Australian Government

Rural Industries Research and Development Corporation

1st International Symposium on Biotechnology Applications in South American Camelids, Peru

RIRDC Publication No. 07/058

RIRDC Innovation for rural Australia

Australian Government

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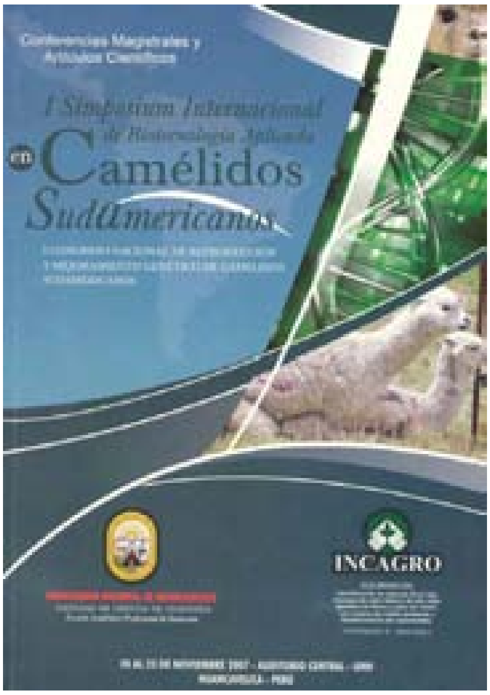
Dr. B. A. McGregor



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Summary

Peru is the world leader in the breeding and management of alpacas and in the processing of alpaca fibre. The largest and most organised alpaca breeding co-operatives are located in Peru. In recent years the Australian alpaca industry has imported most of its superior breeding stock from Peru. RIRDC funded research has led to the publication of numerous papers in international scientific journals and Australian industry conferences that describe the science of alpaca fibre production. The research identified some important issues that need resolution, particularly the need to control and reverse the increase in alpaca fibre diameter that occurs up to 8 years of age (called 'micron blowout') and to reduce and eliminate the contaminant medullated fibres that increase within the fleece as fibre diameter increases. The impact of fibre sampling regimes has also been identified as being important in alpacas. These issues are also important in Peru and led to an invitation to address an international conference in Huancavelica, Peru.

The primary objectives of the visit to Peru were:
1. Accept the invitation to present two papers to the 1st International Symposium on Biotechnology Applications in South American Camelids.
2. Meet and discuss alpaca research with other invited scientists from South America.
3. Engage in discussion with Professor Edgar Quispe Pena regarding the alpaca research program.
4. Inspect facilities of the Lachocc High Andes Research Station and regional collaborating alpaca farmers.

Each conference presentation was attended by over 180 with more than 250 registered for the entire conference. Papers were presented by scientists from 8 countries. The author presented two scientific papers addressing productivity improvements, fleece quality, micron blowout and fibre sampling protocols for alpacas. Other important presentations addressed the critical issue of alpaca breeding and genetic improvement, application of molecular genetic techniques, use of reproductive technology and disease control in alpacas.

Very informative visits were made to the National University of Hauncavelica Centre for Investigations of South American Camelids field station at Lachocc in the high Andes and to two leading alpaca breeders at Santa Ana in the high Andes situated over 4 hours drive from Huancavelica.

Benefits include the following:
1. Opportunity to publish Australian alpaca research before an international forum of alpaca specialists.
2. Networking with leading South American alpaca production and fibre scientists with a good potential to establish further working contacts.
3. Up date on developments in alpaca fibre and production science.
4. Learning experience from visits to high Andes producers.
5. Development of collaborative studies with Peruvian scientists.

The following activities are recommended:
1. Maintain awareness of future conferences in Peru and make strategic plans and financial support available to enable attendance by scientists, producers and/or students.
2. Encourage submission of technical papers to future symposia.
3. Develop opportunities and provide seed funding for future research collaboration.
4. Plan hosting visits by South American scientists if they visit Australia for other functions such as IWTO or wool meetings or specifically for alpaca conferences. This would seem preferable from a scientific point of view rather than inviting industry leaders from the USA or Europe.

Acknowledgments

Professor Edgar Quispe Pena, Professor Nicasio Valencia Mamani, Ing. Hector Guillen Dominguez, Ing. Omar Siguas Robles and the other staff on the organising committee for the conference at the National University of Huancavelica are sincerely thanked for making me most welcome, for doing everything possible for me to enjoy my visit and for part funding the travel. The families who hosted my visit, particularly Mr Remigio Mendoza Quispe and Mrs Hilda Mallma de Mendoza are also thanked. RIRDC is thanked for part funding this travel. The author took unpaid leave to travel to Peru.

About the author

As a Senior Research Scientist, Dr. Bruce McGregor *B.Agr.Sc.(Hons), Ph.D., Advanced Certificate Textile Technology, Certificate IV Assessment and Workplace Training,* has focussed on improving the production and quality of speciality animal fibres. His long interest in the production and nutrition of fibre producing ruminants includes grazing and stocking rate experiments with Merino sheep, Angora goats and alpacas, intensive nutrition studies of housed sheep and goats, studies of the impact of nutrition on skin follicle development, drought feeding and water requirements. He has also studied fibre marketing and processing of natural fibres including Ph.D. studies focussed on the quality of cashmere and its influence on textile materials produced from cashmere and blends with superfine wool. His interests include farm management, fibre quality, fibre testing and genetic evaluation of animals. He has published a number of other RIRDC reports that are available on the RIRDC website.

Contents

Executive Summary

What the report is about
This report provides details of the presentations given at an important international alpaca conference in Peru and of associated field trips.
This work is important as Peru is increasing the organisation of and its investment in alpaca research and these activities have implications for Australian alpaca producers. The outcomes will save on investment requirements in Australia and are leading to collaborative research opportunities between scientists of both countries.

Who is the report targeted at?
This report is written for the technically able reader and for managers of investment into the alpaca industry research and development programs.

Background
Peru is the world leader in the breeding and management of alpacas and in the processing of alpaca fibre. The largest and most organised alpaca breeding co-operatives are located in Peru. In recent years the Australian alpaca industry has imported most of its superior breeding stock from Peru. However Peru has lacked investment in certain areas of fibre production and evaluation. RIRDC funded research has led to the publication of numerous papers in international scientific journals and Australian industry conferences that describe the science of alpaca fibre production. Other countries, especially from the European Community are also investing in alpaca research in Peru.

Aims/objectives
The primary objectives of the visit to Peru were:

1. Accept the invitation to present two papers to the 1st International Symposium on Biotechnology Applications in South American Camelids.
2. Meet and discuss alpaca research with other invited scientists from South America and Europe.
3. Engage in discussion with Professor Edgar Quispe Pena regarding the alpaca research program.
4. Inspect facilities of the Lachocc High Andes Research Station and collaborating alpaca farmers.

Methods used
Two science presentations were made to over 180 attendees. Visits were made to research facilities and to leading alpaca farmers. Numerous discussions were held with other scientists.

Results/key findings
There has been a considerable increase in alpaca research in Peru over recent years and in detailed scientific investigations into key aspects of alpaca fibre production which are of great relevance to Australian producers.
There are a number of important issues that confront alpaca fibre producers in both Peru and Australia that could be jointly investigated.
The Peruvian scientists expressed great interest in collaborating with Australian scientists and since the initial visit Peruvian scientists have been hosted at Deakin University, Geelong, a joint investigation has been conducted and an invitation for a return visit to Peru has been accepted.

Recommendations

- Maintain awareness of future conferences in Peru and make strategic plans and financial support available to enable attendance by scientists, producers and/or students.
- Encourage submission of technical papers to future symposia.
- Develop opportunities and provide seed funding for future research collaboration.
- Host visits by South American scientists to Australia particularly if they are attending other functions such as IWTO or wool meetings. This would seem preferable from a scientific point of view rather than inviting industry leaders from the USA or Europe.

Chapter 1. Objectives of visit

1.1 Background

The Australian alpaca industry and the RIRDC R&D Plan for the Rare Natural Fibres Program visualise an expanding alpaca industry. For this expansion to occur, alpaca production has to be perceived by land-managers as being attractive. The attractiveness of any industry is related to many attributes including financial returns, compatibility with existing enterprises, the status of the product and the technical complexity of marketing and production.

Peru is the world leader in the breeding and management of alpacas and in the processing of alpaca fibre. The largest and most organised alpaca breeding co-operatives are located in Peru. In recent years the Australian alpaca industry has imported most of its superior breeding stock from Peru. Peru introduced restrictions on the export of genetic material in 1997 and access to this genetic resource has been limited. The Australia Alpaca Fleece Ltd. has begun processing textiles in Peru and this may escalate in future if the scouring of alpaca fibre is no longer possible in Australia.

RIRDC funded research into improving the productivity and marketing of alpaca from 1994-1998. This research has led to the publication of numerous papers in international scientific journals and Australian industry conference papers that describe the science of alpaca fibre production. The research identified some important issues that need resolution, particularly the need to control and reverse the increase in alpaca fibre diameter that occurs up to 8 years of age (called ‘micron blowout’) and to reduce and eliminate the contaminant medullated fibres that increase within the fleece as fibre diameter increases. The impact of fibre sampling regimes has also been identified in Australia as being important in Merino sheep, Angora goats and alpacas. These issues are also important in Peru although perhaps to a lesser degree owing to different management and environmental conditions.

University research staff in Peru have identified that the outcomes of Australian research are relevant to their situation. They invited Dr. McGregor to present two seminars on his Australian research. They have tentatively proposed genetic improvement projects in Peru and suggested that Dr. McGregor could be involved in the development and conduct of collaborative studies. This suggestion could lead to a cost efficient method of conducting further studies in ‘micron blowout’ and medullated fibres in alpacas with directed postgraduate student research, access to large herds of white alpacas and reduced costs to the Australian industry.

This symposium also appears to be an excellent opportunity to learn about other recent developments in alpaca biotechnology. The opportunity will be taken to establish dialogue about alpaca research with the aim of establishing professional contact for joint research and further interchange of knowledge and skills.

This report describes the objectives and outcomes from an 8 day study tour during November 2007.

1.2 Project Objectives

The primary objectives of the visit to Peru were:

1. Accept the invitation to present two papers to the 1st International Symposium on Biotechnology Applications in South American Camelids.
2. Meet and discuss alpaca research with other invited scientists from South America.
3. Engage in discussion with Professor Edgar Quispe Pena regarding the alpaca research program.
4. Inspect facilities of the Lachocc High Andes Research Station and regional collaborating alpaca farmers.

1.3 Project Itinerary

The itinerary is shown in Table 1.1.

Table 1.1. The itinerary for travel to Peru

Date	Activity
19 November	Depart Melbourne 0600. Travel Sydney, Los Angles
20	Arrive Lima, 0130. Overnight Lima. Travel to Huancavelica
21	Arrive Huancavelica 0200. Conference presentations.
22	Conference
23	Conference, regional visits
24	Visit Lachocc High Andes Research Station, alpaca farmers
25	Travel to Huancayo. Regional visits with Professor Pena
26	Visit Huancayo, Travel to Lima
27	Visit Universidad Nacional Agraria la Molina, Lima.
28	Depart Lima 0400, travel Santiago. Depart Santiago 2200
29	Travel via Auckland, Sydney, arrive Melbourne 1130

Photo 1: International delegates at the conference were accommodated at Hotel Presidente which faced the Plaza de Armas. During the conference the Hospital Peru mobile health care was placed in the Plaza and attracted large crowds.

Chapter 2. 1st International Symposium on Biotechnology Applications in South American Camelids

2.1 Background

The conference scientific presentations were attended by over 180 with over 250 registered for the entire conference. Most people came from Peru and many are associated with research organisations and universities. Alpaca farmers from the region were also in attendance. The organisers had ensured that many university students studying veterinary, animal and agricultural sciences were invited. Papers were provided by invited scientists from the U.S.A., Mexico, Spain, Argentina, Chile, Bolivia and Australia as well as Peruvian scientists.

Further details about the conference can be found at the website:
http://www.unh.edu.pe/contenido/zootecnia.htm

Huancavelica is situated in the High Andes, about 10 hours by bus from Lima, travel by plane is not available. This city has a population of about 30,000 and is a regional hub for education. The conference was held at the National University of Huancavelica, a new institution that is still developing. The conference aimed to:

- bring together the leading camelid researchers in South America;
- increase international dialogue on alpaca improvement; and
- network and train local and national alpaca researchers.

Photo 2. The author (second from right) and some Peruvian delegates outside the conference centre during a break in proceedings.

2.2 Presentations

2.2.1 Presentations by grantee

The author prepared two scientific papers addressing issues identified by the conference organisers. These papers were accepted and copies are provided in Chapter 4. Presentations for each paper using Powerpoint lasted for 1 hour, including Spanish translations. There was rigorous and wide ranging questioning following each presentation with written questions being sought from the audience.

2.2.2 Other presentations

2.2.2.1 Characterisation of MC1R in alpaca (Lama pacos) fleece color differentiation.

Powell, A.J., Moss, M.J., Tree, L.T., Roeder, B.L., Carleton, C.L., Campbell, E. and Kooymann, D.L. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 33-37, National University of Huancavelica, Peru.

Dr David Kooyman, Brigham Young University, Provo, Utah, USA presented findings from a team of 7 scientists on their research into genes associated with colour inheritance in alpacas. They collected DNA from 112 alpacas to examine the Melanocortin 1 Receptor (MC1R) and the role it plays in the differentiation of red versus black phenotypes in alpacas. Two melanin pigment proteins, eumelan (black) and pheomelanin (red) dictate coat colour in mammals. The interaction between MC1R, melanocyte stimulating hormone (MSH) and Agouti Signaling Protein (ASIP) determines which pigment is present by controlling the amount of MSH that is bound to its receptor MC1R (He et al. 2003). The melanocyte is constantly producing pheomelanin so the default colour will be red/brown. If MSH is bound to MC1R then the melanocyte will be stimulated to convert pheomalanin into eumelanin and be black in colour. If ACIP is bound to MC1R, MSH is unable to bind and only pheomalanin will be produced. The resulting phenotype will be non-black and the actual colour will depend on the colour of other determining genes of the animal (Wolff 2003).

Kooyman presented results that showed the alpaca MC1R gene was highly polymorphic with 11 mutations identified. There was not a complete correlation between each mutation with coat colour. For example, brown alpacas were more likely to be homozygous for two alleles, whereas fawn alpacas were more likely to homozygous for two other alleles. For 24 alpacas homozygous for one particular allele were white, while the remaining 3 were light fawn.

The authors concluded that there could be as many as 7 different alleles at MC1R in alpacas with the potential to deactivate this gene. Due to the complexity of coat colour gene interactions more will be learned about alpaca MC1R as other coat colour genes are investigated. The next gene to investigate in detail will be the Agouti gene. When MC1R and Agouti are investigated together the results should shed more light on alpaca coat colour because of the antagonistic action of Agouti on MC1R.

References cited:
He, L. et al. (2003) Annals of the New York Academy of Sciences 994: 288-298.
Wolff, G.L. (2003) Pigment Cell Research 16: 2-15.

2.2.2.2 Biotechnology applications for production animals
Spanish scientists Drs Arana and Soret, Public University of Navarra, provided a detailed overview of how biotechnology applications have been used in a diverse range of animal production systems. The examples included fish, pig, sheep and cattle. The use of DNA to identify and modify the genetic makeup of animals for disease control, growth etc were illustrated with examples of PCR techniques. These scientists also had two final year students undertaking major projects (development work and fibre production) in collaboration with the National University of Huancavelica.

2.2.2.3 The basis for a program to improve alpaca production in the high Andes of Huancavelica region

Quispe, E.C., Alfonson, L., Flores, A. and Guillen, H. (2007). Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 70-84. National University of Huancavelica, Peru.

Professor Quispe introduced the program to improve alpaca production. The Huancavelica region has over 225,000 alpacas and these animals form the main and often only means of deriving an income for 3,300 poor families in 60 communities. Most alpacas (90%) are Huacaya grazed at altitudes 4,000 - 4,800 m. There has been little attention paid to alpacas grazed in the High Andes as most of the studies have been on the altiplano. Alpacas in the High Andes region produce a biannual fleece of about 2.2 kg, with only about one third of fleeces being graded as finer than 26 μm. Pastures are composed mainly of *Poaceae, Cyperaceae, Asteraceae and Juncaceae.*

The University has commenced a study with farmers in the High Andes regions where temperatures are typically: winter days, -5 to 0°C; and for summer days, 14 to 18°C. Annual precipitation averages 750 mm. Data from 540 alpacas has been collected with the median measurements (± S.E.) as follows: greasy fleece 2300 ± 39 g; mean fibre diameter at mid side 21.56 ± 0.12 μm; coefficient of variation of fibre diameter 22. 8 ± 0.12%.

The alpaca population in the region is predominantly white (86%), and 10% are registered . Typical production indices are: hembras per macho 25, 40% produce cria, mortality of cria 10%, mortality of adults 5%.

Table 2.1. Production data (mean ± S.E.) for alpacas farmed in the high Andes in the region near Huancavelica, Peru (Quispe et al. 2007) with five selected farms to illustrate the variation between the 19 communities in the sample. Within factor, variables with different superscripts differ significantly (P < 0.05)

Factor	Number	Greasy fleece weight (g)	Mean fibre diameter (μm)	Coefficient of variation of fibre diameter (%)
Sex				
Female	458	2272 (42)^{a}	21.7 (0.13)	22.7 (0.13)
Male	86	2450 (112^{b})	21.0 (0.26)	23.2 (0.30)
Age				
Up to 18 months	272	2006 (44)^{a}	20.8 (0.15)^{a}	23.1 (0.18)
18 to 36 months	109	2420 (76)^{b}	21.7 (0.24)^{b}	22.6 (0.26)
3 to 4 years	115	2668 (87)^{c}	22.8 (0.26)^{c}	22.5 (0.25)
> 4 years	48	2818 (191)^{c}	23.0 (0.44)^{c}	22.4 (0.38)
Selected farms				
UNH1	56	3228 (155)^{g}	22.2 (0.33)^{ef}	22.9 (0.27)^{bcdef}
SAL1	29	2505 (130)^{ef}	20.5 (0.42)^{abcd}	23.2 (0.36)^{bcdef}
CAR2	43	2489 (98)^{ef}	23.4 (0.44)^{f}	24.2 (0.45)^{f}
SAN1	29	2314 (148)^{ef}	20.0 (0.40)^{abc}	20.2 (0.44)^{a}
SAL2	19	2002 (149)^{bcd}	23.3 (0.73)^{f}	23.8 (0.72)^{cdef}
CHO2	19	1942 (169)^{bcd}	19.1 (0.41)^{a}	22.4 (0.64)^{bcde}
PUC1	20	1330 (106)^{a}	22.0 (0.65)^{def}	22.9 (0.63)^{bcdef}

2.2.2.4 Reproduction studies in camelids

Canorio, N. and Yaldivia, M. (2007). Cioprreservacion de espermatozoides epididimarios de alpaca (*Vicugna pacos)*. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 85-94. National University of Huancavelica, Peru.

These scientists from the National University of San Marcos, Lima, reported their results from different semen freezing experiments using a range of preservatives and concentrations. Their best results using dimetilacetamide (0.385 M) was 34% progressive motility, 55% viability and 60% of sperm with intact plasm membranes following freezing and thawing.

Parrguez, V.H. and Raggi, L.A. (2007). Reproduction de la vicuna (Vicunga vicugna) en cautiverio: mitos realiddades. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 102-104. National University of Huancavelica, Peru.

From the University of Chile Dr Parrguez summarised a series of 10 different experiments with vicuna and compared the results with commonly held myths regarding the vicuna. Most of the studies were with wild vicuna grazing in the far north of Chile. As only 6% of the vicuna population exists in Chile, funding for this work was difficult to obtain and has since concluded. Results of this work have only previously been published within Chile.

Ratto, M.H., Huanca, W. and Adams, G.P. (2007). Superovulacion y coleccion de embriones en llama/alpacas. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 105-108. National University of Huancavelica, Peru.

From the University of Chile, Dr Ratto describes various experiments that examined the superovulation of alpacas and the development of blastomeres. The techniques used were similar to other published work on camelids and was not dissimilar to work with bovidae. Results have been published elsewhere in the reproductive science literature.

Miragaya, M.H. (2007). Biotecnologias reproductivas en camelidos Sudamericanos. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 114-116. National University of Huancavelica, Peru.

Dr. Miragaya summarised recent research at the Universidad de Buenos Aires into camelid reproduction. He recently published a review on this subject (Miragaya 2006). The research included optimising embryo production in llamas, use of CIDRs, *in vitro* fertilisation, and embryo transfer in llamas. For machos, the research included semen collection, refrigeration of semen and insemination procedures. It is possible that their research conducted on small numbers of llamas has application in alpacas.

Reference cited:

Miragaya, M.H. et al. (2006). Small Ruminant Research 61: 299-310.

2.2.2.5 Molecular genetic studies with alpaca

Agapito, J and Bailon, J.G. (2007). Identificacion de marcadores moleculares y su utilidad en el mejoramiento genetico de la alpaca. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 109-111. National University of Huancavelica, Peru.

With the objective of improving genetic selection the study of the 329 alpacas from Huancavelica began last year in a major cooperative study among leading Peruvian institutions. DNA and RNA extractions were completed. Methods for microsatellite marker use are based on three papers published in *Animal Genetics* during the late 1990s.

Ruiz, J.A., Trivinos, F.J., Van Hussel, F, Diaz, M.M. and Correa, J.E. (2007). Posibilidades y perspectives de al clonacion y transgenesis en camelidos Sudamericanos. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 122-124. National University of Huancavelica, Peru.

This presentation summarises a Ph.D. project that has just commenced at the Universidad Austral de Chile with Ing. Ruiz being a staff member from Huancavelica on study leave. Some references to the history of transgenesis work in Argentina can be found at: http://www.biosidus.com.ar and http://sidus.com.ar .

2.2.2.6 Alpaca health

Rosadio, R., Maturrano, L., Perez, D., Yaya, K. and Lanco, L. (2007). Biotecnologia en problemas de salud en camelidos Sudamericanos Andino. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 112-113. National University of Huancavelica, Peru.

From the Unidad de Biologia y Genetica Molecular and Instituto de Investigaciones CONOPA a lengthy Powerpoint presentation was given on various disease problems in alpaca. The main focus was on the impact and control of enterotoxaemia caused by *Clostridium perfringens*. This disease has been well researched in Australia and prevention is easily achieved with vaccination programs. Apparently this is not normal in Peru where the disease causes 19 to 45% of cria deaths according to the results of two surveys, the majority Type A enterotoxaemia. Not surprisingly, in a controlled experiment vaccination of hembras reduced cria mortality to 1% compared with the control of no vaccination with 24% cria deaths. There also appears to be an interaction between the vaccination program and other causes of cria deaths such that the total cria mortality was 9.5% in the vaccinated group but 45% in the unvaccinated control treatment.

Rosadia, R., Maturrano, L., Castillo, H. and Veliz, A. (2007). Identificacion y selection de moleculares de resistencia genetica a enterotoxemia y neumonias en alpacas. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 120. National University of Huancavelica, Peru.

This presentation introduces a new project that has just been financed to attempt to identify genetic markers for resistance to enterotoxaemia and pneumonia in alpacas. These two diseases together account for 40 to 80% of cria deaths.

Valencia, N., Chaves, A., Garcia, M., Suarez, F. and Casas, E. (2007). Abortion by toxoplasmosis in alpacas at Huancavelica. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 157-161 National University of Huancavelica, Peru.

Abortion rates from alpacas with a fertility rate of 70.4% in a group of 108 hembras were studied. Of these 27.6% were infected with *Toxoplasma gondii*. The risk factor indicated that the probability to abort among seropositive alpaca to *T. gondii* was 3.3 times higher than in seronegative ones.

2.2.2.7 Genetic gain in alpacas the Huancavelica region

Mueller, J. (2007). Genetic resources, limitations and strategies for the genetic improvement of South American alpacas. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids, National University of Huancavelica, Peru.

Dr Mueller is the geneticist in charge of the Argentine Government genetic improvement program for the wool industry. His laboratory at Bariloche includes fibre testing laboratories and facilities for animal studies. He undertook Ph.D. training at the University of New South Wales in the School of Wool and Pastoral Science, recently visited Australia for the Perth World Merino Conference and clearly has an affinity with and understanding of Australian wool science. He is up-to-date with Australian alpaca science literature, for example, having requested copies of recent science publications from this author.

Dr Mueller's presentation summarised the current state of development in the implementation of alpaca genetic improvement programs. Apparently a three year program for alpaca improvement was agreed to and a $6.5 million loan from development banks was approved but the new Government ignored the industry plan and so it was never implemented.

There are 8 institutions in South America interested in alpaca improvement. These include:

1. DESCO, Arequipa, Peru. Using a classic herd structure, 6000 hembras provide the basic herd, with 850 hembras selected in the advanced herd and 260 hembras in the nucleus.
2. INIA, Puno, Peru. Inseminate 14,000 alpacas with semen from selected machos.
3. SPAR, Macusani, Puno, Peru. This program is supported by Oxfam, FCPF and CONACS with an established nucleus of 150 hembra (Zenon Choquehuanca 2006).
4. Grupo Inca, Peru
5. Michell et Cia, Peru
6. Rural Alianza, Puno, Peru, farm 40,000 alpacas.

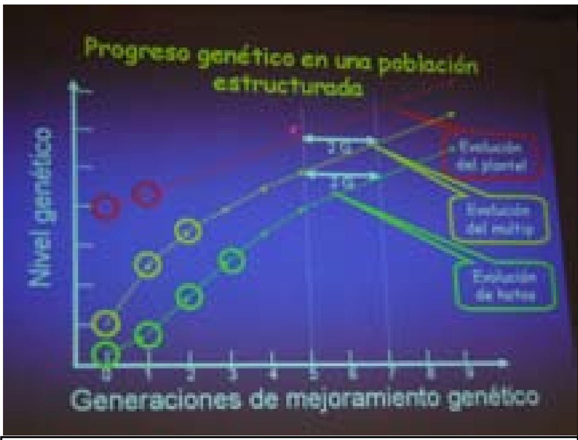
For Peru a model improvement program has been conceptualised as follows:
2,000,000 in general herd; 62,500 in expansion herds for multiplication; with 3,900 of selected machos. For each region a main nucleus would support five or six multiplication herds. The rate of genetic improvement is illustrated in the attached figures. Given that the generation interval would be about 4 years, the genetic improvement in the main herd would be about 8 years behind the nucleus.

The main problems and issues with such a program in Peru are likely to be:

1. The scientific ability to carry out such a program.
2. Adoption of improvement. The involvement of the beneficiaries to implement the program would be essential to improve rates of adoption.
3. Maintenance of genetic progress. This depends on maintaining the selection differentials, generational intervals, accuracy of selection, and selection of attributes, particularly mean fibre diameter.
4. Provision of service laboratories and facilities for analyses and interpretation of results. It is important to use both production and genetic data to optimise progress.
5. Organise national alpaca genetic service, 'Proalpaca'.

Dr. Mueller concluded his thorough presentation with the following points:

Balance was needed for the intelligent application of science and practical issues.
Genetic improvement programs need to supply practical solutions to issues with the active participants of Criaodores (breeders).
The economic benefits of genetic improvement must be clearly explained.
Functional institutions must be supported by all parties.



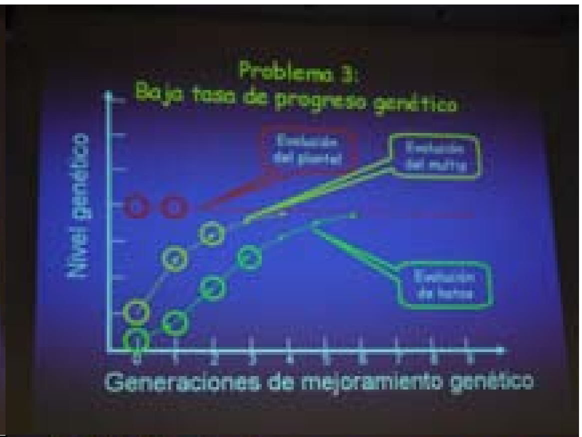


Photo 3. Some illustrations from Dr Mueller's presentation (reproduced with permission). Above: genetic progress and structural differences between the nucleus, multiplier and breeder levels of the industry. Top right: maintaining genetic progress presents a challenge to avoid reaching a plateau (Problem 3). Right: determining genetic merit is clearer when a combination of visual and production measurements are used and improved further with BLUP measurements based on pedigrees.

Quispe, E.C., Alfonso, L., Paucar, R. and Guillen, H. (2007). Prediction of genetic gain on Huacaya alpacas in highland region at Huancavelica, Peru. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 129-133. National University of Huancavelica, Peru.

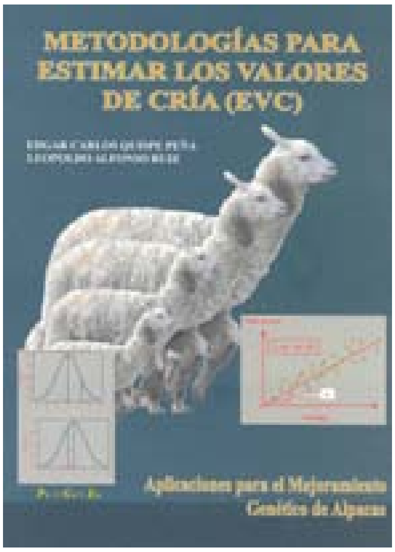
The predictions for annual genetic gain based on review of published genetic data were:

- greasy fleece weight, 45 to 95 g/year
- mean fibre diameter, -0.13 to -0.28 μm/year.

The economic gain using national fibre valuations were between $0.18 to $0.53, while using an index the gains were slightly higher at $0.30 to $0.62. The generation intervals averaged 5.5 years.

Professor Quispe has co-authored several publications on genetic selection in alpaca in South America, in both book and DVD format, and copies have been obtained for Australian scientists.

References cited:
Quispe, E.C. and Alfonso, L. (2007). Methdologias para estimar los valores de cria: Aplicaciones para ael Mejoramiento genetico de alpacas. National University of Huancavalecia, Huancavalecia.
See also
http://www3.unileon.es/congresos/seg07/documentos/resumenes_seg07.pdf



Ayala, J. and Chavez, J. (2007). Indices de seleccion genetica para el diamentro de fibra de alpaca Huacaya tuis y adultas. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 134-140. National University of Huancavelica, Peru.

A study of 96 alpacas provided some heritability data for local alpacas. The values were similar to other published work These authors reference the Australian AGE project and earlier RIRDC funded work published by Ponzoni and co-workers.

2.2.2.8 Skin follicle development in alpacas

Badajoz, E., Sandoval, N., Chavera, A. and Garcia, W. (2007). Caracterizacion histologicia del complejo folicular piloso en crias de alpacas. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 150-153. National University of Huancavelica, Peru.

These veterinarians from various institutions in Lima studied cria skin taken from 42 male and female Huacaya and Suri alpacas. The number of animals was probably too small to make clear conclusions and no statistical support was provided to clarify results.

Photo 4. Some of the scientists present at the conference.
From left back: Dr Mueller, Dr Wheeler, two local staff, Dr McGregor, Conference Secretary Ing Vola Ramos Espinoza, Professor Quespe Pena, Dr Soret, Professor Nicaso Valencia, Dr Arana. Left front: local support staff, Dr Rosadio.

2.3 Discussions with National University of Huancavelica

2.3.1 Environmental factors affecting alpaca production

Professor Edgar Quispe Pena is leading a study of the effects of environmental factors upon the production and quality of alpaca fibre (see Section 2.1.2.3). New work is programmed to commence at 25 field sites in December 2007.

In particular the work would link with the development of a new genetic model based on BLUP analyses. Fixed effects would include: Age, Sex, Herd, Season, Year, Time of shearing, Body condition score. Random variables would be used to estimate breeding values for animals. It is intended to develop a Selection Index using EBVs to include fibre diameter and fleece weight.

The program would incorporate some of the attributes measured in Aylan-Parker and McGregor (2002) but using traditional genetic evaluation procedures. The scope for more thorough fleece testing was discussed at length with the possibilities of fleece testing and evaluation being conducted in Australia. The testing in Australia could include attributes such as staple strength, resistance to compression and other difficult to access testing procedures.

The discussion included managing practical issues such as transhipping samples, quarantine requirements in Australia, pre-treatment in Peru to remove vegetable matter, availability of laboratories and actual testing. Opportunities for the training of Peruvian staff were discussed. Such a proposal has some real management issues to resolve given the alpaca harvesting was to be undertaken in December 2007 and April 2008 and possibly following years. There was no resolution of funding issues and accommodation in Australia if staff were to travel for training.

Photo 5. In an isolated part of Region Huancavelica, a billboard promotes the Proalpaca project. Sponsors include the regional government, CONACS and the EU.

2.3.2 Office of UNHC Co-operation

Ing Omar Siguas Robles manages the Office of UNHC Co-operation. This office arranges collaborations between the National University of Huancavelica and other institutions. For example, the University has agreements with the University in Navarre in Spain (see Section 2.1.2.2). Omar was happy to discuss any potential co-operation agreement. His contact details are:
Email: osiguas@yahoo.es; Phone: 051 067 453 763

2.4 Field visits

2.4.1 Huancavelica region

This region is characterised by high rocky mountains covered by sparse grasses and bare rocky expanses. Conditions are harsh and temperatures extreme. Animals are managed in the traditional manner with grazing usually supervised by a shepherd to be seen nearby, even during hail storms which were frequent during my visit. Alpacas are commonly returned to a corral at night to protect them from extreme weather and predators. This provides much needed manure to fertilize vegetable gardens or for application to small plots of improved pasture for strategic grazing by hembras.

The city of Huancavelica is nestled in a narrow valley surrounded by rocky peaks.

Photo 6. Left: In the region around Huancavelica city, most herds of camelids include llamas. The llamas produce fibre, are used to carry goods and are a valuable part of sustainable grazing systems as they eat itchu tussock grasses whereas alpacas graze softer shorter plants. Right: The author overlooking Huancavelica city with the University in the distance on the outskirts of the city.

2.4.2 Lachocc region

The Lachocc community is centred in the Tucumachay locality that is located over 2.5 hours drive by winding gravel roads from Huancavelica. Locals use buses, 4WDs and minivans for transport. Power is available at most communities and the region is crossed by high voltage power transmission lines. The peaks soar to well over 5500 m and on these remote pastures wild vicunas were seen grazing. Local people muster vicunas using traditional ‘chaccu’ for the annual harvest.

The UNH Centro de Investigacion y Desarrollo de Camelidos Sudamericanos is located at Lachocc (Photo 7). Several staff live at the station to supervise the alpaca herd. The facilities include a laboratory building suitable for accommodation of visiting staff, shearing shed, working yard and sundry service facilities. The herd numbers about 200. Alpacas were mustered for inspection and the animals displayed typical Peruvian features. Discussions covered fleece quality, colour types, genetic links between certain features, body condition scoring and harvesting techniques.

Photo 7. The Lachocc research centre is based in the high Andes. Vicuna were grazing the high pastures in the background.

Photo 8. University of Huancavelica staff with an alpaca showing the colouration of a vicuna

Photo 9. Alpacas grazing high Andes pastures of rough grasses and other native plants.

Photo 10. Alpacas prefer to graze green herbs in wetter areas, areas that are often overgrazed and are a source of internal parasite infection.

2.4.2 Santa Ana

The Sallcca community is based near Santa Ana, over 4 hours drive from Huancavelica. Visits were made to two farming families. Each family lived on the income derived from grazing their herds of 200 alpacas, about 60 sheep and up to 20 llamas. During the visit, the pasture was very short, as expected as the season was coming out of the cold dry winter period. The summer rains had arrived, guaranteeing some pasture growth.

The alpaca herd of Mr Remigio Mendoza Quispe and family had a very well earned reputation as producing leading sires, having won many regional competitions for fleece and animal constitution. Mr Mendoza Quispe had travelled to the conference in Huancavelica and asked me many questions about Australian fibre research. Animals were mustered into a small paddock that was planted with improved grasses. Alpacas were restrained first with lasso and then by hand. Fleeces showed excellent coverage, fineness, and were all white and the animals healthy. The most noticeable aspects of the fleeces were the existence of long medullated guard hairs protruding from the lower portion of each fleece, the variable staple length across the saddle, the extent of staple tippiness and the very weak staple strength near the tips of staples. Typical production values for alpacas in this community are illustrated in Table 2.1, shown by farms SAL 1 and SAL2. It is possible that the higher coefficient of variation of fibre diameter of the fleeces from farms SAL1 and SAL2 reflect the higher incidence of medullated fibres at the mid side site as shown by visual inspection.

Mr Mendoza Quispe was assisted by his wife and three children, although the children were educated at schools in Huancavelica. The family showed their detailed mating records, and birth records, which all members of the family were expected to contribute to their upkeep. The arrival of each cria was recorded to the nearest 5 minutes and so pedigree records were very accurate. Mating records were made easier by the use of three mating pens, upon which were displayed last year’s sire names. The mating yards were close to shelter sheds covered with corrugated iron. Walls of the sheds and house were made from rammed earth and stones. The farming families in this region were showing the benefits of EU funded development programs to alleviate rural poverty.

The other farm visit was the neighbour to the first. Here the animals were easily restrained as they were attracted by the feeding of high quality oaten hay. These animals displayed typical Andean ear tags of red ribbon tied in different patterns and lengths. As with the other farmer, alpacas also displayed numbered ear tags. The fleece characteristics were similar to those of the first farm.

Both farmers were interested in Australian alpaca marketing methods, they wanted to know about the pricing system for Australian alpaca fibre and how we were improving the animals and fibre. They also lamented the problems of keeping their family together with the declining real price of alpaca fibre meaning that most of the children will have to find income from outside the family farm.

Photo 11. The farm of Mr Remigio Mendoza Quispe and Mrs Hilda Mallma de Mendoza at Santa Ana. The alpacas are grazing in a special paddock with improved grasses. In the background is the corral used at night and in bad weather.

Photo 12. Mr Remigio Mendoza Quispe holds a prizing winning alpaca while Ing. Hector Guillen Dominguez from UNH inspects the fleece. Mrs Hilda Mallma de Mendoza looks on while Ms Edith Mendoza Mallma restrains another alpaca. These prize winning alpacas represent the elite animals in the district and come from an all white herd.

Photo 13. The fleeces of alpacas in the Santa Ana community show excellent staple crimp formation, uniform white colour and variation in staple length across the fleece.

Photo 14. The farmers who own the second alpaca herd inspected at Santa Ana are shown in a typical pasture setting. The woman is holding a lasso used in the capture and restraining of alpacas.

Photo 15. Alpacas from the second herd at Santa Ana were fed oaten hay during my visit.

Photo 16. Alpacas grazing high Andean pastures have to withstand sudden and frequent hail and snow storms. During my visit, sheep grazing with the alpacas were lambing in the snow.

2.5 Discussions at Universidad Nacional Agraria La Molina

Professor Jorge Aliaga Gutierrez, received his Ph.D. from Lincoln University in New Zealand in wool science. As Head of Animal Production he leads investigations into social and science programs into wool, sheep and alpaca production in Peru. His Department has fibre testing, chemical and other laboratories relevant to nutrition, animal and wool science. His work includes improvements to local sheep production for meat and pelts. Numerous postgraduate students investigate animal science projects throughout Peru.

Professor Gutierrez recently published a 420 page book on Sheep Production, primarily for undergraduate training. While Peru does produce wool and imports wool from Australia, the priority for sheep production in Peru is for meat, milk and pelts. Thus there has been more interest in the evaluation of exotic genotypes that may assist sheep production via increased litter size, greater lactation or ability to withstand dry desert conditions that predominate along Peru’s seaboard.

Clearly there is potential to build on Australia’s reputation as a leader in sheep production by developing post-graduate training opportunities for South American students.

Chapter 3. Benefits and significance

3.1 Benefits to grantee for his work

Benefits include the following:

- Opportunity to publish Australian alpaca research before an international forum of alpaca specialists.
- Networking with leading South American alpaca production and fibre scientists with a good potential to establish further working contacts.
- Up date on developments in alpaca fibre and production science.
- Learning experience from visits to high Andes producers.
- Development of collaborative studies.

Three areas identified as areas for collaboration were:

1. Research into fibre properties of alpaca produced in the high Andes.
2. Information exchange from visits and seminars in Argentina and Chile.
3. Hosting of visits of alpaca scientists to Australia.

Since the visit, Professor Pena has visited Deakin University and initiated collaborative research. A joint science paper is being prepared following detailed objective and statistical analyses of alpaca fleece samples from the National University of Huancavelica alpaca research herd. A return invitation to visit the National University of Huancavelica has been accepted.

3.2 Benefits for the Australian alpaca industry

Collaboration with South American scientists does offer hope for efficient and cost effective research. The priorities for research into alpaca colour genetics, selection, and reproductive technologies offers the potential for faster and more reliable research using the abundant and low cost source of animals.

The potential exists for the exchange of scientists and post-graduate students to work in Peru, Chile or Argentina. Clearly the initial costs for travel must be overcome and support for people and projects would be needed in overseas countries (either way) but the opportunities are there and diplomatic support for such ideas needs to be garnered. Already Spain and other EU countries are working their networks to establish better links with these South American countries.

Visits by scientists to South American conferences are a very efficient method of gaining access to new scientific information in a cost effective manner. Such visits also promote the high standard of Australian science and technology to the South American science community and as such promoting not only our alpaca industry but the prospect of visiting Australia or sending students to study. There are also opportunities to collaborate with scientists from other countries conducting research on alpacas.

3.3 Recommendations to RIRDC and the industry

The following activities are recommended:

- Maintain awareness of future conferences in Peru and make strategic plans and financial support available to enable attendance by scientists, producers and/or students.
- Encourage submission of technical papers to future symposia.
- Develop opportunities and provide seed funding for future research collaboration.
- Plan hosting visits by South American scientists if they visit Australia for other functions such as IWTO or wool meetings or specifically for alpaca conferences. This would seem preferable from a scientific point of view rather than inviting industry leaders from the USA or Europe.

Chapter 4. Papers presented at conference

Two papers were presented by the author at the conference and are reproduced in full in the following pages. The papers were:

McGregor, B.A. (2007). Techniques of evaluating alpaca fleeces and the implications for genetic improvement.. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 23-32, National University of Huancavelica, Peru.

McGregor, B.A. (2007). Production, variation with age and relative value of alpaca fleeces and implications for animal selection. Proceedings 1st International Symposium on Biotechnology Applications in South American Camelids pp. 38-51, National University of Huancavelica, Peru.

TECHNIQUES OF EVALUATING ALPACA FLEECES AND THE IMPLICATIONS FOR GENETIC IMPROVEMENT

Dr. Bruce A. McGregor,
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1. Introduction

Evaluating the attributes of alpaca fleeces subjectively by eye is difficult and unreliable as alpaca fleeces show large variations in attributes. In addition, our eyes (and brain) are limited in their ability to discern fibre diameter, the average of other attributes and the extent of naturally occurring contaminants. Alpaca fleeces are also affected by environmental conditions, in particular humidity, and also by storage conditions. These same limitations apply equally to wool, mohair and cashmere.
To assist in the commercial trading of fibre for textile processing, a range of testing procedures have been developed to help reduce the errors associated with subjective assessment. These testing procedures are approved by the International Wool Textile Organisation (IWTO) as the basis for the international trade in wool and other animal fibres. Associated with objective tests are a range of errors related to the sampling and testing procedures.
To help breeders evaluate alpaca fleece attributes the starting point is understanding the types of variation found in and between fleeces; the most appropriate method of sampling alpaca fleeces; and the application of this information for evaluating fibre test results. This article should be read in conjunction with McGregor (2007).

2. Variation within animal fleeces

Within a fleece there is considerable variation in fibre attributes related to the following components.

2.1 Within a staple

Most of the variation in fibre diameter occurs between fibres within a staple. The difference between the fibre diameter of fibres growing from primary and secondary skin follicles in an alpaca may be more than 20 µm. Many medullated fibres in alpaca fleeces are more than 10 µm coarser than the mean fibre diameter (McGregor 2006).

2.2 Along the fibre

Changes occur in the fibre diameter, dust, grease and vegetable matter content as the fleece grows during the year. In the example shown in Figure 1 (McGregor 1999) diameter varied from a low of 21 µm to a maximum of 27 µm. During the first few months of life the mean fibre diameter ranged from 21 to 23 µm and then increased to 25 to 27 µm before declining to 21 to 22 µm. Nutritional changes, weaning, rapid growth, the affects of disease and reproduction all influence fibre diameter along the fibre.

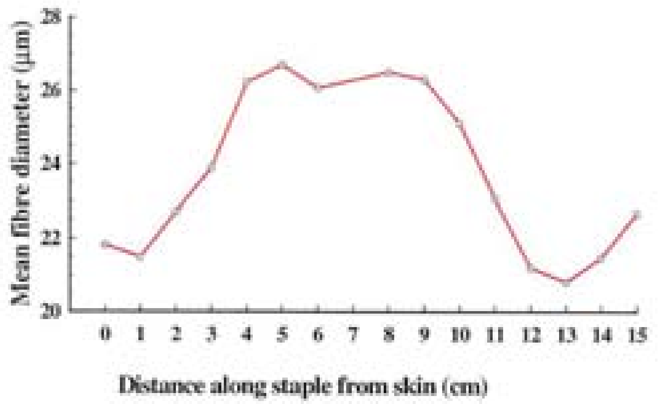

Figure 1. Changes in the mean fibre diameter along a fibre staple from a tui alpaca grazed near Juliaca, Peru and sampled in November (McGregor 1999). The most recent fibre grown is 0 to 4 cm from the skin.

2.3 Different positions within the fleece

Fibre diameter, incidence of medullated fibres, grease, dust and vegetable matter contaminants vary significantly with the position in the fleece (Table 1, Aylan-Parker and McGregor 2002). The mean for the entire fleece was calculated to include the skirtings and was calculated using the weight of the fleece components. In these Australian alpacas there was significant variation in the fibre diameter (MFD) over the body and this variation was associated with high variation in the coefficient of variation of the fibre diameter (CVD). The fibre from the mid side site was 1.2 µm finer than fibre from the saddle and neck, 3.7 µm finer than the mean for
the entire fleece and 10.1 µm finer than fibre from the skirtings. Fibre from the

Table 1. Variation in attributes of Australian Alpaca fleece measured from mid side samples and fleece component grid samples including mean fibre diameter (MFD) and coefficient of variation of fibre diameter (CVD) (Aylan-Parker and McGregor 2002).

Sampling site	MFD[1] µm	CVD %	Clean washing yield %	Medullated fibre by number[2] %	Medullated fibre diameter[2] µm
Mid side site	27.5[a]	24.3[a]	90.2[a]	24.4[a]	32.7[a]
Saddle	28.8[b]	27.0[b]	91.4[b]	33.1[b]	34.4[b]
Neck	28.7[b]	28.6[b]	88.9[a]		
Skirtings	37.6[d]	30.6[d]	92.8[b]	44.5[d]	41.1[d]
Mean entire fleece	31.2[c]	28.1[c]		35.2[c]	36.0[c]

[1] *Within attributes, sampling site values with a different superscript are significantly different.* [2] *Medullation on white fleeces only.*

saddle was 2.4 µm finer than the mean for the entire fleece and 8.8 µm finer than fibre from the skirtings. There was a large variation in CVD over the body. The CVD of mid side fibre was 2.7% lower than fibre from the saddle, 3.8% lower than the mean for the entire fleece and 4.3% lower than for neck fibre. The significantly lower clean washing yield of the mid side and neck compared with that of the saddle and skirtings shows that the distribution of dust, dirt and grease content are not equally distributed over the body of alpacas.

The incidence of medullated fibres at the mid side site was 8.7% less than in the saddle, 10.8% less than the mean of the entire fleece and 20.1% less than in the skirtings. Similar differences were seen in the diameter of medullated fibres (Table 1).

In summary, for each fleece attribute, fibre at the mid side site had lower values than the fibre from the saddle and the mean of the total fleece. For each fleece attribute, except for clean washing yield, the saddle had lower values than the skirtings and the mean of the total fleece.

3. Fleece sampling methods

There are three main methods of fleece sampling available for alpaca breeders: the mid side, the staple and the grid sampling methods. Each method has it own advantages and disadvantages. A fourth method is used to core sample bales.

3.1 Mid side sample method

Since 1947, the accepted method for testing sheep wool has been to take a mid side sample (Turner et al. 1953). The mid side sample has been used to test characteristics of importance such as fibre diameter, fibre population, staple length, density of fibres per unit area and staple crimp. The site for taking the mid side sample is located over the third last rib, halfway between the mid-line of the belly and the mid-line of the back. The mid side site is convenient to use for sampling because it can be easily located during shearing and can be shorn without removing the entire fleece. In sheep, the theory behind using a mid side sample is that a mid side sample test result is close to the mean of both the top to underside and the front to rear variation found in a fleece. For this to be true the mid side sample has to be either mini-cored or testing after carding.

In alpacas, if the mid side sample is taken to low, it may include fibre that is really part of the skirting component. If this happens the test results for MFD and other fibre attributes will be seriously over estimated (see Table 1).

The mid side sample MFD has been reported in Merino sheep, Angora goats and Alpacas to actually test finer than the average for the whole fleece (see Table 1). With Merino wool, this was particularly so for the finer sheep in the population. It was suggested that this was due to intense selection over the years for finer fleece based on the mid side sample rather than selection for a finer entire fleece (Stadler and Gillies 1994).

3.2 Staple sample method

If a staple of fibre is carefully cut at the skin level it can be tested in two ways. The location from where the staple is cut is important and is usually at the mid side site but other sites can be used. A staple sample does not include any of the variation due to position within the fleece.

Average fibre diameter measurements for the staple can be provided by the OFDA2000 (Anon 2007). This type of measurement can be completed within minutes and the results used to class the fleece into fibre diameter lines prior to sale.

Alternatively a staple sample can be tested after butt cutting, as is common in the United States of America. A butt cut is a fibre sample taken only at the end of the fibre closest to the skin. A butt cut sample does not include any of the along the fibre variation or differences due to position within the fleece. The effect of butt cut sampling can be seen in Figure 1. The sample nearest the skin averages less than 22 µm whereas the entire staple would average about 24 µm.

3.3 Grid sample method

The grid sample includes differences due to position within the fleece and so can detect variations in the fleece that the mid side or staple samples do not detect. The grid sampling technique involves:

- laying out the shorn fleece to be tested on a flat surface, ideally on a table measuring about 3 m^2. The fleece needs to be laid out evenly.
- taking 16 to 32 random grab samples from the surface of entire fleece. To help this process it is common for breeders to lay a physical grid over the fleece and to take a sample from each grid. A suitable grid can be made from plastic garden trellis mesh with a mesh size of approximately 10 cm x 10 cm. The idea is to take unbiased samples by pulling a tuft of sample from each square in the grid.

Butler et al. (1991) found that processed wool top produced from Merino wool was better predicted by grid sampling than by mid side samples. Grid sampling is the best method for taking samples from cashmere goats as the mid side sample overestimates the commercial yield of cashmere and underestimates cashmere fibre diameter (McGregor 1994).

Grid sampling can be completed while the next alpaca is being shorn or can be undertaken after a fleece has been stored. Grid sampling can be replicated by using Fleecescan equipment, which involves placing the skirted fleece into a sampling container so the fleece can be minicored. The fibre samples from the minicores are then automatically tested and the results rapidly determined for use in classing the fleece prior to packing.

Core sampling of bales can be done by hand but is difficult and time consuming. Core samples of bales include variation due to differences within staples, along the fibres, between different positions within the fleece and between animals.

4. Sampling and testing variability

If repeat samples are taken from a fleece, differences in the reported measurement will be found. These differences are related to two main causes.

Variation between samples: Each sample tested is different. These differences are related to the variation in animal fleeces but in this case are due to sampling variation. Samples are also frequently sub-sampled once or twice and variation also occurs during these processes.

Variation between tests: Variation occurs between tests. This variation is related to preparation of the sample and the operation of equipment. Each sample tested is different, so differences in the reported measurement are to be expected. Scientific laboratories monitor their testing procedures to ensure the reliability of the test results.

4.1 Interpreting test results

Alpaca farmers need to be aware that each test has an inherent error related to the variability associated with sampling and testing procedures. This error exists even if only one sample is taken and measured.

Some farmers have submitted fleece samples to different testing services and expressed criticism at the "difference in results" they receive. Such an outcome is to be expected. **But do these "different results" really differ?**

By determining the sampling variance, the 95 percent confidence limits can be calculated for a particular sampling and testing procedure. The sampling variance and confidence limits for mid side and saddle grid samples have been measured in Australian alpacas.

The sampling variance for alpaca fibre diameter attributes are similar to values reported for Merino wool (Aylan-Parker and McGregor 2002). Except for clean washing yield, the sampling variance for saddle grid samples was generally 2 to 4 times greater than the sampling variance for mid side samples. As a consequence, for most fleece attributes, the 95% confidence limits for the saddle grid sample were about double those of mid side samples (Table 2).

Table 2. The 95% confidence limits for fibre attributes measured from mid side or saddle grid samples in Australian alpacas (Aylan-Parker and McGregor 2002).

Attribute	Mid side	Saddle
Mean fibre diameter,	1.6	3.7
Fibre diameter CV	2.3	3.6
Incidence medullated fibres, % weight	5.7	19.1
Medullated fibre diameter	2.0	3.8
Clean washing yield	4.1	4.8

Sampling variance for the incidence of medullated fibres in saddle grid samples was very high, possibly due to the difficulty in sampling and measuring these fibres. Contamination of saddle fleece samples with fibres from the skirtings and by coloured fibres will also increase the sampling variance of medullated fibres.

5. Evaluating and undertaking alpaca fibre testing

5.1 Use of mid side sample

The mid side sample was found to be an appropriate sample from which to predict the mean fibre diameter and the clean washing yield.

The mid side sample does not measure a large enough area of the fleece to detect sufficient variation in fibre diameter coefficient of variation (CVD) or in the incidence of medullated fibres.

5.2 Use of the saddle grid sample

Breeders only wanting to improve CVD and/or spinning fineness (McGregor 1998) measurements of the alpaca saddle, in the most efficient way, should use the saddle grid sample. Breeders using either mid side samples or saddle grid samples to improve total fleece CVD, will improve neck CVD at the same time with similar effectiveness.

The saddle grid sample was found to be the appropriate sample to predict the incidence of medullated fibres in the entire fleece.

5.3 Sampling procedure

The large 95% confidence limits for all the tested fibre attributes indicate that alpaca breeders and advisers need to consider taking suitable duplicate measurements and other precautions during breeding and animal selling programs. In Australia, duplicate testing is normally only done when bales of fibre are tested before commercial sale.

5.4 Interpreting fibre test results

The 95% confidence limits for mean fibre diameter (± 1.6 µm) show that alpaca breeders and advisers need to exercise caution when interpreting fibre test results. The research indicates that breeders cannot confidently distinguish between animal test results where the MFD differs by less than 1.6 µm.

There is only a 5% chance that two alpacas with the following mid side MFD test results are different:

a) 19.7 µm compared with 21.2 µm
b) 25.9 µm compared with 27.4 µm

Small differences in MFD are unlikely to be valid grounds upon which to discriminate against animals.

This interpretation has even greater weight when using saddle grid samples to select animals, as the sampling variance for these samples is at least twice that of mid side test results.

6. Application for genetic selection to maximise profit

It is not valid to compare the fibre testing results from individual animals obtained among properties or between years unless special precautions are taken during the collection and analysis of data. Large between year differences in the environment will affect alpaca fibre attributes (McGregor 2002) and farm and year affects can interact (McGregor 2007). Thus during the design of genetic improvement programs, arrangements must be made to account for these influences if serious attempts are to be made at identifying real genetic differences.

For commercial alpaca farmers undertaking genetic selection projects, the question is how do you combine all the information on all the different traits in which you may be interested, in order to make the most progress. Professor Mike Goddard, a leading Australian animal geneticist has recommended that the selection of commercial animals is best undertaken using the commercial value of their product. Thus a breeder can move from a situation of many traits to a situation of one trait if you simply calculate, for all the animals, the amount of money which they made last year, or over their lifetime. Essentially, **you select on the profit which that animal makes for you.** This means that you should include in your selection decision, all of the traits that contribute to making money. If this means that you have to select for a number of traits, then so be it. If you find that in your selection decisions, that you are putting a lot of weight on things that have a relatively small effect on dollars, then you are probably doing the wrong thing. One of the most common mistakes that people make in breeding livestock is that they put too much emphasis on traits which do not have that big an effect on dollars.

Figure 2 illustrates this principle using two traits, for example, fleece weight and dollars per kilogram, you receive for the fleece (quality). In this graph, Goddard (1991) compared two different ways of breeding.

Method 1

In Method 1 we have the two parents, X and Y. We have selected one parent which is very good for fleece weight, but poor for quality and have mated this to another which is good for quality and poor for fleece weight. This is a common practice. Breeders assume that if they mate these two animals, they will get progeny which are good in both directions. However, you do not get the best of both of them, on average their progeny will be half-way in between each other, so that you end up with animals that are intermediate for both fleece weight and quality.

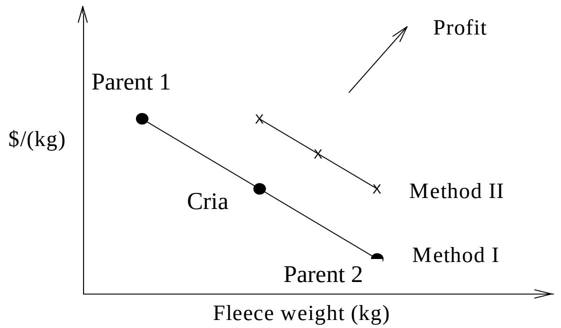

Figure 2. Illustrates the principle of using two traits to select on the profit which an animal makes

Method 2

In Method 2 a slightly different philosophy is used. Neither of the two parents is the best animal for fleece weight or the best for quality. They are more in between animals but they are the best for making money. In this case we are using a Bell shaped curve for financial returns. The same thing happens here, the progeny will be intermediate between the two parents. **However, all of the progeny from this mating are more profitable than those from Method 1.** Thus, if you have been selecting on profit, the trait you really wish to improve, you would prefer Method 2 animals over the Method 1 animals and have obtained more profitable progeny as the outcome.

If you want to maximise dollars, you need to use the parents which have the highest economic merit, that is whose progeny are worth the most money.

This is the reason to determined the relative value of alpaca fleeces based on mean fibre diameter (McGregor 2007). There is very good market information that mean fibre diameter is the major determinant of fleece value, usually more important than all the other traits combined. If other fleece attributes are important they can also be used to determine fleece value, such as fleece colour and fibre length, provided there is sufficient market information to determine the premiums or discounts that apply. As the alpaca fibre market moves through fashion price cycles it is better to use long-term information about prices to determine the relative value over time. The relative values do not change much as they are similar during periods of high and low market values. However if MFD is not properly determined or not measured at all then profit cannot be determined and farmers are likely to select animals with fleeces that are heavier because they are coarse.

If you want to maximise dollars, you need to use the parents which have the highest economic merit, that is, those whose progeny are worth the most money. These animals are likely to have reasonably heavy fleeces with reasonably fine fibre diameter.

In Australia, the economic value from fibre production of alpacas aged six years and older was about half or less of that of alpacas aged one to three years (McGregor 2007). This reduction in economic value will be minimised or eliminated if farmers can substantially reduce fibre diameter increase with age (McGregor 2007).

7. Conclusions

If alpacas are to be selected for characteristics such as low mean fibre diameter and high fleece weight then the mid side sampling site is recommended. It is best to accurately measure mean fibre diameter and use the results to determine the value of the fleece. Selecting alpacas for profit is the best commercial strategy. Alpaca breeders and advisers need to exercise caution when interpreting absolute fibre test results. Evaluation of fibre attributes among alpacas should take into account the 95% confidence limits of the sampling procedure.

Acknowledgments

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PRODUCTION, VARIATION WITH AGE AND RELATIVE VALUE OF ALPACA FLEECES AND IMPLICATIONS FOR ANIMAL SELECTION

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1. Introduction

Most alpaca fibre is processed on equipment designed for the wool industry. Extensive trials in wool processing mills have shown that mean fibre diameter, staple length, staple strength, position of break, vegetable matter and yield account for approximately 80% of the variation in Hauteur (the mean fibre length in the top before spinning) and fibre wastage experienced during top making (Anon 1988). The remaining 20% of the variation is explained by variation between processing mills, fibre diameter variation, crimp definition, style and other characteristics. Consequently there are many attributes of raw alpaca fibre which are of commercial importance during textile processing (Table 1). Some raw fibre attributes are of great importance in early and latter (spinning) stage processing while others are only of importance in early stage processing. These raw fibre attributes are commercially significant as they directly affect: the speed of processing, processing yield, quantity of waste products, yarn quality, dyeing performance, visual attributes, handle attributes, fabric properties, cost of product and appeal to customer. The difficulty for farmers is that they have to produce a fibre that will please all stages of the industry from the early stage processor right to the consumer and make a profit at the same time.

With other animal fibres, such as wool and mohair, the major influence on fibre value is mean fibre diameter (Table 1, Anon 2007a, McGregor and Butler 2004a) and this attribute can be manipulated by management and animal selection. As our studies have shown, the mean fibre diameter of alpaca fibre is not fixed, it varies with age, live weight, genetics and seasonal nutritional fluctuations. Thus the economic value of alpaca production must change with time.

Table 1. The relative commercial importance of attributes of raw speciality animal fibres. The more ** the greater is the significance at that stage of processing (McGregor 2006)**

RAW FIBRE ATTRIBUTE	STAGE OF PROCESSING			
	Scouring	Top	Yarn	Fabric
Mean fibre diameter	****	****	****	****
Washing yield	****			
Vegetable matter contamination (amount and type)	***	***	**	**
Mean fibre length	**	***	**	**
Staple strength/position of break	**	*		
Clean fibre colour	*	*	**	**
Incidence of dark fibres	*	*	*	***
Incidence of medullated fibres	**	**	**	***
Mean fibre diameter variability			**	**
Proportion of fibres > 30 µm			*	***
Fibre length variability	**	**	*	*
Resistance to compression (crimp)	*	*	**	**
Incidence of cotts	**			
Degree of staple tipiness	*	*		
Style and handle			**	**

This paper summarises the results of recent investigates into the commercially important fibre attributes of alpaca fibre grown in southern Australia, with particular emphasis on fibre diameter. Also presented are the outcomes of quantifying the changes in the relative economic value of alpaca production when various production and management attributes are manipulated and the paper discusses the application of these findings for evaluating and selecting alpacas. This article should be read in conjunction with McGregor (2007).

2. Methods

Surveys of alpaca fleece production and quality were conducted at a number of farms over four years. Full details are provided elsewhere (McGregor 2006). Prior to shearing all Huacaya and Suri alpacas were weighed on live stock scales to the nearest 0.5 kg. At shearing, mid side samples were taken and staple length determined. Fleeces were separated into their components of saddle, neck and skirtings and weighed to the nearest 5 g. Detailed fleece measurements were made using modern computer based laboratory equipment (OFDA100) to measure: mean fibre diameter (MFD), the absolute distribution of fibre diameter as the standard deviation (SD), the relative distribution of fibre diameter as the coefficient of variation of fibre diameter CVD, the proportion of fibres with diameter over 30 µm, the incidence of medullated fibres (Med, % by number and % by weight, only recorded for white and light fawn fibre), and fibre curvature (degree/mm). The remaining sample was used to estimate the clean washing yield (CWY) of the greasy sample. A random selection of samples from each farm were tested for resistance to compression and staple strength.

The relative economic value of each fleece was determined using price data for white tops based on prices reported by the major international alpaca trader Alpha Tops (Anon 2007b). Using two complete price cycles (peak to peak) the mean elative price for each grade of alpaca fibre was calculated based on the area under each price curve over time. The relative price data was converted into a mathematical relationship between price and mean fibre diameter using linear regression analyses to allow an average relative price for any mean fibre diameter to be estimated. For most of the 25 years where price data is available the maximum price of alpaca fibre was paid for fibre with a mean fibre diameter of 22 µm, so this fibre has been given a relative value of 100 units per kg. All other fibre has a lower relative value.
The relative economic value for a fleece was then determined by:
1). Multiplying the weight (kg) of each component of the fleece (neck, saddle, skirtings) by the relative value predicted by placing the measured mean fibre diameter for that component into the appropriate prediction equation; and
2). Summing the relative values for the three components together.

Given that most of the fleece skirtings measured exceeded 34 µm, the relative value at 34 µm was applied to all fibre coarser than 34.0 µm (17 units/kg). Colour was not taken into account, all fibre was assumed to be white. Suri fibre values were increased by 10% relative to Huacaya which approximates the market for the period 1995 to 2002. An adjustment was made to correct for differences between the mean fibre diameter measured with mid side sampling and the fibre diameter for saddles and pieces based on research carried out within the same population of alpacas (Aylan-Parker and McGregor 2002). For this analysis, the mid side was taken as 1.5 µm finer than the saddle (this topic is discussed further elsewhere in this conference McGregor 2007).

Statistical analyses

The mean ± se for age at shearing shown in graphs include all data ± 0.5 year. As the numbers of Suri was 11% of the data set, the results for Suri are less reliable than data for Huacaya. Graph data points with large error bars indicate that only a few measurements were available and that the data was very variable. For some fleece parameters the relationships between the fleece parameter and age, live weight or other variable have been determined showing coefficient standard error in brackets. Only regressions with significant variables are given ($P < 0.05$). The effective spinning fineness of fibres (MFD adjusted for CVD), was determined according to Butler and Dolling (1995). Spinning fineness was calculated using a CVD of 24.0% as the typical value. CVD values below 24.0% result in a spinning fineness lower than the MFD and CVD greater than 24.0% result in a spinning fineness higher than the MFD.

To determine the effects on alpaca MFD and CVD of age, farm, sex, breed, fibre colour, live weight, and individual, and interactions of these effects, data were analysed by a multiple regression approach, using a restricted maximum likelihood (REML) algorithm. Some of the terms were transformed and interactions between terms calculated. Full details can be found elsewhere (Butler and McGregor, 2002, McGregor and Butler 2004b).
Some cria fleece weights were missing and it became clear that to exclude these measurements in order to include fleece weight would considerably reduce the potential value of the results. In commercial practical terms, the value of a fleece weight measurement for purchasing decisions is limited by a prospective purchaser's inability to control shearing interval or to weigh fleeces. For these reasons, fleece weight was excluded from further analyses in order to use all available data from cria fibre diameter measurements.

3. Results

3.1. Fleece weight

Greasy fleece weights and saddle weights of Huacayas peaked at 2 years of age but then declined with increases in age until about 6 years of age (Figure 1). With Suris greasy fleece weights increased until 3 years of age and then declined. Mean greasy fleece weights of Huacaya did not appear to be affected by MFD (Figure 1) whereas in Suris greasy fleece weights increased with MFD reaching a peak at 29 to 33 µm before declining.
The mean clean washing yield for the different farms were (mean ± sd): 0.93 ± 0.004; 0.94 ± 0.003; 0.92 ± 0.003; 0.90 ± 0.004 and 0.91 ± 0.004 giving an overall mean of 0.92 ± 0.002.

The proportion of the raw greasy fleece as saddle, neck and skirting components was (mean ± se): saddle 0.559 ± 0.009; neck 0.163 ± 0.005; skirtings 0.278 ± 0.006.

3.2. Mean fibre diameter, coefficient of variation of fibre diameter and spinning fineness

About 10% of Huacayas had fleeces with mean fibre diameters < 24.0 µm while 14% of Suris had fleeces < 24.0 µm. Both Huacayas and Suris had about 50% of fleeces with mean fibre diameter > 29.9 µm. Nearly 40% of all Huacaya fleeces had CVD < 24% and only 14% had CVD > 29.9%. For Suris only 26% had CVD < 24% and 22% had CVD > 29.9%.

For Huacayas the spinning fineness measure indicates that a higher proportion of fleeces would spin well (< 24.0 µm) compared to the use of only MFD values. For Suris the opposite trend was evident.

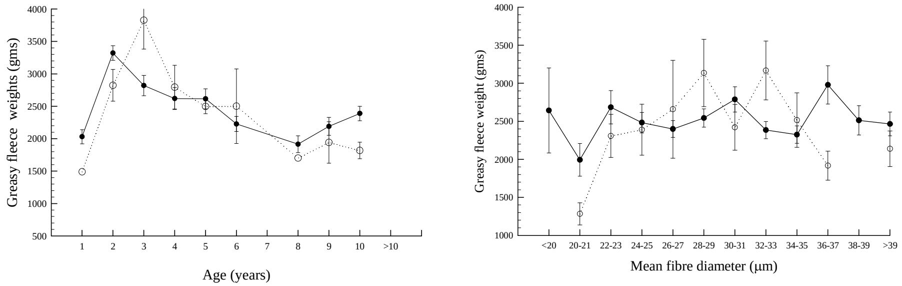

Figure 1. Greasy fleece of Huacaya (●) and Suri (O) alpacas of various ages and mean midside fibre diameters

3.3 Variation in fibre diameter between animals, herds and properties

3.3.1 Mean fibre diameter

The best model to predict mean fibre diameter was influenced by farm, year, age, breed, live weight and colour of fibre. The influence of farm and age are shown in Figure 2. MFD increased to 7.5 years of age. Correlations between MFD at 1.5 and 2 years of age with the MFD at older ages are much higher than correlations at younger ages. Fibre diameter increase with age (micron blowout) was positively correlated with the actual MFD at ages 2 years and older.

There were important effects of farm on MFD that differed with year and shearing age. Suris were coarser than Huacayas with the effect reducing with increased live weight. Fleeces of light shade were 1 µm finer than fleeces of dark shades. There was no effect of sex on MFD.

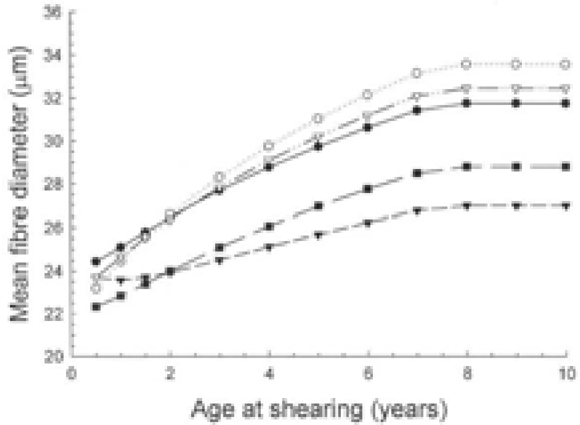

Figure 2. Responses of mean fibre diameter to age at shearing after adjustment for year, live weight, colour of fleece and breed on five different farms (modified from McGregor and Bulter 2004b). Each symbol represents a different farm

3.3.2 Coefficient of variation of fibre diameter (CVD)

The best model to predict CVD was influenced by farm, year, age, breed, and colour of fibre. There were strong effects of age at shearing on CVD that differed with farm and year. CVD declined rapidly between birth and 2 years of age reaching minimum at about 4 years of age and then increasing (Figure 3). CVD measurements on young animals were very poor predictors of CVD at older ages. Suris had a higher CVD than Huacayas on most properties. MFD, liveweight and sex did not affect CVD. Fleeces of dark shade had higher CVD than fleeces of light-shade in 2 of the 4 years.

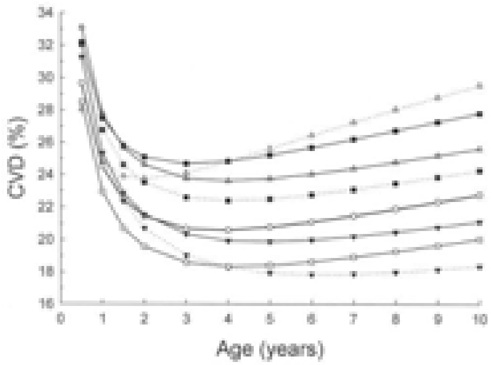

Figure 3. Responses of coefficient of variation of fibre diameter (CVD) to shearing age after adjustment for colour and breed on different farms and in different years. Years have different line styles. Each farm has a different symbol (simplified from McGregor and Bulter 2004b)

3.4. Incidence of medullated fibres

For both Huacaya and Suri alpacas the incidence of medullated fibres (Med %w/w or Med % number) increased linearly from 10 to 60% by weight, as the mid side MFD (µm) increased from 22 µm to 40 µm (Figure 4) as shown by the following regressions:

Med %w/w = -48.2(4.8) + 2.83(0.16)MFD – 7.9(1.8)$Breed_{Suri}$; P<0.001; RSD 13; r=0.75.

Med %number = -58.3(5.1) + 3.23(0.17)MFD – 6.4(1.9)$Breed_{Suri}$; P<0.001; RSD 14; r=0.77.

For Huacaya and Suri alpaca the incidence of medullated fibres increased 3.1 and 2.5% units respectively for each 10 kg increase in live weight (Figure 5). The mean incidence of medullated fibres in animals 5 to 8 years of age was about double that of 1 to 4 year old animals (Figure 5).

The increase in the weight of medullated fibre can be explained by the increase in the number of medullated fibres and the increase in the fibre diameter of medullated fibres (MedMFD, µm) as the MFD of all fibres increased (Figure 4) as shown by the regresssion:

MedMFD = 16.8(0.8) + 0.60(0.03)MFD; P<0.001; RSD 2.1; r=0.83.

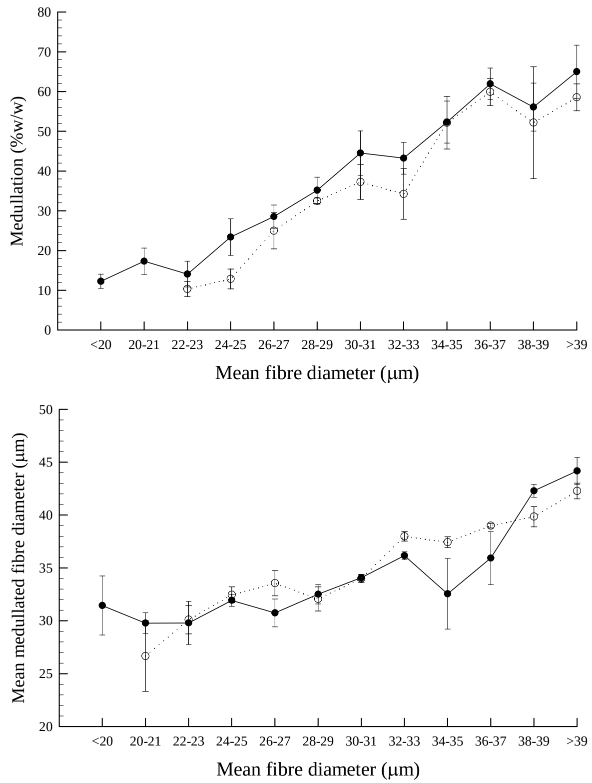

Figure 4. The relationship between mean fibre diameter and a) the incidence of medullated fibres, b) the fibre diameter of medullated fibres for Huacaya (●) and Suri (O) alpaca (McGregor 2006)

3.5 Relative economic value of alpaca fibre

The relative value of alpaca fibre related to the MFD is shown in Figure 6. The data indicate an average decline in price of 11% per 1 µm increase in fibre diameter up to 26 µm. Above 26 µm the average decline in price was 5% per 1 µm increase in fibre diameter. Fibre of 32 µm was valued at only 27% of the value obtained for the finest fibre. Given the limited number of data points the best regression fit between mid side fibre diameter (MSMFD) and relative economic value (RELVAL) was provided by two linear regression equations as follows:

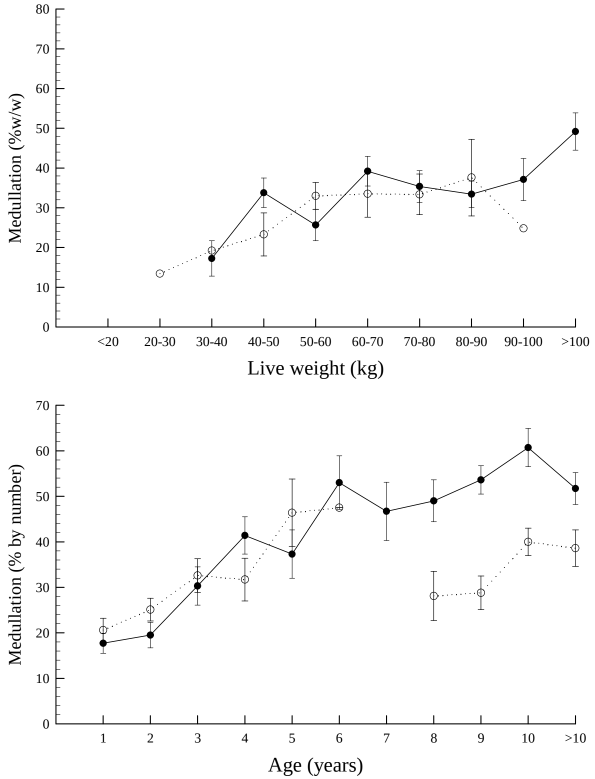

Figure 5. The relationships between the incidence of medullated fibres and a) the live weight and b) the age of Huacaya (●) and Suri (O) alpaca (McGregor 2006)

1. For MSMFD values 22.0 to 26.0 µm; RELVAL = - 10.90 × (MSMFD + 1.5) + 339.8;
2. For MSMFD values 26.1 to 34.0 µm; RELVAL = - 4.933 × (MSMFD + 1.5) + 184.8; and
3. For MSMFD values greater than 34.0 µm; RELVAL = 17.

Note that if saddle grid samples or bale core samples are used for fibre diameter measurements, then these values would substitute for the term within the bracket.

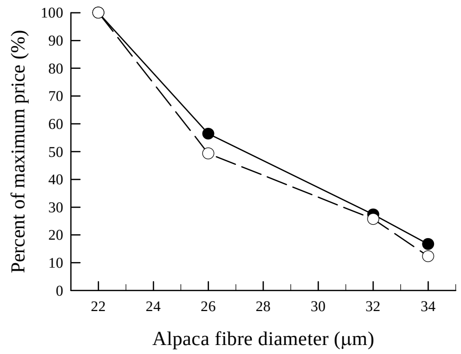

Figure 6. The effect of alpaca fibre diameter on the relative price of white alpaca tops over a 10 year period 1985 to 1995 (●) and during the price cycle troughs in 1986, 1991 and 1992 (O) (McGregor 2006)

3.6 Relative economic value of Australian alpaca fleeces

The total relative economic value increased with increasing fleece weight (Figure 7a) and with increasing weight of the saddle up to a saddle weight of about 2.5 kg (Figure 7b). Note the large error bars for the data for saddle weight from 2.5 to 4.5 kg. These error bars indicate the large variability of the economic value at these heavier saddle weights. There are heavy fleeces with high economic value as a result of having a fine fibre diameter and other heavy fleeces with low economic values as they have coarse fibre diameters.

Total relative economic value declined as mean fibre diameter increased above 23 µm closely reflecting the price discount curve (Figure 7c). Total relative economic value declined with increasing live weight above 60 kg (Figure 7d) and with increasing age above 2 years for Huacaya and 3 years for Suri (Figure 7e).

Generally Australian Huacaya and Suri showed the same economic responses to changes in fibre diameter, fleece weight and age. However if the price premium of 10% for Suri fibre was eliminated (as happened between 2003-2006) then Huacaya would produce fleeces of higher relative economic value (in other words the Suri relative value line would move down 10%).

Clearly the greater the weight of the saddle, the greater the economic return. However, given that the mean fleece weight did not change with changes in mean fibre diameter

(Figure 1), the greatest driver for increased economic value was reducing mean fibre diameter.

3.7 Other fleece attributes

The measured attributes of alpaca fleeces there were tested for all attributes are given in Table 2.

Table 2. The mean and standard deviation of measured attributes of alpaca mid side samples that were tested for all attributes

Fibre attribute	Mean	SD	Minimum	Maximum
Greasy fleece weight, kg	2.44	1.15	0.41	5.24
Clean washing yield	0.92	0.004	0.82	0.99
Mean fibre diameter, µm	28.1	6.0	18.5	45.0
CVD, %	23.6	3.5	17.1	33.7
Staple length, cm	11.2	4.2	5.0	26.0
Staple strength, N/ktex	76	21	25	140
Staple strength SD	14	8	0.5	39
Fibre curvature, degree/mm	27.8	10.6	9.9	49.2
Resistance to compression, kPa	4.7	0.7	2.8	6.7

4. Discussion

4.1. Fleece production

The Australian Huacaya alpacas had an average annual fleece production of 2.5 kg/animal/year. This value is similar to the average fleece weight harvested from Peruvian alpacas in the late 1970s (Calle-Escobar, 1984). The alpacas in the present study had much greater live weights than the 45 kg mean live weight reported for traditional farming systems in Peru (Bryant et al., 1989). The live weights were similar to the live weights reported for alpacas farmed in high input systems in Peru and New Zealand where live weights of 56 to 73 kg were measured (Davis et al., 1991).
The progressive decline in fleece weight from 3 years of age indicates that the effects of physiological stresses are reducing the growth of fibre. The physiological stresses from pregnancy and lactation and age related changes in the maturation, activity and senescence of skin fibre follicles are likely to be the main contributors to this decline in fibre growth. In the present study, alpaca owners wanted to protect their substantial capital investment in animals by taking “no risk” animal

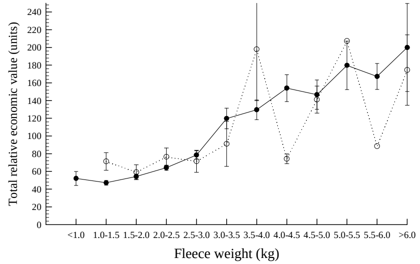

Figure 7a.

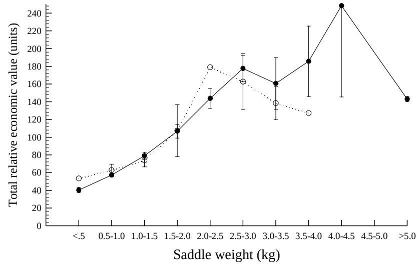

Figure 7b.

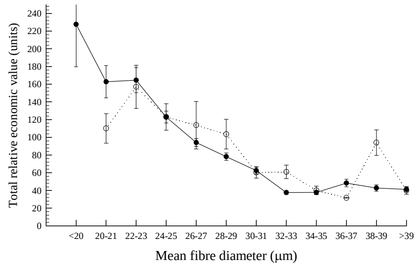

Figure 7c.

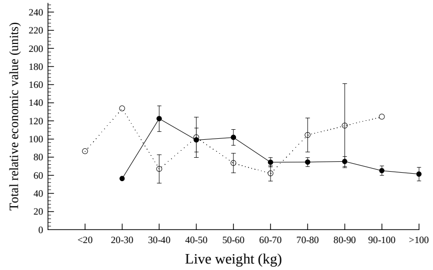

Figure 7d.

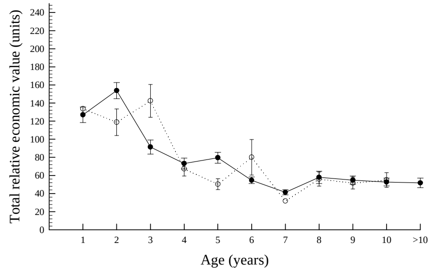

Figure 7e.

Figure 7. The relationship between the total relative economic value of fibre grown by Australian Huacaya (●) and Suri (O) alpacas and a) total fleece weight, b) saddle weight, c) mean fibre diameter, d) live weight at shearing, and e) age at shearing (McGregor 2006)

management measures. For example, none of the alpacas were being grazed at commercial stocking rates. However as the Australian alpaca industry adopts more commercial stocking rates or with the advent of a long-term drought cycle that is common in southern Australia, annual fleece production per animal will decline (McGregor 2002).

The practical application of the price discount curve (Figure 6) to alpaca selection can be seen if the amount of alpaca fibre needed to equal the value of 1 kg of 22 μm fibre is calculated for all fibre diameters. This is can be done by calculating the inverse of the proportion of the maximum price for any mean fibre diameter and converting the value to kg (Figure 8). Figure 8 shows that to equal the value of 1 kg of 22 μm alpaca fibre, 2 kg of 28 μm alpaca fibre is required. If alpacas actually produce 2.5 kg at 22 μm, then for equal value 5 kg would be needed of 28 μm fibre, and 10 kg of fibre would be needed at 32 μm. Do such animals exist?

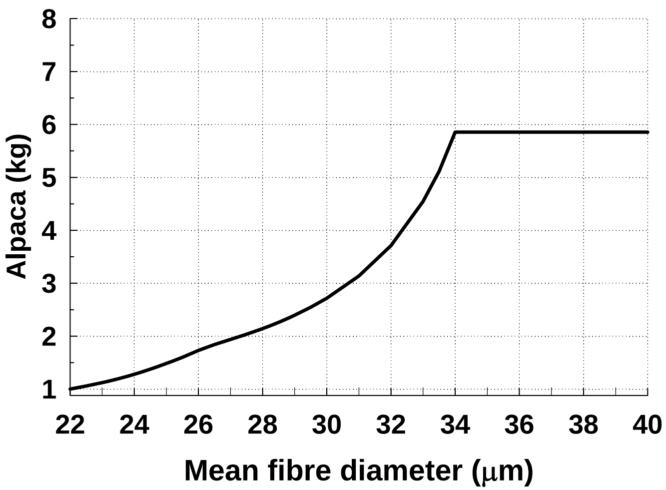

Figure 8. The amount of alpaca fibre at different fibre diameters needed to equal the value of 1 kg of alpaca fibre at 22 μm based on the relative price of alpaca as shown in Figure 6. Every 1 kg of fibre grown at 22 μm has the same value as 2 kg grown at 28 μm and 4 kg at 32 μm.

4.2. Mean fibre diameter, fibre diameter coefficient of variation and spinning fineness

Improving the spinning performance and the quality of alpaca fibre are important elements in the establishment of a viable alpaca industry. There are large opportunities to improve fibre diameter attributes through selection and breeding, particularly to reduce the increase in fibre diameter with age that is not due to short term environmental influences and a progressive reduction in the CVD.

Depending on the farm, the average increase in mean fibre diameter between ages 0.5 and 7.5 (7.5 being the approximate age before the response plateaus) is around 7.5 μm (Figure 2). The increase for an individual animal at a typical farm was 7.5 ± 7.5 μm (McGregor and Butler 2004b). Thus it is estimated that 95% of the repeatable increases in mean fibre diameter from 0.5 to 7.5 years of age will be between 0 and 15 μm. This implies that some alpacas will not increase their fibre diameter at all from a young to an old age, while some other alpacas will increase their fibre diameters about 15 μm.

Furthermore, the increase in fibre diameter with age is only weakly correlated with the inherent animal fibre diameter at a young age. It would appear that the issue of finding the cause of differences in micron blowout, whether genetic or environmental, is crucial in being able to control fibre diameter of Australian alpacas through their lifetime.

The existence and possible cause of substantial micron blowout in Merino sheep is highly controversial within the stud Merino breeding industry. However, the existence of huge differences in 'micron blowout' is confirmed, beyond any reasonable doubt, for alpacas. This is clearly one of the most important issues that needs addressing within the Australian alpaca industry.

For CVD it was estimated that 95% of the repeatable <u>decreases</u> in CVD from 0.5 to 7.5 years of age will be between 0 and 16%. This implies that repeatable animal to animal variation is such that some alpacas will not decrease their CVD at all from a young to an old age, while some other alpacas will decrease their CVD about 16%. This decrease in CVD is equivalent to a decrease of about 3 μm in MFD, when considered as spinning fineness (Butler and Dolling, 1995). The easiest method of including CVD measurements in animal selection is to combine the measurement with MFD by using spinning fineness as the parameter for selection.

The Australian Alpaca industry has already been advised to use spinning fineness for the following reasons to ensure alpaca retains its soft luxurious handle, to exclude prickly fibres, and to simplify fleece assessment procedures (McGregor 1998). The implication for selection programs is that alpaca fibre needs to be tested in laboratories which can provide mean fibre diameter and CVD measurements. The easiest method for this in Australia is to use the OFDA100 (laboratory) or OFDA2000 (portable) or Laserscan (laboratory) or Fleecescan (portable) computer operating fleece testing equipment.

4.3 Optimum age for alpaca selection and fleece sampling

There is clearly higher risk attached with alpaca selection using samples taken at earlier than 2 years of age. Fleece sampling and genetic selection of alpacas at ages greater than 3 years of age will produce an opportunity cost of delaying the potential benefits from earlier selection of alpacas.

In order to identify animals that exhibit micron blowout, successive annual measurements of mean fibre diameter are required. To reduce the cost of this operation, the testing of sires would appear more cost effective than testing the entire herd.

4.4. Incidence of medullated fibres

Medullated fibres affect numerous textile qualities and readers are referred to Hunter (1993) who reviewed this issue in mohair. All alpaca processors I have spoken from Peru (personal communication Inca Tops, Michell & Cia, Productos del Sur), Japan, Europe and Australia regard the presence of medullated fibres in alpaca as serious contaminant fibres that interfere with the production of premium textiles. The medullated fibre incidence increases dramatically as MFD of alpaca fibre increases. It is highly likely that methods that result in a reduction in MFD will directly lead to a reduction in the incidence of medullated fibres as is seen in mohair (Lupton et al., 1991).

The present work has shown that medullated fibres are more noticeable in fine alpaca as the fibre diameter of medullated fibre is up to 40% greater than the MFD for the fleece whereas in coarser fleeces the differential between the fibre types declines to about 10%. However in practice, in alpaca with a mid side MFD of 20 µm, the medullated fibres represent 10% by number of fibres and have a fibre diameter of 30 µm. This incidence of medullated fibres in Australian alpaca corresponds exactly to a skin follicle population of 9 secondary skin follicles per primary skin follicle. In practice S/P ratios in Australian alpacas have been less than 9:1 (Ferguson et al. 2000), implying that all primary and some of the secondary follicles are producing medullated fibres.

To reduce the incidence of medullated fibres the alpaca industry needs to focus on the production of fine alpaca fibre, concentrate animals in commercial herd to ages of less than four years, evaluate sires for incidence of medullation before use; develop codes of practice which focus on improving fibre handling to minimise contamination during and after harvest and combine this with a comprehensive program of training and education with the objective of reducing the contamination of the saddle fleece with medullated fibres and other contaminants.

5. Conclusions

The main drivers of economic value for Australian alpaca fleece production are lower mean fibre diameter and increasing fleece weight. Higher economic value for fleece was associated with younger alpacas and alpacas that did not show fibre diameter increase with age. This work provides a method to assign an economic value to alpaca fleeces thus enabling animal selection based on commercial economic values. A range of activities are available to improve the fleece value of alpacas including the use of spinning fineness.

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1st International Symposium on Biotechnology Applications in South American Camelids, Peru

by Dr. B. A. McGregor

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Peru is the world leader in the breeding and management of alpacas and in the processing of alpaca fibre. The largest and most organised alpaca breeding co-operatives are located in Peru.

This report provides details of the presentations given at an important international alpaca conference in Peru and of associated field trips.

This work is important as Peru is increasing the organisation of and its investment in alpaca research and these activities have implications for Australian alpaca producers. The outcomes will save on investment requirements in Australia and are leading to collaborative research opportunities between scientists of both countries.

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Cover photo: Alpacas grazing in the Andes, Peru (courtesy Dr Bruce McGregor)

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