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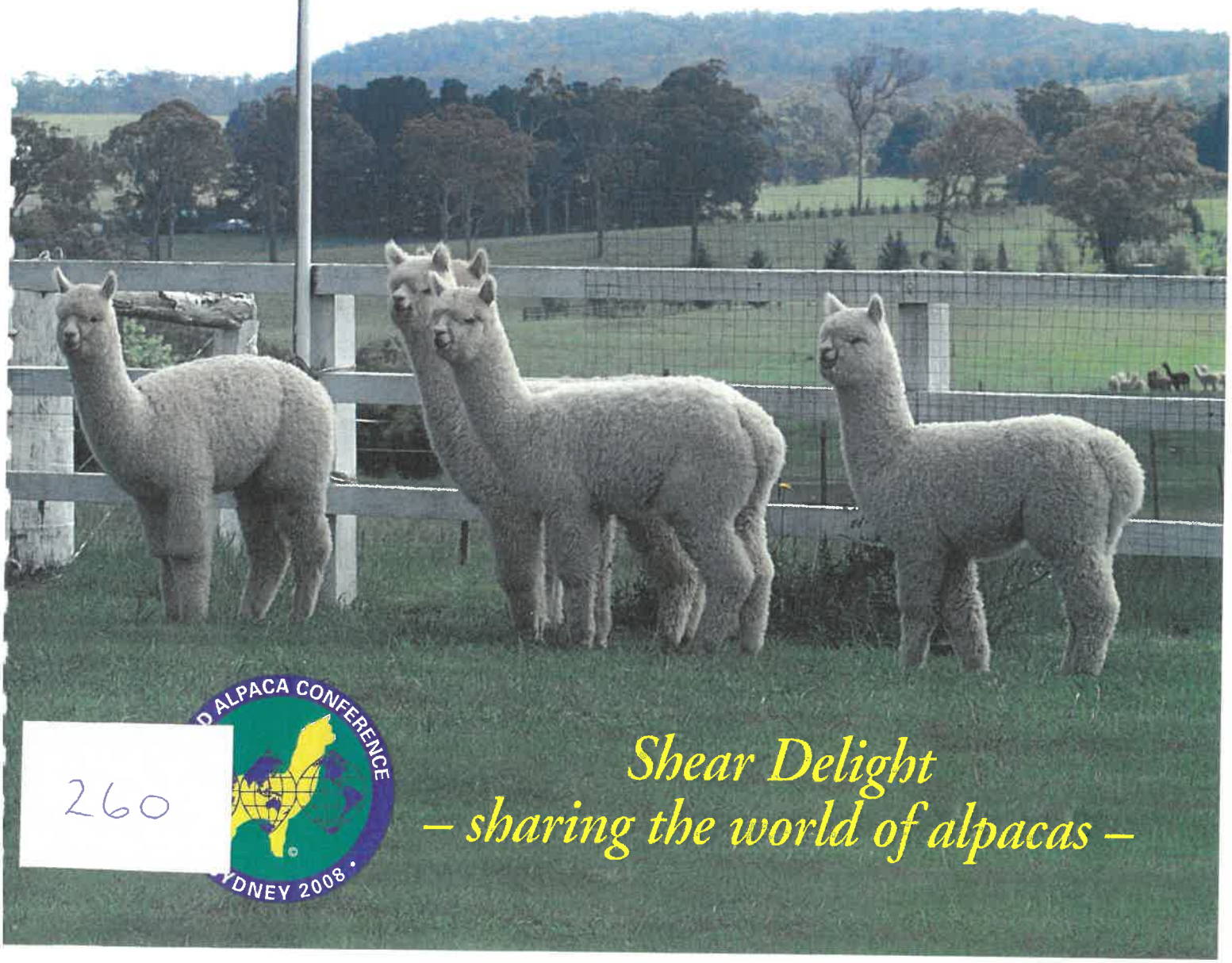
WORLD ALPACA CONFERENCE

PROCEEDINGS

Darling Harbour • Sydney • Australia
28-30 March 2008



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Welcome to the World Alpaca Conference 2008

As President of the Australian Alpaca Association Limited, and representing over 2,000 Australian alpaca breeders, it is my privilege to welcome the delegates that have gathered here in Darling Harbour for this inaugural World Alpaca Conference. In attendance are alpaca breeders from all corners of the globe, and we look forward to sharing our insights and experiences with each other. It is a landmark event, not only for the Australian Alpaca Association, which is celebrating its 20th anniversary, but for the international alpaca industry, with the convening of the first of what we expect will become a regular event. The American Alpaca Owners and Breeders Association has taken the first step to ensure that future by enthusiastically offering to convene the 2nd WAC in the US in 2009, and we look forward to that event. I congratulate all those who have chosen to be a part of world alpaca history by their attendance here, and note that their place in that history will be individually recorded in a journal commissioned expressly for that purpose.

It is only through the generosity of the traditional South American custodians and guardians of the South American camelid that the people gathered here today have reason to convene at all. For at least the last 6,000 years, those animals have been the unique concern of the South American people, and their husbandry and development have been an integral part of their culture and way of life. To those people, the alpaca is more than just an animal to be traded, shorn or slaughtered as a part of a subsistence rural economy. The iconic role of the alpaca in South American civilisation is quite literally woven through the very fabric that is the history of those people: their garments, their housing, their religious and ceremonial vestments, their bedding, their quipus.

The decision of these people a mere 20 or so years ago to share these animals, is the quintessential gesture that is the very theme of this conference: *Shear delight: sharing the world of alpacas.* May I take this opportunity, on behalf the many alpaca breeders around the world, but especially of those present here today, to acknowledge that fact, and to thank the people and governments of South America for their generosity in allowing us to share in that privilege and responsibility. The WAC is about sharing our experiences, our knowledge, and our vision to meet that responsibility and to develop the breed to new standards of productivity, recognition, and excellence.

Fellow alpaca breeders, on behalf of your hosts, the Australian Alpaca Association, I most warmly welcome you to Sydney, Australia, and to this landmark conference, and hope that you return home enthused, invigorated, and enriched by the experience, and proud to be a part of that growing international community that has elected to accept the privilege and the responsibility of owning, breeding and developing…*alpacas.*

Dr Ian M Davison
President – Australian Alpaca Association Ltd

On behalf of the WAC committee, I extend to you a very warm welcome to Sydney and to the World Alpaca Conference 2008. In November 2006 when the Australian Alpaca Association Ltd advised that it was New South Wales' turn to host the National Alpaca Conference on their behalf, the natural choice of location was Sydney and preferably close to our wonderful Harbour.

The next major decision was the format for this conference. As Convenor I felt that as 2008 would be Australia's 20th year in the alpaca industry, we should open this event to not only Australian alpaca breeders, but also to alpaca breeders from around the world and so, the World Alpaca Conference was born. It is rewarding to have many countries of the world represented here embracing this concept. Next year AOBA has asked to conduct the 2nd World Alpaca Conference and we wish them well.

So many new and exciting things are happening in the industry worldwide and the time has come for us all to get together to share our experiences and our techniques for successful alpaca breeding.

The conference will take us on an exciting journey from the beginning of the alpaca as we know it to today's cutting edge technology which will propel this fascinating animal and industry into the future.

This conference has opened many doors, most particularly the Australian Quarantine and Inspection Service (AQIS) granting permission to allow full alpaca fleeces into Australia so that we could hold an International Fleece Show.

Saturday evening will feature our fashion parade with garments from various countries around the world.

Many of you have spent the week preceding the conference visiting the Royal Agricultural Show, various alpaca studs, the Australian Wool Testing Authority, vineyards and enjoying a Sydney Harbour Luncheon Cruise.

Our venue, 'Dockside' is situated on the foreshore of Cockle Bay in Darling Harbour and is close to the Sydney Aquarium, Sydney Wildlife World, Australian National Maritime Museum, China Town, Star City Casino. Taronga Zoo is a ferry trip away and there are various forms of transport such as the monorail, buses, taxis and water taxi. The shopping opportunities will tempt the most jaded traveller. I invite you all to enjoy our city and the 'downunder' hospitality as we all get together, learn much, make new friends and have fun in the *shear delight of sharing the world of alpacas!*

Heather Vickery
Convenor – WAC 2008

Program

Time	Topic	Speakers
FLEECE EXPO		**Friday 28 March 2008**
8.45–9.00	Welcome to delegates	Heather Vickery, Dr Ian Davison
9.00–10.30	The Use of Technology as an Aid to Selection in the Merino Industry	Mark Mortimer
10.30–10.45	Morning Tea	
10.45–11.15	The Next Phase in Alpaca Farming	Steve Ridout
11.15–12.45	Reinventing the Alpaca	Dr Jim Watts
12.45 –1.30	Lunch	
1.30–2.30	Developing an International Market for Australian Alpaca	Michael Talbot
2.30–3.15	Manufacturing Tops and Yarns	Derek Michell
3.15–3.30	Afternoon Tea	
3.30–4.15	Judges' Forum on World Fleece Quality	Cameron Holt, Jill MacLeod
4.15-4.30	Presentation to Championship winners, International Fleece Show	
CONFERENCE		**Saturday 29 March 2008**
8.30–9.00	Introducing AAA President	Heather Vickery
	Welcome to all	Dr Ian Davison
	Official Opening	Peter O'Byrne FAICD, CEO, Austrade
9.00–10.00	Around the World in 60 Minutes	Overseas Presidents' Forum, Questions and Answers
10.00–10.15	Morning Tea	
10.15–11.15	Alpacas: Past, Present and Future	Dr Jane Wheeler
11.15–12.45	Embryo Transfer Strategies in the South American Camelids	Paul Taylor
12.45–1.30	Lunch	
1.30–2.30	Enterotoxemia: New Evidence on Pathogenesis	Dr Raul Rosadio
2.30–2.45	Afternoon Tea	
2.45 – 3.30	Retailing Alpaca Around the World	German Freyre
CONFERENCE (continued)		**Sunday 30 March 2008**
9.00-10.00	The Top Ten Tips for Feeding Alpaca	Dr Jane Vaughan
10.00-10.30	Understanding Alpaca Dental Anatomy: The Normal and the Abnormal Mouth	Allison Quagliani
10.30-10.45	Morning Tea	
10.45-11.45	The Search for Molecular Markers in Alpacas	Dr Kylie Munyard
11.45-12.00	The Coming of A.G.E.: Breeding a Better Alpaca	Dr Ian Davison
12.00-1.00	A New Angle on Alpaca Conformation	Dr Pierre Baychelier
1.00-1.30	Lunch	
1.30-1.45	Presentation of Supreme Champion Fleeces. Announcement of successful silent aution bidders.	
1.45-3.15	Breeding a Prepotent Line of Alpacas	Dr Wayne Jarvis
3.15-3.30	Afternoon Tea	
3.30-4.30	Overview of Veterinary Conference	Dr Chris Cebra
4.30	Conference Close and Overview	Dr Ian Davison

Conference Papers

The Use of Technology as an Aid to Selection in the Merino Industry

MARK MORTIMER

Centreplus Merino Group Australia

Mark left school at age 16 to work on the family farm, 'Devondale', Tullamore, NSW. At 21 he went to Sydney University (Orange) for three years to receive a Bachelor of Management in Farm Business before returning to the family farm where he developed a strong interest in the technological side of sheep breeding.

Mark has been measuring and analysing sheep data for the past 19 years and working with and using across flock breeding values since 1990. He developed his own software to handle and deliver data under working conditions in the yards and incorporated RFID tags into all aspects of the sheep breeding program using his own software.

His family's stud is one of the few merino studs using EBV predictions and computer added mating programs to help with mating. Mark developed and implemented the first pedigree recording system using RFID tags.

Along with his father, Mark runs educational workshops offering essential knowledge needed to run a modern sheep breeding program.

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Editor's Note: *This paper is a powerpoint presentation. Some of the reproductions in this document may be too small to read effectively, therefore the author has made them available to download from the following web site:*

http://www.centreplus.com.au

Slide 1

Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's
- Using Breeding values to predict the future
- Incorporating Breeding values with visual selection
- Impact of management on selection
- The use of RFID technologies

Slide 2

Tools for Selection within flock

- Knowledge of genetic variation in Flock
- Pedigree Recording
- Measurement & Scoring of Traits
- BLUP EBV's for separating the environment from genes
- Index Values for identifying animals with more profitable trait combinations

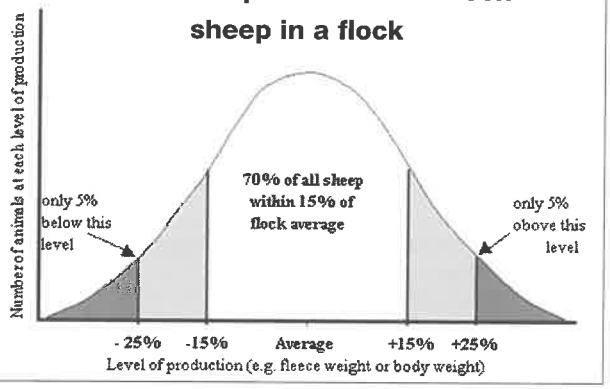
Slide 3

Speed of Genetic Improvement (Population Genetics)

- Selection Differential x Heritability Generation Interval
- Selection Differential = The superiority of selected animals above the average of the drop they came from.
- Heritability = The degree to which each character may be inherited.
- Generation Interval = The average age of breeding animals at the time of lambing.

Slide 4

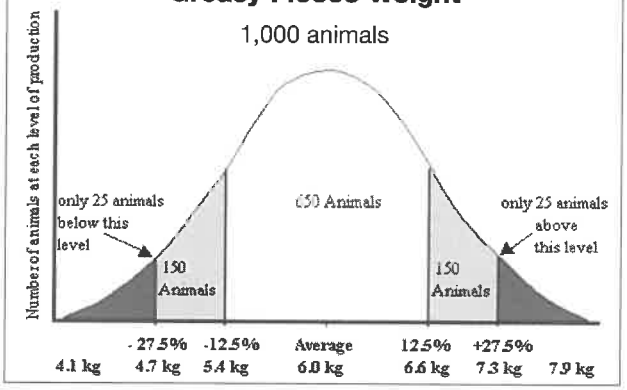
Variation in production between sheep in a flock



Slide 5

Greasy Fleece Weight

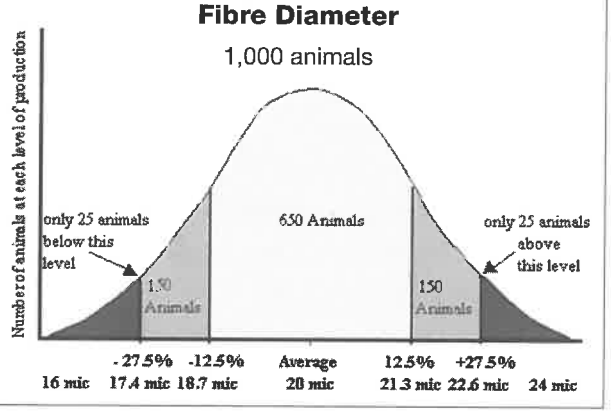
1,000 animals



Slide 6

Fibre Diameter

1,000 animals



Slide 7

Variation of Traits within a Flock

- Average of 13 commercial flocks

Trait	Average	Highest	Lowest
GFW%	100%	147%	63%
FD dev	0.0	+4.7	-3.8
BW%	100%	133%	68%

Slide 8

Variation of Traits in progeny of a sire.

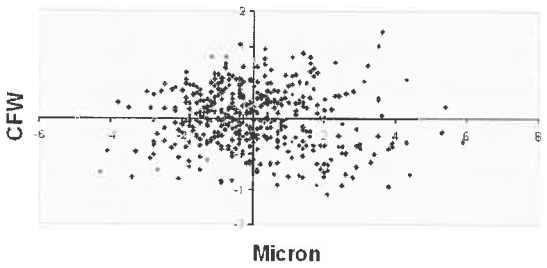
Average of 19 sires with av 23 progeny

Trait	Average	Maximum	Minimum
CFW%	100%	120%	78%
FD dev	0.0	+ 3.0	- 2.1
BW%	100%	118%	84%

Slide 9

CFW V's Micron

Whole Drop



Slide 10

A simple Index example

- If Index task is to select GFW & BW equally
- If flock average GFW is 5.0kg
- and flock average BW is 50kg
- Then Index will be GFW*10 + BW
- An average sheep would be 5*10 + 50 = 100
- A good sheep would be 6*10 + 60 = 120 etc.

Slide 11

An example of simple Index for a commercial flock

- This Index includes weighting's on
- GFW, FD, CV fd, & BW
- 2.28 * (GFW-av GFW)
- -1.6 * (Proc FD-av Proc FD)
- +0.3 * (BW-av BW)

Slide 12

TRAIT RATIO selected by Index

- Average performance of top 3% of ewes
- Selected from 13 flocks for six years
- Trait — Selection Differential
  - av GFW% — 112%
  - av FD dev — -1.4
  - av SD fd dev — -0.5
  - av CV fd dev — -1.2
  - av PF dev — -1.7
  - av BW — 110%

Slide 13

Commercial Flock Selection Differential

using an Index

	Flock	Flock	Flock
• Trait	Average	Culls	Kept
• Number%	100%	35%	63%
• GFW%	100%	92%	104%
• FD dev	0.0	+0.6	-0.3
• BW%	100%	95%	102%

Slide 14

Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's

Slide 15

Why Do we need EBV's ?

Single born verse Twin born

shorn at 5 months and measured at 17 months

Average of six flocks

	Flock Av	Twin	Single	Single Ad
• Trait				
• CFW%	100 %	97 %	102 %	+ 5 %
• Fd dev	0.0	+ 0.3	- 0.3	- 0.6
• BW %	100 %	98 %	104 %	+ 6 %

Slide 16 (Dr. A. Ball LAMBPLAN)

Dam age and Age effects

- Dam age effects
  - Hogget Weight -1.9 kg per year away from 4.5 yrs
  - Hogget GFW -0.35 kg per year away from 4.5 yrs
  - Hogget FD +0.25 um per year away from 4.5 yrs
- Age effects
  - Hogget Weight 0.1 kg per day
  - Hogget GFW 0.01 kg per day
  - Hogget FD 0.01 um per day
- A twin born 20 days later than average and from a 2.5 old ewe.

These effects could total: 5 kg BW, 0.85 kg GFW, 0.65 um in FD

Slide 17

LINKAGE across FLOCK & YEAR's

How does it work? The following example shows sire progeny means for 12-month fleece weight across 2 flocks. We'll assume that corrections have already been made for twin/single status, age, and management group, and that the sires had similar numbers of progeny, so we are looking at sire progeny test averages:

Flock A		**Flock B**	
Sire	Progeny Average (clean fleece weight)	Sire	Progeny Average (clean fleece weight)
Hero	3.5 kg	Hero	4.0 kg
A1	3.1 kg	B1	3.3 kg
A2	3.2 kg	B2	4.2 kg
A3	3.8 kg	B3	3.9 kg

Slide 18

Flock A		**Flock B**	
Sire	Progeny Difference (clean fleece weight)	Sire	Progeny Difference (clean fleece weight)
Hero	3.5 - 3.5 = 0 kg	Hero	4.0 - 4.0 = 0 kg
A1	3.1 - 3.5 = -0.4 kg	B1	3.3 - 4.0 = -0.7 kg
A2	3.2 - 3.5 = -0.3 kg	B2	4.2 - 4.0 = +0.2 kg
A3	3.8 - 3.5 = +0.3 kg	B3	3.9 - 4.0 = -0.1 kg

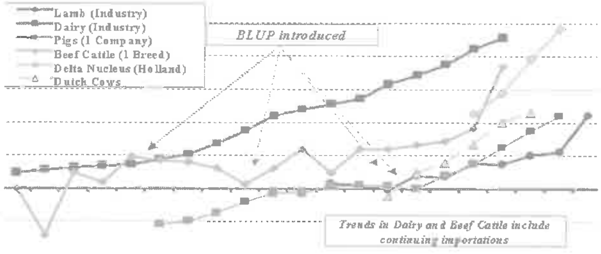
Slide 19

Flock A		**Flock B**	
Sire	Breeding Value (clean fleece weight)		Breeding Value (clean fleece weight)
Hero	0 kg	Hero	0 kg
A1	- 0.4 kg	B1	- 0.7 kg
A2	- 0.2 kg	B2	+ 0.2 kg
A3	+ 0.3 kg	B3	- 0.1 kg

Slide 20

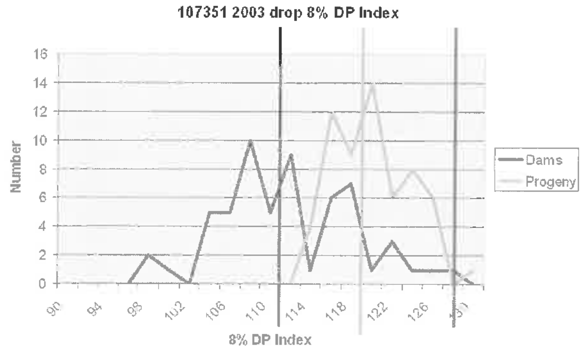
BLUP EBV's to the Rescue

Genetic Trends in Australian Livestock



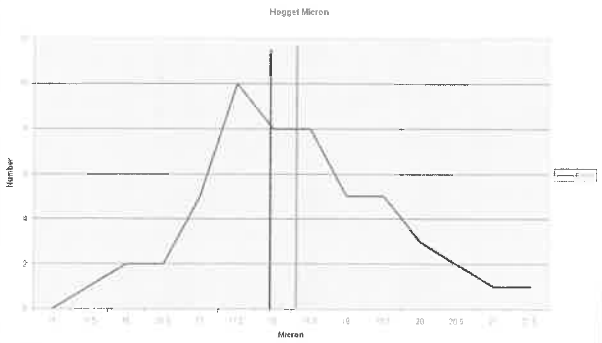
Slide 24

Sire/Progeny EBV comparisons



Slide 21

Sire/Progeny Micron comparisons



Slide 25

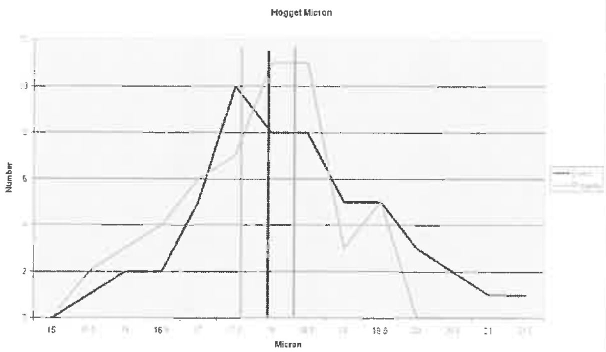
Sire/Progeny EBV comparisons

ID	Progeny No.	Ewe 8% DP	Average Sire 8% DP	Prediction	Average Progeny 8% DP	Difference
Average	4	109.40	111.96	110.68	110.68	0
Max	6	128.88	120.07	122.87	126.53	3.36
Min	3	99.60	97.78	102.90	101.84	-2.73
Range	3	30.20	22.29	19.92	24.69	6.11

ID	Progeny No.	Ewe 8% DP	Average Sire 8% DP	Prediction	Average progeny 8% DP	Differance
6012501997707322	6	128.88	113.94	[illegible]	121.82	0.41
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	125.53	3.36
[illegible]	6	121.85	[illegible]	[illegible]	117.83	-0.87
[illegible]	[illegible]	[illegible]	[illegible]	116.57	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	120.46	121.42	0.56
[illegible]	[illegible]	[illegible]	[illegible]	118.87	119.14	0.27
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	120.31	0.64
[illegible]	5	[illegible]	[illegible]	114.86	116.01	1.13
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115.22	-1.74
[illegible]	[illegible]	[illegible]	112.09	[illegible]	115.85	0.63
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	117.13	[illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	116.42	0.11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	114.98	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6012501997707685	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4	[illegible]	114.16	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	113.99	116.04	115.02	[illegible]	[illegible]

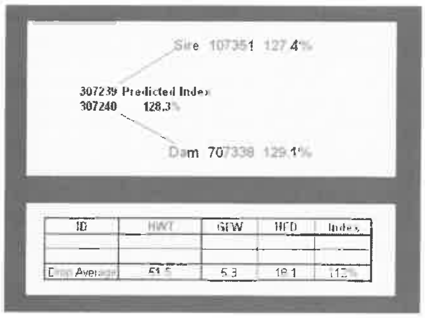
Slide 22

Sire/Progeny Micron comparisons



Slide 26

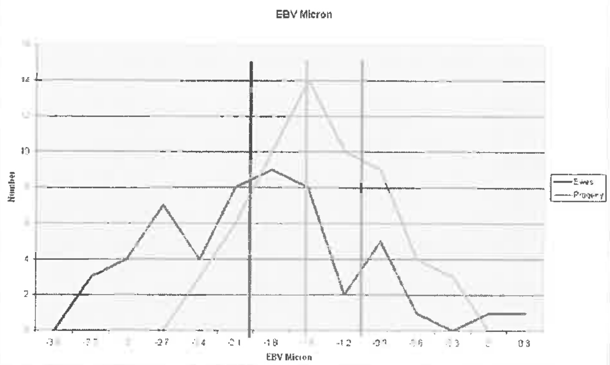
Sire/Progeny EBV comparisons



ID	HWT	GFW	HFD	Index
Drop Average	51.5	5.3	18.1	112%

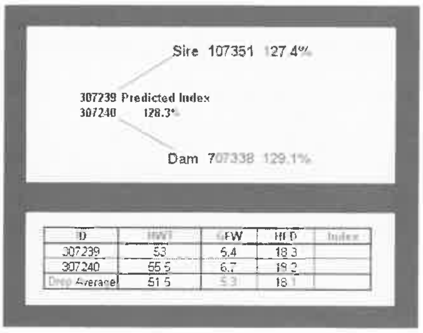
Slide 23

Sire/Progeny EBV comparisons



Slide 27

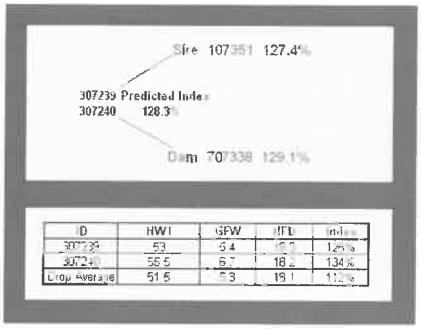
Sire/Progeny EBV comparisons



ID	HWT	GFW	HFD	Index
307239	53	5.4	18.3	
307240	55.5	6.7	19.2	
Drop Average	51.5	5.3	18.1	

Slide 28

Sire/Progeny EBV comparisons



ID	HWT	GFW	HFD	Index
307239	53	5.4	19.2	126%
307240	55.5	5.7	18.4	134%
Drop Average	51.5	5.3	19.1	112%

Slide 29

Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's
- Using Breeding values to predict the future

Slide 30

TGRM Prediction & Results

TGRM Report for 2001 mating

Trait	Sire Mean	Dam Mean	Prog. Mean	Actual
HWT	1.86	0.82	1.34	
YFAT	-0.25	0.02	-0.12	
YEMD	-0.1	-0.13	-0.12	
HCFW	0.04	0.14	0.09	
HFD	-2.44	-1.07	-1.76	
HFDCV	0.07	-0.13	-0.03	
NLW	0.03	0.01	0.02	
8% DP	117.83	110.25	114.04	

Slide 31

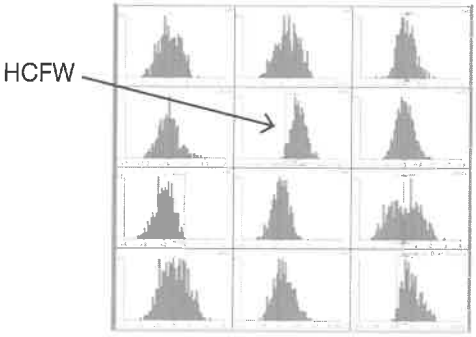
TGRM Prediction & Results

TGRM Report for 2001 mating

Trait	Sire Mean	Dam Mean	Prog. Mean	Actual
HWT	1.86	0.82	1.34	
YFAT	-0.25	0.02	-0.12	
YEMD	-0.1	-0.13	-0.12	
HCFW	0.04	0.14	0.09	
HFD	-2.44	-1.07	-1.76	
HFDCV	0.07	-0.13	-0.03	
NLW	0.03	0.01	0.02	
8% DP	117.83	110.25	114.04	

Slide 32

TGRM Histograms



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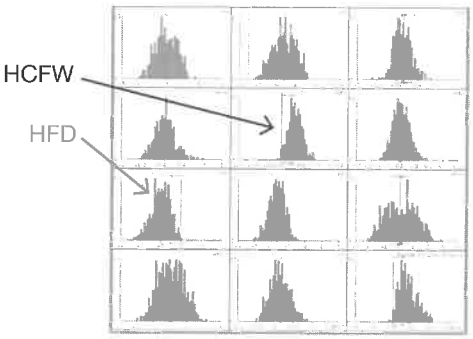
TGRM Histograms



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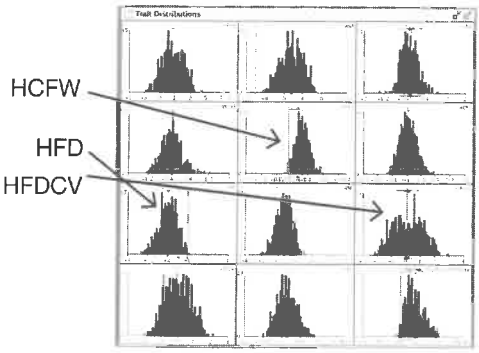
TGRM Histograms



Slide 35

TGRM Prediction & Results

TGRM Report for 2001 mating

Trait	Sire Mean	Dam Mean	Prog. Mean	Actual
HWT	1.86	0.82	1.34	
YFAT	-0.25	0.02	-0.12	
YEMD	-0.1	-0.13	-0.12	
HCFW	0.04	0.14	0.09	
HFD	-2.44	-1.07	-1.76	
HFDCV	0.07	-0.13	-0.03	
NLW	0.03	0.01	0.02	
8% DP	117.83	110.25	114.04	

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Slide 36

TGRM Prediction & Results

TGRM Report for 2001 mating

Trait	Sire Mean	Dam Mean	Prog. Mean	Actual
HWT	1.86	0.82	1.34	1.869
YFAT	-0.25	0.02	-0.12	-0.426
YEMD	-0.1	-0.13	-0.12	-0.244
HCFW	0.04	0.14	0.09	0.038
HFD	-2.44	-1.07	-1.76	-1.513
HFDCV	0.07	-0.13	-0.03	-0.223
NLW	0.03	0.01	0.02	0.088
8% DP	117.83	110.25	114.04	112.199

Slide 37

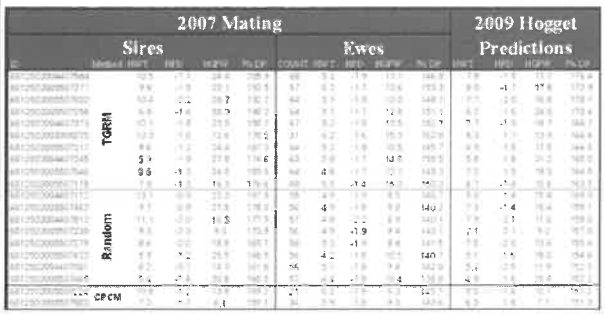
TGRM Prediction & Results

TGRM Report for 2001 mating

Trait	Sire Mean	Dam Mean	Prog. Mean	Actual
HWT	1.86	0.82	1.34	1.869
YFAT	-0.25	0.02	-0.12	-0.426
YEMD	-0.1	-0.13	-0.12	-0.244
HCFW	0.04	0.14	0.09	0.038
HFD	-2.44	-1.07	-1.76	-1.513
HFDCV	0.07	-0.13	-0.03	-0.223
NLW	0.03	0.01	0.02	0.088
8% DP	117.83	110.25	114.04	112.199

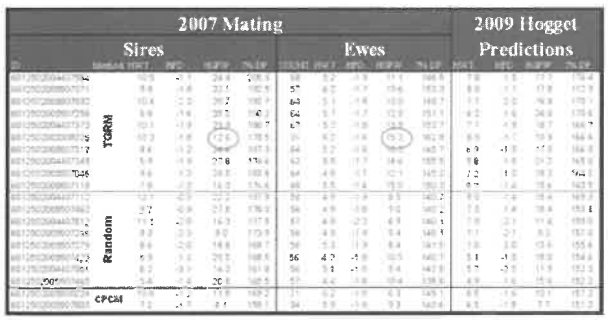
Slide 38

Mating Predictions



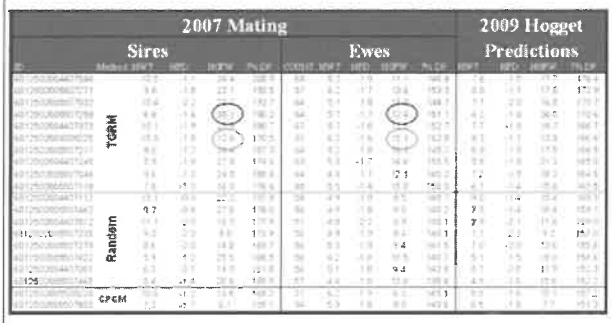
Slide 39

Mating Predictions



Slide 40

Mating Predictions



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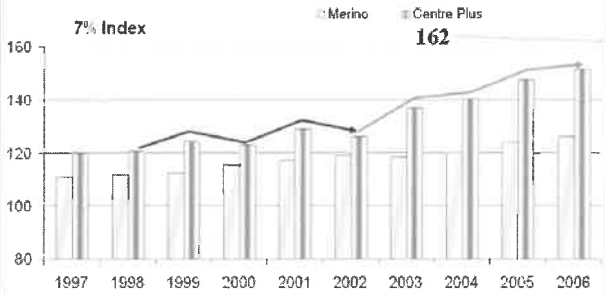
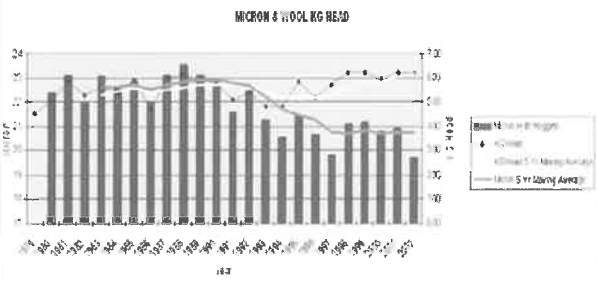
Mating Predictions



Slide 42

Robert Gill commercial flock



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Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's
- Using Breeding values to predict the future
- Incorporating Breeding values with visual selection

Slide 44

Centre Plus 2005 Selection

	Index	WT EBV	GFW EBV	FD EBV
1141 Ewes	110	1.61	0.14	-1.19
514 Hoggets	112	2.55	0.26	-1.08
Top 1250	113	1.98	0.24	-1.23
6 Link Rams	120	3.95	0.54	-2.01
Top 12 Hoggets	125	5.52	0.62	-1.50
2004 Drop	113	2.39	0.26	-1.21
Prediction	118	3.40	0.42	-1.47

Slide 45

Centre Plus Older Ewe Selection

186 Ewes Culled Visually (16%)

-6% Colour

-20% Wool Style

Slide 46

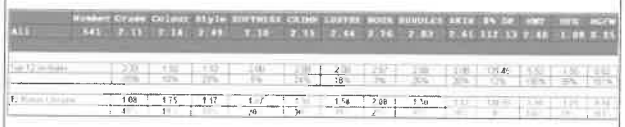
Centre Plus 2005 Ram Selection

Slide 47

Centre Plus 2005 Ram Selection

Slide 48

Centre Plus 2005 Ram Selection



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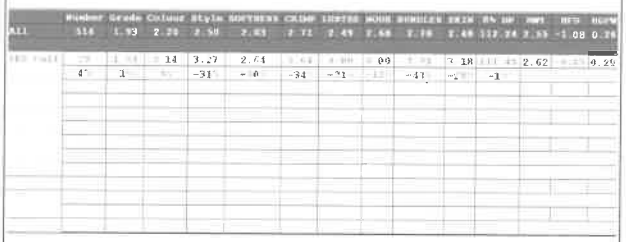
Centre Plus 2005 Ram Selection

Slide 50

Centre Plus 2005 Ram Selection



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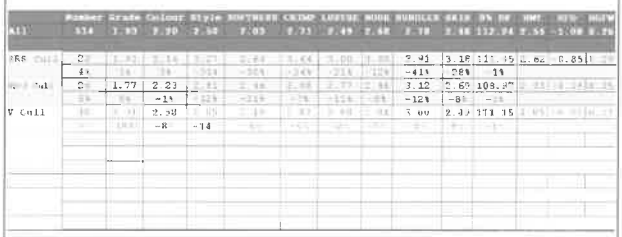
Centre Plus 2005 Ram Selection

Slide 52

Centre Plus 2005 Ram Selection



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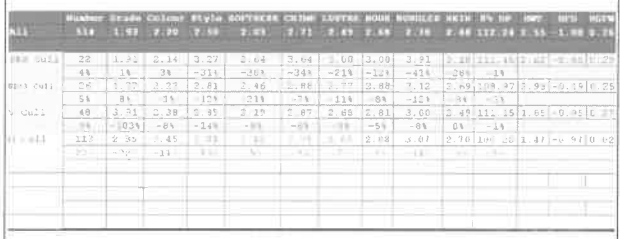
Centre Plus 2005 Ram Selection



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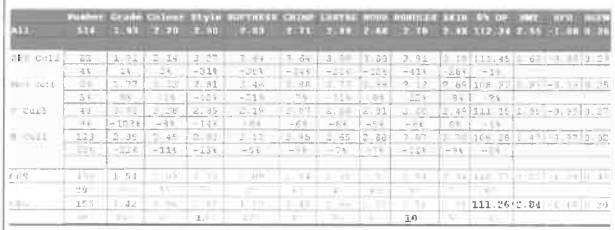
Centre Plus 2005 Ram Selection



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	Index	HWT	HGFW	HFD
2004 Drop	113.21	2.39	0.76	-1.21
2005 Ram Mating	118	2.4	0.22	-1.47
2005 Specials	117.68	4.23	0.39	-1.26
2005 Generals	117.52	2.39	0.27	-1.20
Combined Mating 2005	115.55	3.47	0.31	-1.21
Deviation from 2004 drop	2.34	1.08	0.09	0.03
Deviation from Max	2.13	0.07	0.09	0.03

Rams	Sheep	Index	HWT	HGFW	HFD
Rams	Average Generals	121.66	6.32	0.64	-1.17
	Average		4.14	0.48	-1.87

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Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's
- Using Breeding values to predict the future
- Incorporating Breeding values with visual selection
- Impact of management on selection

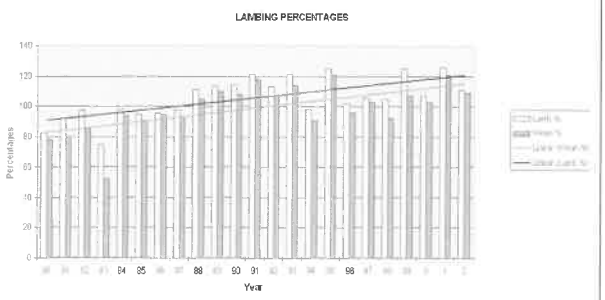
Slide 57

Knowing what a breeding system is *really selecting for:*

- To get a broader picture of how a breeding system works, one can think of nature and the evolution of species, and how the environment along with the health and vigor of animals play a role in selecting future genes.
- This is referred to as G x E 'genes x environment, interaction.

Slide 58

Robert Gill commercial flock



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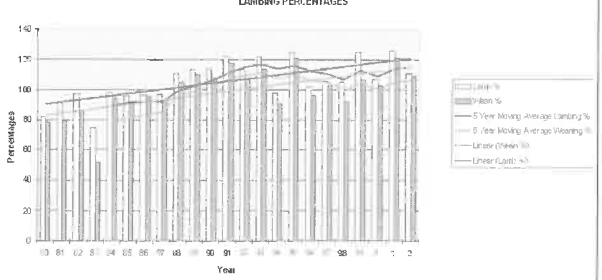
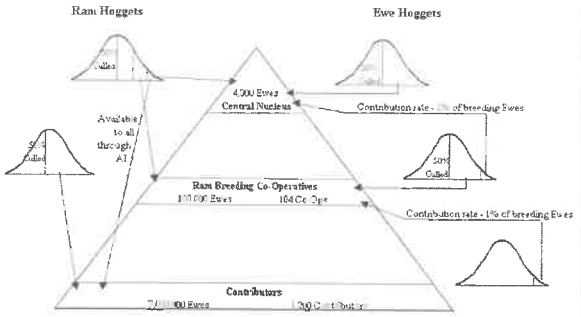
Robert Gill commercial flock



Slide 60

A Breeding System

AMS three tier breeding structure



Slide 61

Ewe temperament scores 2003

Scanning to Lamb Survival for 2003 Drop

Results from Dams with a 1 or 2 for temperament

Age	Number of Ewes	Number of Lambs	Scanning Lambs per Ewe	Survival Lambs per Ewe	Potential Lambs from scanning	Lamb Losses	Percentage of Lambs lost
Hogget	86	91	1.38	1.06	119	28	23%
2nd Lamb	76	94	1.51	1.24	115	21	18%
3rd Lamb	112	129	1.69	1.15	189	60	32%
4th Lamb	64	94	1.64	1.47	105	11	10%
5th Lamb	65	75	1.72	1.14	112	37	33%
Average/Total	403	483	1.588	1.21	639	156	24%

Results from Dams with a 3 to 5 for temperament

Hogget	38	32	1.24	0.87	47	14	30%
2nd Lamb	19	19	1.24	1.00	23	4	15%
3rd Lamb	9	7	1.44	0.78	13	6	46%
4th Lamb	2	1	2	0.5	4	3	75%
5th Lamb	4	2	1.5	0.75	6	3	50%
Average/Total	71	61	1.484	0.79	93	29	32%

Slide 62

Ewe temperament scores 2004

Scanning to Lamb Survival for 2004 Drop

Results from Dams with a 1 or 2 for temperament

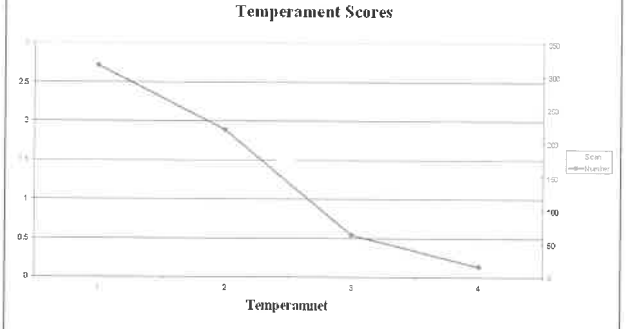
Age	Number of Ewes	Number of Lambs	Scanning Lambs per Ewe	Survival Lambs per Ewe	Potential Lambs from scanning	Lamb Losses	Percentage of Lambs lost
Hogget	142	146	1.38	1.02	197	51	26%
2nd Lamb	109	136	1.72	1.25	182	46	25%
3rd Lamb	77	116	1.73	1.51	133	17	13%
4th Lamb	104	143	1.66	1.38	172	30	17%
5th Lamb	63	112	1.81	1.78	114	2	2%
Average/Total	493	653	1.66	1.35	800	147	18%

Results from Dams with a 3 to 5 for temperament

Hogget	24	19	1.42	0.79	34	15	44%
2nd Lamb	20	17	1.65	0.85	33	16	48%
3rd Lamb	9	11	1.67	1.22	15	4	27%
4th Lamb	8	11	1.75	1.38	14	3	21%
5th Lamb	1	1	1	1	1	0	0%
Average/Total	62	59	1.498	1.05	97	38	39%

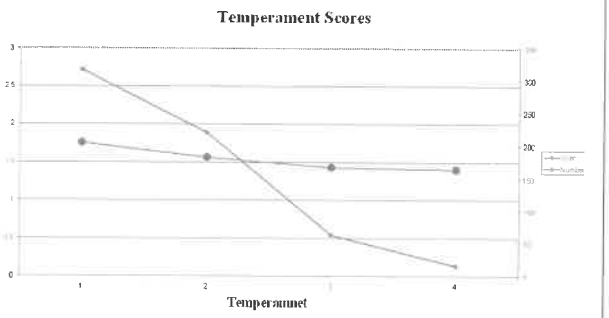
Slide 63

Ewe temperament scores 2007



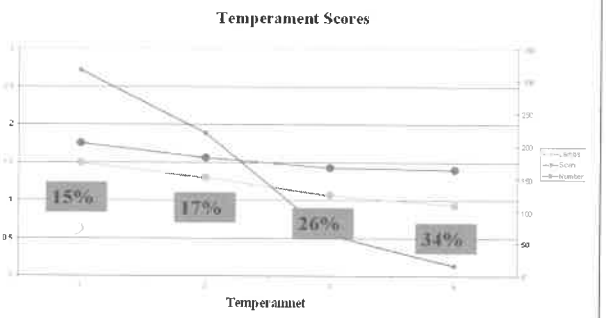
Slide 64

Ewe temperament scores 2007



Slide 65

Ewe temperament scores 2007



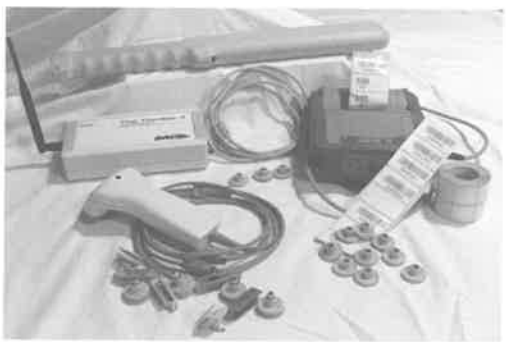
Slide 66

Technology in the Merino Industry

- Variation of traits within a flock
- Removing environmental effects using BLUP EBV's
- Using Breeding values to predict the future
- Incorporating Breeding values with visual selection
- Impact of management on selection
- The use of RFID technologies

Slide 67

Individual Animal Management



Slide 68

Where we are now – Body Weighing

- Body Weighing Before EID

3 people (1 on the scales, 1 on the computer and 1 forcing up)

Top speed	- 180 per hour (Whole mob)
Normal speed	- 150 per hour
ERRORS	- 0.2% to 0.5% tag reading errors

- Body Weighing with EID

2 people (1 on scales, 1 forcing up)

Top speed	- 300 per hour (Whole mob)
Normal speed	- 250 per hour
Peaks of	- 380 per hour.
ERRORS	- Similar percentage of weighing/ System errors

Slide 69

Where we are now – Body Weighing

	Visual	EID's
Mob size	700	700
Number / Hour	180	300
Labour Units	3	2
$ per hour	$ 16.00	$ 16.00
Man hours	11.67	4.67
Total Cost	**$ 186.67**	**$ 74.67**
Cost per Weight	$ 0.27	$ 0.11
Percent of original cost		40%

Slide 70

Where we are now – Body Weighing

	Visual	EID's
Mob size	700	1750
Number / Hour	180	300
Labour Units	3	2
$ per hour	$ 16.00	$ 16.00
Man hours	11.67	11.67
Total Cost	**$ 186.67**	**$ 186.67**
Cost per Weight	$ 0.27	$ 0.11
Percent of original cost		40%

Slide 71

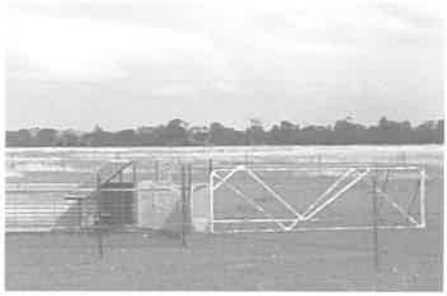
Match Maker

Walk Over Pedigree

Slide 72

Match Maker

Walk Over Pedigree



Slide 73

Match Maker

- 189 Ewes
- 230 Lambs
- 2500 Tag reads per day

Slide 74

Play Equipment

Slide 75

Match Maker Different lambs that followed a single Ewe

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102009054	982 000102396494	N	1	1.00	53.33
982 000102009058	982 000102396494	Y	15	1.07	800.00
982 000102014677	982 000102396494	N	1	2.00	53.33
982 000102015904	982 000102396494	N	1	2.00	53.33
982 000102396723	982 000102396494	N	1	2.00	53.33
982 000102398873	982 000102396494	N	1	1.00	53.33
982 000102399977	982 000102396494	N	1	2.00	53.33
982 000102400231	982 000102396494	N	1	2.00	53.33
982 000102402431	982 000102396494	N	1	2.00	53.33
982 000102402544	982 000102396494	N	1	2.00	53.33
982 000102403149	982 000102396494	N	1	1.00	53.33
982 000102403261	982 000102396494	N	1	2.00	53.33
982 000102404672	982 000102396494	N	1	2.00	53.33
982 000103191887	982 000102396494	N	1	1.00	53.33
982 000103197172	982 000102396494	N	1	2.00	53.33
982 000103199224	982 000102396494	N	1	2.00	53.33

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Match Maker Different lambs that followed a single Ewe

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102396723	982 000103191881	N	1	2.00	41.67
982 000102396045	982 000103191881	N	2	2.00	83.33
982 000102398180	982 000103191881	N	1	1.00	41.67
982 000102398873	982 000103191881	N	2	1.50	83.33
982 000102401622	982 000103191881	N	1	2.00	41.67
982 000102402031	982 000103191881	N	1	2.00	41.67
982 000102402033	982 000103191881	N	1	1.00	41.67
982 000102402431	982 000103191881	N	2	1.50	83.33
982 000102403869	982 000103191881	Y	12	1.17	500.00
982 000102403986	982 000103191881	N	1	2.00	41.67

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Match Maker Different lambs that followed a single Ewe

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102399011	982 000102399964	N	1	2.00	70.00
982 000102016289	982 000102399964	N	2	1.00	140.00
982 000102395523	982 000102399964	N	2	1.00	140.00
982 000102395867	982 000102399964	N	1	2.00	70.00
982 000102395588	982 000102399964	N	1	2.00	70.00
982 000102396723	982 000102399964	N	1	1.00	70.00
982 000102396973	982 000102399964	N	1	2.00	70.00
982 000102397922	982 000102399964	N	1	2.00	70.00
982 000102398873	982 000102399964	N	1	1.00	70.00
982 000102399410	982 000102399964	N	1	2.00	70.00
982 000102401897	982 000102399964	N	1	2.00	70.00
982 000102402031	982 000102399964	N	1	2.00	70.00
982 000102402033	982 000102399964	N	1	2.00	70.00
982 000102402777	982 000102399964	N	1	2.00	70.00
982 000102403140	982 000102399964	N	1	2.00	70.00
982 000102403261	982 000102399964	N	1	1.00	70.00
982 000102403869	982 000102399964	N	2	2.00	140.00
982 000102404086	982 000102399964	Y	3	1.00	210.00
982 000102404294	982 000102399964	N	1	1.00	70.00
982 000103198756	982 000102399964	N	5	1.40	350.00
982 000103199226	982 000102399964	N	1	1.00	70.00

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Match Maker Different lambs that followed a single Ewe

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102401897	982 000103197581	Y	19	1.00	926.83
982 000102401897	982 000103213655	N	3	1.67	255.00
982 000102401897	982 000103213278	N	2	1.00	146.15
982 000102401897	982 000103199087	N	2	2.00	116.67
982 000102401897	982 000102404487	N	2	1.50	151.72
982 000102401897	982 000102015217	N	2	1.50	89.80
982 000102401897	982 000103220724	N	1	1.00	69.61
982 000102401897	982 000103212466	N	1	1.00	94.19
982 000102401897	982 000103211413	N	1	2.00	73.68
982 000102401897	982 000103198268	N	1	2.00	82.61
982 000102401897	982 000102404196	N	1	1.00	52.78
982 000102401897	982 000102402911	N	1	2.00	75.86
982 000102401897	982 000102401851	N	1	2.00	56.67
982 000102401897	982 000102399964	N	1	2.00	70.00
982 000102401897	982 000102809396	N	1	1.00	66.67
982 000102401897	982 000102803959	N	1	1.00	57.69
982 000102401897	968 000001501704	N	1	1.00	66.67
982 000102401897	968 000001500751	N	1	1.00	46.88

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Match Maker Different Ewes that a lamb followed

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102403149	968 000001500751	Y	16	1.25	750.00
982 000102403149	982 000102404487	N	2	1.50	151.72
982 000102403149	982 000102395880	N	2	2.00	76.47
982 000102403149	982 000102809396	N	2	1.50	133.33
982 000102403149	982 000103197581	N	1	1.00	48.78
982 000102403149	982 000102404196	N	1	1.00	52.78
982 000102403149	982 000102399964	N	1	2.00	70.00
982 000102403149	982 000102396494	N	1	1.00	53.33

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Match Maker Different Ewes that a lamb followed

EID	EWE	CHECK	COUNT	AVG_POS	PERCENTAGE
982 000102402033	982 000102137748	N	1	1.00	392.31
982 000102402033	982 000102729724	N	2	1.50	121.21
982 000102402033	982 000103216453	N	2	1.00	109.52
982 000102402033	982 000103197581	N	2	1.50	97.56
982 000102402033	982 000103217737	N	1	1.00	94.44
982 000102402033	982 000102214494	N	1	2.00	69.70
982 000102402033	982 000102134557	N	1	2.00	85.00
982 000102402033	982 000102137468	Y	1	2.00	44.19
982 000102402033	982 000102211671	N	1	2.00	50.00
982 000102402033	982 000102199087	N	1	2.00	58.33
982 000102402033	982 000103197193	N	1	2.00	72.97
982 000102402033	982 000103196487	N	1	1.00	60.57
982 000102402033	982 000103192956	N	1	2.00	53.33
982 000102402033	982 000103194681	N	1	1.00	61.67
982 000102402033	982 000102191405	N	1	1.00	65.12
982 000102402033	982 000102404687	N	1	1.00	75.86
982 000102402033	982 000102403759	N	1	1.00	57.50
982 000102402033	982 000102402911	N	1	2.00	75.86
982 000102402033	982 000102399964	N	1	2.00	70.00
982 000102402033	982 000102399886	N	1	2.00	47.47
982 000102402033	982 000102398387	N	1	2.00	57.14
982 000102402033	982 000102381434	N	1	2.00	32.33
982 000102402033	982 000102378781	N	1	1.00	74.39
982 000102402033	982 000102357171	N	1	2.00	44.90
982 000102402033	982 000102130384	N	1	1.00	60.87
982 000102402033	982 000102118879	N	1	1.00	63.33

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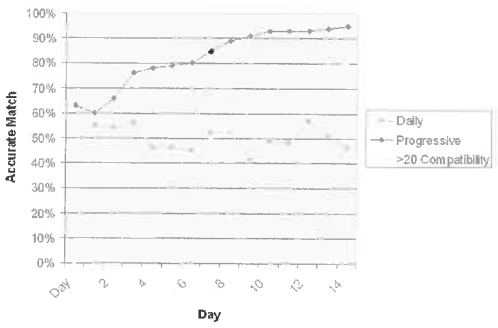
Match Maker

Match Maker Results



Notes

Notes

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The Next Phase in Alpaca Farming

STEVE RIDOUT

Steve's professional life is in the International Transport and Logistics arena and over the years he has transported many exotic/endangered species across the globe to assist with many zoos' breeding programs. Steve's passion to help these animals led him to help the 'Free the Bears Fund' organisation which rescues bears from Asia, provides sanctuary and often relocates them to zoos in Australia. "It's great to see some of what you are passionate about, free and happy again after suffering so much".

Steve made the lifestyle change to alpacas in 1997. With the help of many breeders imparting their knowledge and advice, he embarked on a successful breeding program with huacayas. Following considerable experience in the show ring acting as a Ring Steward or Chief Steward Steve has now recently qualified as a Judge.

Steve has recognised that the alpaca industry is mature enough to find a broader market place for its products. Alpacas in Australia have now become a livestock industry and the alpaca needs to be recognised as such. Steve fought long and hard with his own emotions but a challenge arose in the industry that needed tackling. Alpaca meat, LaViande Pty Ltd was established. It's a topic that many have differing opinions about but the reality of our industry is that the next phase in alpaca farming has arrived in Australia.
The product is unique and has a very exciting future across the globe.

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The industry in Australia hasn't matured as yet but is maturing. The physical numbers of alpaca, the growers and industry have matured to a point where the introduction of the meat side of the alpaca needs to be developed. LaViande will enable the stud industry, fleece industry to survive, grow and prosper long term.

In the following presentation we will cover current costs and the long term effects that the industry needs to recognise and address to ensure a safe transition to the next phase. We will also cover the positive aspects and the benefits to growers of developing a meat industry that will enhance the industry today, future growers and offer an alternative to current farming techniques.

It will also give you an insight into:
> LaViande the company,
> LaViande the quality product and
> LaViande the business plan.

IS THE ALPACA INDUSTRY SUSTAINABLE?

Current Costs to Growers

Everyone can put their own costs to their own feed, veterinary bills and shearing, but who really knows how much it does cost the grower in not only the actual physical cash outlay but land degradation due to increase in herd size? Your time also needs to have a dollar value put to it in order to really quantify the total cost to your business.

Let's put a monetary figure to the basic costs of raising an alpaca from birth until 3 years of age...

Shearing ..... $15 x 3 = ... $45
Feed ..... $5 per week x 156 = ... $780
Vet costs, this will vary but let's assume no costs until wethered $70
Husbandry $50
TOTAL $945

LESS

Price sold as a wether ..... (approx) $500

A Loss of $445

The land degradation aspect will vary depending on land and herd size but we all know as growers the effect of not being able to rest paddocks, the lack of feed (drought and overstocking) even down to controlling alpaca diseases such as worms correctly.

Long Term Effects

Currently we are seeing a considerable drop in the prices for our alpaca, this is due to the increase in numbers, drought and associated costs.

The increase in numbers through good breeding has increased the quality to such an extent that we are now wethering males that 5 years ago were potential stud quality. More growers have their own males so even the stud side of the business has dropped away. It's resulting in a lesser ability to move stock on lowering returns for the grower. Growers in turn are seeing less new breeders coming into the industry, also many original breeders are now opting out due to age and the above effects. All result in more and more alpaca coming onto the market diminishing or lowering the dollar return. These factors are resulting in slower growth for the alpaca industry.

The AAA and growers alike need to have an action plan, strategic steps to ensure we don't end up like the deer industry.

We have taken the next logical step forward!

The Positives

Diversification in farming attitudes is the next thought process for all growers. Current, new and prospective breeders need to look at where they fit in the alpaca industry and where they want to be as the industry matures further.

Currently we really have only the stud and fleece growers. However, for this industry to survive, the meat industry needs to fill a void that has been created by the natural growth of the alpaca industry here in Australia. By adding the meat as a viable, long term, profitable business we will be able to entice current breeders to stay in the industry and new entrants who see that the industry is maturing and recognise that the alpaca is a livestock enterprise. It may lead to a diversification in farming practices for current breeders, new breeders and possible farmers seeing females instead of wethered males as a possible source of farm revenue. The wethered males will be used in the meat side of the business ultimately giving the stud industry an outlet for lesser quality females to a wider market place.

Benefits to Growers / Breeders

The benefits of supporting the LaViande business are measured across the board. The lowering of stock numbers (de-stocking), less feed, less vet costs, ability to adequately rotate paddocks, less degradation of farming land and effective handling of drought conditions for the remaining herd. It will ultimately affect the stud and fleece industry by removing lesser quality stock from the industry. The quality of the fleece being sent in for production will increase having only stud or fleece herds remaining to supply that aspect of the alpaca industry. This is a long term effect and won't be felt until demand is at a point that we are reducing the lesser quality alpaca. The ability to on sell your unwanted stock into the meat industry provides another income stream. We are purchasing alpaca at 6 months up to 30 months of age. For those who decide to sell at 6 months it offsets any further expense that alpaca might cost them.

LAVIANDE BUSINESS PLAN

Quality Product and Name, Quality of Supply and Regular Supply

LaViande is being branded as such to give it a quality name for a quality product. The branding is just as important as the product itself so that's why we have been careful to offer a name / brand to the market place that sets it apart from current products we will compete with. Following on the lines of our main competitor, venison, we steered away from just calling it alpaca to stay away of the cute / cuddly aspect of the alpaca.

LaViande, the product, is unique – so the marketing, quality, handling, packaging all need to be of a high standard. Following on from current food practices, experiences in the beef, lamb and venison industries, we have set out to achieve what we think will take LaViande into the market place and make it a success.

We have listened to markets, chefs and industry professionals that have gone before us with other products, learnt by their mistakes and understood their industry so we can provide a product that the consumer will accept and can expect consistency in taste and regular supply.

The basics of consistent quality of the product, correct packaging, good visual labels and keeping the cool chain in place whilst transporting, have been at the forefront of our efforts prior to launching the product. As you can see throughout this presentation and product on display we have kept the generic theme across the board. It's so important to brand your product correctly.

With this in place coupled with advertising, information about the meat and alpaca we have been able to achieve market acceptance of the product quite quickly.

Generic Products

LaViande has been quick to recognise that more and more Australians are requesting product from their own backyard so to speak, food on offer should be home grown, from the region in which they dine! We endeavour to source product where it's going to be served. Our marketing is also based on this principle with promotional cards such as this being made generically for each state. It allows us to promote not only the product but alpaca (LaViande) from suppliers' regions.

LaViande Carcass

The carcass, for those who haven't actually seen one, is very lean indeed; this shows you very little body fat but lean high grade meat. The live weight of the alpaca we are slaughtering is approximately 40-50kg resulting in a 25-35kg carcass.

Cuts

Types of cuts are similar to those of lamb and venison – we have our prime cuts such as backstraps, 8 rib racks, tenderloins, short loins with secondary cuts, such as denvered legs where the leg muscles (round, rump, topside, and silverside) are cut away, de-sinewed and then placed back together in a pack known as a denvered leg set. This is done to ensure the complete leg muscles are sold so we are not left with any of the lesser desired cuts. In stating this we have found each individual muscle is as good as each other when cooking.

As you can see we have a variety of cuts that the consumer can choose. Many of the primal cuts are what the restaurants are choosing so we are concentrating on marketing the lesser cuts in order for a greater percentage of the carcass to be utilised.

Restaurants in Sydney , Brisbane and Melbourne are ordering LaViande with the Adelaide Hilton promoting it through their Brasserie Restaurant and high profile chef Simon Bryant (ABC TV program, *The Cook and the Chef).*

Versatility

LaViande is lean, high in protein, high in moisture; it leaves a buttery after taste and is not gamey at all. It lends itself to become a very versatile meat indeed with prime cuts being fillet steaks; trim used in pastas, pies and sausages; legs for roasting; de-boned legs marinated with native herbs is ideal to throw on a hot BBQ; slow cooking the shanks or neck rosettes in an *Osso Bucco* style is also exquisite.

LaViande takes on many flavours so it's easy to overspice it – spices such as chilli, lemon myrtle, basil, garlic, rosemary and thyme are ideal.

Value Adding

When value adding to the carcass, we must take into account the hides and pelts being produced. These come in varying grades and quality. Shearing plays a big part in where the pelt/hide ends up, not to mention the cost of stripping the hide from the carcass. Longer fleeced alpaca need manual stripping due to the long fleece tearing the hide through the mechanical stripping process thus resulting in a higher end cost of butchering the carcass. Shorter fleeced alpaca are put through the mechanical process.

We are currently putting together a grading system and working with tanneries to ultimately offer the market place anything from wall hangings and throw rugs to leather goods and the like.

MARKET SUPPORT

Markets and Marketing

LaViande markets are predominantly the restaurants and gourmet food outlets in major cities. We consciously target these areas that produce the greater returns, it's also coupled with not wanting to retail or denigrate the product through a mass outlet approach. The actual physical numbers of (slaughter quality) alpaca in Australia are not high enough to be able to supply a large volume product. The business needs to be able to have enough supply to cover current and budgeted increase in demand whilst still offering a regular supply and quality product.

Export potential is also being investigated to yield a greater return and usage of the carcass.

2008 will see more trade displays and further industry awareness events such as this conference, in order to establish the product and brand in the market place.

We all market ourselves and businesses in order to maximise our sales and profitability – LaViande is no different. We compete with an already established variety of products in a competitive environment so we need to run the company as lean and as profitable as possible in order for the business and industry as a whole to survive.

Grower Support

You, the breeder, can only decide if this next phase is what you want to be a part of. Most breeders entered into alpaca breeding for a lifestyle change and this aspect of the industry probably isn't for you.

However!

We all need this business to survive and supporting what we are doing through basic acceptance or being preferred suppliers to LaViande will enhance our ability to ensure longevity of the alpaca industry in Australia. ●

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Reinventing the Alpaca

DR JIM WATTS M.V.Sc., Ph. D.,

SRS® breeding system

Jim is a research veterinarian who has developed a new way of breeding fleece-coated animals. The breeding system, called the Soft Rolling Skin® or SRS® system, is based on improving the density and length of fibres grown by the animal, and has been applied to Merino sheep flocks and Angora goat herds in Australia since 1988 and more recently to Huacaya and Suri alpaca herds in Australia, New Zealand, North America and the United Kingdom.

Jim has developed measurement systems for fibre density and length as well as accurate subjective methods, based on fleece structure, of assessing density and length. He has shown that animals with measurably high levels of fibre density and length produce fleeces consisting of long and thin staples of high crimp amplitude and low crimp frequency. A key concept is that the 'fibre bundle', representing the fibres produced by the skin follicle group, is the basic unit of fleece structure.These scientific discoveries impact directly on the design and implementation of fleece breeding programs as well as conventional methods of animal and fleece judging. Currently, over 100 alpaca seedstock producers are using the SRS® breeding system.

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INTRODUCTION

'Guard hair', the coarse and medullated primary fibres that form the outer coat of many alpacas, is a major problem for textile manufacturers. It spoils the look and feel of finished products.

Adult alpacas produce fleeces that average about 24 to 25 microns for fibre diameter with the primary fibres being about 35 microns diameter (Table 1). By contrast, approximately 1,000 years ago the Incas bred alpacas with fleeces of superb fineneness and quality *(Wheeler et al 1992).* Alpacas with 18 micron fleeces, and possibly as fine as 12 to 13 micron, existed. The fleeces were each remarkably uniform for fibre diameter with standard deviations of about 1 micron. Such low variability of fibre diameter within the fleece could only occur if the primary wool fibres were as fine or finer than the secondary wool fibres. The animals must have been free of 'guard hair'. This high standard of fibre quality in alpacas is not seen today, and the reasons are well-documented. You can imagine what the commercial value of such fleeces might be. Cashmere (dehaired) at about 16 microns, is currently worth at least $100 per kilogram. Fibres of about 12 micron could be almost priceless.

If we were to try to reinvent such quality in alpaca fleeces, how might we go about it?

BREEDING OBJECTIVE

My approach is to breed alpacas with low primary fibre diameter and high levels of fibre density and fibre length.

Primary fibre diameter is a highly heritable trait whilst fibre density and fibre length are moderately heritable. The phenotypic correlation between fibre density and fibre length in alpacas is close to zero *(Watts, unpublished data)*, and it would be reasonable to expect the genetic correlation to be similar, indicating that co-selection for high fibre density and high fibre length is feasible.

If an alpaca has low primary fibre diameter, it will have less guard hair. If the primary fibres (and secondary fibres) are about 17 microns in diameter, there will be no guard hair and no medullation in most alpacas (Figure 5).

If the alpaca has high fibre density and length, that is, many fibres on its body, and these fibres are long, then it will produce high fleece weight. And as density increases, the fleece becomes finer in diameter, the fibres highly aligned, uniform in size and shape, and exquisitely soft. The processing performance of the fibre and the quality of the finished products escalate.

The scope for genetic improvement of both fibre density and length in alpacas is at least two-fold, or a four-fold increase in the fibre production of the animal. This would change the fleece of an alpaca, for example, from producing 3kgs of 25 micron wool per year to one producing about 7.5kgs of 20 micron wool or 4.2kgs of 15 micron wool per year.

REGULATION OF FIBRE GROWTH

Moore et al *(1984, 1989, 1998, unpublished data)* proposed that fibre density, fibre length and fibre fineness are regulated genetically by the number, distribution pattern and activity of pre-papilla cells in the foetal skin.

High density and length of fine fibres are thought to be the result of:

> A large starting population of pre-papilla cells being available in the foetal skin to form wool follicles.

> These pre-papilla cells being distributed as small clusters to form a high density of wool follicles.

> Because all the clusters are small, the fibres, whether from primary follicles or secondary follicles, are fine in diameter and non-medullated.

> These small clusters emitting strong signals to stimulate the growth of long fibres.

Considerable experimental evidence exists to indicate that the genetic regulation of wool follicle formation and fibre growth differs between primary wool follicles and secondary wool follicles. This biological reality needs to be addressed in the design of breeding programs. If primary fibre diameter, or an accurate indicator of primary fibre diameter, is not used as a selection criterion, then the alpaca is likely to remain two-coated and producing guard hair.

CURRENT INDUSTRY STANDARDS

Measurements of follicle and fibre characteristics from 392 Huacaya alpacas, averaging 45 months of age, and 83 Suri alpacas, averaging 39 months of age, are summarised in Table 1. The testing of skin and fleece samples from alpacas located in Australia, Canada, New Zealand, Peru and USA was done at my laboratory between 2001 and 2006.

The Huacaya samples are biased toward alpacas whom the owners consider to be among the best in the herd. The Suri samples are a more random samplingof herd animals.

The key points arising from Table 1 are:

> Huacaya alpacas have higher follicle densities (43.3 follicles per square millimetre) than Suri alpacas (31.5 follicles per square millimetre).

> Suri alpacas grow longer fibres (0.42mm per day) than Huacaya alpacas (0.35mm per day).

> Alpacas can have densities as high as 91.4 follicles per square millimetre.

> Alpacas can grow fibres as long as 0.69mm per day.

> Primary fibre diameter needs to be reduced by at least 10 microns to produce a uniform fleece in which the primary fibres are similar in diameter to the much finer secondary fibres.

> The current mean diameter of alpaca fleeces is about 24 to 25 microns which is at least 5 microns and perhaps 10 microns coarser than it needs to be to become a prestige fibre in the luxury retail market.

> Medullation is a major problem for the quality of alpaca fleeces. The medullation levels of both primary fibres (guard hair) and secondary fibres (gare) need to be greatly reduced or eliminated.

> There is much scope to increase the crimp amplitude of Huacaya fleeces.

> Huacayas produce, on average, fibres that are only 11% longer than the fleece (a fibre length to staple length ratio of 1.11 to 1). A fleece that forms a crimp wave equivalent to a semi-circle (ideal shape) will have fibres that are about 50% longer than the fleece length.

> Huacaya fibres crimp, on average, every 16.6 days, although there is great variation (6 to 66 days) between animals.

Table 1: Mean values and ranges of follicle and fibre characteristics of 392 Huacaya alpacas and 83 Suri alpacas.

Parameter	Huacaya		Suri	
	Mean	Range	Mean	Range
Follicle density (per square millimetre)	**43.3**	14.8 to 91.4	**31.5**	17.0 to 59.1
Primary follicle density (per square millimetre)	3.8	1.6 to 7.6	3.3	2.0 to 5.1
Fibre length (millimetres per day)	**0.34**	0.17 to 0.69	**0.42**	0.22 to 0.61
Primary fibre diameter (microns)	**34.7**	17.3 to 58.3	**36.9**	27.3 to 53.6
Primary fibre medullation (%)	**97.7**	0 to 100	**99.8**	94 to 100
Standard deviation of primary fibre diameter (microns)	5.5	1.8 to 11.1	5.6	3.0 to 11.1
Secondary fibre diameter (microns)	**24.0**	13.5 to 39.2	**25.1**	18.3 to 35.3
Secondary fibre medullation (%)	**50.9**	0 to 100	**58.4**	1 to 100
Standard deviation of secondary fibre diameter (microns)	3.6	1.7 to 7.4	3.9	2.4 to 8.5
S/P ratio	10.0	5.9 to 16.2	8.2	5.2 to 12.5
Fibre length to staple length ratio	1.11	0.71 to 1.46	-	-
Crimp frequency (per 10 mm)	2.2	0.3 to 3.9	-	-
Crimping time (days)	16.6	6 to 66	-	-

ANIMAL SELECTION

The fleece traits under selection, namely primary fibre diameter, fibre density and fibre length, can be visually assessed on the animal as well as measured in the laboratory. Both methods are used in SRS® breeding programs. Figure 1 shows the fleece structure of a Huacaya alpaca with measurably high density.

photo courtesy of Halcyon Alpacas

Figure 1: High density brings to the Huacaya fleece an assembly of thin, not thick, staples that are soft and lustrous and have high crimp amplitude. Even though this is a high density alpaca, the wool follicles occupy no more than about 15% of the skin area.

At 21 months of age, the Huacaya alpaca shown in Figure 1 had a density of 68 follicles per square millimetre. The mean diameters of the primary fibres and secondary fibres were 24.8 microns and 18.6 microns respectively. The fibres were growing in length at the rate of 0.33mm per day. As density increases, guard hair disappears, and the fibres become fine and evenly sized, deeply crimped and smooth surfaced (Figure 2).

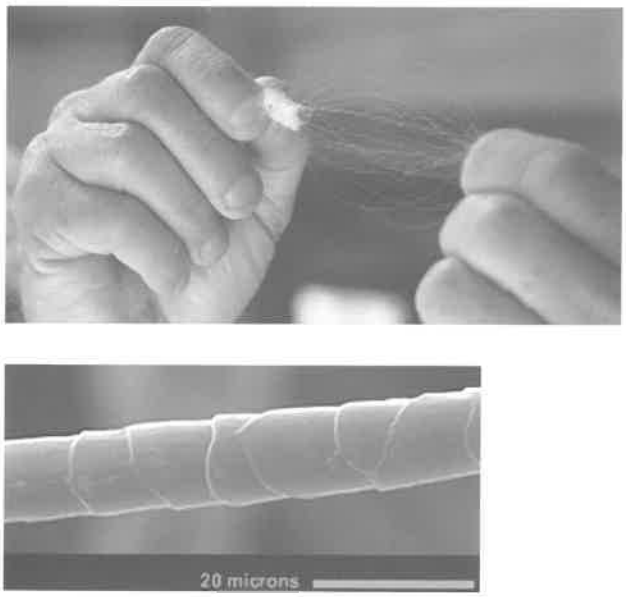


Figure 2. Top: The fibres, when withdrawn from the thin staple of a high density Huacaya alpaca are seen to be fine and uniform in diameter, deeply crimped and elastic. Bottom: a magnified view of a single fibre shows that the outer scales are long and flat, creating a smooth fibre surface.

Figure 3 shows the patterning of wool follicles in the skin of another high density alpaca. It is compared with an alpaca of average density.

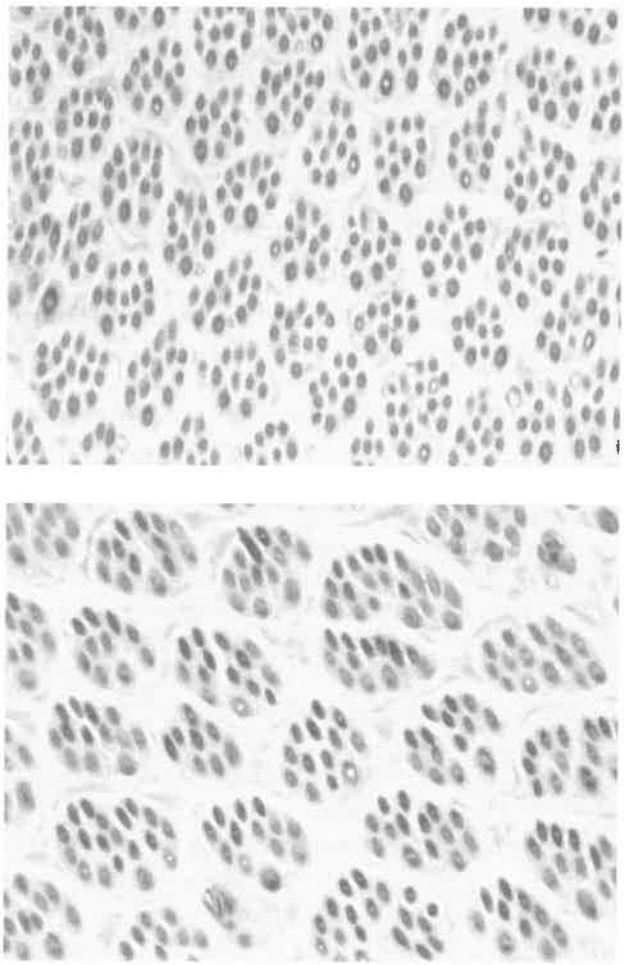


Figure 3. Horizontal skin sections (x 60 magnification) from: Top: a high density alpaca (Huacaya) with 73 follicles per square millimetre. Bottom: and an alpaca with a density of 34 follicles per square millimetre. The wool follicles (black rings) contain wool fibres (white centres) embedded in a matrix of connective tissue (open spaces).

The high density alpaca in Figure 3, at 23 months of age, had 73 follicles per square millimetre , and fibres growing in length at 0.37mm per day. The fibres appear similar in diameter and non-medullated (no guard hair). When measured, the primary fibres were found to have a mean diameter of 28.9 microns and a low standard deviation of 2.8 microns. The secondary fibres had a mean diameter of 19.9 microns and also a low standard deviation of 2.7 microns.

The average density alpaca in Figure 3, at 17 months of age, had 35 follicles per square millimetre, and fibres growing at the rate of 0.40mm per day. The fibres appear to vary considerably in diameter and most of the fibres are medullated. When measured, the primary fibres were found to have a mean diameter of 39.6 microns and a high standard deviation of 7.5 microns. The secondary fibres had a mean diameter of 26.3 microns and a standard deviation of 3.5 microns.

Note in Figure 3 that the follicles are arranged in oval shaped groups.

In the high density alpaca shown in Figure 3, each follicle group is about 0.75mm (750 microns) wide (actual size) and about 78 microns apart. Within each follicle group, there are about 34 follicles, each follicle being spaced about 20 microns apart. The follicles are packed closely together, and much closer than the distance between each follicle group. Consequently, the fibres that grow out of each follicle group in the skin and into the fleece tend to lie side by side without entangling, and clearly separated as a cluster of fibres from the clusters growing from adjacent follicle groups. The cluster of fibres growing from each follicle group is called a **'fibre bundle'** to distinguish it from a staple (lock). The fibre bundle will only be about 0.75mm wide as its size corresponds to the size of the follicle group.

The high density alpaca in Figure 1 is producing thin staples, each about 5mm wide. It is not at the stage where follicles are so closely packed together that fibre bundles are visible in the fleece but it is nearing that standard. When this standard is reached, the fleece will consist entirely of fibre bundles (Figure 4).

Figure 4: This is a high density and length fleece from an adult Merino ewe. Note that it consists entirely of fibre bundles. The animal's density was 120 follicles per square millimetre, and its fibre length, 0.50mm per day. The ewe produced 8kgs of 16.0 micron wool for 12 months fleece growth.

It can be concluded that the fibre bundle is the basic unit of fleece structure originating from the basic pattern of follicle arrangement in the skin, the follicle group.

In the average density alpaca shown in Figure 3, each follicle group is about 1.0mm (1000 microns) wide (actual size) and about 370 microns apart. Within each follicle group, there are about 31 follicles, each follicle being spaced about 42 microns apart. Since the follicles are not packed closely together, the fibres grow in more or less random directions, and become entangled with fibres from adjacent follicle groups, and form staples.

So what is a staple or lock ?

It is a structural artefact that occur when fibres entangle. Fibre entangle when the distance between the follicles within the follicle group increases, that is, as density decreases. The fibres then grow in more or less random directions and intermingle with fibres from adjacent follicle groups, resulting in a staple. The thicker the staple is (and it can be as much as 40mm wide), the lower the density is and the greater is the degree of fibre entanglement.

Being able to measure primary fibre diameter allows us to determine with certainty that we are selecting alpacas with less guard hair. When the skins of the high density alpacas shown in Figures 1 and 3 were examined under the microscope, there was still a difference of 6.2 microns and 6.3 microns respectively in diameter between the primary fibres and the secondary fibres. You could say that coarse and medullated primary fibres can still be 'invisible' in stylish fleeces, but not invisible when the top or fabric is made. Skin testing allows more selection pressure to be placed on eliminating guard hair and meeting our customer's requirements.

In Suri alpacas, similar visual and tactile indicators of high fibre density and length can be used as described for Huacaya alpacas. However, since Suri fibre twists rather than crimps, fibre bundles from adjacent follicle groups will merge at the point where the first coil is formed in the fleece. Instead of reaching the final stage of a fleece being composed of fibre bundles, the advanced Suri fleece will consist of uniformly thin and long staples that coil gently from base to tip and are exquisitely soft and lustrous (Figure 5).

photo courtesy of Surilana Alpacas

Figure 5: A Suri alpaca with high fibre density and length. Note that the staples are consistently thin from base to tip throughout the fleece. Fibre bundles can be seen emerging from the skin, only to twist together into thin staples.

It appears to be more difficult to estimate visually density in Suris than in Huacayas. The common practice of not shearing Suris until two years of age means that the fleeces are overgrown and may appear to have high fleece weight and good density. This can be misleading. Also, the smoother fibre surfaces of Suris impart a softer handle which could be mistakenly judged as density and fineness.

It also appears more difficult to estimate 'guard hair' content in Suris. Because the Suri fibre twists rather than crimps, the fibres are tucked away into the body of the staple. Again, because the fibres have smoother surfaces, 'guard hair' is not readily distinguished on handle or sight. An additional factor might be that Suri fibre, more so than Huacaya fibre, tends to grow intermittently throughout the year, with the 'guard hair' being hidden in the body of the staple as short fibres.

These considerations suggest that skin testing has a critical role to play in Suri breeding programs.

NEW BREEDING STANDARDS

What are the new breeding standards required to produce alpaca fleeces that are:

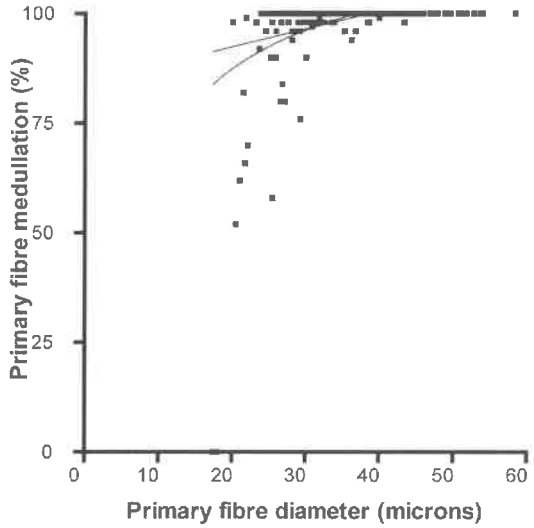
> Free of medullation.

> As fine as cashmere.

> Of high fleece weight.

> Of high processing performance and product quality.

Currently, nearly all alpacas have medullated primary fibres and medullated secondary fibres. The proportion of medullated fibres is close to 100% in the primary follicle population and about 58% in the secondary follicle population (Table 1). Figure 6 indicates that the mean fibre diameter of primary fibres and secondary fibres need to be reduced to about 17 microns before medullation disappears in most alpacas.



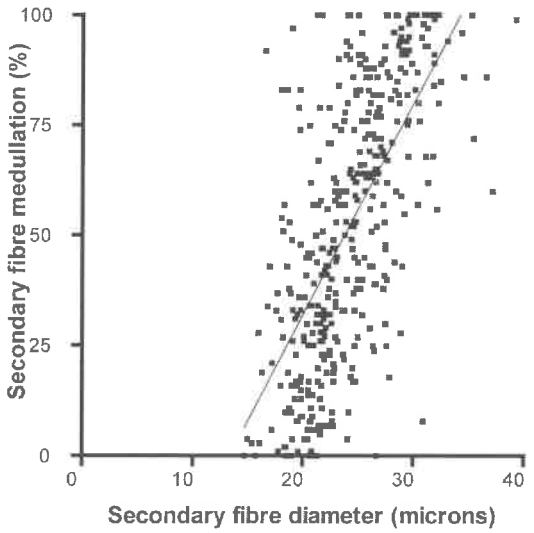
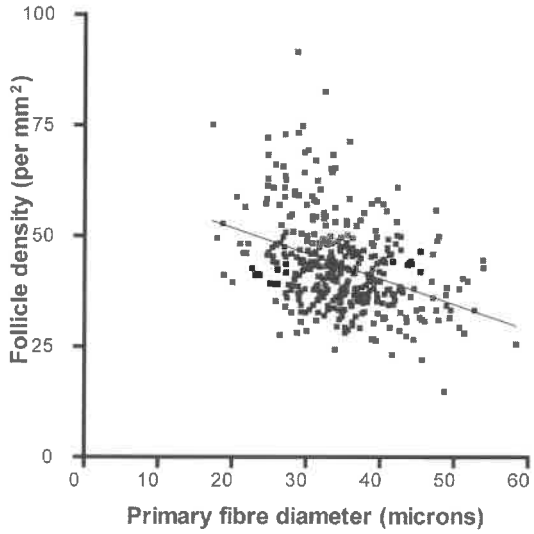


Figure 6: The fibre diameter of both primary fibres and secondary fibres needs to be reduced to about 17 microns before medullation disappears. Note that whilst the diameter and medullation of secondary fibres are closely correlated phenotypically (r = 0.68, P < 0.001, n = 210), the relationship for primary fibres is non-linear.

To produce a cashmere fine (16 micron) fleece with high fleece weight, the alpaca needs to have a follicle density of at least 60 follicles per square millimetre (Figure 7).



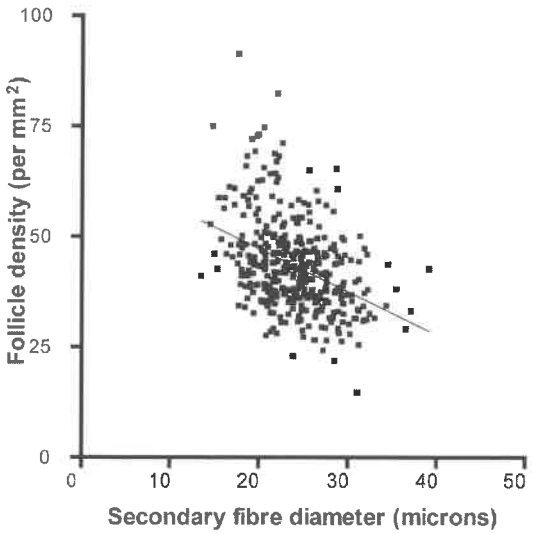


Figure 7: Fibre diameter decreases as follicle density increases. The phenotypic correlations between follicle density and fibre diameter are: r = - 0.39, P < 0.001, n =210, for primary fibres and r = - 0.42, P<0.001, n = 210 for secondary fibres.

Fibre length decreases rapidly with age in both male and female alpacas. Table 2 illustrates this well-known effect, using Huacaya data as an example.

Table 2. Fibre length decreases with age.

Age (years)	Fibre length (mm per day)	Range	Number of animals
1 to 2	0.39	0.27 to 0.69	76
2 to 3	0.38	0.26 to 0.57	57
3 to 4	0.33	0.19 to 0.47	36
4 to 6	0.30	0.19 to 0.60	43
Older	0.28	0.17 to 0.33	35

Huacaya alpacas crimp, on average, every 16 days, or about twice the period Merino wool takes to crimp. However, the crimping time varies from 6 to 66 days between individual alpacas (Table 1). Much of this variation is avoidable (genetically) as it is due to 'dogginess' associated with ageing and slow fibre growth.

To overcome this problem, it is probably necessary to select for reduced crimping time (suggest about 12 days) whilst maximizing fibre length. This may require alpacas to be bred which are more efficient converters of feed and have much better organized blood networks to the wool follicles (the latter accompanies selection for high follicle density).

Crimp amplitude needs to be improved (genetically) in order to improve fibre elasticity which in turn, improves drape and drape retention in finished products. Fibre length to staple length ratio is an indirect measure of crimp amplitude. A fleece with a fibre length to staple length ratio of 1.51 to 1 forms crimp waves that resemble semi-circles; close to perfect crimping in fibres.

Huacayas have a mean fibre length to staple length ratio of 1.11 to 1, ranging from 0.71 to 1 to 1.46 to 1 between animals (Table 1), well below the desired level.

CONCLUSIONS

Alpacas have the potential to produce finer and more valuable fibre than cashmere. Each alpaca has the potential to produce about 40 times more fibre than a cashmere goat.

Alpacas that produce this high quality fibre will be in high demand as seedstock and for the fibre. ●

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Developing an International Market for Australian Alpaca

MICHAEL TALBOT

Australian Alpaca Fleece Ltd

Michael Talbot joined the original Australian Alpaca Co-operative Ltd in 2000 as a part time consultant. His main brief at that stage was to market and sell the stockpile of Co-op fleece, turn it into products to try to get some cash flow into the business and organize to get some strategic partners on board. He managed to get a number of Australian and New Zealand companies involved, working in conjunction with the Co-op in manufacturing and selling Australian Alpaca products.

Michael is now the Managing Director of Australian Alpaca Fleece Ltd (AAFL), which came about in March 2004. It was during this stage that AAFL launched its own wholesale label, *Australian Alpaca Connection*, and also added two very important strategic partners being the Micheil Group and Incalpaca. AAFL currently sells product to New Zealand, China, Hong Kong, Japan and the USA as well as throughout Australia. The Australian alpaca industry is now very much a global business. Michael's background spans 25 years working in the women's clothing industry where he operated a family business involving manufacturing, retailing, importing and wholesaling.

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Editor's Note: *This paper is a powerpoint presentation. Slide 1 of the presentation is the title slide. These notes start from slide 2. Some of the reproductions in this document may be too small to read effectively, therefore the author has made them available to download from the following web site:*

http://www.aafl.com.au

Slide 2

Current fleece situation

AUSTRALIAN ALPACA

- Australia wide there are approximately 80,000 alpacas producing 160,000 kg of fleece annually average of 2kg per animal
- Of this AAFL will receive 80,000kg for the 2007/08 financial year
- This will be classed in to 95 lines of huacaya and 46 lines of suri of which nearly all fleece is classed in store and not on farm
- Current classing lines consist of 10 colours and micron ranges of:
  Under 20
  20-23
  23-26
  26-30 and
  30 and above

Slide 3

Percentage of fleece received at AAFL by state

Slide 4

Collection Points and Fleece Workshops

AAFL has setup over 30 collection points across Australia where growers can drop off their fleece and have it consolidated with other growers, significantly reducing the transport costs to individual growers.

RECENT FLEECE WORKSHOPS

Adelaide, SA
Innisplain, QLD
Bungendore, NSW
Goulburn, NSW
Richmond, NSW
Bayles, VIC
Albany, WA
Grafton, NSW
Sunshine, VIC
Maffra, VIC
Armadale, WA
Gidgegannup, WA
Wagga, NSW
Horsham, VIC
Warrnambool, VIC

UP-COMING FLEECE WORKSHOPS

Hobart, TAS
Launceston, TAS
Toora, VIC Eastern
TBC, VIC Central

FLEECE COLLECTION POINTS

WESTERN AUSTRALIA
Beaufort River
Gidgegannup
Armadale
Albany

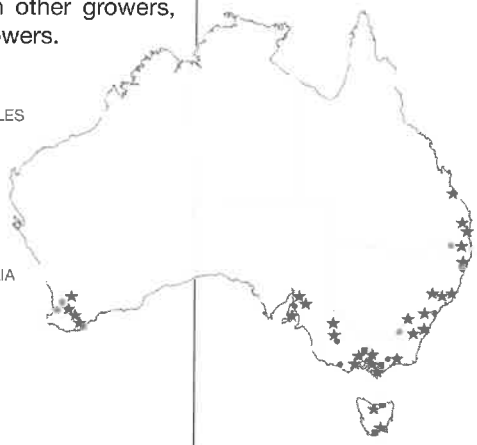
QUEENSLAND
Palmwoods
Brisbane
Bargara
Boyland

VICTORIA
Freshwater Creek
Avonsleigh
Maffra
Flowerdale
Tynong
Red Hill
Acheron
Underbool
Horsham
Bylands

NEW SOUTH WALES
Bowning
Canyonleigh
Bungendore
Morpeth
Braxton
Lorne
Little Hartley
Grafton

SOUTH AUSTRALIA
Kersbrook
Nangkita
Birdwood

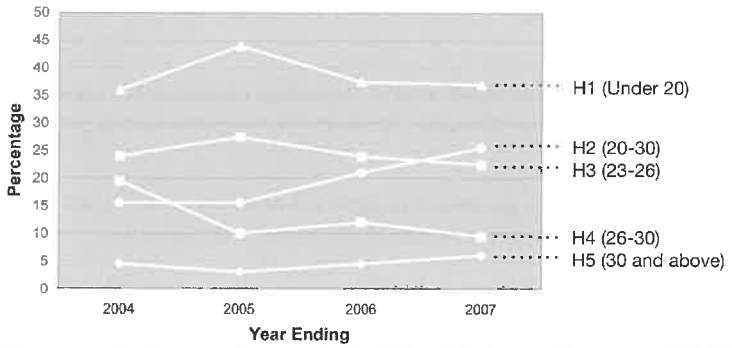
TASMANIA
Kingston
Westbury



Slide 5

Improvement in fleece quality

Within the past 4 years we have seen a dramatic improvement in the overall quality of fleece being supplied to AAFL. The quantities in the finer grades (H1 & H2) have been steadily lifting whilst the broader grades are decreasing. The chart below shows each grade as a percentage of the total fleece received over the past 4 financial years.



Slide 6

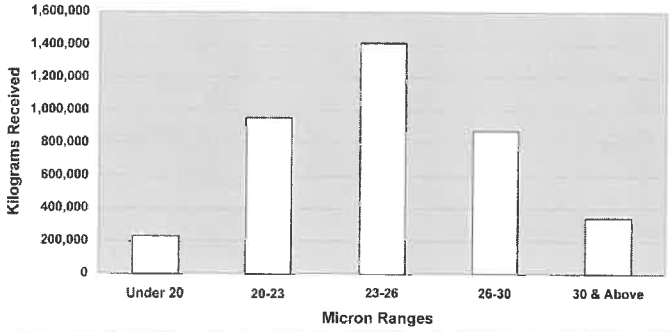
The Future – Vision for 2020

- National herd of 1.2 million alpacas producing 4 million kg of fleece
- Average per alpaca increased to 3.3kg through improved breeding using techniques such as embryo transplant, SRS and across-herd genetic evaluation (AGE)
- AAFL will be handling and marketing around 95% of the fleece produced
- The number of classing lines will increase
- Micron ranges of each line will no longer be 3-4 micron but 1-2 micron
- Colour ranges will also be separated even further to produce more consistent colour lines
- The major issues with alpaca – being guard fibre and the incidence of coloured fibres in white fleece will have been reduced and these advancements will lead to noticeable improvements in the finished products.

Slide 7

Fleece volumes in 2020

The chart below shows the approximate quantities of each grade AAFL would be receiving by 2020 based on the receival of nearly 4 million kilograms. Percentages of each type are based on those from the 2006/07 financial year and does not allow for the expected improvement in fleece fineness we will see over the next 12 years and is really a "if nothing improved" scenario.



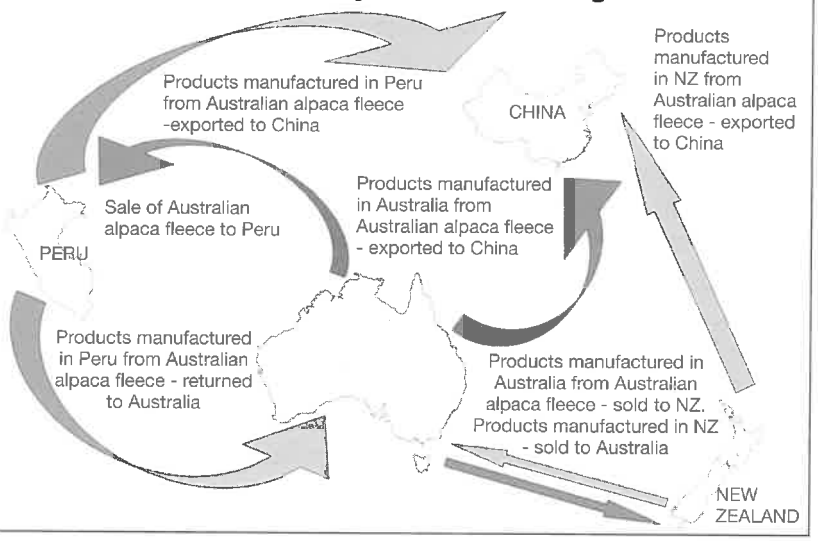
Slide 8

Current AAFL operations in 2008

- Fleece classed and sold greasy at world price to local Australian manufacturers and Peru
- Products sold nationally through traditional retail chains, department stores and specialty shops
- Small export to New Zealand, China, Korea, Hong Kong and North America
- As we are only able to sell a limited number of products in Australia more sales are needed in the Northern Hemisphere during our summer months
- We are developing a marketing program promoting Australian Alpaca to premium markets of the world like Japan and Europe
- Our concern is ensuring as the clip grows we can sell the quantity collected

Slide 9

Global reality of manufacturing



Slide 10

Control of our own destiny

This logo, developed by Australian Alpaca Fleece Ltd, is used on all our labels and packaging and is owned by all shareholders of AAFL.

AUSTRALIAN ALPACA
CONNECTION

Slide 11

Why Australian Alpaca Connection was created

AUSTRALIAN ALPACA
CONNECTION

- Not enough margin in buying and selling fleece
- Needed to value add to increase margin, hence return for shareholders
- Needed our own label for export promoting our logo
- Needed to make a strong statement to the world about Australian Alpaca fleece
- Needed to develop export business in Northern Hemisphere so we are selling product over 12 months of the year

Slide 12

Current marketing of our product

- Began our marketing and selling in Asia because of proximity and opportunity
- Now looking at opportunities in Europe and Japan

Slide 13

AAFL's position in 2008

Australian Alpaca Fleece Ltd. will continue to work with 11 main organisations, both nationally and internationally, in the commercialisation of Australian alpaca fleece.

Crewnich	Blankets and throw rugs
MERINO GOLD AUSTRALIA	Men's and women's knitwear and accessories
natural carpet	Carpet
Kelly & Windsor	Quilts, pillows and underblankets
zenger	Quilts, underblankets, scarves, throw rugs, knitwear and accessoried

Slide 14

design spun	Fine spinning yarns and hand knitting yarns
Pussyfoot	Men's and women's dress and work socks
HYSPORT	Beanies, gloves, scarves, shawls, baby blankets and fashion knitwear
Masterweave Textiles Ltd.	Throw rugs and scarves
INCALPACA TPX	Tops, yarns, men's and women's accessories, knitwear, coats, wall hangings and rugs
MICHELL	

Slide 15

2008 and beyond

AUSTRALIAN ALPACA

- Work with growers establishing:
  - further educational programs and better communication
  - coordination of fleece improvement programs i.e. reduction in guard hair, coloured fibre, etc.
  - improve harvesting and transportation of fleece
  - work to ensure a better return
- Continue to establish our brand both locally and in the world market
- Work on expanding our export business to more countries, mainly Japan and Europe

Manufacturing Tops and Yarns

DEREK MICHELL LOPEZ DE ROMANA

Michell Group, Peru

Derek was born in Arequipa, Peru in 1968 and attended primary and secondary English school in Arequipa, except for two years, when he lived in England (1977-1979). He studied General studies at Universidad de Lima (1985-1987) and graduated with a BSBA in Business Administration at Boston University (1987-1990). He worked for Nagawa Co., a Japanese Textile Trading Company, in 1990 and has been working for the past 17 years in the alpaca industry, with his present position being Manager-Director of Michell & Co.

He is married, with three daughters, aged 8, 7 and 2.

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Notes

Notes

Alpacas: Past, Present and Future

DR JANE C WHEELER

CONOPA, Peru

Jane Wheeler is Vice President for Research, CONOPA, Peru. She holds degrees from American University, Cambridge University, and the University of Michigan, and completed postdoctoral studies at the University of Paris. For more than 30 years she has conducted broad based research on the South American camelids, covering topics from origin, evolution and domestication of alpacas and llamas, to molecular genetics, breeding and fibre production, as well as vicuña and guanaco genetics and conservation. Her current research includes the study of genetic diversity and management implications in the Peruvian guanaco (Darwin Initiative, UK), genetic diversity and sustainable utilization of the vicuña in the Andes (EU INCO-DC Project MACS) as well as identification and rescue of vicuña genotype alpaca (non-hybrids) from the threat of extinction (INCAGRO Peru – World Bank, CONCYTEC, the Peruvian National Science Foundation, among others). Over the past year, CONCYTEC has funded study of the Pacomarca (Grupo Inca) alpaca herd using DNA testing with the goal of establishing the first elite herd of genetically pure alpacas in Peru.

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THE PAST: ORIGINS

Currently available palaeontological evidence indicates that the ancestors of the family Camelidae originated in North America during the Eocene, 30-35 million years ago, with *Poebrotherium* the oldest known form. The last common ancestor of the Old and New World camelids has long been thought to be *Procamelus*, 16-6 million years ago, but research published in 1998 *(Honey, Prothero and Stevens)* suggests that the oldest *Aepycamelus* (17.5-6 million years ago) fossils more likely represent the last common ancestor. The subsequent separation into Lamini and Camelini, the tribes of New and Old World camelids, respectively, is dated to 11 million years *(Harrison 1979: Webb 1974)*, with migration to South America and Asia occurring around 3 million years ago *(Webb 1974)*. Fossils of the extant New World genera, Lama and Vicugna are found in South American palaeontological deposits dated approximately 2 million years ago.

Two branches of the Lamini evolved from the ancestral North American *Pliauchenia* (11-9 million years). The first exclusively North American branch contains *Alforjas* (10-4.5 million years) and *Camelops* (4.5-0.1 million years), while the second includes *Hemiauchenia* (10-0.1 million years), *Palaeolama* (2-0.1 million years), *Lama* (2 million years to present) and *Vicugna* (2 million years to present) all of which are found in South America. Although it has been suggested that *Hemiauchenia* should be classified within the genus *Palaeolama*, this seems unlikely based on dental conformation and it is clear that *Lama* and *Vicugna* evolved from *Hemiauchenia*. By the end of the Pleistocene, the only surviving members of the Lamini were the South American *Lama* (the guanaco) and *Vicugna* (the vicuña).

The South American camelids are classified within the order Artiodactyla, suborder Tylopoda and family Camelidae. Some taxonomists have divided the species into two genera and four species: *Lama guanicoe* (guanaco), *L. pacos* (alpaca), *L. glama* (llama) and *Vicugna vicugna* (vicuña), while many others have favored placing the four species within the genus *Lama*. Recent genetic studies, however, have shown that the Camelidae are comprised of two genera, *Lama* and *Vicugna*, each containing two species: *L. guanicoe* (guanaco) and *L. glama* (llama), *V. vicugna* (vicuña) and *V. pacos* (alpaca) *(Kadwell et al. 2001, Wheeler, Chikhi and Bruford 2006, Marin et al. 2007a)*.

Although four subspecies of guanaco (*L. guanicoe guanicoe* in Patagonia, Tierra del Fuego and Argentina south of 35°S, *L.g. huanacus* in Chile, *L.g. cacsilensis* in the High Andes of Peru, Bolivia, NE Chile and *L.g. voglii* on the eastern slope of the Andes in Argentina between 21-32°S) have been described based on geographic distribution and physical characteristics, DNA evidence has shown that only two exist, the northernmost *L.g. cacsilensis* and the southern *L. g. guanicoe* which also includes *L.g. huanacus* and *L.g. voglii (Marin et al., 2008)*. The existence of two vicuña subspecies, *V. vicugna mensalis* from 9°30' to 18°S and *V.v. vicugna* from 18 to 29°S has also been confirmed by DNA testing *(Marin et al. 2007b)*. These two studies indicate that the northernmost forms, *L.g. cacsilensis* and *V.v. mensalis*, are the ancestors of the domestic llama and alpaca respectively.

THE PAST: DOMESTICATION

Over the years a series of hypotheses have been put forward concerning llama and alpaca origins *(Wheeler 1995)*. The oldest is that the alpaca descends from the vicuña and the llama from the guanaco. The second, and until recently dominate theory, holds that both the alpaca and the llama descend from the guanaco and the vicuña was never domesticated. The third, now discredited theory dating to the 1930s, held that wild alpacas and llamas existed during the last Ice Age in Argentina and that these were the ancestors of the domestic forms, while the vicuña and guanaco were never brought under human control. The fourth theory, based on the study of behavior in zoo animals, holds that the alpaca is a product of hybridization between llama and vicuña. Although there has been considerable speculation about the ancestry of the alpaca, there has been no doubt but that the llama descends from the guanaco.

The central theme in the debate about alpaca origins has been whether or not the vicuña ever was, or could be, domesticated. Starting in the 1950s, German scientists W. Herre, M. Röhrs and M. Fallat argued on the basis of changes in skull structure, brain size and skin follicle pattern in the domestic llama and alpaca, that the vicuña was never brought under human control and that the alpaca was a breed of llama selected for fiber production. In the 1980s, J.C. Wheeler argued, based on the analysis of animal bones excavated at Telarmachay Rock Shelter in the central Peruvian highlands, that changes in incisor conformation and other evidence indicated a vicuña to alpaca domestication 6-7,000 years ago. Analysis of hemoglobin and amino acid sequences from zoo animals in Germany (1980-90s) and Chile (1960) produced evidence both for and against vicuña domestication, while immunological and protein-sequencing data from studies in the United States (1980-90s) was inconclusive. Faced with such contradictory evidence concerning alpaca origins, resolution of the debate appeared impossible until the mid 1980s when advances in DNA technology accelerated analytical capability to the point that the study of DNA became routine and genome mapping possible. In 1994, Stanley, Kadwell and Wheeler reported the South American camelid cytochrome b gene sequence, the first published study of South American camelid DNA. Subsequently, with an expanded team, they utilized both mitochondrial and nuclear (microsatelite) DNA to define camelid phylogeny, demonstrating that the alpaca descends from the vicuña and the llama from the guanaco, and at the same time documenting the existence of hybrid animals *(Kadwell et al. 2001)*.

Direct evidence of the domestication process is available in the organic remains of South American camelids recovered during archaeological excavations at sites in the high Andes. The huemul deer, vicuña and guanaco, have inhabited this region since the last glacial advance and were the prey of early hunters. At one site, Telarmachay Rock Shelter, located at 4,420 meters above sea level in central Peru, a 9,000 year long record of human occupation was recovered. The first inhabitants were generalist hunters taking vicuña, guanaco and huemul deer equally, but through time their descendents came to specialize in hunting the wild camelids, and eventually began to control and finally domesticate them *(Wheeler 1995)*. Evidence of this process is recorded in the massive increase of bones from neonatal mortalities as stress, disease and predators attacked the most vulnerable segment of the captive vicuña and guanaco herd. Through time changes in the genome occurred due to inbreeding in the small captive population, including modification of the incisors with the adult domestic form (alpaca) retaining the milk tooth pattern of the wild ancestor (vicuña). The appearance of both domestic alpaca and llama at Telarmachay is dated 6-7,000 years ago, but because the evidence comes from bone remains nothing is known of the physical appearance of these early animals. Additional evidence from sites in Argentina and Chile suggests the possibility of multiple domestication events for the llama.

Llama and alpaca herding spread from the high Andes to lower elevation valleys and into northern Chile 3,800 years ago, and was established along the Pacific coast of Peru 1,500 years later. Textile remains suggest the possible appearance of specialized fiber producing animals as early as 3,000 years ago, but lack of preservation in the highlands makes this difficult to accurately determine. Llama caravans led by warrior-traders provided support for development of the first high elevation Andean city at Pucara (Puno, Peru) almost 1000 years ago, and continued to play a fundamental role in development of Andean civilization. Under Inca rule, camelid herds were owned by the state, the church and communities as well as by individuals and rigorous breeding standards were maintained. Coat color was of particular importance in defining appropriate ritual status for sacrificial animals, and high quality fiber was essential for state controlled textile production. Spanish taxation records record that within a century of contact up to 90% of the llama and alpaca herds disappeared, and it is likely that a similar fraction of the wild vicuña and guanaco populations may also have vanished. The impact of such devastating loss on the vicuña and guanaco genomes is slowly being documented, but to date similar research on the alpaca and llama genomes is lacking.

THE PAST: PRECONQUEST ALPACA AND LLAMA BREEDING

Excavations at Chiribaya culture sites in the lower Osmore River valley on the coast of southern Peru (17° south latitude) have produced extremely well preserved 900 to 1300 year old alpaca and llama remains *(Wheeler, Russel and Redden 1995)*. These include naturally desiccated mummies found under house floors and in human burials, as well as alpaca and llama heads found in tombs. The animals were sacrificed by a massive blow between the ears which fractured the skull, and then either decapitated or buried in a natural sitting position with the neck turned to the side and the head resting beside or under the legs, or occasionally, the neck was bent backwards so the top of the head came to rest on the back. In most cases, the animals were buried shortly after sacrifice. Offerings of guinea pigs, coca leaves, thread wrapped sticks, turquoise and marine shell beads, small silver plaques, feathers, fish, corn and burning charcoal accompanied the alpacas and llamas buried beneath the houses. The extreme aridity of the

photo courtesy Grant Deline

Alpaca mummies from the site of El Yaral

environment, plus the fact that the animals were interred in sand, resulted in exceptional preservation so that fiber, skin, internal organs, and frequently, even the genitalia were preserved. Most of the sacrificial animals were llamas, but alpacas were found at three sites and several different lines of evidence indicate that they were being raised in the valley. At one site, El Yaral, 26 perfectly preserved, naturally desiccated llama and alpaca mummies were found. Analysis of the alpaca fleeces revealed uniform fiber fineness with two groups at 17.9 +/- 1.0 and 23.6 +/- 1.9 microns, both significantly finer relative to most of today's Andean animals, while the llama fleeces averaged 22.4 +/- 2.3 microns and included both single and double-coated animals. The overall evidence suggests that the Chiribaya herders may have exerted such intense selection on their herds as to produce alpacas and llamas with physical characteristics approaching present day breed standards.

THE PRESENT

The 1994 analysis of South American camelid mitochondrial DNA sequences by Stanley, Kadwell and Wheeler produced evidence for considerable bidirectional hybridisation between alpaca and llama, and this has subsequently been confirmed through continuing research. In 2001, *(Kadwell et al.)* using a large trans-Andean sample set, and both mitochondrial and nuclear (microsatellite) data, these researchers reported that 80% of the alpacas and 40% of the llamas sampled were hybrids. Although ongoing research is producing additional information on the incidence of hybridization in the South American camelids and more sophisticated analytical tools are being utilized *(Wheeler, Chikhi and Bruford 2006)*, much remains to be done. It is clear that hybridization has played a major role in the formation of alpaca and llama populations. None the less, the details of this process remain to be documented and until they are it is of crucial importance that the original, and clearly endangered, non-hybrid alpaca genome be preserved.

THE FUTURE

Just as DNA is providing important information about the origin and genetic makeup of alpacas and llamas, there can be no doubt that DNA marker assisted breeding will play an increasingly important role in future. In the South American camelids, the use of DNA testing for parentage/ pedigree testing is well established, but molecular markers for diversity, diagnostics, traceability, and determination of genes of economic value are scarce, and to date it is not possible to pinpoint regions of the genome under selection. As advances in DNA technology continue to rapidly accelerate analytical capability, it is to be anticipated that, as in the case of other domestic animals, genes of commercial interest will be identified for the South American camelids and come to play an increasingly important role in breeding management. Nonetheless, it is crucial that the DNA data also be used to insure the conservation of alpaca and llama biodiversity, and especially to insure survival of the original non-hybrid alpaca and llama genome. ●

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Notes

Embryo Transfer Strategies in the South American Camelids, Continuous Cycling vs. Superovulation

PAUL TAYLOR

Paul Taylor was born in San Francisco in 1942 and attended Stanford University before training as a dentist at the University of California. Paul and his wife, Sally, became interested in llamas in 1975 and in 1983 Paul retired from dentistry to devote his attention full time to the llama project.

Paul's interest in embryo transfer (ET) began in 1992 and in 1994 they produced their first live babies by ET, and after a further 12 years of research and experimentation produced the first live babies from frozen embryos. Paul and other researchers around the world are currently working to perfect an embryo freezing protocol which will make international movement of frozen embryos of the South American Camelids (SAC) practical in the near future.

Paul and Sally performed the first commercial embryo transfer in SAC and produced the first alpaca babies carried and nursed by llama surrogate mothers. Under a cooperative agreement with Louisiana State University they were involved in projects that resulted in the first viable camelid embryos produced by sperm injection and by cloning.

The Taylors have written many articles and papers about advanced reproduction in SAC. They teach camelid ET at their Montana ranch clinic and Paul has addressed seminars on ET in Peru, Argentina and Chile.

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There is great interest now in the potential for embryo transfer to make dramatic genetic improvement in the South American Camelids (SAC), and especially in alpacas in Australia and in Peru. Embryo transfer is a practical way to amplify the production of selected females by 10X. Embryos from a few top-quality females, bred to top-quality males, can be transferred into females that are of poorer quality.

There are two basic strategies for producing embryos for transfer. The simplest is called **continuous cycling.** The two domesticated members of the SAC, the llama and alpaca, cycle continuously, producing new follicles on their ovaries year-round. A donor alpaca female can be flushed for an embryo about every 12-13 days without any kind of hormone treatment, and an embryo can be expected from about 70% of these flushes. A simple, non-surgical flush of the uterus is done 7-8 days after the breeding to obtain the embryo, and the female can be ready to breed again only 3-4 days later. This is a low-tech, low-cost approach to obtaining embryos for transfer, and it can be repeated on every cycle, continuously, for the normal reproductive lifetime of the donor female. The practical significance of this is that up to 26 flushes can be done per year, per donor female, resulting in about (0.70x26) 18+ embryos per year for transfer on average.

Continuous cycling embryo transfer requires that competent people be available year round to do the embryo transfer work, and that competent people are available to oversee the birth of the special ET babies produced and to provide shelter for the newborns and their surrogate dams during bad weather. To ensure adequate nutrition and to eliminate nutrition-based variations in embryo production and rate of pregnancy after transfer, all the animals (donors, pregnant, non-pregnant and lactating recipients) should be fed hay year round.

A program of continuous cycling is ideal for the situation in Peru, where there are no regulations requiring that an ET technician be a licensed veterinarian. Any person with a small hand, and the knowledge and ability, can do ET in alpacas there. It would also be ideal for any family raising quality alpacas anywhere in the world if the wife, daughter or an employee has a small hand and is interested to do the work... and, if government regulations would permit it.

The other strategy for producing embryos is called **superovulation** or MOET (multiple ovulation embryo transfer). This is especially useful in bovines because they don't produce follicles as regularly or as often as the camelids do. Superovulation is a treatment with hormones, mainly follicle

stimulating hormone (FSH), to induce formation of more than the normal single follicle usually produced on each cycle without hormone treatment. Each follicle on the ovary contains a single ovum, so if several follicles are present at the time of a fertile breeding, there is a chance for several ova to be released and fertilized. This can lead to production of several embryos from the same breeding and they can be collected with a single flush of the uterus.

Embryo production from superovulation in the SAC is extremely variable from one animal to another, and some animals treated with FSH do not respond at all or even stop cycling temporarily. Flushes of the remaining donor females result in an average yield of between 2 and 3 embryos, with actual results varying between zero (the most common numeric result) and 10 or even more. Female alpacas and llamas should have at least 4 months between FSH treatments for their cycles to normalize and for subsequent FSH treatments to be effective. This means that production of embryos from the animals that are acceptable subjects for superovulation is going to be 2.5 (average yield per flush) x 3 (the number of flushes per year), or around 8 embryos per year on average.

FSH treatment, especially in the hands of an inexperienced technician, can result in over-production of follicles and actually destroy the ovaries and leave an animal infertile. It is best to use a very modest dose of FSH on animals not previously exposed to injections of this hormone to learn how they respond.

In such a scenario, using a modest dosage of FSH, female alpacas can be expected to react in one of three ways, with roughly 1/3 of the animals in each category. The first third will react very strongly, producing 10 or more follicles on each ovary. The second third will have a moderate reaction, producing 2-4 follicles on each ovary. It is this group that will produce the most embryos at the time of this first collection, as we will discuss later. The final 1/3 of female alpacas will have very little or no response, or even produce zero follicles and stop normal cycling temporarily. The animals in this last group can be removed from future FSH treatments, as they will never respond favorably. Animals in the middle group are good subjects for future superovulation treatments, and their dosage of FSH can be adjusted slightly on the basis of their most recent response. The animals which respond very strongly can be used for subsequent superovulation but with a reduced dosage of FSH.

It is interesting and significant that females who respond dramatically to FSH, whose ovaries look like a cluster of grapes because of the many follicles on them, usually produce zero embryos. We think this is because the ovary expands so much with all this follicle production that the fimbria, the finger-like projections of the upper end of the oviduct that surround the ovary to collect oocytes and guide them into the oviduct for fertilization, simply cannot expand enough to enclose the expanded ovary. Also, with so much follicular fluid being released from all those ovulating follicles at about the same time, it is likely that most of it (and the oocytes it contains) is lost into the body cavity at the time of ovulation.

In my own experience, in llamas, individual animals will react less to FSH on repeated exposures. Production of embryos from an individual female decreases over a period of two to three years, with most animals eventually becoming unresponsive after less than 10 exposures to this hormone. Of course, there will be some animals that respond very favorably to superovulation treatment at first, who yield 20 or even 30 embryos per year, but that is rare, and it is very rare for the animal with the genetics you most want to amplify to be the best candidate for superovulation. There is a general risk in a superovulation program that you will selectively amplify the production of the animals that are best at responding to FSH rather than those that are truly the highest quality.

In the US and Canada, the registry for alpacas (ARI) has prohibited registration of babies produced by any form of assisted reproduction. This has resulted in a general lack of interest on the part of alpaca producers in these countries to use embryo transfer technology. The laws in North America allow the owner of an animal (or, in most states, an employee of the owner) to perform procedures considered to be the practice of veterinary medicine. In the case of embryo transfer, the only relevant practice is the passing of a catheter or ET gun through the cervix, non-surgically, in order to obtain or transfer an early embryo. My wife, Sally, and I live in Montana, in the US, and we have followed a strategy of continuous cycling to produce more than 400 live llama babies during the past few years. We have not been able to flush each donor on each cycle, as we travel quite a lot and have to interrupt our ET program, losing track of the cycles of donors and potential recipient animals when we are away from the ranch for more than a few days.

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In Peru, at least two privately-funded projects are starting up, dedicated to continuous cycling embryo transfer programs. This approach works best in the Peruvian situation, where no animal welfare restrictions prevent the teaching or learning of alpaca embryo transfer technology and no legal restrictions prevent non-veterinarians from practicing it.

In Australia, as of a few months ago, only one qualified person was offering embryo transfer services to alpaca breeders. Dr. Jane Vaughan, who recently passed the landmark of 1000 alpaca ET babies produced in Australia and New Zealand, is unable to keep up with the demand for her services. She has developed an ET strategy based on superovulation.

The genius of Dr. Vaughan's superovulation protocol is that it can be applied in her absence. She can provide detailed instructions to alpaca owners and their veterinarians for the combination of injections and "spit-off" tests which will establish and synchronize the animals' cycles before the injections of FSH. Her presence is required only at the time of the embryo flushing, and this is one of the keys to her remarkable effectiveness. As the only alpaca embryo transfer practitioner in a whole country full of forward-thinking alpaca enthusiasts, she must make sure that the time she spends flushing embryos is as productive as possible.

Some alpaca owners and their veterinarians will be more capable and more precise in applying this superovulation protocol than others. For this reason, and because climate and feed have something to do with fertility in general, production of embryos from any given flush will always be variable and unpredictable. But, the whole point of this expensive and time-consuming exercise is to collect more embryos per flush.

Dr. Vaughan gets between 2 and 3 embryos per flush, on average, after FSH treatment, and that is a very good record. This means she can be 3 or even 4 times as productive of embryos for transfer using superovulation as she can by flushing for single embryos. Remember that a flush without FSH can be expected to yield an embryo about 70% of the time, so the comparison is between .7 embryos per flush and 2.5 embryos per flush. This is obviously the best use of Dr. Vaughan's limited time and it is also the best strategy for her to use on behalf of Australian alpaca breeders in this situation where only one person must serve the embryo transfer needs of the entire Australian gene pool of alpacas.

It seems clear that authorities will have to provide a pathway for non-vets to get training and be licensed to do practical alpaca embryo transfer in the future, both in the US (where alpaca breeders will eventually recognize the power of the technology) and in Australia and New Zealand (where ET in alpacas is already appreciated but there just are not enough interested licensed veterinarians with small hands available). The non-surgical technique requires that the technician have a very small hand, especially for work with alpacas. This physical requirement eliminates at least 90% of candidates from a random group. If the practice of embryo transfer is limited to licensed veterinarians, you immediately limit it to vets with small hands who have experience, access to alpacas and interest in doing the work. That will be quite a small subset of a relatively small group.

Alpaca embryo transfer is not really stressful on the animals, and it is not very demanding technically. More than half of the people we have tried to teach have been able to do it well in a relatively short time. Several of the young people we taught in Peru came from the altiplano and had no technical education at all. Considering what is at stake, the ability to achieve rapid genetic gain with a low-stress, low-tech and inexpensive procedure, it seems clear that alpaca breeders around the world will want to create a pathway for capable, interested people to receive training and certification in embryo transfer and be able to practice it legally. I think some of the larger studs will want a resident team of two or three technical people to do continuous cycling embryo transfer.

In any real-world application of embryo transfer in alpacas, program managers will use whichever option best fits their situation. Cost of hormones, cost of technical people to do the work, market value of quality babies produced, available time, climate and seasonal changes all will enter into the decisions about how to get the most benefit from a program of embryo transfer. ●

Enterotoxemia: New Evidence on Pathogenesis and Prevention of the Number One Cause of Neonatal Alpaca Mortality in South America

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With more than 4 million animals, Peru is the leading alpaca (*Vicugna pacos*) producing country in the world. Since its domestication in the central Peruvian Andes some 7,000 years ago this domestic camelid has played a key role in the economy, and today more than 300,000 peasant communities located at elevations of 3,800 meters are largely dependant on the alpaca for survival. Evidence that high neonatal mortality was associated with the domestication process shows that alpaca rearing has always been difficult in the extreme climatic conditions of this area, and up to the present massive losses from infectious diseases continue to be a problem. In the Andes the primary cause of alpaca neonatal mortality is enterotoxemia, a disease which affects alpacas world wide.

It is generally accepted that Enterotoxemia, produced by *Clostridium perfringens* type A, and rarely type C infections, is the most devastating infectious disease of Peruvian neonatal alpacas. First described during the 1950s, this disease is characterized by epizootic outbreaks occurring throughout the highlands every 4-5 years with mortality rates up to 70% among neonates between 3-9 weeks of age *(Ramírez 1991; Ameghino and DeMartini 1991)*. The clinical picture corresponds to fatal toxemia causing hemorrhagic and/or necrotic enteritis of mostly jejunum and ileum *(Moro 1987; Ramírez et al. 1985; Ameghino and DeMartini 1991; Palacios et al. 2006)*.

THE ENTEROTOXEMIA AGENT

The causative agent, a rod-shaped, gram positive, anaerobic facultative, motile and spore-forming bacterium, is responsible for various diseases in humans and animals *(Hatheway 1990; Songer 1996)*. Virulence depends on more than 14 toxins, some of which are used for classic and molecular typing. Type A produces only α toxin; type B: α, β1 and ε toxins; type C: α and β1 toxins: type D α and ε toxins; and type E α and ι toxins *(Hathewa, 1990, Petit et a, 1999)*.

Although, enterotoxemia has a strong negative impact on the alpaca industry, very little is known about the etiopathogenesis of the disease. It is still debatable if the Type A α toxin is solely responsible for the fatal pathological alterations. For decades, the enterotoxin or *cpe* (toxin associated with bacterial sporulation) was considered the main toxin responsible for the disease *(Ramirez 1987)*, but more recently analysis of the pathogenic roles of the classic exotoxins *(Prehn et al. 1999)* and the isolation of a novel β2 toxin from intestinal pathologies *(Bueschel et al. 2003)* have provided important new insights into the nature of the disease.

IDENTIFICATION OF BACTERIAL TOXINS ASSOCIATED WITH FATAL ENTEROTOXEMIA

During the 2005-2006 birthing seasons two hundred and twenty-four C. *perfringens* samples were isolated from 132 neonatal alpacas with fatal enterotoxemia. The diseased animals came from 22 alpaca farms in the Puno (n=60), Arequipa (n=36), Cusco (n=31) and Huancavelica (n=5) Departments of southern Peru. All the isolates corresponded to *Clostridium* based on morphology, hemolytic pattern, Gram stain and negative catalase. Of the total, 219 isolates had lecitinase activity (tested positive for Nagler's reaction) and 86.8% (190/219) showed sulfite reduction in TSC – egg yolk agar (Tryptose sulfite cycloserine agar enriched with 10% sterile egg yolk) *(Perez 2006)*.

One to three typical colonies were taken from each positive isolate of *C. perfringens*, cultivated in meat broth and incubated at 45°C for 24 to 48 hours under anaerobic conditions. These *C. perfringens* isolates were characterized by molecular genotyping (main toxins) and subtyping (secondary toxins) using a modified Multiplex PCR described by Baums *et al.* (2004).

Of the isolates tested, 223/224 (99.6%) were positive for the *cpa* (α coding) gene corresponding to *C. perfringens* genotype A, and only one (1/224, 0.4%) had both *cpa* and *cpb* (α and β1 coding toxin) genes corresponding to genotype C. The isolates were subsequently subtyped and 204/223 (91.1%) of those with genotype A were found negative for both the *cpe* and *cpb2* genes (subtype $cpe^{-}cpb2^{-}$), while the remaining 19 (8.5%) isolates tested positive for *cpb2* but negative for cpe (classified as subtype $cpe^{-}cpb2^{+}$). The sole isolate of genotype C was also the only *cpe* positive isolate, but was negative for *cpb2* (subtype $cpe^{+}cpb2^{-}$). The reference strains of *C. perfringens* types A and C corresponded to genotypes A and C, respectively, while tests for the *C. chauvoei* and *C. septicum* strains produced negative results *(Perez 2006)*. These results indicate that secreted exotoxins, rather than endotoxins (enterotoxin) are the most probable virulence factors associated with fatality in alpacas.

Our results show that more than 90% of the isolates (204/224) were *C. perfringens* genotype A subtype $cpe^{-}cpb2^{-}$ (*cpe* and *cpb2* negative), suggesting that expression of the *cpa* gene (α toxin) alone is sufficient to establish and develop the disease. A similar relationship has been observed in necrotic enteritis in chickens and pigs *(Engström et al. 2003; Gholamiandekhordi et al. 2005; Kanakaraj et al. 1998)*, enterotoxemia in lambs and calves *(Kalender et al. 2005; Dennisson et al. 2005)* and hemorrhagic gastroenteritis in dogs *(Songer 1996)* suggesting that the α toxin alone may trigger pathological changes in many susceptible animal hosts.

Our results also showed that 19/204 of the Type A isolates had *cpb2* and corresponded to subtype $cpe^{-}cpb2^{+}$ (β2 toxigenic). The potentially pathogenic β2 gene has been described in many isolates associated with pathological maladies from different animals, including 18.6% (8/43) of *C. perfringens* isolates from alpacas with enteric illness *(Bueschel et al. 2003)*. Additionally, the presence of the *cpb2* gene in *C. perfringens* genotype A has been found in nearly 90% of isolates from necrotic enteritis in piglets *(Bueschel et al. 2003; Garmory et al. 2000)*; 50 to 75% of isolates from tiflocolitis cases in fowls *(Herholz et al. 1999; Garmory et al. 2000)*; in enterotoxemia in calves, goats and deer *(Manteca et al. 2002; Embury-Hyatt et al. 2005; Dray 2004)*, as well as hemorrhagic dysentery in lambs *(Gkiourtzidis et al. 2001)*. The potential enterotoxigenic role of this exotoxin awaits further investigation but its presence in 41.6% (15/36) of the isolates from the alpacas in our study, which come for farms with a history of outbreaks associated with elevated losses from enterotoxemia during the 3 years prior to our sample, suggests that the presence of the β2 gene could also be a pathological factor associated with fatal outcomes.

The detection of only one clostridium bearing the *cpe* gene, out of 224 in our study, brings into question the role of this enterotoxin in the pathogenesis of the disease. For decades it has been proposed that *C. perfringens* Type A expressing *cpe* was the most likely causative factor of the disease *(Ramirez 2001)*. However, the low expression of *cpe* reported from diseased animals in more than 4 years of research suggests that exotoxins are more likely to be responsible for the pathological changes. Utilizing our primary results, we began producing a conventional inactivated vaccine (anaculture of bacteria plus exotoxins) against enterotoxemia, and over 5 years of field trials we have documented a progressive decrease in losses caused by the disease *(Yaya and Rosadio 2005)*. Additionally, the pathogenicity of *cpe* does not fit with the clinical alterations described for the disease, since it is mostly associated with profuse, sporadic and self-limiting diarrheas (produced by alteration of intestinal permeability) in immunocompetent individuals *(McClane 2000; Sparks et al. 2001)*, while the classic cases of enterotoxemia in alpacas are usually not associated with diarrheas.

Our results confirm that *C. perfringens* Type A is by far the most prevalent toxinotype associated with enterotoxemia in alpacas. The presence of genes encoding the main toxins (*cpa, cpb1, cpb2*) from the different clostridial toxinotypes does not necessarily imply that they will be expressed (toxin production), but *in vitro* demonstration of incomplete hemolysis and Nagler's reaction verifies the presence of α toxin phospholipase activity in almost all of the isolates. However, it must be kept in mind that since *C. perfringens* type A is part of the normal intestinal flora so the α gene expression will not necessarilly trigger pathology and thus, may not totally explain the associated pathogenesis in enterotoxemia. Consequently, we have recently suggested that the co-existence of coccidia intestinal parasites may possibly alter intestinal health, allowing clostridium overgrowth, toxin production and absorption leading to the establishment of enterotoxemia in alpacas.

IS THERE A PATHOLOGICAL TRIGGER FACTOR IN ENTEROTOXEMIA?

In order to examine the possibility of a pathological trigger factor, we conducted a comprehensive pathological study of neonates dying from suspected enterotoxemia in three different south Peruvian alpaca herds from January to March 2007. A total of 43 intestine samples were taken immediately after death from animals with gross lesions highly compatible with enterotoxemia. Sections of affected intestines were submitted for isolation and genotyping of clostridial organisms, and similar affected sections of duodenum, jejunum and ileum were immersed in neutral 10% formalin and processed for histopathological analysis. Clinically diseased animals were depressed and isolated from the rest of the herd. Most were constipated and consumed plenty of water, while some showed abdominal pain with distended abdomens. Death was sudden in some cases, although in others the animals survived 1-2 days. The majority (25/43) showed no evidence of diarrhoea.

Microscopically, in all cases, the lumen surfaces of the jejunum and ileum were severely necrotized with shortened and severely fused villi, as well as severe and diffusely congested and/or haemorrhagic mucosa in most (Figure 1). In 17/43 of the cases, abundant immature parasitic structures of *Eimeria macusaniensis* were present within both the mucosa and cryptic epithelium of the jejunum and ileum (Figures 1 and 2). In all of the 43 cases *Clostrium perfringens* type A was isolated and genotyped by multiplex PCR and in 4 of these 43 cases, the novel B2 toxins were also detected.

The moderate to severe necrotic lesions of intestinal mucosa were considered to be the cause of fatality by either the α-toxin and/or β2-toxin of *C. perfringens* type A. In a previous Peruvian study *(Perez 2006),* it was suggested that the α-toxin produces lesions and death in neonatal alpacas, but the frequent presence of eimeriosis in enterotoxemia cases found in previous studies *(Rosadio and Ameghino 1994, Palacios et al. 2006),* as well as pathological changes in almost 40% of the cases reported here highly suggest that eimeriosis may well be a predisposing factor in triggering outbreaks of enterotoxemia.

Independently both *C. perfringens* and some *Eimeria* species can cause acute, fatal diseases in neonatal alpacas, but when both are present they may induce more fatal outcomes or one of them may predispose the other. *Clostridium* seems unlikely to predispose neonates to coccidiosis, since destruction of enterocytes would remove sites for potential coccidial development. However, the pathological changes within intestinal tissues from animals dying of enterotoxemia suggest that coccidiosis may well predispose neonates to enterotoxemia.

Very little information exists on possible interactions between *Eimeria* and *Clostridium* in intestinal disorders

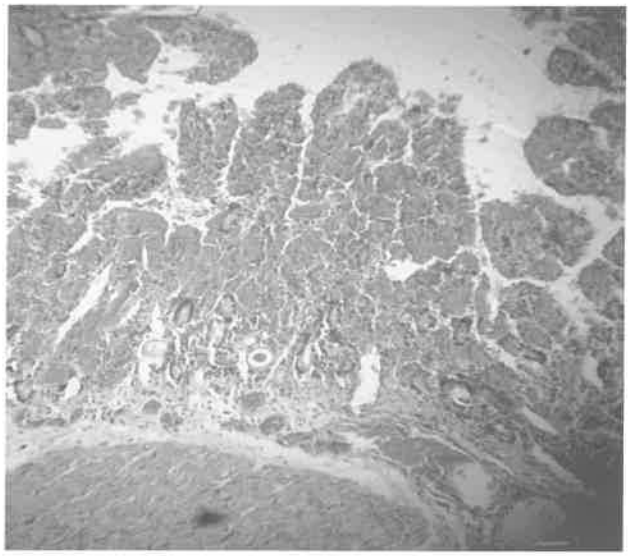

Figure 1: Section of small intestine with severe and diffuse hemorrhagic enteritis associated with C. perfringens Type A infection. H&E stain.

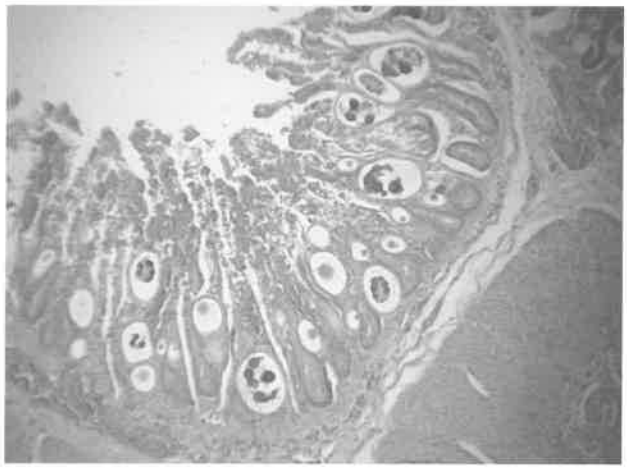

Figure 2: Section of small intestine with severe necrotizing hemorrhagic enteritis and presence of numerous immature parasitic structures (Eimeria macusaniensis) deep in the mucosa and positive for C. perfringens Type A, subtype β2. H&E stain.

in alpacas. Damage to the intestinal mucosa produced by *Eimeria* may disrupt gut integrity and facilitate proliferation of *C. perfringens* and toxin production in the same way that damage caused by coccidial infection apparently predisposes birds to clostridial infection and necrotic enteritis *(Hermans and Morgan 2003).* Certainly, coccidial infections stimulate proliferation of intestinal *C. perfringens (Arakawa and Ohe 1975; Kimura et al, 1976; Dykstra and Reid 1978),* and leakage of plasma proteins due to coccidiosis can provide growth factors for the proliferation of *C. perfringens (Van Immerseel et al. 2004).* Additionally, changes in the pH of the intestine may promote *C. perfringens* growth since low pH, in vitro, inhibited its growth *(Kmet et al. 1993)* and toxin production is increased at high pH *(Taylor and Stewart 1941).* In the samples we studied, the average pH in 51 of the diseased intestines was 6.8, compared with 5.8 found in 3 unaffected ones.

The coexistence of both clostridia and eimeriosis may well be responsible for severe and fatal necrotic enterits among neonates. Intestinal necrosis induced by *E. macusaniensis* may be a pathological factor which promotes clostridium proliferation resulting in fatal enterotoxemia. Although the link between coccidia and enterotoxemia has been suggested to occur in camels *(Kinne and Wernery 1998)*, it is a new concept for the South American camelids and merits further research.

EXPERIMENTAL VACCINE TRIALS

An inactivated anaculture vaccine composed of whole bacteria and exotoxins (but not containing enterotoxins) was prepared from Peruvian alpaca isolates and used in an attempt to reduce losses due to enterotoxemia. Vaccine trials were conducted between 2001-2004 at a large south Peruvian alpaca enterprise in a production unit with a history of high annual losses due to enterotoxemia and a yearly birth rate of approximately 2,000 crias. The vaccine was used in both pregnant animals (2 doses of 2.5 ml S.C., at 2 to 3 months and 2 weeks before parturition) and their crias (2.0 ml S.C. at 10-15 days) *(Yaya and Rosadio 2005)*.

The vaccine induced small localized reactions at the injection site, but no systemic alterations occurred *(Yaya 2003)*. In 2000, prior to initiation of the vaccination program, 18.45% of neonates were lost to enterotoxemia, while after vaccine introduction annual losses decreased to 7.2, 9.1, 5.7 and 1.0%, for the years 2001 to 2004, respectively. Since then the vaccine has been used at other alpaca farms in southern Peru producing a significant reduction of enterotoxemia mortalities. These observations also tend to support the key role of exotoxins, and rule out the *cpe* toxin, in the pathogenesis of the disease *(Yaya et al. 2005)*. Recently, the the Type A β2 strain has been added to the vaccine and field trials are continuing.

Acknowledgements

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Notes

Retailing Alpaca Around the World

GERMAN FREYRE

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German (pronounced Herman) was born in 1964 and was educated in Peru and the United States. At present he is the General Manager of Incalpaca TPX SA located in Arequipa. He has had experience in a variety of industries.

He is Director of Senati, Inca Tops, Collagua, Cecotur, Cover and Comfort, the Asociacion Cerro Juli and Past President of the Chamber of Commerce and Industry of Arequipa. German brings with him a wealth of experience in the world of alpaca retailing.

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Notes

Notes

The Top Ten Tips for Feeding Alpacas

DR JANE VAUGHAN

BVSc PhD MACVSc (Ruminant Nutrition)

Jane Vaughan has worked in mixed veterinary practice throughout Australia and in the UK. In 1996 she accompanied more than 600 alpacas from Peru to the Cocos Islands in the Indian Ocean, where they were held in quarantine for 12 months, prior to entering Australia.

Jane has studied ruminant nutrition to become a Member of the Australian College of Veterinary Science in Ruminant Nutrition. She completed a Doctor of Philosophy entitled, "Control of ovarian function in alpacas". She formed a research group with Professor David Galloway and Dr David Hopkins, to develop commercial artificial insemination techniques in alpacas then with Dr David Hopkins, developed and commercialised embryo transfer in alpacas.

Jane has lectured on reproductive physiology of male and female alpacas, embryo transfer and artificial insemination in South American camelids, treatment of infertile alpacas, and alpaca digestive physiology and nutrition at various veterinary and camelid breeder conferences in Australia, New Zealand, Peru, USA, United Kingdom, Germany and Switzerland. Jane also lectures on reproductive physiology and nutrition to veterinary students at the University of Melbourne, Victoria and Charles Sturt University, New South Wales. Jane is currently Honorary Secretary of the Australian Alpaca Veterinarians. Jane is also involved with Government-funded research projects investigating alpaca nutrition and DNA studies in Suri alpacas.

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Digestion is the process by which large insoluble food molecules are broken down into smaller soluble compounds that are then able to cross the gastrointestinal lining and enter blood and lymphatic vessels and provide the animal with energy, protein, fats, vitamins and minerals, which allows them to grow, reproduce, and produce wool and milk. Camelids mainly eat grasses, legumes and shrubs which contain sugars, proteins and fats along with variable amounts of fibre (provides plant structure in the form of cellulose, hemicellulose and lignin) that cannot be broken down by mammalian digestive enzymes.

The digestive tract in camelids has adapted to facilitate plant digestion by setting up a symbiotic relationship with billions of microbes in the forestomach. Therefore, when you feed an alpaca, you also feed the microbes in the forestomach. Look after the microbes and the microbes will look after your alpaca. Different rations favour different microbes so change feeds slowly to allow the microbes to adjust to the new nutrients.

1. HOW MUCH TO FEED?

Alpacas will eat approximately 1.5% of their body weight as dry matter to maintain body weight (i.e. not growing, pregnant or lactating). **Feed up to maintenance requirements with roughage (pasture, hay, silage).**

eg. 70 kg alpaca: 70 kg x 1.5% of body weight = 1.05 kg as dry matter (DM) i.e. all water removed from feed

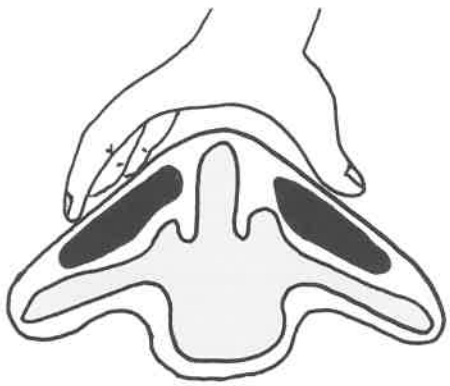
1.1 kg DM x 100/20 = 5.3 kg lush pasture/day (grass with 20% DM content)

1.1 kg DM x 100/90 = 1.2 kg pasture hay/day (hay with 90 % DM content)

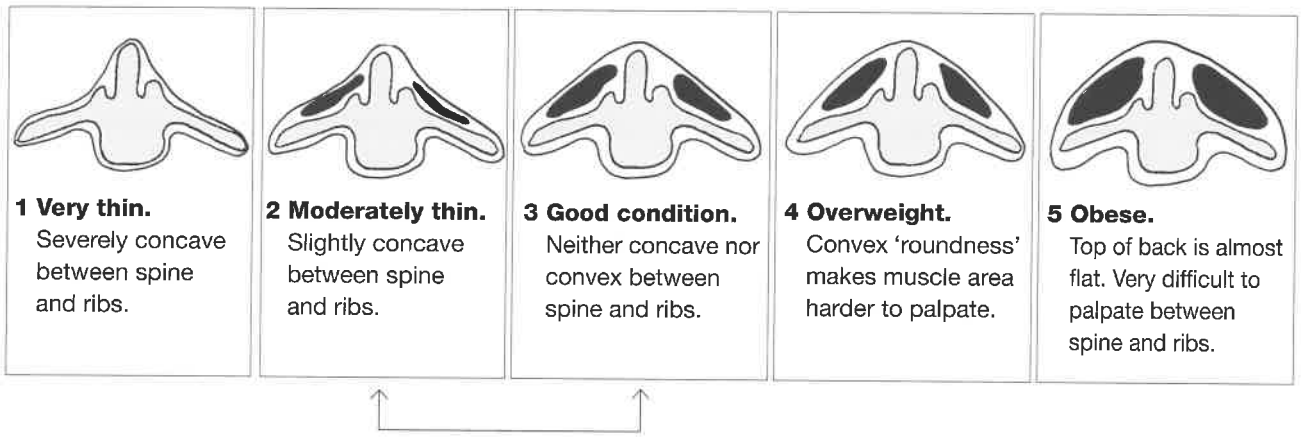
Growing alpacas and late-pregnant and lactating females will eat about 2-2.5% of their body weight as dry matter. Feed up to maintenance requirements with roughage (pasture, hay, silage). Then supplement with energy/protein as required (good quality pasture hay/lucerne hay/oats/lupins).

2. BODY CONDITION SCORE TO MONITOR IF FEEDING TOO MUCH OR TOO LITTLE

Palpate musculature over the backbone at the level of the last ribs.



Palpating muscle between spine and ribs



Aim for body condition scores somewhere between BCS 2.5 and BCS 3

Cross sections for condition scores in alpacas: 1 to 5
Ref: Alpaca Note 4: Body Condition Score of Alpacas. Prepared by AAA Ltd. Education and Training Sub-committee.

If alpacas are too fat, feed less. If alpacas are too thin (eg. during growth, pregnancy or lactation), feed more, better quality feed. If some alpacas in the same paddock are too fat and some are too thin, then divide the group and feed accordingly.

3. PASTURE AND WATER WILL SUPPLY MOST NUTRIENTS

Alpacas require four main ingredients in their diets: water, energy, protein and fibre.

Ensure access to fresh clean water at all times. The daily requirement of water is 50-80mL/kg body weight per day (5-8% BW/day). So a 70kg alpaca requires 3.5-5.6 litres water per day. The amount of water drunk is lower when grazing green pasture (20% DM) compared with hay (90% DM). Alpacas will drink more water in hot weather and when lactating.

Pasture will supply most energy, protein and fibre needs. The proportion of each depend on plant maturity. It will also satisfy most vitamin and mineral requirements.

Greener pastures contain more protein, therefore as pasture matures, protein decreases. Crude protein content of feed required for maintenance is 8-10%. Higher levels are required for growth (12-15% CP), pregnancy (12% CP) and lactation (13-15% CP).

4. FEED LONG-STEMMED ROUGHAGE

Alpacas need long-stemmed roughage (pasture, hay, silage greater than 4cm in length) to keep their fore-stomachs functioning normally. A diet based on very short (or non-existent under drought conditions) pasture, chaff and grain/pellets or very lush spring pasture is not adequate to keep the stomach healthy. Ensure ad lib long-stemmed pasture/hay at all times if pasture fibre is limited.

A rough estimate of plant fibre content in pasture may be gained by manually testing the breaking strength of plant matter – more mature plants contain more fibre (thicker cell walls, more lignin) and are more difficult to break and less digestible.

Observe your alpacas to see if there is enough fibre in the diet:

- greater than 50% of recumbent alpacas should be chewing their cud
- body condition score – adequate fibre in the diet is required for fat deposition
- faecal consistency – % fibre vs % DM in diet

5. VITAMINS

Many of the **water-soluble vitamins** (vitamins B, C) are provided by the microbes that live in the fore-stomachs, so healthy alpacas do not require supplementation if they are healthy.

Of the **fat-soluble vitamins,** vitamins A and E are available from green grass (even from green weeds that come up after brief summer rain) so only need supplementation if pasture is completely dry for more than 8-10 weeks.

Vitamin D supplementation is required in alpacas. Inject all alpacas less than 2 years of age, and all females due to give birth in winter/early spring (to fortify colostrum) with 2000iu vitamin D/kg body weight under the skin or into the muscle. Administer in early May, July (and September in southern climes like Tasmania). Read the label on the bottle to determine vitamin D concentration to determine what volume to administer, eg. A 20kg cria needs 40,000iu vitamin D. If there is 75,000iu per mL vitamin D in your selected source of vitamin D, then the cria would need approximately 0.5mL of solution injected.

6. MINERALS

Are minerals deficient in your area in sheep and cattle? Ask your local Department of Agriculture, local veterinarian and neighbouring farmers for information. If in doubt, you should sample soils, pasture and/or alpacas to determine if mineral levels are adequate, before supplementation. Acid, water-logged soils (annual rainfall > 500mm) contribute to selenium deficiency.

7. FEEDING SUPPLEMENTS

Beware of feeding unnecessary supplements that may be costly, labour intensive to feed out and/or toxic to your animals. Do not feed out supplements designed for use in horses and pigs as they have different digestive systems and different mineral requirements.

8. ACCESS FOR ALL

Animals should have access to long-stemmed fibre at all times (eg. in drought conditions, consider placing a large round bale of pasture/oaten hay in the paddock). If supplementary feeding of concentrates (eg. grain, pellets) is required, make sure all animals can access the feed at the same time. You can feed out directly onto the ground, but you may reduce wastage by feeding in long troughs (eg. guttering, old conveyor belting laid out on ground, shade cloth attached to fence).

Introduce new feeds over a period of 10-14 days to allow adaptation to the new feed. Once adapted to the new feed, feeding twice as much, every second day will save you time and money, but more importantly will allow shy-feeders access to supplements. The dominant animals will fill up quickly (you have seen how they stake out the feed and spit at any animal trying to get near) and move away when full, allowing the shy feeders to eat the supplements later in the day/overnight.

9. FEED WASTAGE

If supplements remain at the next feed out, or hay is being wasted, you are feeding too much (do their body condition scores reflect this?) Ensure that growing, pregnant and lactating animals are fed appropriately with good quality feed and feed the left-over portions to non-pregnant/ non-lactating females, wethers etc.

10. KEEP IT SIMPLE

Complicated recipes containing scoops of this and cupsful of that do not alter cria sex or kill worms, but may waste your time, energy and money. **Feed alpacas up to maintenance requirements** (go back to Point 1!) **with pasture/hay/silage.** Supplements for growth, pregnancy and lactation may be met by providing energy with cereal grains (eg. oats) and protein with lucerne hay and lupins.

Some simple rations to get you started

The following guidelines assume that there is no pasture available. You must combine skills of pasture evaluation with body condition scoring to determine appropriate supplementation. **These are rough guidelines only.** All new feed should be introduced slowly (over a period of 10-14 days) to allow the microbes to adjust to the new substrate.

Supplement all classes of stock up to maintenance requirements with **high fibre** supplements if pasture is limiting, eg. good pasture hay or 3 parts oaten hay / 1 part lucerne hay. Ensure at least 25% of fibre is greater than 4cm in length to optimise stomach function. Animals requiring more than maintenance requirements (growth, lactation) but unable to obtain them from pasture can be supplemented with concentrates, eg. maize/oats/lupins/vitamins/minerals.

A 70 kg adult alpaca can be just **maintained** on 1.2 kg oaten hay (88% DM, 8.7 MJ ME/kg DM, 7.6% crude protein). However, a mixture of 3 parts (on a weight basis not volume basis) oaten hay and 1 part lucerne hay will contain 8.5-9 MJ ME/kg DM and 10-11% crude protein. 1.2 kg of this mix will provide some safety margin for energy and protein needs.

Growing crias require 10.5-11 MJ ME/kg DM and 14-16% crude protein. An appropriate supplement could consist of 2 parts oaten hay, 2 parts lucerne hay, 3 parts oats, 3 parts lupins. This will provide enough energy and protein and calcium and phosphorus in a ratio of 1.7:1.0. Beware of excess intake when grain feeding – introduce feed slowly, do not let grain feed build up in the bottom of feeders, mix well with fibre (hay/chaff) to reduce the risk of grain poisoning and death.

Lactating hembras require 10.5-11 MJ ME/kg DM and 13-15% crude protein. A mixture of 3 parts oaten hay, 3 parts lucerne hay, 2 parts oats, 2 parts lupins would satisfy energy, protein and Ca:P needs. Again, beware of grain feeding. ●

Notes

Understanding Alpaca Dental Anatomy: The Normal and the Abnormal Mouth

ALLISON QUAGLIANI

Alpaca Dental Services

Allison Quagliani has been involved in the Australian alpaca industry since 1996 with the purchase of her first alpacas. As well as being an experienced breeder on her own property in the Toomuc Valley, Victoria, Allison also assists with the husbandry and management of a medium sized stud with another breeder.

It was a dental problem with one of her own animals that sparked Allison's interest in alpacas' teeth. Allison commenced her studies into Alpaca Dentistry early in 2004. She designed and had made all the necessary instruments and equipment required for the treatment of alpacas.

Following on from her training Allison commenced full time practice in January 2006 treating dental disorders in alpacas through her business Alpaca Dental Services. To date Allison has successfully treated over 500 alpacas.

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Alpacas spend more than half of their lives eating. They graze for 5-6 hours a day and ruminate for 8-9 hours a day *(Vaughan, 2006, pp.12-13)*. It is therefore essential as breeders that we understand the basics of alpaca dental anatomy and the effects dental problems can have on the health and welfare of our alpacas. This paper will provide an overview of normal dental anatomy and discuss abnormalities that can have significant detrimental effects on alpaca health.

ANATOMICAL OVERVIEW

The function of the mouth is to prepare food for processing through the digestive system. Teeth play an important role in this process. There are four types of teeth found in the mouth of the alpaca: incisors, canines, premolars and molars (Figure 1). An adult male has 30-32 permanent teeth and an adult female the same or less, as the upper incisors and the canine teeth do not always erupt in females. If they do they are usually much smaller.

Alpacas have two sets of teeth in their lifetime. The first teeth, some of which are present at birth are known as deciduous or baby teeth. These teeth are temporary and are replaced between two and four years of age with permanent teeth.

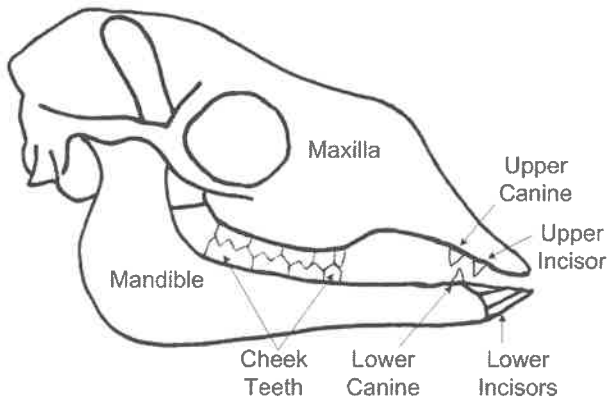

Figure 1: Skull drawing of an adult male showing the location of the teeth.

Incisors

Alpacas have six incisors at the front of the mouth in the lower jaw (mandible) and two incisors in the upper jaw (maxilla). The lower incisors occlude, or meet, with the upper dental pad and are used for cutting grass (Figures 2a & 2b). The two upper incisors have moved backwards during evolution and become caniniform taking on the shape and function of canine teeth *(Fowler, 1998, p. 306)*.

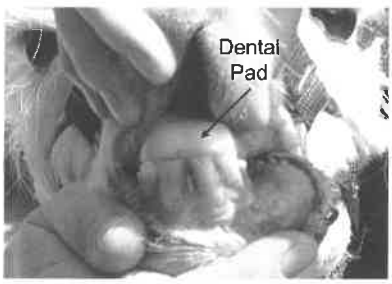

Figure 2a: Incisor occlusion of a 9 year-old. Front view.

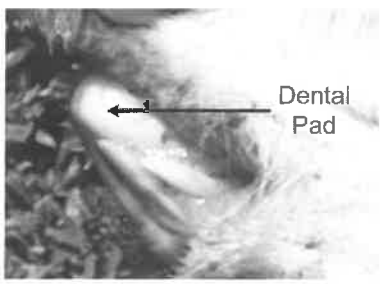

Figure 2b: Incisor occlusion of a 9 year-old. Side view.

The central two deciduous incisors are usually present at birth or soon after with the lateral and corner incisors erupting by the time the cria is six months old. The first deciduous incisors to be replaced by permanent teeth are the two lower central incisors. This happens at around two years of age and by two and a half they are usually in full use. Figure 3 shows an animal at two and a half years of age with good occlusion.

The next two deciduous incisors are replaced at three years of age and the two corner incisors at just over three years of age. Figure 4 shows a three and a half year old alpaca that has just lost his corner incisors.

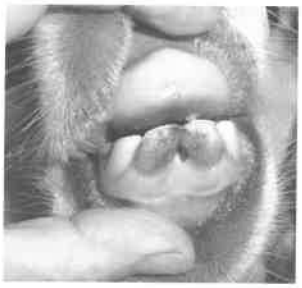

Figure 3: Incisors at 2½ years old.

Figure 4: Incisors at 3½ years old.

Canines

There are two sets of canines, one set in the upper jaw and one set in the lower jaw. Along with the caniniform incisors they are commonly referred to as fighting teeth (Figure 5). These teeth are very sharp. Males generally have large, well developed fighting teeth designed to rip and tear causing serious damage to their opponent during fights for dominance. A small proportion, around 5% of males have deciduous fighting teeth *(Fowler, 1998, p.308)*. The permanent fighting teeth usually erupt at around three years of age. Fighting teeth do not always erupt in females and if present they are usually much smaller and erupt later in life.

Figure 5: Fighting teeth of a mature male.

Premolars and Molars

At the back of the mouth in both the upper and lower jaws are the premolars and molars. These dental arcades are often referred to as the cheek teeth. The cheek teeth are arranged so the upper and lower arcades mesh together to produce an efficient grinding surface. With the addition of saliva, these teeth are used to grind the food to a consistency suitable for swallowing.

OCCLUSION AND MALOCCLUSION

The meeting together of the upper and lower teeth and the dental pad is referred to as occlusion. If the teeth do not occlude correctly then this is referred to as a malocclusion. As teeth continue to erupt for most of an alpaca's life this uneven wear will hamper the animal's ability to graze and chew correctly. If these malocclusions are left untreated they will cause pain and a reduced intake of food resulting in weight loss and associated health problems.

Types of Malocclusions

Undershot and Overshot Jaws

Undershot jaws are one of the easiest malocclusions to recognise as the lower incisors protrude beyond the dental pad. Consequently the teeth do not wear down and can often be seen parting the lips (Figures 6a & 6b).

Figure 6a: Undershot jaw Front view.

Figure 6b: Undershot jaw. Side view.

Overshot (sometimes referred to as parrot mouthed) is when the dental pad protrudes beyond the lower incisors (Figure 7).

Figure 7: Overshot jaw, side view.

Both of these malocclusions can easily be seen by parting the lips and looking at the conformation of the mouth. I would recommend all buyers to look at the mouths of their prospective purchases as these problems are proven to be hereditary in other species *(Fowler, 1998, p. 483)*.

On Australian farms where, for the most part, alpacas are well fed these animals still do quite well. When alpacas are handfed the incisors are not utilised – hay and grain are taken straight to the back of the mouth for mastication. In tougher situations when pasture is in short supply and these animals have to forage for themselves they have difficulty grazing shorter plants. Ultimately their ability to hold condition is compromised.

The Search for Molecular Markers in Alpacas: Genes that Influence Colour

DR KYLIE MUNYARD

B.Sc. (Hons) PhD

Dr Kylie Munyard obtained her undergraduate degree in Biology, with Honours in Veterinary Biology, from Murdoch University, WA. After working as a cytogeneticist, she then went on to complete a PhD (titled 'The Ecology of Rumen Methanogens') at UWA/CSIRO. From 2002 until mid 2005 she worked on projects related to the molecular biology of livestock species, at the Centre for High-throughput Agricultural Genetic Analysis, based at Murdoch University.

Kylie is currently a Lecturer/Researcher in Molecular Biology at the School of Biomedical Sciences at Curtin University. Her areas of research interest are the discovery of microsatellite markers in alpacas, sheep, cattle and ostriches; alpaca coat colour genetics; and inherited ophthalmological diseases in dogs. She currently holds two research grants, one from the Morris Animal Foundation relating to the discovery of microsatellite markers in alpacas, and a second from RIRDC that involves the investigation of the genetics of coat colour in alpacas. In 2006, with funding from the AAA, she worked with alpaca breeders to perform a survey of the incidence of staggers in Australian alpacas.

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INTRODUCTION: *Why should we study colour genetics?*

The answer to the question "why study colour in alpacas?" might seem like a forgone conclusion. And it is; the colour of an alpaca fleece is important for many obvious reasons. However, the answer should not stop there. Some of the other reasons why alpaca colour should be studied include the role of pigment in protection from UV radiation, in vitamin D dose, and as a role in removing toxic by-products of metabolism. Colour in mammals has been widely studied and is fairly well understood. This is because the pigmentation process is a very good model for many cellular processes, because changes in colour are easy to see, and are relatively easy to understand.

BIOLOGY OF COLOUR IN MAMMALS: *The Components*

In general pigmentation in mammals is a highly conserved process although subtle differences between species do exist. That is, the way that colour is generated and controlled is the same in all mammals. The differences that we see between species and within species are caused by variation within the genes that control colour. Some species have only one version (allele) of a gene, while others may have many alleles. A good example of this is the MC1R gene. In humans there are many different versions, while in Golden Retrievers there is only one.

Pigmentation is a complex process that begins in the early stages of the development of an embryo. In summary, neural crest cells differentiate into melanoblasts which then migrate along the back and down the sides (dorsolateral migration). As the melanoblasts migrate, they differentiate into melanocytes. Melanocytes produce internal structures called melanosomes in which pigment granules called melanin are produced in a process called melanogenesis. The mature melanosomes are exported from the melanocyte into specialist skin and hair cells called keratinocytes, to produce the phenotype, the visual colour that we can see.

MELANOCYTES

A good understanding of the pigmentation process is essential in order to study how a phenotype is created. There are two types of neural crest-derived cells; early and late migrating. The early migrating neural crest cells become the peripheral nervous system, craniofacial bones, the heart and the adrenal medulla. The later migrating neural crest cells become melanoblasts, which eventually differentiate into melanocytes as they migrate through the body. There are four basic types of melanocytes, ear, eye, CNS, and skin/hair. The whole process of the development of the melanoblasts is usually completed during embryogenesis. Melanocytes are located slightly differently in skin and in hairy parts of the body (Figure 1). Melanocytes have protuberances called dendrites (or dendritic processes) that are interspersed between the neighbouring keratinocytes (Figure 2). Skin and hair become coloured when mature melanosomes migrate from the melanocyte dendrites into the keratinocytes.

Furred animals don't usually have epidermal (skin) melanocytes except in non-hairy places (e.g. inner ear, nose, paws). One exception is the Polar Bear, which has a high density of epidermal melanocytes to aid in retaining heat.

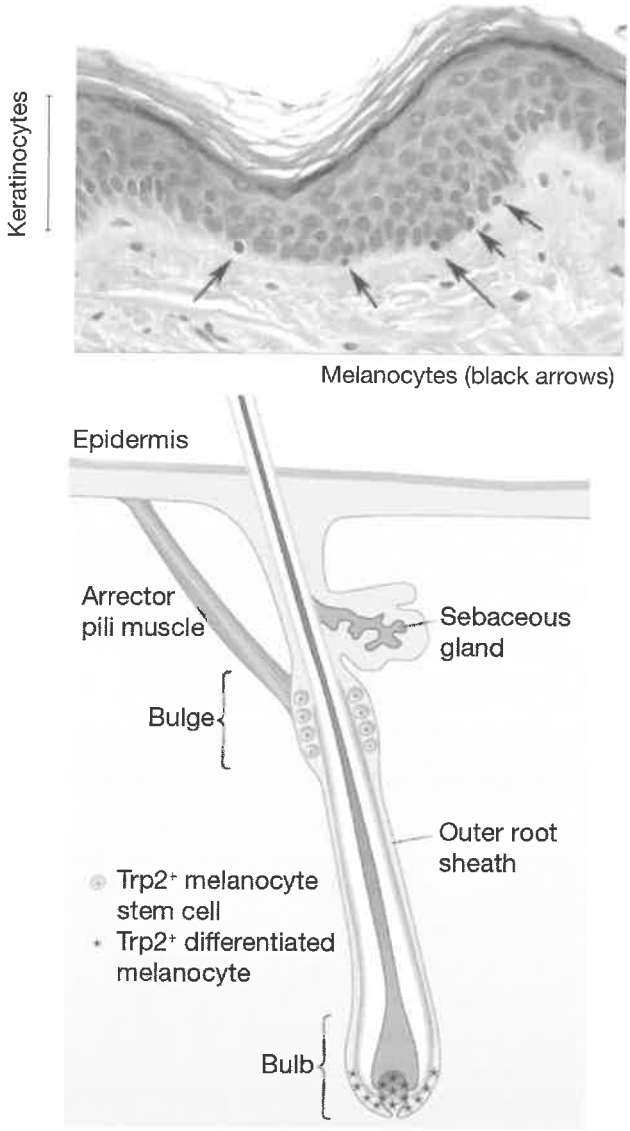

Figure 1: Location of skin (top) and hair (bottom) melanocytes (adapted from Lin & Fisher 2007).

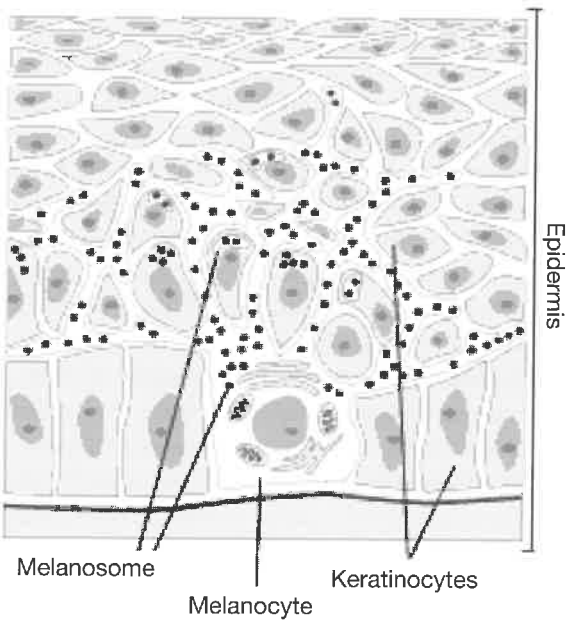

Figure 2: A melanocyte with dendritic processes (from: http://www.hominides.com/html/dossiers/race.html)

MELANOSOMES

Melanosomes are the site of melanin synthesis. Melanosomes are highly specialised organelles that exist in the cytoplasm of melanocytes. Melanosome development follows four distinct stages, I to IV. During Stage I the melanosome is formed from a piece of the endoplasmic reticulum. A protein called Pmel17 is then transported into the melanosome and is cleaved. The Pmel17 protein forms a fibrillar structure within the melanosome during Stage II. This acts as a scaffold that stabilises the melanosome. During stage II the enzymes required for melanin synthesis are transported into the melanosome. Stage III marks the beginning of melanogenesis, and Stage IV is reached when the melanosome is full of pigment and is ready for transport into the keratinocytes.

MELANIN SYNTHESIS

Melanin synthesis (melanogenesis) occurs entirely inside the melanosome. In mammals there are only two types of melanins, eumelanin and pheomelanin. Normal eumelanin is dark in colour, either black or brown, while normal pheomelanin is pale yellow to dark red in colour. The precursor molecule for both types of melanin is the amino acid tyrosine. Tyrosine is converted through a series of reactions and intermediate products into either pheomelanin or eumelanin (Figure 3). Melanosomes that contain eumelanin (eumelanosomes) are ellipsoidal and smaller than pheomelanosomes (pheomelanin-containing melanosomes) which are spherical and about 0.7μ in diameter.

Melanin synthesis also results in toxic by-products such as hydrogen peroxide and quinone intermediates. It is hypothesised that one reason for the sequestration of melanin synthesis into melanosomes is to protect the cell from these toxic compounds.

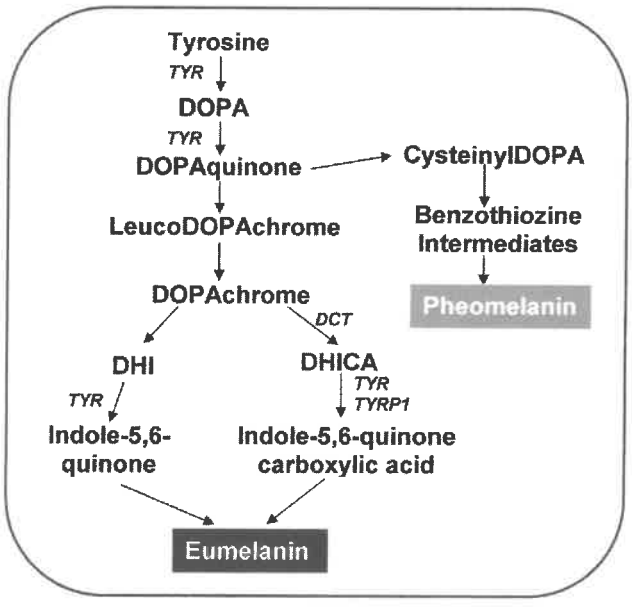

Figure 3: The melanin biosynthesis pathway.

Agouti has over 30 variants in the mouse, and at least three are thought to exist in the dog. The most dominant agouti alleles lead to a pale phenotype, while the most recessive alleles cause black. The alleles in between these extremes cause combinations of pale and dark melanin that leads to the many variations that exist. TRP1 produces an enzyme that acts in the melanin synthesis pathway (Figure 3) and is known colloquially as the "brown" locus. A mutated TRP1 causes brown eumelanin instead of black. The recessive brown variant of TRP1 is found in dogs and mice, but does not exist in horses. It is possible that no brown alleles exist in alpacas because the breeding outcomes suggest that brown in alpacas is dominant, rather than recessive. It is also possible that the same phenotype (i.e. brown) can be caused by two different mechanisms in alpacas and that that both recessive brown and dominant brown (probably occurring at the agouti locus) exist.

An Honours student enrolled for 2008 at Curtin University plans to examine the role of two genes, tyrosinase (TYR) and membrane associated transporter protein (MATP), in alpaca colour dilution. TYR is the gene that produces the enzyme tyrosinase, which is the key enzyme in the melanogenesis pathway. In species such as mice, rabbits and cats, variants of TYR are known to produce a dilution of colour, including albinism. MATP is the gene that is mutated in palomino and buckskin horses. It is hypothesised that some white alpacas are the equivalent of cremello horses. That is, they are chestnut with two doses of the dilution gene causing a massive reduction in the intensity of colour so that they appear white. ●

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Notes

The Coming of A.G.E.: Breeding a Better Alpaca

DR IAN DAVISON

MBBS (Hons), FRCS, FRACS, FA(Orth)A

Dr Ian Davison is an Australian alpaca breeder and full time orthopaedic surgeon. He and wife, Harriet, established Illawarra Alpacas in 1992, a private herd now numbering around 550 alpacas in Cambewarra, south of Sydney.

They have a strong belief in the application of scientific method to accelerate genetic improvement in their breeding program, and Ian's commitment to the AGE (Across-herd Genetic Evaluation program) began as a member of the working party to establish that program. It continues today in both the management of their own herd, and in his championing of that program to alpaca breeders in Australia and overseas. Together with the SRS® Breeding System and Advanced Reproductive Techniques, the AGE is the foundation of their genetic improvement program.

Ian is currently the President and Chairman of the Board of Australian Alpaca Association Ltd.

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We heard yesterday from our eminent principal speaker, Dr Jane Wheeler, of the almost unimaginable quality of alpaca fleece which was being produced by the Incans as recently as 500 years ago. Subsequently, social and economic forces have seen significant regression in that quality, due principally to cross-breeding with llamas, and less discriminatory breeding practices. We are indebted to her for the detective work that has been the foundation of that knowledge, so painstakingly researched through her archaeological exploits across South America over many years. That research is the touchstone which drives our own future goals and endeavours in trying to breed a *better alpaca*.

What constitutes a "better" alpaca will be defined by different breeders in different terms, according to their stated goals. For those wanting to breed exotic pets, it might be variegated fleece patterns. For those wanting herd guardians for sheep or other species, it will be defined by temperament and parental instincts and behaviour. For those who seek to establish a new and exotic industry based on lean meat, it will be carcase weight and early maturity. There may be some who wish to take their lead from the camel industry, and race alpacas, for whom the criterion might be the time taken for an alpaca to run a quarter mile.

But for the vast majority of breeders around the world, it is the exquisite and luxurious quality of the fleece that has captured our hearts and our imaginations, and those breeders will be seeking, very simply, to increase the weight of high quality fleece which can be shorn from an alpaca in 12 months. Quality here refers principally to fineness, but also to evenness, character, lustre, handle, and strength, whilst quantity will be reflected in the density, growth rate and – in a way that will importantly *diminish* quality – diameter of the fibres produced.

Traditionally, growers have elected to define their breeding objectives, and then breed towards them by a combination of selection criteria.

Principal amongst those selection criteria is the *phenotype of the parents:* selecting for those qualities in the parents which we hope to establish in the progeny. Fleece inspection, records of fleece weights and fibre tests, and physical inspection of the parents will all contribute to our vision of what the progeny should (more likely, could) look like.

An inspection of any *previous progeny* resulting from a particular joining strategy is an especially powerful tool in making those same predictions, but numbers for any dam, particularly when joined to the same sire, are invariably fairly limited.

Finally, the recorded *show results* of either parent, or those of their progeny, may serve to confirm the opinion of the studmaster that a particular joining is a desirable one, reinforcing his own opinion of the phenotypic quality of the parents, or the likely outcome in the progeny.

When all else fails, there is no shortage of hype available to reinforce and support whatever decision you may have already made independently.

But those tools are notoriously inaccurate in predicting the outcomes from a given mating. For those not already hardened to this reality from their own

alpaca breeding experiences, I invite you to look no further than your own children or family to confirm that the performance of the parents is no reliable or consistent guide to the performance of the children. And whilst progeny testing improves the accuracy of those statistical predictions, it is extremely slow to yield results, and rarely of a sufficient statistical significance (unless a male has been very widely used) to invest in the outcome with confidence.

It boils down to a combination of intuition and good luck. And even when these techniques are *all* applied, the influences of environment can completely overturn those predictions.

In 2002, the Australian alpaca industry faced something of a crisis. In that year, a government focussed on tax reform and commercial sustainability imposed upon agriculture several criteria designed to test the genuine commercial intent of agribusinesses, as opposed to those simply seeking a tax deduction. Intrinsic to those tests was one which required that breeders have a business plan which reasonably forecast profitability within a five year period.

Faced with that imperative, the AAA recognised the need to rapidly improve genetic performance for traits of commercial significance, and looked, from 2002 onwards, for ways to identify and promote those traits in their national breeding programme. What we needed was a way to measure genes.

Various suggestions and schemes were elaborated and debated, but it was the **Across-herd Genetic Evaluation** programme (AGE) which was eventually chosen, and is now firmly established as the cornerstone of the national strategy for genetic improvement. The science on which it is based is already well established in other industries, and used as the basis of breeding programmes to increase carcase weights, milk productivity, fleece weights, ease of calving, and a host of other productivity traits in a variety of livestock industries. What makes the alpaca industry unique, and confers a distinctive advantage upon it in the application of this technology, is the comprehensive database which links the pedigrees of almost 100,000 alpacas on our national registry.

In the space allocated, there is insufficient time to discuss its evolution, and describe its detailed operation. Suffice to say, it invites our breeders to measure any of an agreed range of about 20 commercially important physical or production traits in a group of alpacas – typically at around the time of that shearing closest to their second birthday – and to "enrol" those alpacas and their trait data in the AGE. Alpacas are then sorted into "management groups", meaning simply that no alpaca in any one group had a distinct advantage or disadvantage in their management over any other in the same group ("equal environment, equal opportunity, and a fair go"), and the results then analysed through a specialised software programme by an independent service company. The output is in the form of *alpaca breeding values* (ABV's), determined individually for each animal and for every trait recorded, and reported *confidentially* to the person submitting the data. The analysis takes into account each alpaca's own phenotypic trait recordings, as well of those of its parents, siblings and half siblings, and all others alpacas raised under the same conditions. It is important to understand that, whilst the ABV for any trait is attached to a given alpaca, its value is as a predictor of how that particular animal's *cria* will perform for that trait, and is best thought of as measuring the "value" of those genes in the parent that will determine the performance of its progeny (for the same trait).

Because of the comprehensive nature of Australia's International Alpaca Registry, now recording up to 15 successive generations, data entered into the AGE for any one alpaca washes back over all its near relatives, and so the data for any one animal is progressively and quickly bedded down by subsequent data entries for other animals.

This is how it works.

Reports are published privately and confidentially to breeders on all the animals they have enrolled in the AGE. For simplicity, let us concentrate on fleece and fibre traits alone. Here is a (real) report on some males from my own herd. The only person who need know those results is myself, unless I choose to make them publicly available. I have chosen to deidentify the males here, identifying them only by a letter, for the purpose of sharing them with you.

Alpaca Name	7% fleece wt fineness	Alpaca Breeding Values		
		FW (kg)	FD (μ)	CV (%)
A	120.6	0.2	-1.4	-0.9
B	110.3	0.1	-0.7	-0.5
C	116.8	0.3	0.0	-1.6
D	111.2	-0.1	-2.3	-1.0
E	120.1	0.2	-1.4	0.4
F	117.5	0.1	-1.6	-0.5
G	137.6	0.8	0.0	-1.1
H	125.7	0.4	-0.2	-2.7
I	133.0	0.5	-0.7	-1.6
K	79.3	-0.4	0.3	1.2
L	93.6	0.0	0.8	-1.0
M	93.0	-0.5	-2.3	1.5
O	104.2	-0.1	-0.6	-1.3
P	100.4	-0.1	-0.6	-0.8

Look firstly at the three traits listed here, being fleece weight, fibre diameter and coefficient of variation (of fibre diameter). A positive value means that it will tend to increase the measured value of that trait in its cria, and a negative value means that it will tend to decrease it (relative to an arbitrary and fixed benchmark, which we defined in our system at a level slightly above the average of all early recorded values). So animal A will increase fleece weight, and lower fibre diameter and CV in his progeny; animal K will reduce fleece weight, but increase fibre diameter and CV.

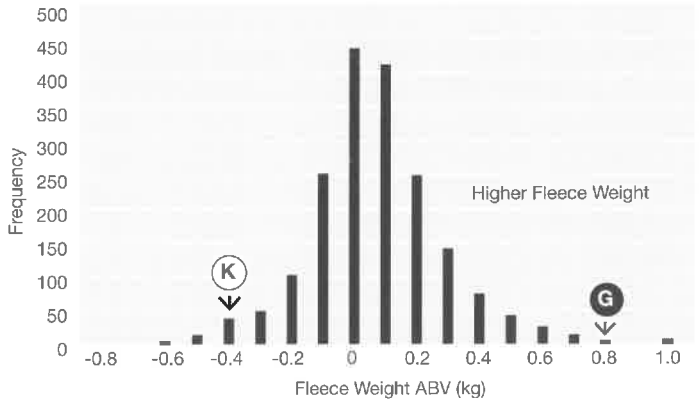
Consider now the one listed Breeding Objective Value. (Forget the 7% name tag, which is a hangover from the sheep industry; regard it simply as a breeding objective which places equal emphasis on increasing fleece weight and reducing fibre diameter.) Anything over 100% will drive the progeny in that direction; anything below it will tend to drive it in the opposite direction.

So most of these males will have a positive influence on my breeding objective of increasing fleece weight and fineness relative to benchmark figures, but three will have a deleterious effect.

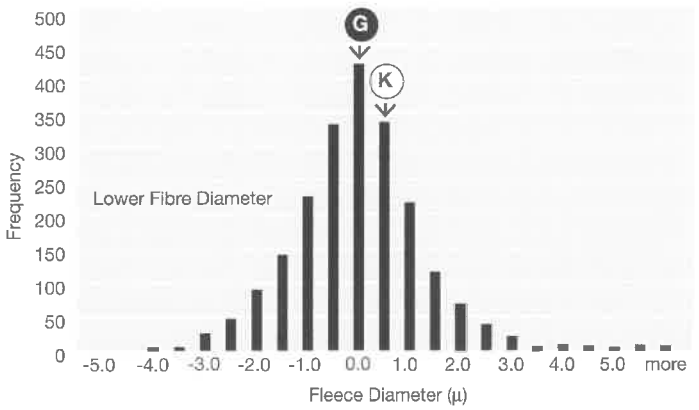
Alpaca G is the outstanding male, and will have the greatest impact on my breeding objective, whilst animal (K), were I foolish enough to use it, would have the opposite effect.

The magnitude of the effects is best seen by comparing the ABVs and BOVs for those two alpacas with the distribution of all estimated ABVs and BOVs recorded in the AGE up to 2007.

Male G will maintain fibre diameter unchanged, but profoundly increase fleece weight. Male (K) will significantly diminish fleece weight, and slightly increase fibre diameter.

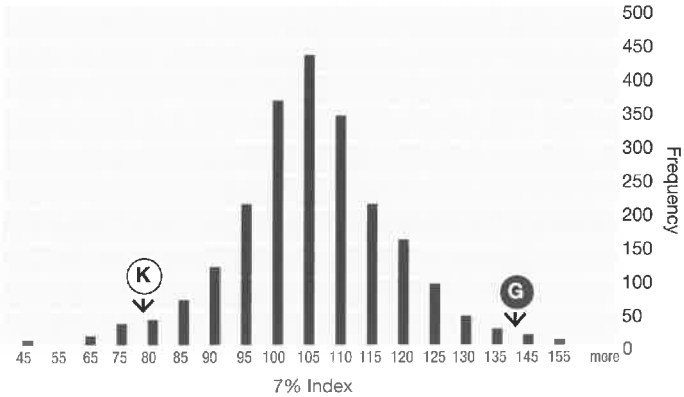


Overall Frequency and Distribution of Fleece Weight ABV
AGE Analysis May 2007: 1822 animals



Overall Frequency and Distribution of Fibre Diameter ABV
AGE Analysis May 2007: 2094 animals

The result is a scientifically validated, and increasingly accurate, predictor of alpaca genetic performance that can be used by breeders to rapidly advance their breeding objectives. Individual ABVs can be *combined,* and tailored to fit the breeding objectives of individual breeders, and alpacas then rated against each other according to their genetic value in achieving that objective in their cria. These values are called *Breeding Objective Values (BOVs).*



Overall Frequency and Distribution of 7% Index
AGE Analysis May 2007: 2109 animals

Looking at the BOV for combining increased fleece weight with decreased fibre diameter, alpaca G is towards the very top of the distribution curve, whilst animal (K) is substantially below average.

Before you suggest that those results would be obvious, allow me to humbly admit that we hadn't rated alpaca K quite so badly, and he was progeny tested over eight alpacas before he was withdrawn from service!

The ouput of the AGE can be tailored and applied to any subset of the total enrolled herd. We can create distribution curves broken down by species (huacaya or suri), colour, sex or nationality, so like animals can be compared with each other. The results can be usefully applied to a range of activities: the selection of appropriate sires for a breeding programme, advertising alpacas for sale or stud duties, making choices when purchasing alpacas, validating the results of an SRS® breeding programme, or choosing which alpacas to select for use in an embryo transfer programme.

In fact, the powerful combination of the AGE, the SRS® Breeding System, and advanced reproductive technology has been the subject of previous articles and presentations by myself, and referred to as "the Holy Trinity" of accelerated genetic improvement. Their combined application should see very rapid progress in the results of those breeding programmes to which they are applied.

As President of the Australian Alpaca Association, and one who was a member of the small Working Party that designed and implemented the AGE, I have had countless enquiries

from overseas breeders with an interest in the AGE, and how it might be administered in countries beyond Australia and New Zealand, for whom alone it is presently configured. Until recently, the answer eluded me, since its operation is fundamentally dependent upon the linkages between animals in the Australian and New Zealand herds *as defined by the Australian owned and run International Alpaca Registry (IAR),* and it could not, therefore, be extended and translated into a different registry, with interchange of data between both.

After much thought, rumination, and discussion between interested members of the AAA and the AANZ, I believe we have found a solution which will enable the AAA to share the AGE.

By way of background, the IAR has been developed over the last 15 years by a partnership between the AAA and ABRI (Agricultural Business Research Institute), an independent and professional body, dedicated to providing and administering livestock registries, and now with a 15 year history of operation, currently recording 35 million animals in eight species, for 80 associations spread over 21 countries and seven continents. The decision by the foundation committee of the AAA to have their registry managed at arm's length by an independent and professional body was both visionary and fortuitous. Through ABRI, the precious database that is our national pedigree has security, probity, continuity and an independence which is guaranteed. Without that arrangement, none of those critical features could be assured.

The IAR is wholly owned by the AAA Ltd., but administered for it by ABRI. However, a recent decision by the Board of the AAA has determined that the Australian registry will henceforth be known as the IAR (Australia), opening the way for any other national alpaca association to negotiate directly and independently with ABRI to establish and administer their own fully owned IAR registry under the same terms, and with the same extensive functionality, as the Australian registry. It is our intention that, under this arrangement, *any* alpaca entered on *any* national IAR could submit data to the Australian AGE, and have their ABVs reported and benchmarked against the Australian industry. Vital genetic data shared between the two registries, such as a common sire, would provide the linkages which would enable the two registries to "talk" across national boundaries, facilitated by the common data fields, analysis and language shared by the two registries.

For those national associations yet to establish a registry, the offer to own and manage their own registry, with all the additional functionality of the Australian IAR, plus the added opportunity to enter their own stock on the AGE, is too good an opportunity to miss. Even for those nations with existing and established registries, there is no reason why they should not explore the opportunities offered by this arrangement, which will maintain the independence, integrity and ownership of their national registries, but enable increased international communication between all national registries managed by ABRI.

Now, *that* would be a serious step towards a better international alpaca. ●

For further information, contact Dr Arthur Rickards, Agricultural Business Research Institute, Armidale NSW Australia *http://abri.une.edu.au/*

Notes

A New Angle on Alpaca Conformation

DR PIERRE BAYCHELIER

Dr Pierre Baychelier is a French trained Veterinarian who graduated from the Toulouse Veterinary School. After two years spent in practice he started a career in the animal health pharmaceutical industry, and has been working in this field since 1989. He is currently employed as Research & Development Manager by Ancare Australia, a company which specialises in parasite control in livestock.

Pierre migrated to Australia in 1994. In 1999, together with Brenton Spehr, he started Alcazar Suri Stud, a suri-only alpaca breeding operation, whose motto is "Keeping the Suri Pure"®. Pierre has written several articles and frequently addresses the alpaca community on health and husbandry topics, genetics, and the suri breed. A recent article entitled A New Angle on Alpaca Conformation, published in Issue 52 of *Alpacas Australia*, forms the basis of his talk.

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INTRODUCTION

Now that our alpacas have been shorn, it is the best time to assess their conformation.

Conformation can be defined as the shape or contour of an animal, resulting from the appropriate arrangement, or balance, of all body parts.[1] It should not be confused with *anatomy* or *morphology*, which is the form and structure of organisms.[2] All alpacas have the same anatomy but individuals differ by their conformation. In particular, conformation is what gives an animal its *type*. Conformation is also very important to the health and well-being of the animal and is discussed in breed standards.[4,5,7,8,10,14]

The terminology used to describe conformation is rich, precise, poetic, often confusing, and sometimes redundant. There are basically two descriptive jargons: the veterinary/biologic terminology and the more current breeders' terminology.

In this article, I will try to offer a new angle on alpaca conformation by concentrating on what is normal (the ideal conformation), rather than abnormal, with an emphasis on conformation of the limbs.

IDEAL ALPACA CONFORMATION

Figure 1 is a diagram of the ideal conformation of an alpaca. The proper (anatomical) terminology is set out in Figure 2.

Some important points should be noted. A few names have been assigned to some animal body parts because they resemble areas in the human body; however they are not the analogous animal counterparts of the human structures. For example the *knee* is really a wrist (carpus), and the *ankle* is actually the metacarpo-phalangeal joint (or metatarso-phalangeal joint for the hind limb). The real knee is called the *stifle* and the real ankle (tarsus) is called the *hock*.

The *withers* correspond to the region between the two shoulder blades. The *back* follows the withers and becomes the *loins* beyond the last rib. The *rump* or *croup* corresponds to the sacrum and is always very bony in alpacas. The expanded *iliac crests* which can be felt under the alpaca rump are one of the Camelid adaptations to allow for the pacing gait.

Figure 1: Ideal alpaca conformation.

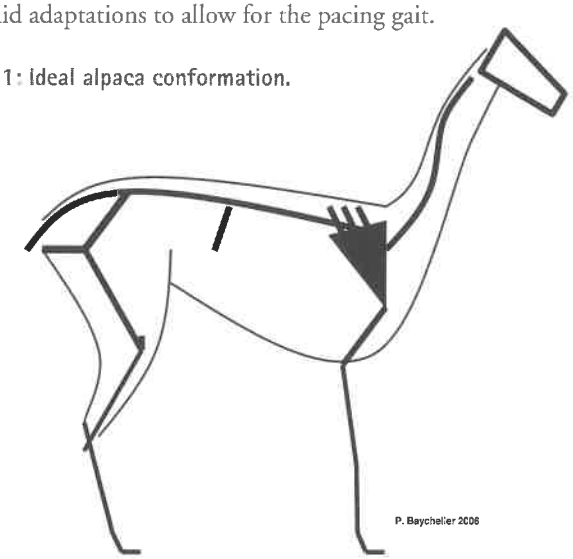
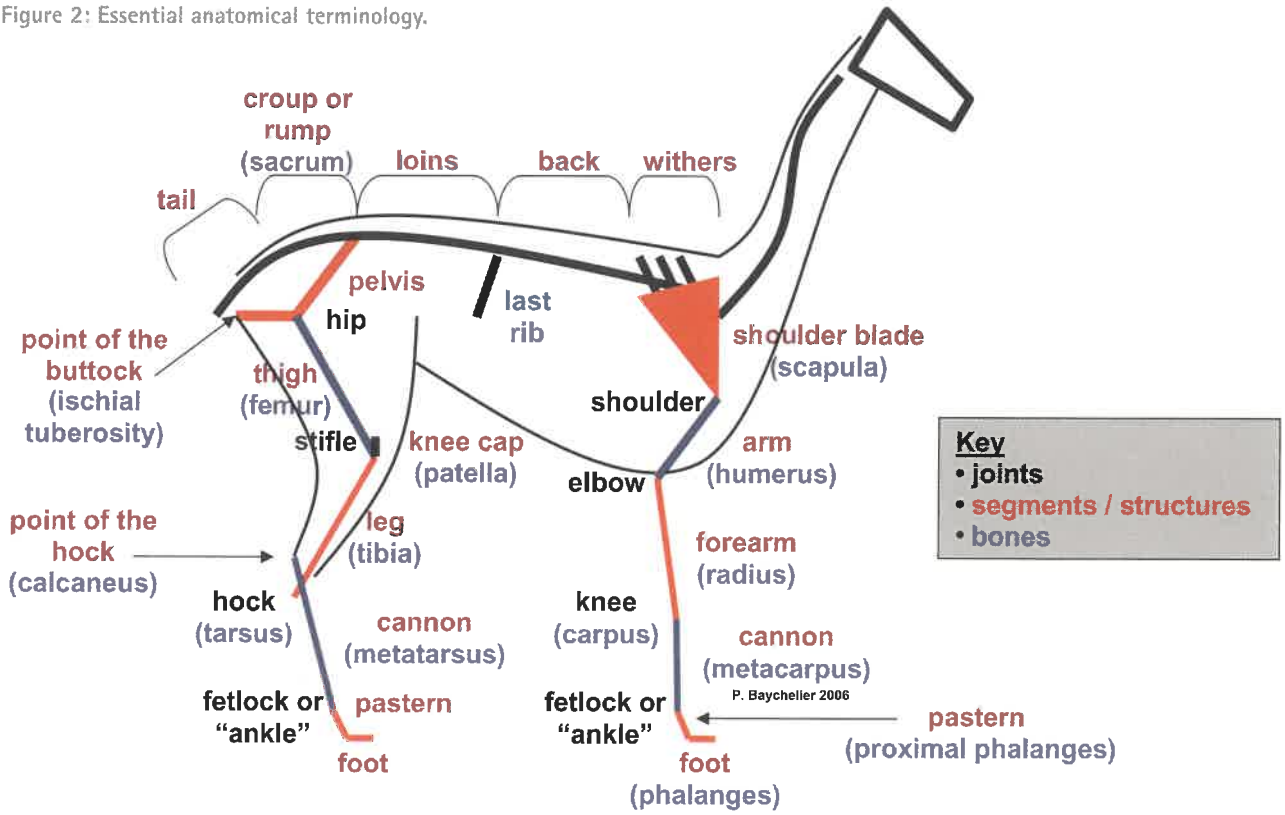


Figure 2: Essential anatomical terminology.



Figures 3 and 4 illustrate the important proportions, ratios and angles which form the basis of the ideal alpaca conformation. The most original alpaca characteristic is that the hindquarters are only slightly higher than the forequarters, as all Camelids have fore and hind limbs of approximately equal length.[11] In Figure 4, distance **D** is the distance between the *point of the buttock* and the ground and it should be equal to the distance between the *hip* (or the *hock*) and a vertical line through the *shoulder joint*. Distance **d** is the distance between the *elbow* and the ground. It should be equal to the depth of the body, and to the length of the neck (up to the *occipital protuberance*). However, in crias this is not the case, as the distance between the elbow and the ground is approximately twice the depth of the body.

Distance **d** is approximately 2/3 of distance **D**. More exactly, on Figure 4, the ratio **D/d** is 1.62. This is a very common ratio in natural structures, and has been used for centuries by architects and artists to achieve ideal proportions in their work. It is called *phi* (φ), the Golden Ratio or Divine Proportion.

The alpaca pelvis forms a 50° to 60° angle with the horizontal. The pastern angle is at least 65° to 70° to the ground, and even more, especially for the front pastern (up to 80° to nearly vertical). When resting, the neck and head should be held at approximately 25° to the vertical. Normal angulation of the hock should be approximately 140°. [1,3,9,10,13,14]

Figure 3: Ideal alpaca proportions.

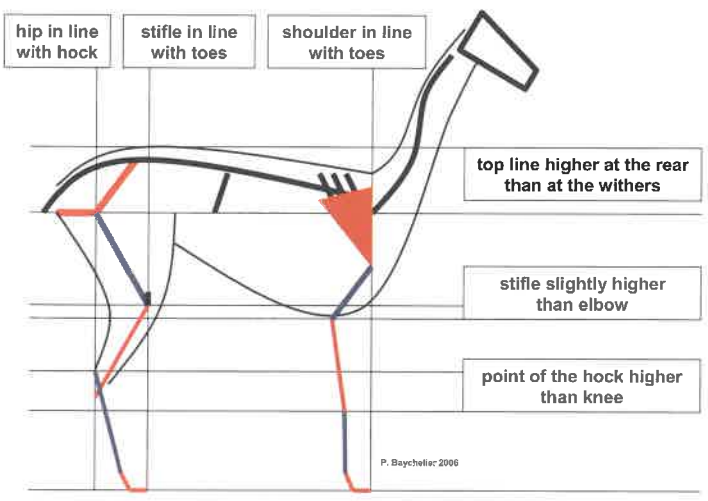


Figure 4: Ideal alpaca ratios and angles

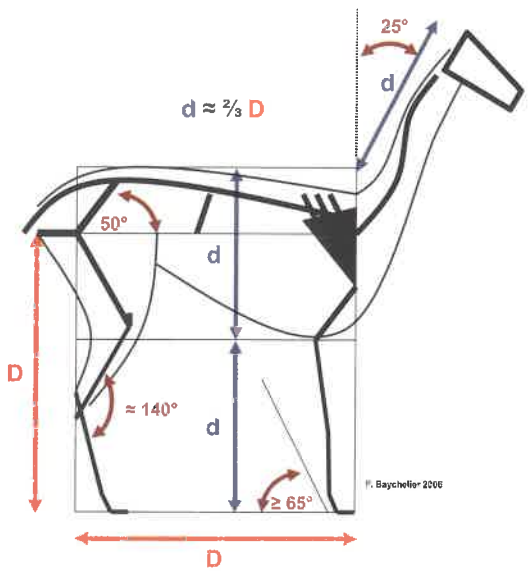
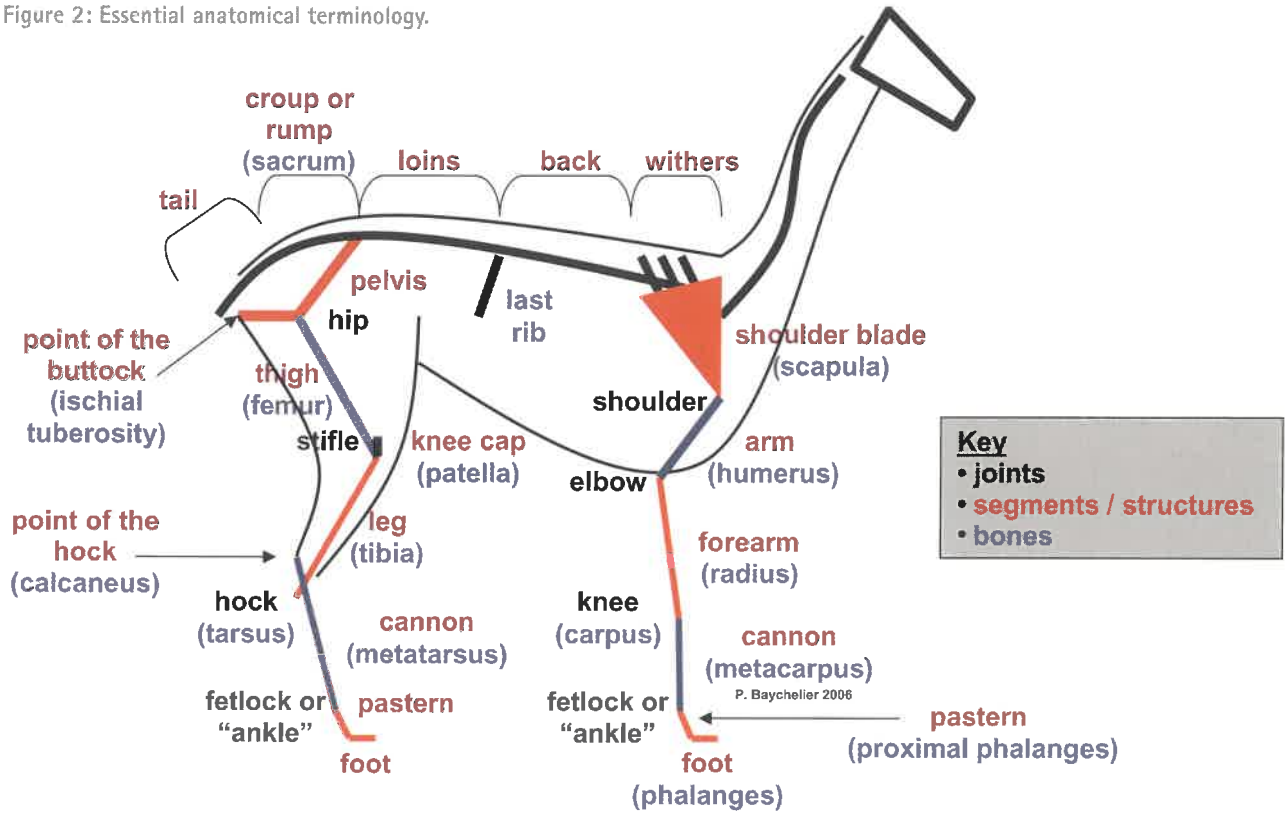


Figure 2: Essential anatomical terminology.



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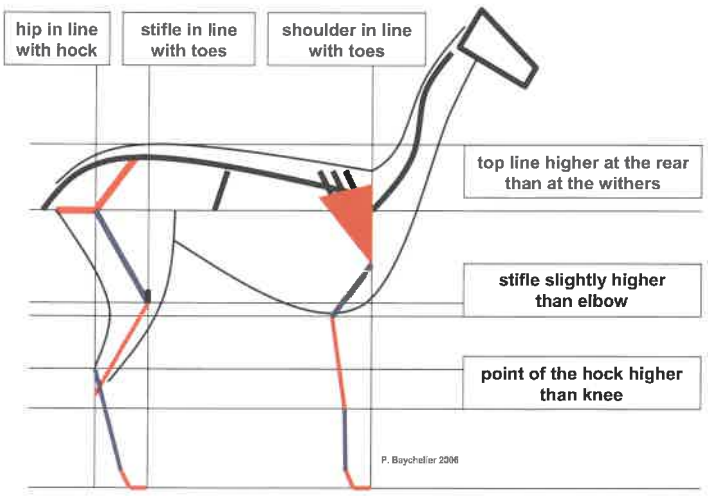
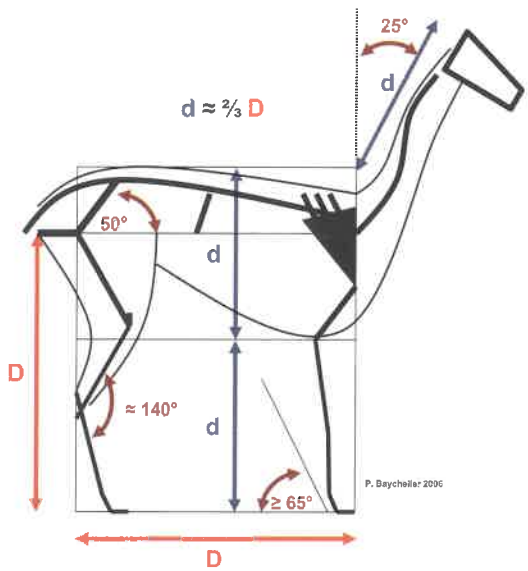


Figure 4: Ideal alpaca ratios and angles



The height *at the withers* in an adult alpaca should be approximately 90cm but can vary from 75 to 102cm, depending on sex and country of origin.[1,9,10,14]

Front and rear views are not illustrated as it is easy to understand what the ideal alpaca conformation should be: "Viewed from the front, a plumb line held at the point of the shoulder should bisect each bone and joint from the knee down, and the plumb bob should end between the toes. Viewed from the rear, a plumb line held at the *pinbone* [other name for *point of the buttock*] should approximately bisect each bone and joint and the plumb bob should end between the two pads of the rear foot." [1]

Similarly, conformation of the head and other parts of the body such as genitalia are not illustrated. The reader is asked to refer to other easily available publications for further descriptions.[1,3,5,7,8,10,14]

CONFORMATIONAL FAULTS

The majority of the common conformational faults affecting the limbs can easily be understood by referring to the joint involved. In these faults, the joint is either in hyperflexion, in hyperextension, or is angled in a plane in which it is not designed to normally move. The latter point deserves an explanation. In Ungulates, of which alpacas are members, the limbs display a number of modifications that adapt them for speed.

There are essentially three modifications:

1. Elongation of the segments;
2. Reduction of the number of bones in each segment to only one main bone;
3. Transformation of the joints into pulley-like structures which greatly reduce or totally eliminate lateral movements.[6]

Sometimes these joints are not formed properly and result in lateral movement or permanent lateral deviation. The names of the most common conformational faults affecting the limbs are found in Table 1.

DISCUSSION

It is of the utmost importance to the health and well-being of alpacas that breeders know and understand the basic anatomy of their animals. It is only by knowing what is normal and desirable that one can recognise what is abnormal and undesirable. Knowing the term(s) used to describe a conformational fault is not as important as being able to identify it. Current standards focus too much on listing conformational faults and do not describe the ideal alpaca conformation in sufficient detail.[5,7,8,10,14]

Essential anatomical terms are not always defined. Moreover, these standards are sometimes incorrect or at least confusing, as illustrated by the following examples.

Table 1: Conformational faults affecting the limbs.

Joint	Hyperflexion	Hyperextension	External deviation *	Internal deviation *
Shoulder	Camped rearward in front	Camped forward in front	Base-wide (external deviation of the whole limb at the shoulder)	Base-narrow (internal deviation of the whole limb at the shoulder)
Elbow		**Straight-legged (hyperextension of elbow and shoulder)**	Out at the elbow	In at the elbow
Knee	Buck-kneed	**Calf-kneed, Sheep-kneed**	Bow-legged (carpal varus)	**Knock-kneed (carpal valgus)**
Fetlock (front or rear)	**Cocked ankle**	**Down on fetlock, dropped fetlock, weak pastern**	Pigeon-toed, toe-in	Splay-footed, toe-out
Hip	Camped forward behind	Camped rearward behind	Base-wide (external deviation of the whole limb at the hip)	Base-narrow (internal deviation of the whole limb at the hip)
Stifle	**Crouched (resulting in rear quarters lower than withers)**	**Post-legged**	"Out at the stifle"	"In at the stifle"
Hock	**Sickle-hocked**		Bow-legged (tarsal varus)	**Cow-hocked (tarsal valgus)**
Knee cap			**Lateral patella luxation**	**Medial patella luxation**

* in the frontal plane
Serious faults are in bold text.

The chest is not broad, but deep and narrow. The rump is not broad either, but also narrow. In fact, Camelids are amongst the most narrow-chested and narrow-rumped Ungulates and this is one of the reasons why they can pace naturally: "Camelid limbs are set more closely to the midline than in other species, eliminating some of the side to side rolling that occurs when the center of body gravity is changed with each stride." [3] Other anatomic modifications found in Camelids which allow them to pace naturally include: long front and hind limbs of approximately equal length and longer than the trunk, absence of skin fold attaching the thigh to the flank, small abdomen ("tucked-in belly"), broad flat ribs, expanded iliac crests, large scapula, and a unique splayed two-toed padded foot. [3,11] All these characteristics put together allow for a longer stride and increased lateral stability.

The height of the pinbone does not equal that of the shoulder. The pinbone (or point of the buttock) and hip are substantially higher than the shoulder. The term shoulder refers to a joint. Unfortunately *shoulder* is sometimes used to describe the entire shoulder blade area. In any case, the pinbone is higher than the shoulder *joint* and lower than the top of the shoulder *blade* (see Figure 3).

It is also generally assumed that the toes should be pointing forward, an especially useful indicator of correct conformation on heavily fleeced animals. [12,13] For example, J. Ault states: "The toes should point forward. An indication of normal conformation would be toes that point forward. Toes that do not point forward may indicate poor conformation or poor toenail trimming. In either case, toes that point forward are important to structurally sound animals." [12] This is not entirely correct. Although the axis of the foot does point forward, the toes do not necessarily point forward but can form a slightly open V. The toes on each foot are not always parallel to each other, as the Camelid foot is splayed. This is more pronounced on the front foot than on the rear foot.

Some authors recommend that the line dropped from the point of the buttock should touch the back of the hock and that the rear cannon should be vertical. [13] Our observations lead us to believe that this is a llama characteristic. An alpaca with such a conformation would be considered as camped rearward in the hind legs. The drawings and descriptions found in other references certainly suggest that alpacas are "conformationally under themselves", compared to llamas. [9] The difference in angulation of the pelvis (50-60° in alpacas vs. 40° in llamas) and of the pastern (at least 65° in alpacas vs. 45-50° in llamas) certainly support this important difference in conformation. [1,3]

CONCLUSION

Breeders should spend time studying and understanding the anatomy and observing the conformation of their shorn animals. Repeated observation and objective assessment are the best means for developing an "eye" for conformation and will help in the selection of superior animals. As recommended by Dr Karen Timm, "when choosing or evaluating alpacas, [...] leg conformation as close to ideal as possible should be a primary consideration." [13]

Acknowledgements

The author wishes to thank Mr Brenton Spehr for his help in the writing of this article.

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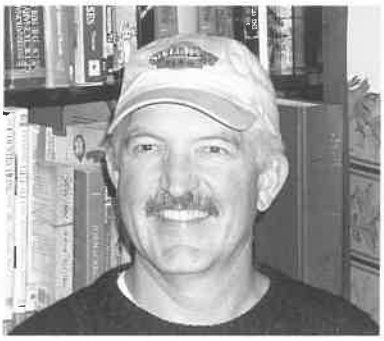
Notes

Breeding a Prepotent Line of Alpacas



DR WAYNE C JARVIS

Dr Wayne Jarvis lives with his wife, five daughters, son-in-law and four grandchildren at Sixth Day Farm in Holley, New York where they breed Saanen dairy goats, Cormo sheep, coloured Corriedale Sheep and Huacaya alpacas, as well as raising layer hens, broilers, many barn cats, a working Border Collie and a Great Pyrenees LGD dam.

Dr Jarvis studied chemical engineering, chemistry and biology, including genetics, as an undergraduate, and has been interested in genetics throughout his career as an oral and maxillofacial surgeon treating developmental deformities of the face and jaws. He has lectured frequently around the world on bone graft and implant reconstructive surgery for the jaws, implantology, the genetics of animal breeding and other scientific topics.

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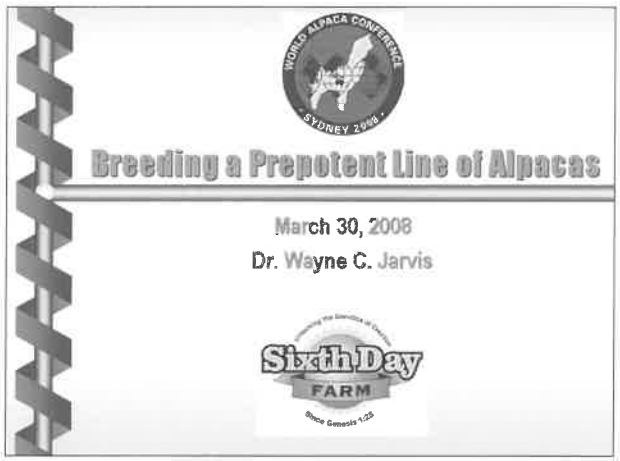
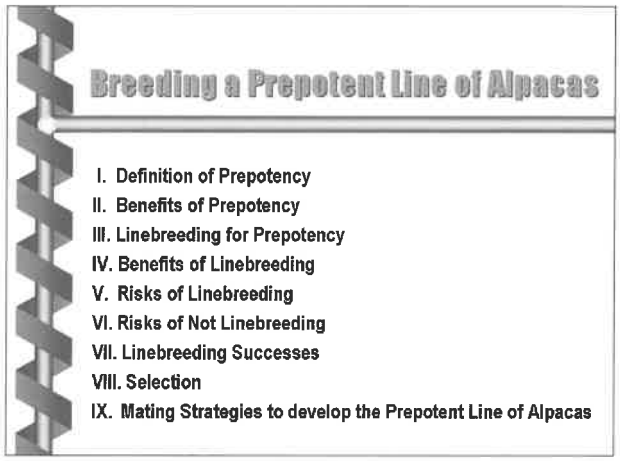


Slide 1



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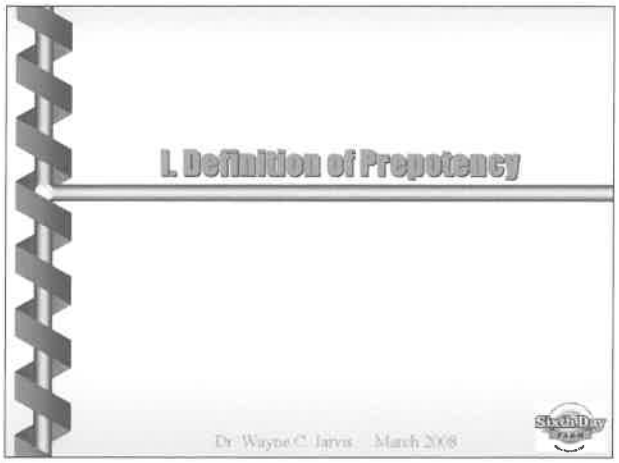

Slide 3

I. Definition of Prepotency

Strictly speaking prepotency is the superior power which one parent has over the other in determining the character of the offspring. But the term is more commonly used to indicate that power which an animal has to transmit its own qualities.

Thomas Shaw, Animal Breeding

Dr. Wayne C. Jarvis March 2008

Slide 4

I. Definition of Prepotency

We could use the classic example Gregor Mendel's experiments of tall and short pea plants. Mendel had two strains of true breeding pea plants, tall and short.

Slide 5

I. Definition of Prepotency

When he bred the tall plants together, he always got tall offspring. When he bred the short plants together he always got short offspring.

Slide 6

I. Definition of Prepotency

This simple example of course means that Mendel's tall strain was prepotent for the characteristic of "tall" in regard to the trait "plant height". The offspring always looked like the one tall parent regardless of what the other parent's characteristic for this trait was.

Slide 7

I. a. General Prepotency

Sometimes prepotency is general, having reference to a breed, race, or species. When it is said that a breed is prepotent, it is meant that plants or animals of that breed are all possessed of much power to transmit the characteristics of the breed.

Dr. Wayne C. Jarvis March 2008

Slide 8

I. a. Prepotency of Breed

Prepotency of breed is clearly brought out when two distinct breeds are crossed. The offspring will more nearly resemble the breed possessed of the most marked prepotency. There is a great difference in the prepotency of breeds as such. The cause is the same in each instance, the long periods during which these animals have been bred pure.

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I. a. Prepotency of Breed

Saxon Merino

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Slide 10

I. b. Prepotency of Individual

In other instances prepotency is special, having reference to the individual. When an individual is said to be prepotent, it is meant that it has much power to transmit its own qualities to the offspring, that is to say when two animals are mated the parent possessed of superior prepotency will transmit in a greater degree than the other its own properties to the progeny.

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I. a. Prepotency of Individual

Prepotency in the individual is shown in the closeness of the resemblance in the progeny to the parent and to one another. The second result is one of the strongest evidences of prepotency in the individual, since it shows in a marked degree **the power of the one individual animal to transmit its own individual characteristics to the progeny, though mated with different individuals.**

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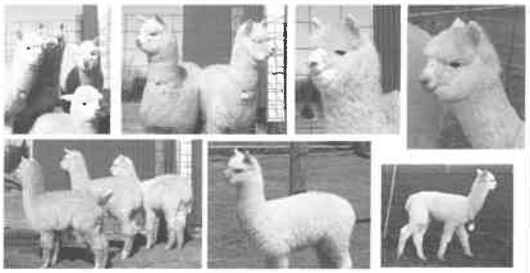
I. a. Prepotency of Individual



Slide 13

II. Benefits of Prepotency

When an individual is said to be prepotent, it is meant that it has much power to transmit its own qualities to the offspring. The great value of such power when breeding animals, especially in males, will be at once apparent.

Thomas Shaw, Animal Breeding

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II. Benefits of Prepotency

The first obvious advantage is predictability of the results of your mating decisions. What ever characteristics the sire has for which he is prepotent you can expect to see in his offspring. This is an advantage within your own breeding program, and in addition makes your sires more attractive to others who want to purchase them or purchase their stud services.

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II. Benefits of Prepotency

The second obvious advantage is uniformity in your herd. What ever characteristics the sire has for which he is prepotent you can expect to see consistently across your herd.

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II. Benefits of Prepotency

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III. Linebreeding for Prepotency

Prepotency comes from homozygosity. If a parent is homozygous at a particular locus, then it can only contribute one possible allele to each of it's offspring, and every offspring will get the same allele. If this particular allele is dominant, then this one parent will determine the expressed characteristic for that particular allele in every one of the offspring.

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III. Linebreeding for Prepotency

We can again go back to Mendel's pea plants for a simple example of this.

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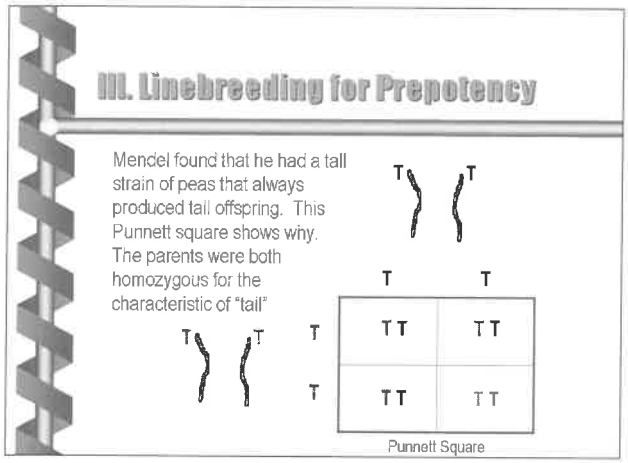

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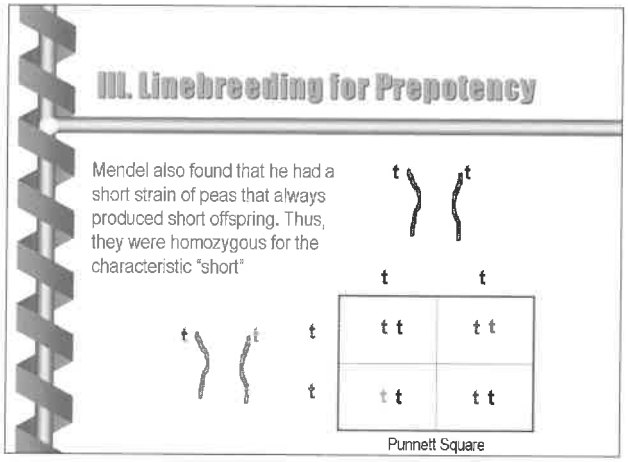

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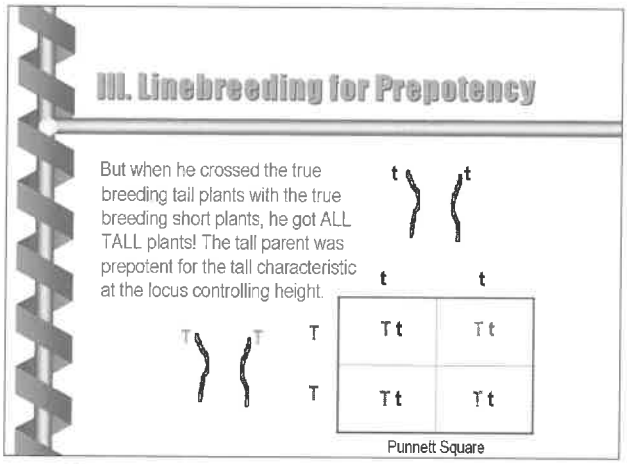

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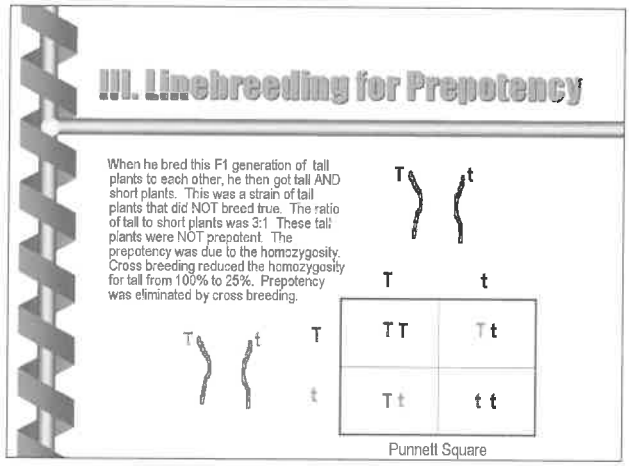

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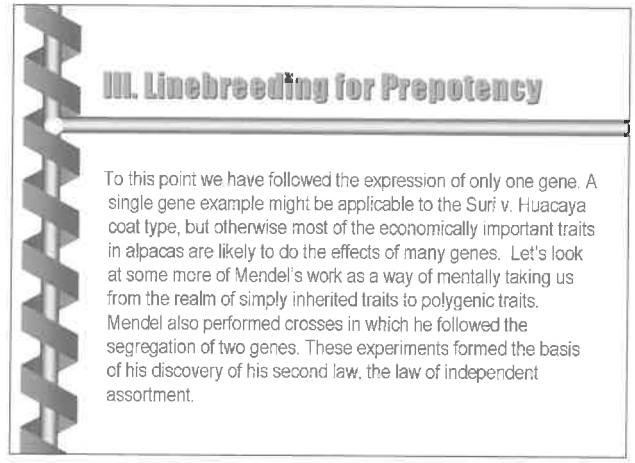

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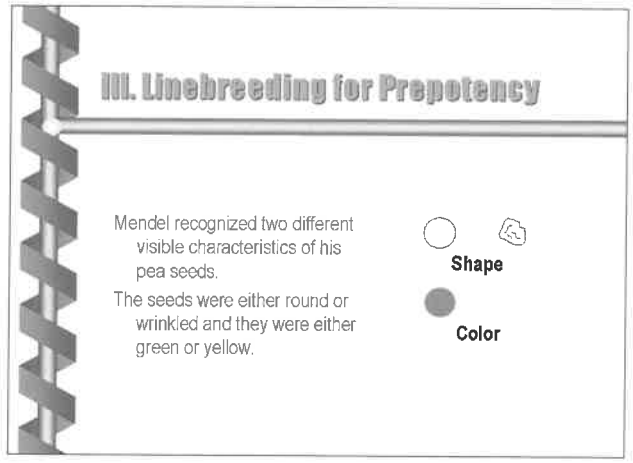

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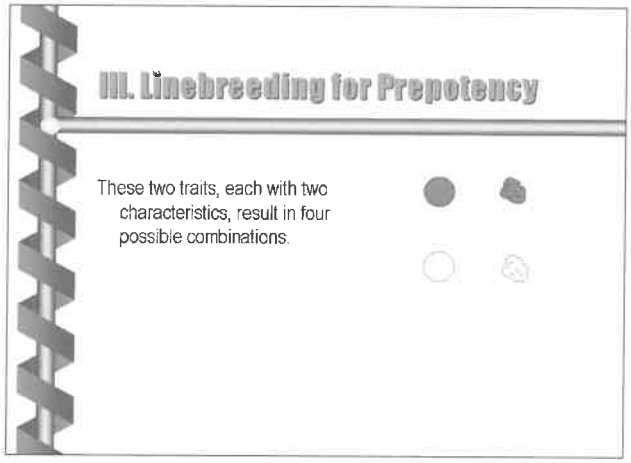

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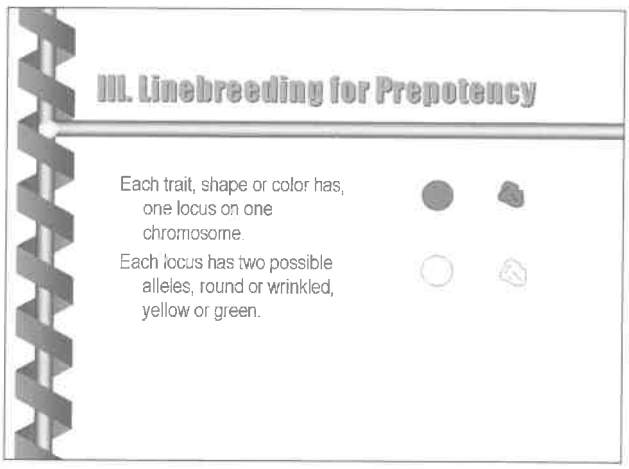

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III. Linebreeding for Prepotency

Round is dominant to wrinkled at the shape locus.

Yellow is dominant to green at the color locus

R r

Y y

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III. Linebreeding for Prepotency

Shape
Color

A pea plant that was heterozygous at both loci could look like this.

This plant would have round yellow seeds. Its genotype would be

RrYy.

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III. Linebreeding for Prepotency

Shape
Color

We know that this parent plant will only pass one allele from each locus to its offspring.

Mendel's law of Independent Assortment tells us that the alleles from each locus will assort independently.

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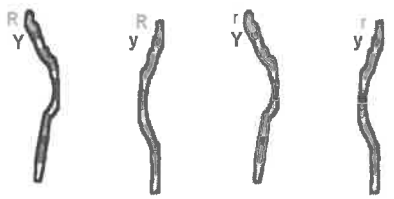
III. Linebreeding for Prepotency

This means that our heterozygous parent, RrYy, could produce four possible gametes

RY Ry rY ry



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III. Linebreeding for Prepotency

Let's use a Punnett square to look at the possible outcomes of crossing two of these heterozygous round yellow pea plants.

RrYy x RrYy

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III. Linebreeding for Prepotency

Both parents look alike, with a round, yellow phenotype. The Punnett square shows us the possible outcomes of this cross.

RrYy

RrYy	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

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III. Linebreeding for Prepotency

Genotype Ratios
9 different genotypes:

RRYY	1
RRYy	2
RRyy	1
RrYY	2
RrYy	4
Rryy	2
rrYY	1
rrYy	2
rryy	1

RrYy

RrYy	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

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III. Linebreeding for Prepotency

With 4 different phenotypes:

9
3
3
1

RrYy

RrYy	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

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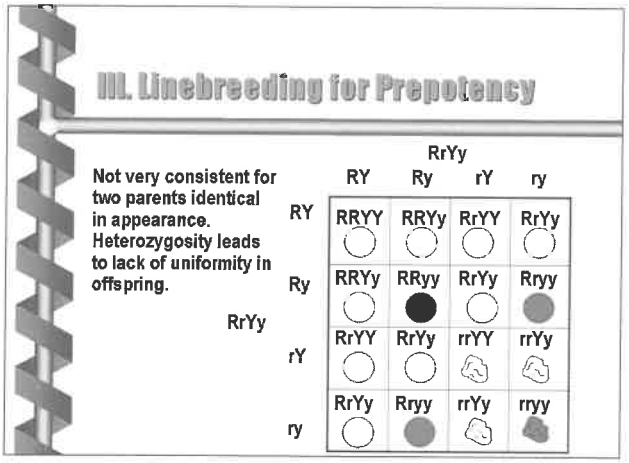

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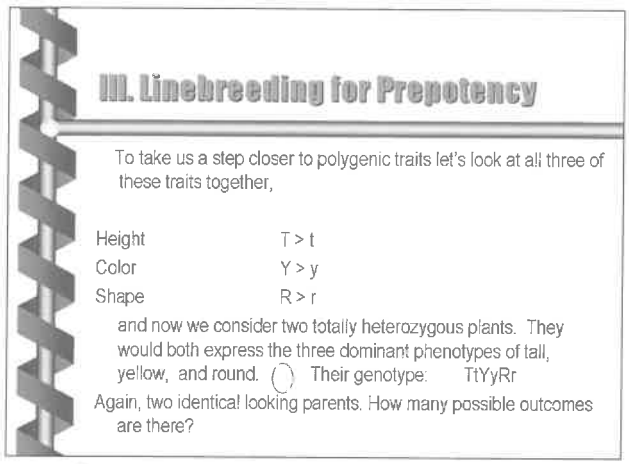

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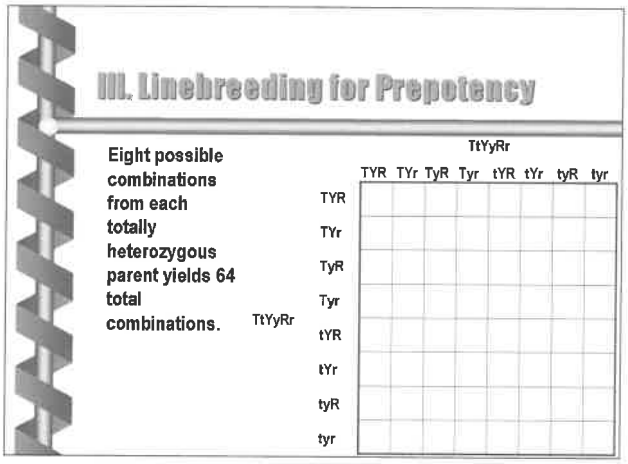

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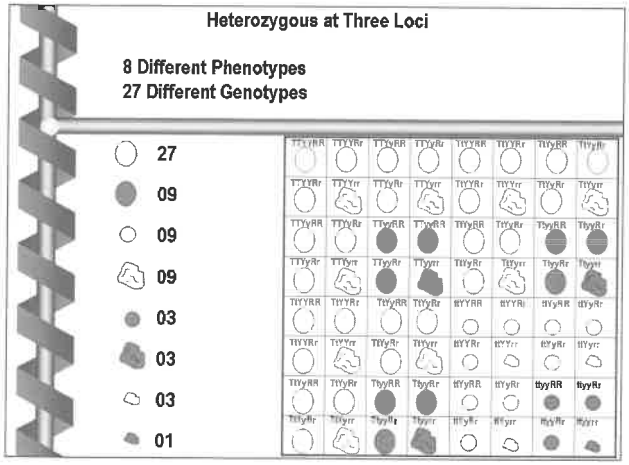

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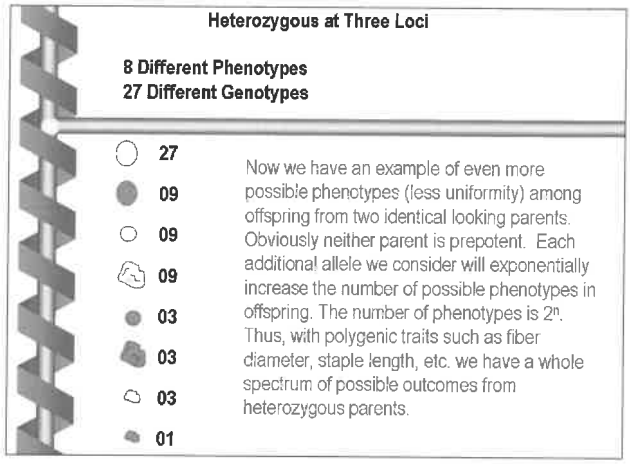

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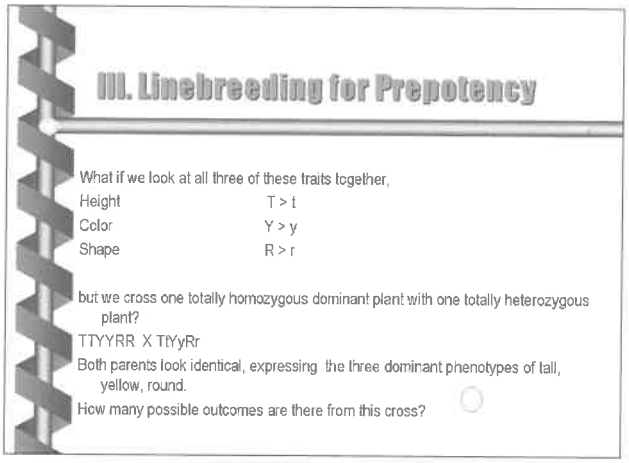

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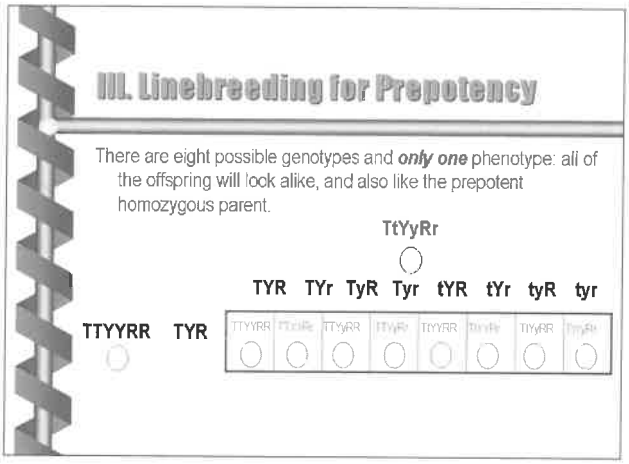

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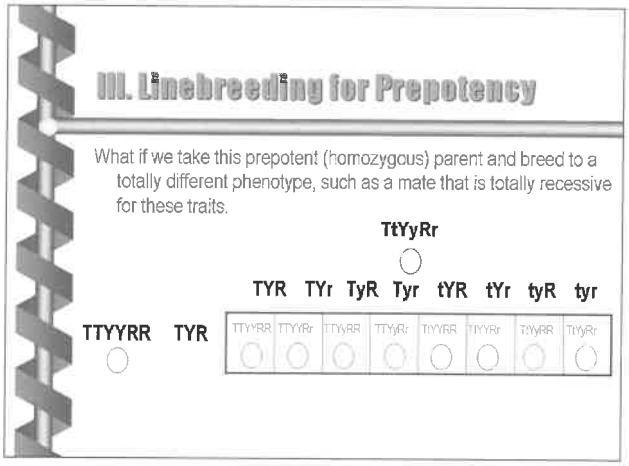

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III. Linebreeding for Prepotency

What if we take this prepotent (homozygous) parent and breed to a totally different phenotype, such as a mate that is totally recessive for these traits.

One parent would express the three dominant phenotypes of tall, yellow, and round. **TTYYRR**

the other would express the three recessive phenotypes of short, green, wrinkled. **ttyyrr**

How many possible outcomes are there from this cross?

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III. Linebreeding for Prepotency

On the other hand, what if we take an identical looking parent that was heterozygous for tall, yellow and round and bred it to the same mate that is totally recessive for these traits.

One parent would still express the three dominant phenotypes of tall, yellow, and round, **TtYyRr**

the other would still express the three recessive phenotypes of short, green, wrinkled. **ttyyrr**

How many possible outcomes are there from this cross?

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III. Linebreeding for Prepotency

One! There is only one possible genotype and phenotype. The tall, yellow, round parent is prepotent over the other parent and thus all of the offspring resemble the one prepotent parent.

TTYYRR

TYR

ttyyrr **tyr** TtYyRr

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III. Linebreeding for Prepotency

Now there are eight possible genotypes and ***also eight*** phenotypes. Again not very consistent or uniform. Obviously the prepotency came from the homozygosity.

TtYyRr

	TYR	**TYr**	**TyR**	**Tyr**	**tYR**	**tYr**	**tyR**	**tyr**
ttyyrr **tyr**	TtYyRr	TtYyrr	TtyyRr	Ttyyrr	ttYyRr	ttYyrr	ttyyRr	ttyyrr

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III. Linebreeding for Prepotency

It is apparent that the prepotency was due to the homozygosity of the one parent.

TTYYRR

TYR

ttyyrr **tyr** TtYyRr

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III. Linebreeding for Prepotency

Now there are eight possible genotypes and ***also eight*** phenotypes. Again not very consistent or uniform. Obviously the prepotency came from the homozygosity.

We can conclude then that in our breeding program the more homozygosity we can create, the greater the prepotency that animal will have as a parent.

Unfortunately, we cannot use such simple analysis and Punnett squares for most of the alpaca traits we are interested in, because they are polygenic.

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III. Linebreeding for Prepotency

What would happen if we bred a herd of 100 short, green, wrinkled "dams" to one homozygous tall, yellow, round "sire"? We would get a herd of 100 tall, yellow, round "crias" out of the short, green, wrinkled dams.

TTYYRR

TYR

ttyyrr **tyr** TtYyRr

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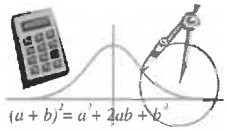
Advanced Genetics for Alpaca Breeders

Part I

I. Polygenic Traits

Many economic traits in farm animals, such as milk production, weaning weights, fiber diameters, etc. show continuous variations throughout a population, primarily because they are controlled by many pairs of genes.



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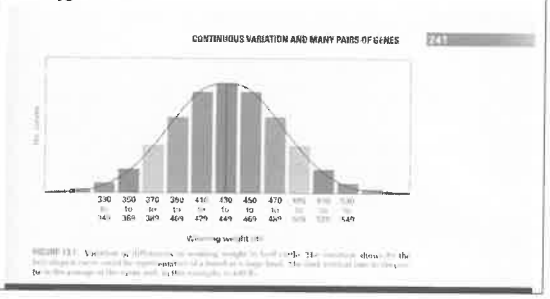
Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits



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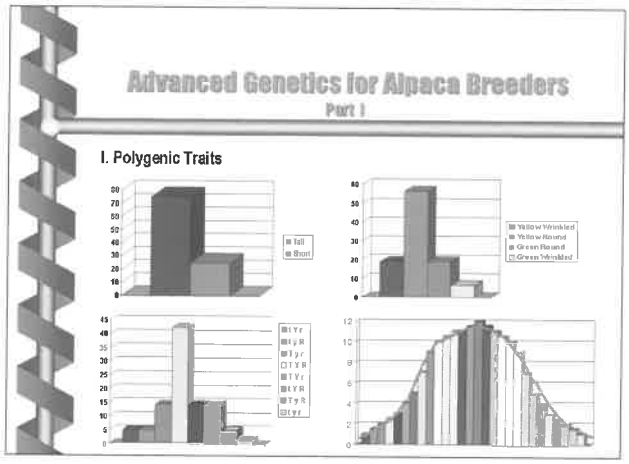
Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits



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Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits

Since so many production traits of livestock, including alpacas, are controlled by so many pairs of genes, we have to expand our thinking beyond inheritance involving one or two or even five or six genes.

We don't know yet exactly how many genes alpacas have, but the number is likely to be greater than 30,000.

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Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits

Let's consider a very simplified example. What if one gene pair on each of an alpaca's 37 chromosomes contributed to a fleece characteristic such as AFD (average fiber diameter)? Remember that for one pair of heterozygous genes, Tt, there are three different genetic combinations, or genotypes. (TT,Tt, tt). For two pairs of heterozygous genes, YyRr there are nine genotypes. How many different combinations for 37 gene pairs?

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Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits

The number of genetically different sperm or eggs for a given number of gene pairs is 2^n.

The number of different genotypes (genetic combinations) is 3^n.

If n (the number of heterozygous gene pairs) is 37, then 2^n = 137 billion; 3^n = 450 *quadrillion*. (450,000 billions)

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Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits

Because polygenic traits are affected by so many genes it is extremely difficult to observe the effects of specific alleles at specific loci. It is therefore impossible to explicitly identify an individual's genotype for a polygenic trait. Imagine writing out the Punnett square for all of the possible combinations of alleles for 37 different loci.

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Advanced Genetics for Alpaca Breeders
Part I

I. Polygenic Traits

Since we are dealing with so many genes, it is unlikely that any animal will be totally homozygous for the traits we are interested in. However, some animals can have a much higher level of homozygosity than others, and hence are much more prepotent than others. The way in which we can increase the homozygosity is by inbreeding.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

Many alpaca breeders condemn inbreeding passionately, often without knowing why other than a superstitious aversion and a vague sense that it is usually associated with the appearance of genetic defects.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

Inbreeding does not create genetic defects any more than the pairing of any two highly unrelated animals does. If both parents pass on a recessive gene for a defect, then that homozygous recessive offspring will show the defect. It doesn't matter if the parents were related or not.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

The primary effect of inbreeding is to increase the probability that the offspring will inherit the same thing from sire and dam. Another way of saying this is that it increases homozygosis. This can be good or bad.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

If it is a pair of recessive genes for some detrimental defect, then the outcome is bad. If it is a pair of alleles that results in a beneficial expression, then it not only affects the offspring by improving its phenotype, it guarantees that as a parent this animal will pass on the desired allele to its offspring; it will be **prepotent**.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

Linebreeding is no different than inbreeding, but the term is usually reserved for matings that have a lesser coefficient of inbreeding, meaning that the common ancestor is somewhat farther back in the pedigree. Inbreeding, including linebreeding, is another tool like selection that an animal breeder can use for the improvement of livestock.

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

Although it has risks and dangers, is not necessarily detrimental. Lush wrote:

"Among animals, laboratory experiments have been extensive on the inbreeding of rats, mice and guinea pigs. Dr. King inbred white rats full brother and sister for more than 70 generations without finding degeneration. Mice have been inbred full brother and sister in many experiments. In at least one case this has been carried further than the 55th generation. In the United States Department of Agriculture experiments on inbreeding guinea pigs, some lines have been inbred brother by sister for more than 30 generations."

Jay L. Lush, Iowa State College Press, *Animal Breeding Plans*, 1945, pp.288

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Advanced Genetics for Alpaca Breeders
Part II

General Mating Strategies

2. Pedigree Relationships

- **inbreeding**

"Many herds today could profit from the use of superior sires by taking advantage of inbreeding, if owners understood the effects and possible consequences of this mating system."

John F. Lasley, Prentice Hall, *Genetics of Livestock Improvement*, 1978, pp. 207

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III. Linebreeding for Prepotency

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IV. Benefits of Linebreeding

I.

Dr. Wayne G. Jarvis March 2008

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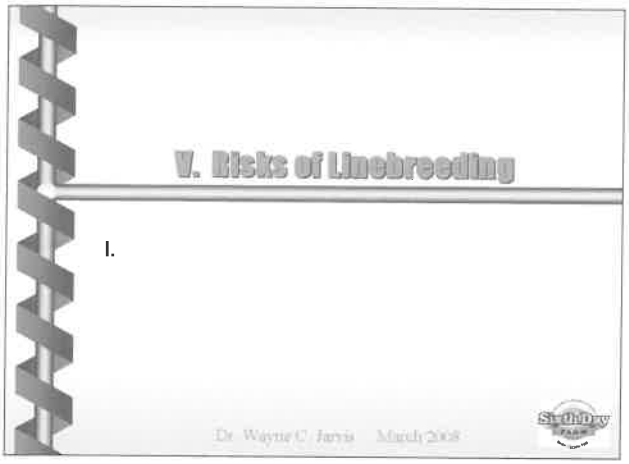

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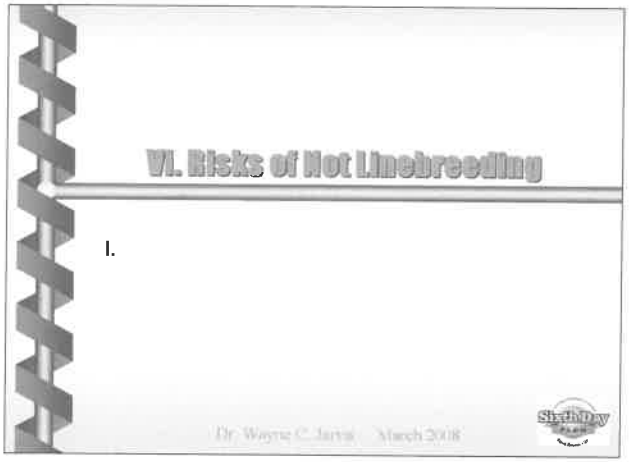

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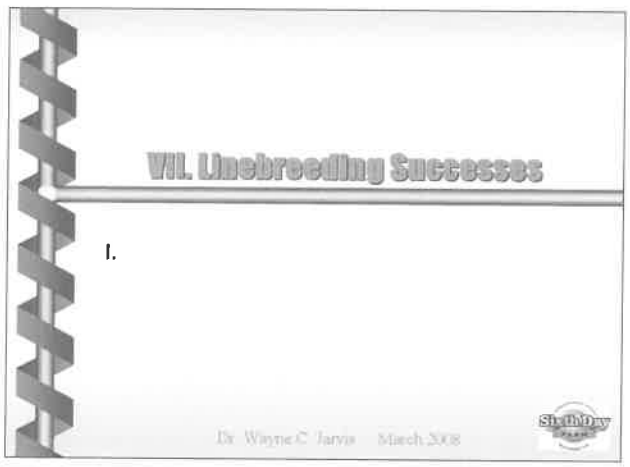

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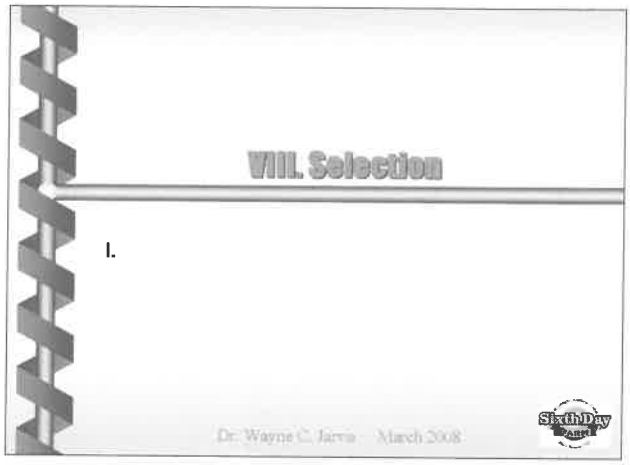

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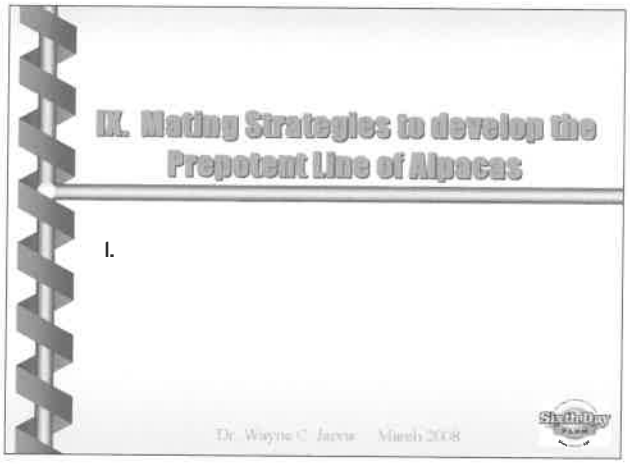

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Notes

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Overview of Veterinary Conference

DR CHRIS CEBRA

VMD, MS, Diplomate ACVIM

A native of the East Coast, Dr Cebra received a Veterinary Medical Doctor degree from the University of Pennsylvania and completed an internship at Cornell University before migrating westward in pursuit of his interest in camelids.

A Diplomate in the American College of Veterinary Internal Medicine, Dr Cebra spent four years at the College of Veterinary Medicine at Colorado State University before joining the faculty at Oregon State University in 1997, where he is an Assistant Professor in the Department of Large Animal Clinical Sciences.

In addition to his clinical duties, Dr Cebra is an active researcher with an extensive list of publications on diseases of camelids. His research interests include disorders of the gastrointestinal system as well as normal energy metabolism and its disorders.

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Notes

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The Second World Alpaca Conference will be held June 2009 in Cleveland, Ohio, USA