there appears to be little data about the level and type of vegetable matter remaining in the cashmere after dehairing. McGregor (2003) has reported that more than half the vegetable matter in main line cashmere is seed and shive. Is dehairing efficient in removing all types of vegetable matter, or like carding, is it efficient in removing burr but not seed and shive? Given that dehairing is conducted in Australia, this is an issue that could be studied locally.

Fibre Curvature

Fibre curvature is not part of the TEAM-2 formulae, but it is increasingly being debated. Studies conducted at CSIRO (AWI/CSIRO Fibre to Fabric Project, 2002), have shown that fibre curvature had a small but noticeable affect on fibre length in top and on processing waste. In general, it was observed that as fibre curvature increased, combing noil increased and top fibre length decreased. Fibre curvature is a fairly recent measurement available from both the Sirolan Laserscan and Optical Fibre Diameter Analyser (OFDA) instruments. Care must however be taken with this property as there is still on-going work in regard to the calibration and accuracy of the measurement.
McGregor and Postle (2004) have reported that the pooled mean fibre curvature of cashmere from a range of international sources was around 59 degrees per mm and that from Australia was between 50 and 60 degrees per mm. From the TEAM-3 trials (TEAM-3 Steering Committee, 2003) database, the average fibre curvature of the 453 consignments was 93 degrees per mm, with the range being 74 to 124 degrees per mm. So we can say that overall, fibre curvature for cashmere is typically lower than that for wool and that the range surveyed by McGregor and Postle is also not as broad as that for wool. This may explain why typically cashmere feels softer than wool of equivalent fibre diameter.

Although fibre curvature can vary within fibre diameter groups, it can be said that in general, wool fibre curvature increases with decreasing fibre diameter. Fibre curvature has been shown to decrease as it is processed from raw wool to top. This is only a temporary set as most of the crimp can be recovered if washed or steamed in an unconstrained state at later stages such as yarn (in hank form), fabric or garment. This assumes however that the fibre has not been given a wet or chemical treatment, such as dyeing, in a constrained state in either top or yarn form. Cashmere would be expected to behave in much the same way.

The CSIRO, Fibre to Fabric trials showed that low crimp wools make lighter woven fabrics than high crimp wools of the same fibre diameter. Additionally, it was shown that low curvature wool may give improved handle. The effect of fibre diameter still dominates, i.e. fine wools make soft fabrics, but panel tests showed that fabrics with low curvature numbers were preferred. This would seem to support McGregor’s assertion that the attributes of textiles made from the Australian low curvature cashmere could enhance the marketability of both Australian cashmere and low curvature superfine wool.

Conclusion
Prediction formulae have given topmakers and woolgrowers the ability to produce tops with a pre-determined set of characteristics. For woolgrowers, the knowledge gained through the understanding of the important fibre characteristics has assisted in understanding how management decisions impact on the subsequent processing performance of their wool. Would prediction formulae be of benefit to the cashmere industry? Most likely the answer is yes. However, until the various relationships are known for cashmere, it will be difficult for cashmere growers to understand what influence on-farm management practices, genetics and environment have on the processing performance of cashmere in worsted topmaking and spinning. Without this information, it will be difficult for Australian cashmere growers to selectively modify breeding, nutrition and shearing parameters to produce the best quality fibre. If the aim of the Australian cashmere industry is to produce a high quality fibre, then developing an understanding of the important fibre properties will be of prime importance.

Although most of the Australian cashmere is processed overseas, there are still perhaps opportunities in Australia to investigate some of the issues mentioned, such as dehairing prior to scouring, the effect on-farm practices have on dehauling efficiency and fibre length, and the effect of linking dehauling with worsted carding on the fibre length in top and waste in topmaking. Improving the fibre properties of Australian cashmere and its subsequent processing performance will enhance Australian cashmere’s premium position for worsted yarn production.

References


Producing the Right Wool for the Right Application, Results of the AWI/CSIRO Fibre to Fabric Project, 2002.
Cashmere benchmarking shows industry has the potential to increase fleece value by 35%.

Bruce McGregor

Department of Primary Industries, 475 Mickleham Rd., Attwood, Vic 3049
www.dpi.vic.gov.au Email bruce.mcgregor@dpi.vic.gov.au

Abstract
Cashmere benchmarking has been undertaken on two-year-old does by 11 producers in four states in a range of environments. Some producers experienced severe drought conditions. Cashmere production varied from 69 to 225g/head and averaged 141 g/head. Fleece value ranged from $6.24 to $21.59 per fleece. The top 30% of producers averaged $20.79 per fleece compared with $15.11 per fleece for all producers. Heavier, higher yielding cashmere fleeces resulted in higher fleece value. If all cashmere producers reached the production level of the top producers it would result in a 35% overall increase in fleece value and total production.

Media summary
Australia’s first cashmere benchmarking study has shown a wide variation in cashmere production and fleece value.

Key Words
Profitability, information, benefits, decision-making, feasibility

Introduction
People make decisions about industries based on financial returns, technical complexity and lifestyle issues. For the cashmere industry to be attractive to investors and to increase returns to existing producers it must focus on providing comprehensive economic data as has occurred in other major agricultural industries. By doing this, producers will be able to:

- define their own objectives more clearly (breeding, nutrition, management);
- extract more value from their activities, such as producing longer higher value cashmere, reducing processing costs and optimising processing activities; and
- improve communication up and down the market chain as a consequence of using objective data to monitor breeding and processing outcomes.

This cashmere benchmarking project was established to collect production data, to estimate fleece value and to undertake trial processing of cashmere from known sources. Benchmarking is an activity that allows participants to begin self-directed learning as they question the how and why of their results. Benchmarking also draws in other producers who wish to find out the reasons for the success of others.

Methods
In spring 2002, 11 cashmere producers responded to advertisements to join the project. Producers weighed a random selection of 1 year old does each month from late spring until their second shearing in mid 2003 and recorded their grazing management decisions. Many producers also weighed a random selection of other aged does or all their goats. At shearing, fleeces were weighed, sampled and cashmere staple length was measured. For fleece testing all samples were cored twice and for
each sub-sample over 6000 fibre counts were recorded and the results averaged. Cashmere yield was determined from clean washing yield tests and OFDA 100 determinations based on fibre diameter profiles. Production records for 1325 goats have been determined. For the purpose of this report, each property was allotted a number.

Fleeces were valued based on the published prices for white cashmere (Anon 2002). The price for cashmere with a fibre diameter between 18.5 and 20.0 µm was the same as for 16.7 to 18.5 µm cashmere. Cashmere with a mean fibre diameter greater than 20.0 µm or identified as cashgora was given the price for cashgora down.

**Results**

Producers originated from New South Wales (n=5), Victoria (n=3), Western Australia (n=2) and Queensland (n=1). Property 1 provided fleece samples only for 10-month-old goats and so does not appear in the graphs.

**Live weight change**

There was a wide range in absolute live weights and live weight change patterns. Some properties were affected by severe drought and so the goats only maintained weight (eg. Property 8, Figure 1) or lost weight (eg. Property 11, Figure 1). For other properties, goats grew over the summer and/or autumn period (eg. Properties 2 and 10, Figure 1). On most properties, goats lost weight at some point during the year.

![Figure 1. Changes in the live weight of cashmere does from late 2002 until June 2003 at four properties. Each curve represents the mean live weight of does of a specific age group.](image)
**Fibre production**

The average cashmere production was 141 g/head (Range 69 to 225 g/head). There was an almost linear increase in weight of clean cashmere as greasy fleece weight increased (Figure 2). The relationship between weight of cashmere and cashmere yield (Figure 3) or with cashmere staple length (Figure 4) were not as strong as that between weight of cashmere and greasy fleece weight. There was no relationship between weight of clean cashmere and cashmere fibre diameter (Figure 5).

**Fleece value**

The average fleece value was $15.11 (Range $6.24 to $21.59), with the highest three properties averaging $20.79 per fleece. Many of the properties with lower fleece values did suffer from extreme drought conditions. However Property 5, which experienced extreme drought and had relatively low live weights and little live weight gain, recorded the second highest average fleece value.

As expected, increasing average fleece value was strongly related to increasing average weight of cashmere (Figure 6). Increasing average fleece value was also related to increasing average greasy fleece weight (Figure 7) and with increasing clean cashmere yield (Figure 8). There was no relationship between average fleece value and cashmere fibre diameter (Figure 9).
Property 9 is an outlier in Figures 3 and 7. This could be related to a lower than expected cashmere yield (along with Property 4, Property 9 has a cashmere yield 5% units lower than the next lowest property) or to the method of fleece sampling. If Property 9 is removed from the analysis, a strong curvilinear relationship existed between increasing fleece value and increasing greasy fleece weight.

**Discussion**

The progress results provide a clear message for Australian cashmere growers. There is large scope to increase both average cashmere production and financial returns. Based on this sample, if all producers were to achieve the average fleece value of the top 30% of producers, then the rest of the cashmere industry producers would need to increase production/goat by 64%. Assuming that these results reflect the entire industry then increasing average cashmere production to that of the top 30% of producers would increase industry production and total value by 35%.

**Fleece value and greasy fleece weight**

Economic value of cashmere is primarily a function of weight and fibre diameter. In this study, there was a strong relationship between increasing greasy fleece weight and clean cashmere weight (Figure 2), an interesting finding given the range of environments and seasonal conditions prevailing during the project. As a
consequence, increasing fleece value was related to greasy fleece weight (Figure 7). When comparing the results for different properties, the weight of cashmere was also related to cashmere yield and staple length but not to mean fibre diameter.

While a strong relationship between greasy fleece weight and fleece value is expected in Merino sheep and Angora goats, this relationship should not be assumed to exist in cashmere goats where the clean cashmere content (the value portion) of greasy fleeces commonly varies from only 25 to 45%. In fact many breeders do not believe that greater greasy fleece weight equates to more value. The benchmarking results show that economic value of cashmere fleeces is more related to cashmere yield and greasy fleece weight than to staple length or fibre diameter. The first step to increasing cashmere production is for all producers to increase the weight of fleeces. Producers should fleece weigh and use staple measurement to aid culling and breeding decision.

**Live weight and fleece value**

Further analysis is continuing on the effects of live weight on fleece production and value. Previous work with commercial cashmere goats has shown that nutritional practices can increase cashmere weight by over 70% (McGregor 1988, McGregor and Umar 2000). The variation in average live weight, the gain in live weight and the loss of live weight during the cashmere growing period, has accounted for 77% of the variation in cashmere production of grazing goats (Table 1). Changes in average live weight and greasy fleece weight accounted for 88% of the variation in cashmere production in that study of grazing goats.

<table>
<thead>
<tr>
<th>Changes in cashmere growth</th>
<th>Absolute (g)</th>
<th>Relative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>increase in mean live weight</td>
<td>+ 43</td>
<td>+ 18</td>
</tr>
<tr>
<td>gain in live weight</td>
<td>+ 90</td>
<td>+ 38</td>
</tr>
<tr>
<td>loss of live weight</td>
<td>- 110</td>
<td>- 47</td>
</tr>
</tbody>
</table>

Some properties in the benchmarking study experienced severe drought and probably had depressed cashmere production. Previous research suggests that supplementary feeding for cashmere production should be limited to obtaining live weight gains of between 1 and 4 kg during the summer period. Feeding goats more than this amount could increase cashmere fibre diameter reducing sale price and the economics of feeding (McGregor 1988, 1992).

**Conclusion**

There is a large variation in commercial cashmere production and in cashmere fleece value. Cashmere producers can use the benchmarking information to determine the relative performance of their flocks compared to the wider industry. The industry can use this information in comparisons with other industries.

**Acknowledgments**

RIRDC and the Victorian Department of Primary Industries funded the project. Participants, the advisory group and Mr. Tim Johnson are thanked for their input and hard work.
References
You've got to be attractive to sell: a commercial view of the cashmere industry.

Stephen Chaffey\textsuperscript{1} and Bruce McGregor\textsuperscript{2}

\textsuperscript{1} PO Box 3204 Albury, NSW 2640. Email sjchaffey@bigpond.com
\textsuperscript{2} Department of Primary Industries, 475 Mickleham Rd., Attwood, Vic 3049
www.dpi.vic.gov.au Email bruce.mcgregor@dpi.vic.gov.au

Abstract
The critical pathway for growth in the cashmere industry is to make cashmere production more attractive to potential investors. The industry must attract people who are likely to make a significant contribution to the medium and long-term success of the industry. These people will judge the cashmere enterprise on its profitability. The cashmere industry must remove inefficiencies that make it less appealing including slow payment and a long supply chain. The industry needs to: repackage information to enable people to quickly assess their compatibility to cashmere production; establish a financial feasibility model that allows people to test enterprise feasibility under a wide range of situations; implement a communication plan that uses specific features, advantages and benefits package; control more steps of the investment decision-making process and focus investment in the development of a commercial vision.

Media summary
A new business plan outlines six steps for the development of a commercial Australian cashmere industry. The key issues are profitability, accessible information and benefits.

Key Words
Profitability, information, benefits, compatibility, decision-making, feasibility

Introduction
The Australian cashmere industry is an established small industry exporting less than 0.5\% of the world's cashmere. The industry has significant potential to expand and needs to increase production 10 times to obtain economies of scale and to attract commercial services to overcome the burn out of volunteer labour. While the infrastructure and supply chains exist for a considerably larger cashmere industry, existing farmers and land-holders have not been attracted in sufficient numbers to counteract the exit rate. The cashmere industry has undertaken business-planning without consulting land-holders that were not in the industry nor with people exiting from cashmere production. It is fair to say that without some creative change in strategy that the cashmere industry may not develop to its market potential and may wither. The present work aimed to identify the perceived impediments to diversifying into cashmere production and to suggest targeted programs and strategies.

Methods
Targeted interviews of people (n=45) internal and external to the cashmere industry were conducted by telephone (interviews approximately 45 minutes). The questions focussed on the five attributes of an investment opportunity such as financial, compatibility, marketing, information and perception issues (Figure 1) to identify views of the cashmere industry. The analysis differentiated the views and expectations
of small and large-scale producers as well as large-scale producers who were not involved in the cashmere industry (Chaffey and McGregor 2004). A focus group (n=35) was also conducted at the Australian Cashmere Growers Association (ACGA).

![Figure 1. Attributes of any investment decision. A rating of 1 means poorly prepared while 5 means highly prepared. A common finding in new industries is that current producers report they are not as proficient as they wish (Chaffey and McGregor 2002 unpublished).]

annual general meeting in May 2003. Material provided by ACGA and Rural Industries Research and Development Corporation (RIRDC) to people interested in cashmere production was analysed. The principles of selling, the way the selling process is conducted and of the investment decision-making process were reviewed. Based on the information, suggested strategies for government agencies and private sector providers and the industry were developed.

**Results and discussion**

*Motives for operating a cashmere enterprise*

Profitability was given as the primary financial motive for running a cashmere enterprise followed by financial security. Job satisfaction, and to a lesser extent job variety, were the major non-financial motivators for a cashmere enterprise. People who have large herd sizes and a large capital investment in the enterprise, appeared to be motivated more by profitability and the satisfaction they get from running an enterprise and participating in an industry. The focus for motivating people about cashmere production should be:

1. Establishing profitability of the enterprise compared to other possible enterprises;
2. Financial stability of the enterprise over time;
3. Personal satisfaction and achievement.

*Feasibility assessment*

People unrelated to the industry rated feasibility and comparative advantage as being highly important. They perceived finding information more difficult than people in the industry and they had less trust in the people’s opinions (Figure 2). Larger producers thought smaller hobby producers were not very helpful in improving their ability to produce commercial cashmere. People thought there was a lack of experienced and qualified people to give them advice they could rely upon.
Views on financial feasibility of the cashmere enterprise

People unrelated to the industry were not aware of financial studies. Difficulties arose for potential investors because of the lack of ability to assess over a number of years the financial feasibility of an enterprise and the impact of variables on an enterprise. People in the industry indicated the financial analysis of their enterprise was not detailed or very reliable. Hence they were likely to find that enterprise budgets and estimates were very different to reality. While basic financial information is available the following weaknesses emerge:

1. There is a lack of credible, comparable benchmarking information upon which to base financial feasibility and comparisons with other enterprises;
2. There is no system to enable people to adequately and quickly test the financial feasibility of cashmere and little information on the assumptions they might make about variables affecting the enterprise over a number of years;
3. Information about the additional benefits of pasture improvement, synergies with other livestock and weed control is not part of any current financial analysis; and
4. There is no credible comparison between cashmere and other animal enterprises.

Views on market feasibility of the cashmere enterprise

People unrelated to the industry were not sure where to find market information but their expectations of brokers providing market information were high. They wanted to know critical size of the enterprise and market risk. Reading about the cashmere markets in the mainstream papers would increase their knowledge and confidence.

Views on comparative advantage

When people consider investment in a particular enterprise they consider the suitability of their farm system to that enterprise. Currently, assessing the suitability of cashmere is not easy and comprehensive enough to ensure people make a fast and considered decision. Experienced people with a large-scale cashmere enterprise
indicated that determining compatibility was both important and easy to do but potential commercial investors needed benchmarking data over a number of years.

Information

Larger scale farmers have a higher demand for credible and detailed information that has been proven correct over time. They respect credible consultants, local Department of Agriculture, Associations and commercial farmers. Alternative Farming Field days, breed societies and other small breeders are less likely to provide credible information to this segment. We found that information is available but it may not be readily accessible and / or in an appropriate form to make decision making easy, fast and effective for people inexperienced in the cashmere industry.

This implied two types of problems:
- People indicated that costs and time required end up becoming larger than anticipated. This is a planning, budgeting problem for the investor and could be caused by the common problem of over optimism. This is shown in Figure 1 where prospective producers were more optimistic about the compatibility of their farm and financial management than existing producers; and
- Information was judged to be either inadequate, in that important information was either not available or hard to find, and / or unreliable when they did find it.

Thus there were a number of difficulties raised about information.
1. People identified credibility and reliability of information as a problem. For example, people not giving honest answers or people who provided information to potential commercial producers that they were not qualified to give. This view may reflect the fact that the cashmere industry (like many other new industries) has attracted people running small-scale operations in locations not ideally suitable for cashmere goats such as the urban fringe and coastal Australia.
2. While breeder producers are considered an important source of information they are also regarded as a source of biased and unreliable information that is directed by self-interest. People from outside the industry are looking for reliable, credible and independent information and advice.
3. Commercial technical data residing in the industry is difficult to find and is incomplete to enable logical, clear and fast decision making for people investigating the cashmere enterprise. For example, there were specific difficulties on technical matters such as equipment, set costs, drenches and labour time. These are issues that could be answered from a well-organised producer network.
4. There was an expectation of information from the industry association. There was a need for connecting to people who were experienced or were doing the same thing, in a similar location or situation. A mentoring program was suggested.
5. Existing commercial producers are not being harnessed sufficiently to advance the credibility, appeal and on-selling of the industry to the rural community. They could provide assistance, guidance and information to new people during their enterprise start-up phase. Many of these producers are approaching retirement age.
Focus group findings
People taking part in the workshop at the 2003 AGM of the ACGA were asked what they thought were the advantages and benefits of the cashmere enterprise compared to other animal enterprises. These questions identified a range of features and benefits about the enterprise and the industry. Most comments were not well organised into ‘feature advantage benefit’ statements. What it does show is that the industry is not articulating very well the reasons why anyone should adopt a cashmere enterprise. Some claims of enterprise benefits lacked proof and a connection to profitability.

Features, advantages and benefits and proof do the selling
Features are traits that make something what it is. Every feature has one or more advantage or function. The feature must serve some purpose to someone otherwise it cannot be important (Buzzotta et al. 1982). People make decisions to buy because they think they will be better off. Sales people are constantly attempting to sell benefits that indicate to a customer ‘what’s in it for them or their business or their family’. It means demonstrating that if they buy they will be better off than where they are now.

Benefit statements do the convincing. They are designed to prove the product or service will make the customer better off. In terms of investing in a cashmere enterprise, people will do so if they can be convinced they will be better off once they have done so. Benefit statements are proof statements, that suggest an individual with particular needs, will be better off.

Benefit statements alone are not enough. Proof (net gain) is needed. Proof is a general statement of evidence that shows a product or service will make people better off compared to some other comparable product, service or pursuit (e.g. surveys by … or research by … shows that profit from cashmere exceeds …).

Implications
There are many implications that arise from the findings. These include: the need for the industry to understand fully the diversification decision process; to develop features, advantages and benefit statements; to provide proof to support benefit statements; to make information more accessible; to identify a target market for growth from more cashmere enterprises; to create a story about cashmere with real benefits; to overcoming resistance to cashmere; to increasing the visibility of the enterprise and industry; to streamline the supply chain and to speed up payments (Chaffey and McGregor 2004).

Conclusion
The following strategies are recommended to grow the Australian cashmere industry:
1. Use the existing commercial cashmere and goat meat producers as information generators and case studies for other interested people;
2. Improve the quality of the information available to people interested in cashmere so they can make a faster and more informed decision about the enterprise;
3. Implement a communication plan to articulate the features, advantages and benefits of cashmere production and the management of objections to the enterprise to change the perceptions of potential investors towards cashmere;
4. Investigate the feasibility of harvesting cashmere from feral goats;
5. That RIRDC and the Australian Cashmere Growers Association commit significant resources to implement these proposals.

Acknowledgments
RIRDC and the Victorian Department of Primary Industries funded the project. The office bearers of the ACGA and the Goat Industry Council of Australia and the participants who responded to interviews and provided their views and experiences are thanked.

References