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AUSTRALIAN ALPACA ASSOCIATION
NATIONAL CONFERENCE
ADELAIDE 2006

CONFERENCE PROCEEDINGS

Adelaide Convention Centre
19th & 20th August 2006

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PROCEEDINGS OF THE

NATIONAL CONFERENCE

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Contents

Welcome to the Adelaide Conference 2006

From the National President

Bringing together an attractive and informed list of speakers for the 2006 Australian Alpaca Association Conference in Adelaide is a challenge. Jolyon Porter and the team have succeeded beyond expectations and we gratefully acknowledge their efforts.

The biennial conferences of the Association celebrate the advancement of our industry and our knowledge of the alpaca. Our conferences were an annual event during the early stages of our development but since 2000 have been held every two years to enable a longer perspective on change and increase in our knowledge.

Our members take advantage of conferences to meet old friends and new and to network to their mutual advantage. Welcome.

Kerry Dwyer
National President

From the Conference Convenor

On behalf of the organising committee, I would like to welcome you all to Adelaide for the 2006 Alpaca National Conference, "From Here...To Wear". As you will all know, the Conference has been organised on behalf of the Australian Alpaca Association, the predominant industry representative body in this country. As such, the biennial Conference must be considered as the predominant learning experience for the industry. Consequently, we have tried to put together a programme which is varied in content, educational, and also entertaining.

Organising a conference is a demanding task, and much more so when you have never previously been involved in such an undertaking. Attempting to keep costs under control, whilst finding informative and entertaining speakers on topics that will grab the prospective delegate's attention, is difficult and at times daunting.

I have been lucky to have a good team of 'co-convenors', who have been ready and able to assist with the numerous tasks that are required to make this event a success. We have also been fortunate to have received the support of sponsors who see the importance of these conferences in disseminating the valuable information our speakers are presenting here this weekend.

At the beginning of preparations, we read through all the comments written by participants at the 2004 Conference in Hobart, looking for guidance and direction from the membership. A number of points came to light and we tried, as much as possible, to fulfil the most common desires.

We also found a number of conflicting comments; some wanted more of one thing and less of another, with almost equal numbers wanting the direct converse! This was fairly common in the feedback forms which covered a number of topics.

The most common theme though, was the ability to see and hear all, or at least most, of the speakers, and so this became our goal. And what a difficult goal it proved to be!

Our call for 'expressions of interest' in presenting to this Conference, elicited a large number of responses covering a vast array of information. We suddenly had too many speakers and topics to choose from for the limited time available. Cutting them down was not going to be easy, as we had to balance the topics and subjects to suit a varying level of delegate knowledge. We had to try and satisfy the long term breeders who "know it all", through to the new breeders whose knowledge base was very narrow, but who would be hungry for it all.

We also had another consideration, which we had not initially bargained on, but which became obvious as negotiations with speakers ensued. The majority of them actually wanted to hear all the other speakers as well. So, understandably, they were very reluctant to do repeated presentations. Something we were actually keen on.

Following our theme of "From Here...To Wear" we have brought together some twenty-eight speakers, from overseas and around Australia, to make presentations on a diverse range of topics including animal husbandry, fibre production, value adding and production.

Many hours, over numerous meetings, were spent trying to satisfy our goal. Our Programme Co-ordinator, Mark Gishen, spent even more hours of his time on this task. We eventually had to settle on the programme we are about to present. Some of you, no doubt, will be disappointed at having to miss a number of the speakers, and for that we apologise, but trust you will graciously accept the difficulties of organising such a weekend.

However, to cover this overlap of presentations is the production of 'The Proceedings', which all of you will have received in your delegate's bag. Here you will find nearly all of the presentations in written form for later reference. Whilst there is nothing quite like hearing and seeing a speaker in the flesh, I am sure their comprehensive notes will ease the disappointment.

I would like to close by thanking all those who have helped put this conference together; the organising committee who have put in countless hours of personal time; the local members who have come forward to assist in whatever way they could; the sponsors and exhibitors who have put their faith in this event; the speakers who have made their own personal sacrifices towards the conference; and finally you the delegates who have made the long, or short, journey here to listen, learn and enjoy.

I trust you will all find this event a worthwhile experience in your life with alpacas.

Jolyon Porter
Conference Convenor

Soil composition and health impacts

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Abstract
The following examines the role of the macro and trace elements as constituents of soil, proteins, cell walls and mechanical structures plus their role as catalysts in complex chemical reactions. Soil, plant, feed, water and animal tests as diagnostic aids will also be discussed.

Minerals in Soil Health
Soil is a living organism. Like other living organisms soils breathe and require adequate water and nutrition. Also like animals soils need appropriate management. Soils have a basic nutritional requirement for optimum management and sustainability even without considering raising crops or stock and their specific requirements. This is often referred to as the chemistry of the soil, and will affect soil structure, soil moisture management and microbial population and diversity.

The life of the soil considers all living organisms in the soil including insects, worms, bacteria and fungi. Without these organisms the soil would be dead and unproductive. Soil organisms perform the following important functions in the soil plant environment:

- Improve nutrient availability
- Improve soil structure, moisture availability and drainage
- Protect plants from pathogens

A balanced approach to soil and plant management will ensure sustainability and the best out come in terms crop and livestock health and profitability. This balanced approach is achievable. Farmer and land managers now have the technological tools to assist with soil and land management. These include a comprehensive soil audit, plant tissue analysis and numerous in-field tools including penetrometers, pH and soil moisture meters.

Understanding Soil Balance
To appreciate the role of soil balance in animal nutrition, it is essential to first understand the relationship between cations and anions and base saturation in the soil colloid.

What are cations? They are positively charged elements that are electrically held to the negatively charged soil particle (see *Figure 1*). The important cations that influence soil fertility include:

Calcium	Ca^{++}
Magnesium	Mg^{++}
Potash	K^{+}
Sodium	Na^{+}
Manganese	Mn^{++}
Cobalt	Co^{++}
Iron	Fe^{++}
Zinc	Zn^{++}
Copper	Cu^{++}
Aluminium	Al^{+++}

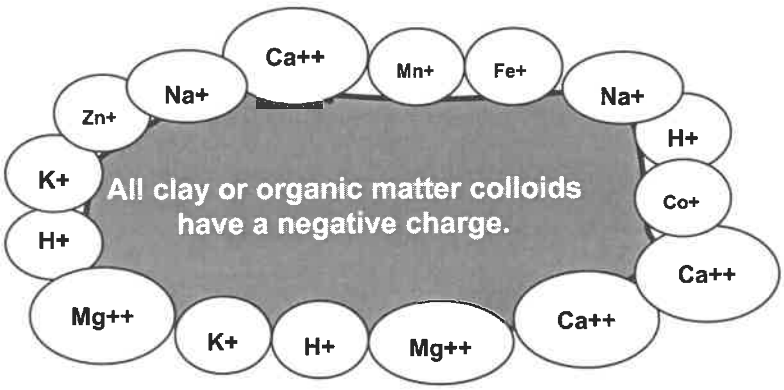

Figure1: Illustration of the soil colloid surrounded by cations.

What are anions? They are negatively charged elements and include:

Phosphorus	P^{---}	They oppose the negatively charged soil particle
Sulphur	S^{--}	
Nitrate	NO_3^-	Available anions are generally in the soil solution.
Chloride	Cl^-	Therefore, they can be limiting in dry or wet conditions.
Boron	B^-	
Molybdenum	Mo^-	
Selenium	Se^{--}	

Base Saturation Percentage is the extent to which the soil particles or colloids (exchange complexes) are saturated with exchangeable cations. Refer Table 1. They are expressed as a percentage of the total exchangeable cations on the surface of a soil particle – referred to as the total cation exchange capacity (TEC). The TEC is a measure of the total cation storage capacity of a soil and is expressed as meq/100 g of dry soil.

Table 1: Illustration of the base saturation in two soil samples, where one soil is balanced and the other is not balanced.

Cations	Desirable %	Undesirable %
Calcium++	68%	30%
Magnesium++	12%	28%
Potassium +	5%	10%
Sodium+	1%	14%
Other Bases (trace elements)	2%	6%
Hydrogen+	12%	12%
Total	100%	100%
pH	6.2	6.2

Note that the pH is the same in both, showing that pH is not an indication of a balanced soil. When soils have or are near this ideal balance the soil minerals work together. When out of this range antagonism can occur.

Colloids are highly weathered soil particles composed of clay, silica or humus (refer *Figure 2*). They are some of the smallest particles in the soil. Mineral colloids represent clay particles and organic colloids are called humus. Organic colloids or humus hold in the order of 10 times the moisture and nutrient per weight compared to clay colloids.

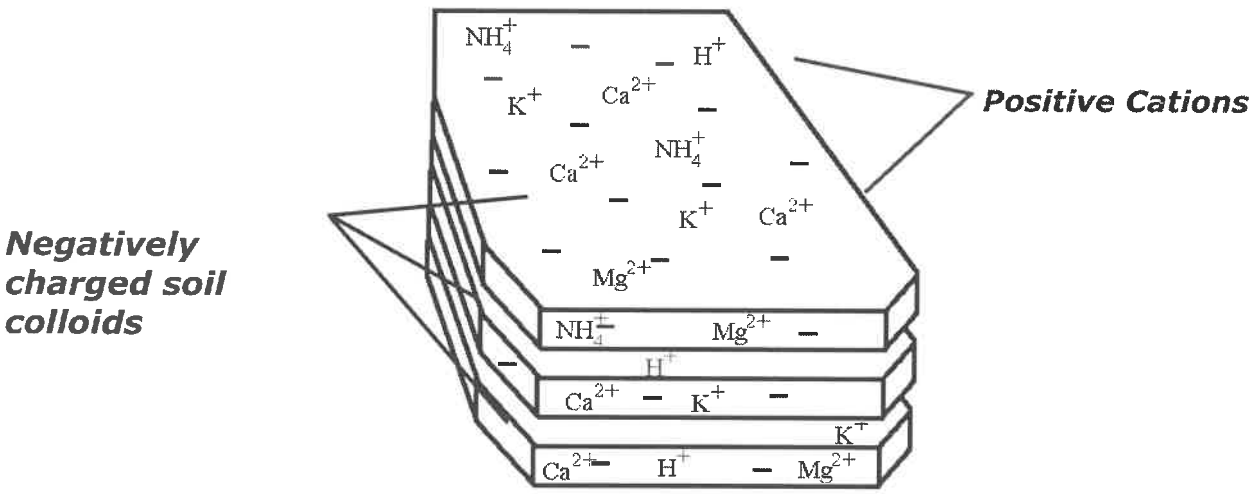

Figure 2: Schematic representation of silica layers in a soil colloid showing negative sites on the clay particles.

Total Exchange Capacity (TEC) is the sum of the total exchangeable cations. It is a measure of the total cation storage capacity of a soil. It is expressed as a meq/100 g of dry soil.

Base Saturation Percentage is the expression of the extent that the exchange complex is occupied by specific cations and the calculation is shown below. It is expressed as a percentage of the total exchange capacity. Each cation (Ca, Mg, K, Na, H) is analysed in meq/100g of dry soil. The total of the cations in meq is the exchange capacity.

pH

pH is an important parameter of soils and plant-soil interactions affecting:

- root development – can be inhibited by extremely high or low pH.
- seedling germination - especially low pH
- nutrient availability and the predominant form of a specific nutrient.
- rates of weathering of minerals and organic matter.
- microbial population and diversity.

Soil pH is a measure of the hydrogen ion (H^+) and hydroxyl ion (OH^-) concentration in the soil solution.

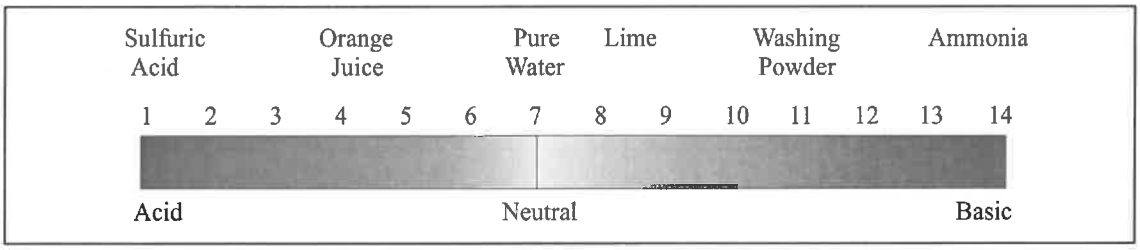

Figure 3: pH scale illustrating the pH of some common substances.

Effects of pH on Nutrient Availability

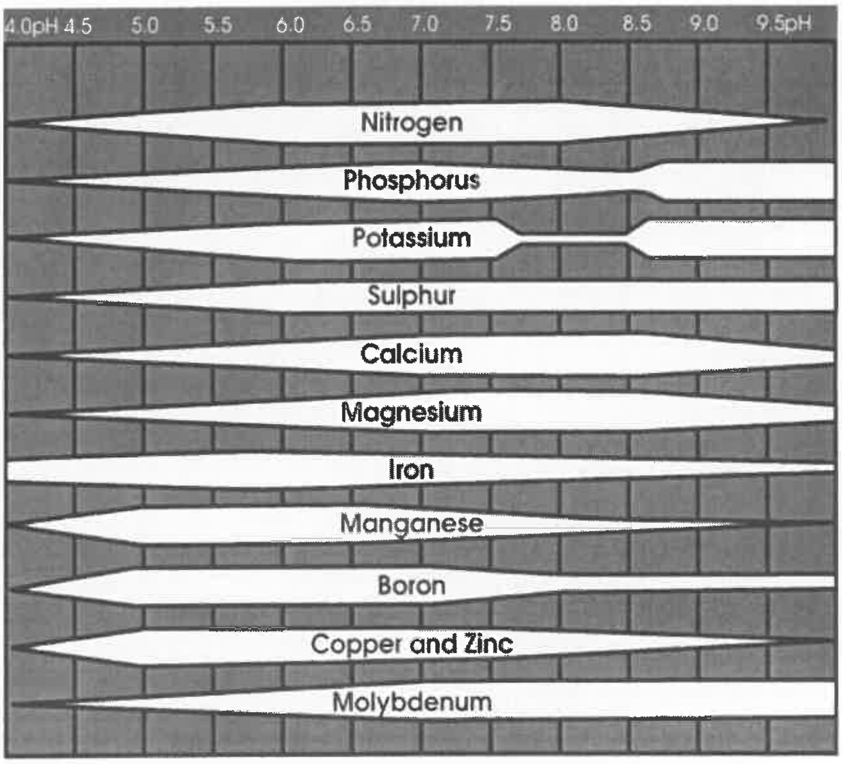

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Figure 4: Width of each bar represents the relative availability of each nutrient in relation to pH.

Generally, high (alkaline) or low (acidic) pH conditions reduce the availability of macro and trace elements. For example, phosphate forms complexes with either iron or aluminium at low pH or calcium at high pH. Phosphates like most other nutrients are most available when the pH (in water) is slightly acidic ie 6.2 – 6.5. This is also the case when the base saturation of a soil is balanced. If the soil is not already balanced, the aim is to achieve soil balance through the application of soil amendments such as humates, composts, lime, dolomite or gypsum.

Mono-ammonium and di-ammonium phosphate is generally the preferred forms of phosphate fertilizer because they tend to be more available for a longer time – especially where pH extremes result in poor phosphate availability (refer *Figure 5*).

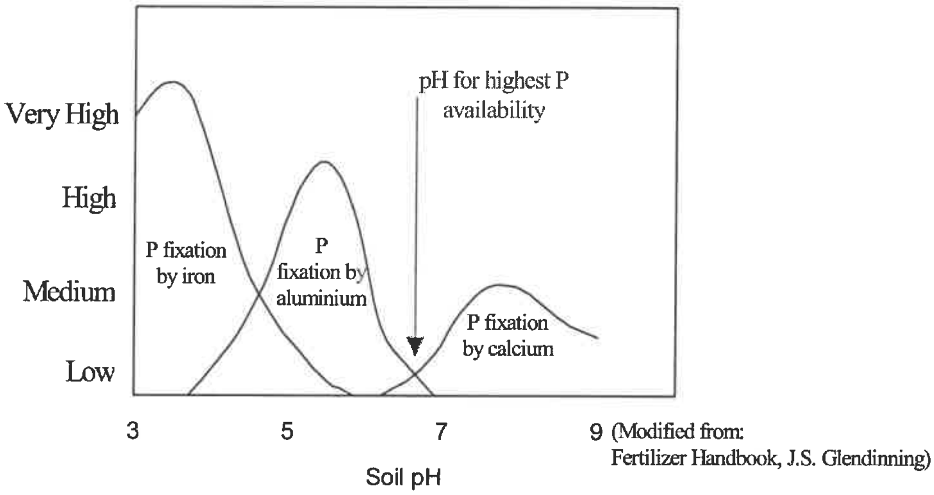

Figure 5: Relationship between soil pH and phosphorus availability.

A final consideration in this brief account of soil nutrition is the nutrient removed by harvesting of farm produce. Table 2 shows the impact of farming practices with respect to the amount of calcium removed. Lime is approximately 33% calcium, depending on the source, and significant amounts removed with grazing, forage and cropping procedures need to be replaced to ensure sustainable farming practices.

Table 2: Lime required to balance the acidifying effects of growth and removal of farm products.

Product	*Kg lime/tn product*	*Yield tn removed*	*Kg lime required/ha*
Lucerne hay	60	4 t/ha	240
Grassy hay	30	4 tn/ha	120
Wheat grain	9	2 tn/ha	18
Lupins	20	1 tn/ha	20
Wool	14	10 dse, 6 kgs wool/dse	1
Meat	170	0.6 cow/ha	6
Milk	4	1 dse	8
Dung			= 50kg/year

Role of Plants in Animal Health

Plant mineral deficiencies not only occur due to lack of a soil supply, but are also created by excesses. A nutrient excess will always cause a nutrient deficiency in some other element (refer Figure 6). Nutrient interactions are complex and require consideration when planning fertiliser programs for crops and pastures. Table 3 summarises the main nutrient interactions commonly observed. The effect of beneficial and antagonistic reactions can be demonstrated with tissue analysis. Further to this it explains the need for tissue analysis to correct any nutrient disorder due to deficiency or some other nutrient interaction which can impact on animal health and production.

STIMULATION AND ANTAGONISM CHART

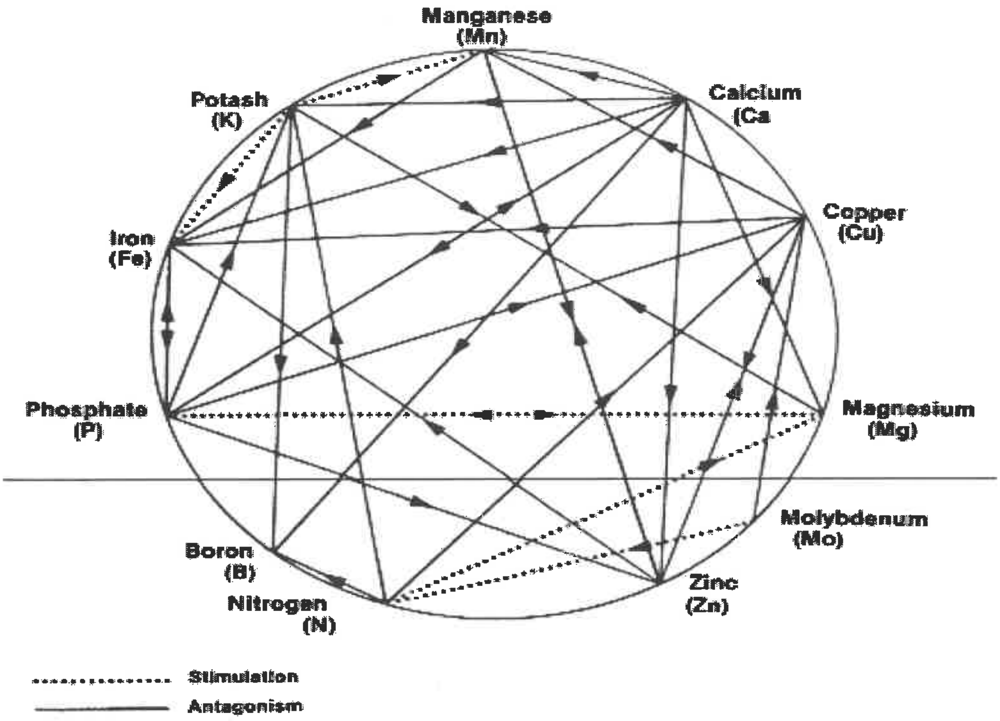

Figure 6: Mulders Chart of beneficial and antagonistic relationships between soil nutrients. (McLeod 2003)

Table 3: Main nutrient interactions commonly observed in soil and plant antagonisms.

Soil excess of:	*Reduces the plant/animal availability of:*
Calcium	Magnesium, Potassium, Phosphate, Iron, Boron, Manganese and Zinc
Potassium	Magnesium, Sodium and Calcium
Phosphorus	Calcium, Potassium, Iron and Zinc
Nitrogen	Sodium, Calcium and Copper
Copper (vine soils)	Iron

Minerals in Animal Health

Minerals have three major roles in animals. They:

- Provide structural material to bones and connective tissue;
- Allow electrical impulses to be transmitted across nerves;
- Act as catalysts involved in the numerous physiological processes such as DNA replication, digestion, immune function, endocrine synthesis, neurological activity, energy storage and release, muscle contraction and numerous other functions.

As a consequence, mineral deficiencies can have devastating consequences on animal and human health. For example, magnesium alone is responsible for 100 enzymatic reactions in the human body. Zinc accounts for another 200 and a deficiency of only these two minerals can account for 300 physiological malfunctions.

The availability of nutrients in appropriate quantities is a major factor determining the health of grazing livestock, but is usually poorly understood or appreciated. At least 15 minerals are essential to animals (Judson and McFarlane, 1998). The major elements obtained from the atmosphere are carbon (C), hydrogen (H), oxygen (O) and nitrogen (N). The major nutrients obtained from the soil are calcium (Ca), chlorine (Cl), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), and sulphur (S). Essential trace elements obtained from the soil include cobalt (Co), copper (Cu), iron (Fe), iodine (I), manganese (Mn), selenium (Se), zinc (Zn) and molybdenum (Mo).

Minerals in plant and animal health

Most of the 16 nutrients are regarded as essential for plants and animals. Animals have an additional requirement for I_2 and fluorine (F). Most plants have little or no requirement for Na, Cl, Se, I and Co – except for the Co required by rhizobia for N fixation. Plants have a higher requirement for K, Fe and Ca (legumes) and a lower requirement for Cu than animals. Other mineral requirements are similar which means that both pasture and animals can benefit from these nutrients applied as solid or foliar fertiliser.

The critical nutrient levels for plant growth are sometimes lower than the minimum levels required for animal diets. It is therefore possible for plants to be growing perfectly normally, but to contain suboptimal levels of nutrients for grazing livestock. Conversely, high levels of certain nutrients in plants, for example Mo, Se, nitrite (NO_2) and nitrate (NO_3) can be toxic to animals without harming plant growth.

Investigation of production and disease

Advisors to the grazing industry are often only consulted when livestock production is already compromised and then focus on blood analysis for Cu, Co, Se and sometimes Zn to examine mineral intake. Caple (1989) and Hosking et al (1986) stated the commonly recognised mineral deficiencies and disease syndromes in livestock at pasture are associated with the major elements Ca, P, Mg, Na, S and trace elements Co, Cu, I, Mn, Se and Zn. Gupta and Gupta (1997) highlighted that excessive intake of minerals such as Cu, Mo, Fe, S, Na, Se and fluorine (F) can affect livestock productivity as much as deficiency in these minerals.

A strategy combining soil, pasture and blood analyses will provide a much more comprehensive diagnostic tool for disease investigation than blood tests alone. Similarly, this strategy is ideal for the development of nutritional programs for optimum health and nutrition.

Comprehensive soil and pasture tests are available in Australia that provide an estimate of the availability of the 15 essential nutrients in the diet. The nutrition of grazing animals is a complicated interaction of soil, plant and animal. An example is the interaction between Cu x Mo x S and Cu x Fe. If Cu deficiency is present in livestock, but pasture Cu is high (> 10ppm DM), there is no benefit in applying Cu as fertiliser as an antagonism with Mo, S or Fe must be occurring. Direct Cu supplementation to the animal is indicated in this instance. Alternatively, McFarlane et al (1990) stated that Cu fertiliser may be the cheapest and most effective option to treat Cu deficiency in livestock if pasture Cu is relatively low (< 7 ppm DM). Suttle (1991) found that in practice if the pasture Cu:Mo ratio is above 3:1, then livestock are not at risk to Cu deficiency.

Nutrient deficiencies

Factors affecting the incidence of nutrient deficiencies and disease in animals include seasonal conditions; age, sex & physiological status of the animals; soil type & nutrient status; pasture species mix & feed on offer; previous stock treatments and grazing history of the paddock concerned. Consequently, the incidence of these conditions is variable over time. Blood and pasture analyses need to be taken over a range of seasonal conditions to establish if the problems are likely to be recurrent.

Advances in the analysis of soil, plant, grain, conserved fodder, blood, milk, urine, faeces and liver tissue has provided the best opportunity to evaluate the nutrient intake by livestock. Implementing strategies based on regular monitoring of the nutrient status of soil and feed in the form of pasture or supplements or specifically formulated rations can effectively minimise production loss due to malnutrition or disease.

The soil and pasture analysis offers a value added service to the traditional blood test to diagnose mineral and / or disease concerns and enables implementation of preventative strategies to optimise livestock health and production.

A critical step in undertaking soil and pasture analysis is identifying a laboratory(s) that will provide the appropriate range and sensitivity of nutrient analyses. Another important requirement is to establish optimal values for each of the nutrients analysed. Reuter & Robinson (1997) have published critical and adequate levels for these nutrients in their plant analysis manual.

Conclusion

Macro and trace elements provided in a balanced diet are fundamental to livestock health and productivity. The most comprehensive approach to herd and flock production & preventative health will include the use of soil and plant analyses as a means of monitoring these nutrients in conjunction with tests on blood, liver, milk, urine, faeces, grains, conserved feeds and water as appropriate. The livestock owner and consultant equipped with this information as well as their knowledge of season, pasture availability, grazing management and the class of stock is then able to make production and management decisions with a high degree of confidence.

References

Albrecht WA (1996). The Albrecht Papers. Acres USA, Metairie, Louisiana USA
Caple IW (1989) Proc 2nd Int. Cong. for Sheep Vet., Massey University: New Zealand pp277-284.
Glendinning JS (1990). Fertilizer Handbook, Incitec Ltd, Morningside Qld
Gupta UC and Gupta SC (1997) Proc. Int. Soil and Plant Analysis Symp., Minneapolis, Minnesota USA pp81-104.
Hosking WJ et. al. (1986) In Trace Elements for Pasture and Animals in Victoria, Dept of Agric. and Rural Affairs, Melbourne Vic.
Judson GJ and McFarlane JD (1998) Aust. J. Exp. Agric. 38:707-723.
Judson GJ (2001) In Proc. Optimal Livestock Production CRT
Kinsey N & Walters C (1995). Hands on Agronomy. Acres USA, Metairie, Louisiana USA
McLeod BL (2003). Understanding Your Soils and Plants Workshop Manual, Aust Perry Ag Lab, Magill SA
McFarlane JD, Judson GJ and Gouzos J (1990) Aust. J. Exp. Agric. 30: 187-193.
NRC (1985). Nutrient Requirements of Domestic Animals, 6th ed, National Academy of Sciences, Washington, DC
Reuter DJ and Robinson JB (1997) Plant Analysis: An Interpretation Manual 2nd edn CSIRO publishing: Collingwood Vic.

Managing native pastures for agriculture and conservation

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Abstract
Native pasture is a general term used to describe a wide variety of pastures. Generally they are dominated by native perennial grasses together with a variable number of native herbs and can also contain volunteer introduced or naturalised grasses, legumes and broad-leaved weeds. Native pastures help maintain soil and ecosystem health, provide valuable ground cover and clean water. Native pastures can be categorised into 3 broad types; native grasslands, modified native pastures and highly productive native pastures. Management of the three pasture types will vary and this paper outlines the appropriate management options for the three native pasture types whether for agriculture or conservation. Identifying and understanding the key features of the major pasture species present is the first step in pasture management planning. Livestock grazing is a powerful tool for managing pasture composition, productivity and health of native pastures but this takes knowledge, care and time; however there is no single grazing management system that can be applied in all environments and to all species to achieve the same results. Native pastures and grasslands can be managed and their composition shaped by a wide variety of farm management tools and can be much more productive than is often recognised.

Introduction
This paper is a summary of the principles expounded within the book "*Managing Native Pastures for Agriculture and Conservation*" (Langford et al 2004).

Native pasture is a common term used to describe a wide variety of pastures. Generally they are dominated by native perennial grasses together with a variable number of native herbs. They can also contain volunteer introduced or naturalised grasses, legumes and broad-leaved weeds. On the tablelands, most native pastures have developed from the ecosystems found here at the time of European settlement. These ecosystems were grassland, grassy woodland and open grassy forest. The tablelands has good examples of these grassy ecosystems, but mostly their extent and condition has been highly modified.

Native grasslands are defined as *vegetation dominated by grasses and forbs containing less than 10% woody plant cover.* They are dynamic ecosystems, where species composition and structure can change from year to year and season to season in response to rainfall, temperature, fire, grazing pressure and management. These grassy ecosystems can exist in a variety of states. For instance an undisturbed grassy woodland is characterised by widely spaced trees with a grassy ground layer and while there might be younger trees and wattles, taller shrubs are rare. Elsewhere the same ecosystem may have trees that are very closely spaced as a result of earlier clearing. Another area may be mainly grassland with few or no trees after more recent clearing or repeated burning. These disturbed or altered grasslands are called secondary or derived grasslands.

It is relatively rare to find a natural grassland or grassy woodland with a high diversity of native grasses and other herbs. This is because nearly two centuries of grazing (by both domestic livestock and the introduced pest, rabbits), plant introduction, fertiliser and/or herbicide application and cultivation has gradually removed many native grasses and herbs from most paddocks. This process has altered botanical composition from original and resulted in a reduction in biodiversity. Areas where such diversity still exists have a very High Conservation Value (HCV).

Pastures dominated by native grasses and derived from these vegetation types are called 'native pastures.' Native pastures occur across a wide range of physical and climatic environments and have various levels of modification. A wide variety of plant species, both grass species and other species, shows this. This variety of environments and species mixes lead to great difference in both their productive potential and conservation value. Figure 1 shows how these communities have developed over time.

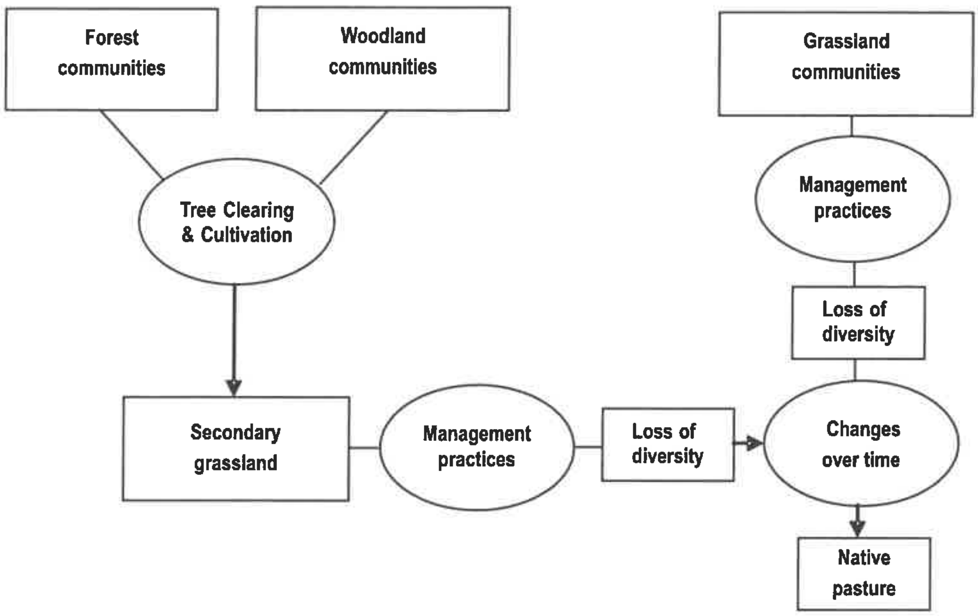

Figure 1: A sequence of native vegetation communities and modification that can occur over time.

Native pastures include a wide range of species, structure, condition and management histories. For the purposes of this paper they have been divided into 3 broad categories; native grassland, modified native pasture or highly productive native pasture.

These categories are based on the degree to which they have been modified from their native vegetation origins, indicated by which native grasses have become dominant and Table 1 outlines the main features of each native pasture type.

Table 1: Types of Native Pasture

Native Grassland	• Mainly native grasses that dominated the pre-European grasslands or woodlands as they were well adapted to the original soil conditions (low P, S & N levels). • Historically received low intermittent grazing pressure and burning • Dominated by tall summer growing species. • Usually contain many other native grasses and herbs including daisies, peas, lilies, orchids, sedges and rushes. • Grasslands with all these components and few weeds have high conservation value.
Modified Native Pasture	• Derived from native grasslands, grassy woodlands or forest having been modified by clearing, grazing, fertilising, oversowing with legumes or minimal cultivation. • Now dominated by native grasses that were a minor component in the original vegetation. • More tolerant of increased often continuous grazing pressure and respond positively to increased soil fertility and better able to tolerant plant competition from annual grasses and broadleaf weeds. • Stability depends on grazing and fertiliser management and the native grass species present. • Depending on species composition, soil type and fertility, can have high value either for conservation or production.
Highly Productive Native Pasture	• Highly modified from their original grassland composition. • Dominated by species such as microlaena and wallaby grasses which are tolerant of high grazing pressure and increased soil fertility. • The number of species tends to be small. • Contain introduced legumes and annual grasses. • Winter production is strongly influenced by the diversity and production from annual grasses and legumes. • For long term stability, grazing pressure needs to be maintained in early to mid spring to reduce the competitive affects of the annual species on the native perennial grasses.

Resource assessment

To be able to effectively manage native pastures you need to understand the natural capital resource of your property. Agriculturally, there are five major factors which determine where native and/or modified native grass-based pastures are likely to best fit. These are land class, slope/erodibility, soil acidity, aspect and drought tolerance and resilience

The response of native grasses and forbs to increases in soil fertility and grazing pressure varies from species to species. Recognising the major species present in each paddock, knowing how they respond to the environment and management and how best to manage them, is essential. Major native perennial species present in the south east region and a broad indication of their drought persistence, Acid soil tolerance, grazing value and fertility response is presented in Table 2 and Table 3 shows the ranking of pasture types for their suitability to various slope and soil conditions.

Table 2: Major features of the most common perennial native grasses

	Species Common Name	Botanical Name	Drought Persistance	Acid soil Tolerance	Herbage Value (green leaf)	Fertility Response
Summer Growing	Kangaroo Grass	*Themeda australis*	*****	***	*	*
	Red grass	*Bothriochloa macra*	*****	*	***	***
	Wiregrass	*Aristida ramosa*	*****	*****	*	*
Year-long Green	Wallaby grass	*Austrodanthonia spp.*	*****	****	***	****
	Microlaena	*Microlaena stipoides*	*****	*****	*****	*****
	Poa	*Poa spp.*	****	****	**	****
	Spear grasses	*Austrostipa spp.*	****	****	**	**
Key: High **** Medium-High **** Medium *** Medium-Low** Low **						

Table 3: Interactions and features of different pasture type in relation to topography and soil factors.

Pasture Type	Suitability to Land Slope[1] Flat[3]	Undulating[4]	Steep[5]	Soil Acidity Low	High[2]	Soil Fertility Low	High
Native grassland	*	**	*****	*	*****	*****	*
Modified native pasture	**	***	****	**	*****	****	**
Highly productive native pasture	***	****	***	***	*****	***	*****
Introduced pasture with sown perennial grasses	*****	****	*	*****	**	*	*****

Note: More ***** indicates better suitability and long term sustainability.

1 Related to persistence and production of perennial pasture, ground cover and steepness of land.
2 High acidity (pH in both top and sub soil below 4.6 with aluminium above 15%)
3 Arable
4 Arable by direct drilling
5 Non trafficable - can only be sown or fertilised aerially

Managing Native Pastures

There are five things that graziers can influence or change in managing their properties; soil fertility, grazing management, weed control, pasture species and livestock enterprise. Native pastures have varying growth periods, herbage quality, responses to soil fertility, persistence under grazing and to drought. Understanding these differences is the key to successful management.

The rainfall and pasture growth of south eastern Australia is characterised by variability within and between years. This represents a challenge to livestock and farm managers to maintain sustainable productivity from perennial grass based pastures.

Historically pasture development and improvement has focussed on the replacement of existing vegetation with introduced species, increasing soil fertility with fertilisers and introduced legumes and then hoping that the system would be sustainable and cost effective. Whole farm planning and fencing was based primarily on rabbit control, portion boundaries and cash flow, and generally had little to do with soil and landscape features. Australian landscapes are geologically old and heavily weathered resulting in soils which are impoverished and poorly structured. Crawler tractors enabled clearing of many areas which in hindsight should not have been cleared. In many cases, sown perennial grasses did not persist due to being sown on soils for which they were not suited (see Table 3).

Native pastures were largely ignored until problems such as increasing soil acidification, accelerating input costs (particularly fertilisers), eucalypt die-back and soil and pasture degradation forced a major rethink of priorities by many landholders. Survey work has shown that many pastures classified as 'improved' have a significant component of native grasses that now contribute to the productivity of the pasture. In some cases sown pastures have thinned out or disappeared over time and native species have recolonised. It is important to identify why the sown pasture failed as it may well signify that native pasture is much better suited to this paddock.

Management Strategies

The first step is to establish clear goals for the management of your native pasture types. To retain healthy native pastures, grasslands and grassy woodlands for commercial grazing and conservation, active management is required. We know that some species are adversely affected by grazing and others respond positively to increasing fertility. A period of several years will be required for development and change in native species composition. A gradual or slow approach to increasing soil fertility is important for the long term sustainability of native grasses in pastures. This gradual evolution with increasing fertility and stocking rates allows more productive species such as Microlaena which were previously restricted to particular spots such as under wattle trees or in wetter areas to become more dominant across the whole paddock.

The challenge, both technically and economically, is whether to improve the agricultural productivity or the conservation aspects of these pasture types. It is important to discriminate and be selective with fertiliser and herbicide recommendations based on land capability, the species present and production goals particularly in non-arable hill country.

Agriculturally, there are three broad whole farm options:

Option 1: Minimal Management

This strategy is appropriate where there are major limitations that cannot be modified e.g. shallow, skeletal, low water holding soils on exposed westerly aspects. These are difficult and costly, if not impossible to fix and the return on dollars invested will be very poor. In these situations it is important to recognise the environmental limitations and operate within them. These areas are better retired from pasture production and may be used for trees and shrubs. Occasional grazing may be appropriate for these areas.

Option 2: Maintain or encourage regeneration of native perennial grasses

This strategy is appropriate where limitations are less severe. There may be a good stand of native species present or regeneration may be occurring following the inappropriate sowing of introduced species. There are three strategies which focus on the three types of native pasture in Table 1.

1. manage native pasture for its conservation value to preserve the current species and maintain or increase biodiversity (native grassland);
2. manage native pasture to retain the present species composition and agricultural productivity (modified native pasture);or
3. manage for agricultural performance without losing stability, sustainability and current species composition (highly productive native pasture).

Option 3: Sowing introduced pastures

This should only be contemplated where soil, climate and other conditions are suitable and it needs to be part of a vegetation plan for the whole property. This option is not considered in this publication. Remember the most profitable pasture is one that persists indefinitely and maintains production. Most recent surveys of landholders show many do not expect their introduced pastures to last more than 6-10 years. To cover the high cost of establishment, pastures have to last 10-20 years and stocking rates need to rise substantially. Few introduced pasture species have been reliably persistent. Where Australian phalaris will not successfully establish and remain productive (e.g. on soils with sub soil acidity (pH below 4.5 CaCI 2 test) the economics of a complete replacement approach has to be seriously questioned. By comparison, many of our native species tolerate acidic soils.

Management options for native pasture types

Production removes nutrients from the soil, these need to be replaced using fertilisers, the amount applied will depend mainly on the level of production. Table 4 summarises fertiliser recommendations for the three pasture types for different levels of production.

Managing Native Grasslands

Grassland productivity will be reasonably low and management will focus on preservation of species and increased biodiversity rather than animal production or financial gain. These areas accordingly should be considered areas of *High Conservation Value (HCV).* It is also important to maintain adequate ground cover, species diversity (both flora and fauna) and habitat. Ensure these areas retain connectivity with other remnant vegetation. Also keep in mind that it is essential to reduce weeds with minimal off target damage and retain habitat structure (tussocks, rocks, tree hollows, logs, etc.)

The guiding principle is to try to mimic the pre-European environment.

- No fertiliser should be applied.
- Don't remove all grazing from native grassland; some grazing is beneficial, as it will:
  a) reduce build-up of fuel levels which can alter bushfire intensity and result in a species change; and
  b) maintain a natural species biodiversity as these grasslands were grazed by marsupials. By removing all grazing, eventually the area may be taken over by a few dominant species at the expense of other species which gave the area its natural biodiversity.

The grazing principles for biodiversity in these areas are:

- use rotational grazing rather than set stocking.
- graze with high livestock numbers for short periods to prevent selective grazing.
- use long periods of rest from grazing to ensure flowering and re-seeding occur.

Where grazing is not a chosen or possible practice, alternatives are:

- slashing, but care needs to be taken to prevent fires and that the slashed material does not smother re-growth.
- fire is really only necessary to prevent excessive accumulation of herbage when no other form of defoliation can be used. The intensity, frequency and timing of fire all have an influence on the long term outcomes.

Managing Modified Native Pasture

These pastures can be managed for either conservation or production but the primary aim is to maintain ground cover and persistence of the native perennial species. This can be achieved by using grazing as a tool to maintain the health of these pastures and targeted low levels of fertiliser to improve ground cover and reduce weed invasion.

For Conservation

The aims are to increase native biodiversity and retain for connectivity with other remnant vegetation. It is also necessary to maintain a low input system and reduce weeds with minimal off target damage.

What to do:

- the same management practices outlined above for the native grasslands - using grazing (or slashing or burning) to encourage high ground cover, plant density, vigour and recruitment of native species
- retain habitat structure (tussocks, rocks, logs, etc.)
- employ integrated weed control approaches
- no cultivation or sowing of introduced species
- no fertiliser

For Production

The aims are to enhance productive species (particularly legumes); improve feed quality; increase livestock carrying capacity and product output; increase net returns per hectare; maintain persistence of perennial species and maintain or increase tree and shrub cover for habitat value (such as wind breaks for livestock and pastures or logs for lizards).

What to do:

- apply fertiliser to stimulate legumes, increase fertility and to overcome deficiencies and promote presence and growth of the more productive native perennial species
- over-sow more legume where levels are low
- the above strategies will promote growth of winter active annual species resulting in increased carrying capacity
- it will be necessary to increase stocking rates to utilise extra feed grown and prevent dominance of annual species especially in spring
- promote green leaf by rotational grazing
- use strategies (including fencing, resting and high intensity grazing) which reduce selective grazing
- fence off shrub and tree remnants and replant as appropriate
- do not remove fallen logs and dead trees; instead leave for wildlife habitat

Managing Highly Productive Native Pastures

The basis for the agricultural productivity from these pastures is the presence of the year-long green perennial native grasses e.g. Wallaby grasses and Microlaena plus annual legumes (particularly sub-clover) and annual grasses.

The grazing and fertiliser management strategies aim to:

- maintain high perennial grass levels
- avoid spring legume and annual grass dominance, especially on pastures with Wallaby grass and Red grass
- maintain ground cover above 80 percent
- limit weed levels to less than 5 percent
- maintain soil fertility to achieve high productivity levels
- maintain or increase tree and shrub cover for livestock shelter and habitat value
- provide adequate soil fertility (refer to Table 4)

What to do:

- use rotational grazing together with periodic spelling to enable re-seeding to occur
- maintaining a stable and resilient year-long, green, perennial, grass-based pasture is the key to the management of highly modified native pastures and are often more important agriculturally than species biodiversity
- graze to achieve high pasture utilisation
- graze to maintain perennial grass dominance by controlling annual grasses
- use strategies (including fencing, resting and high intensity grazing) which reduce selective grazing
- fence off shrub and tree remnants and replant as appropriate
- do not remove fallen logs and dead trees; instead leave for wildlife habitat

The most agriculturally productive modified native pastures are those with a dominance of Microlaena and are in the 650 mm plus annual rainfall areas with long active growing seasons. Table 4 summarises the fertiliser recommendations for the three pasture types for different levels of production and suitability to enterprise.

Table 4: Comparison of the features of different types of native and introduced pastures on the Southern Tablelands of NSW.

Typical conditions	Native grassland	Modified native pasture	Highly productive native pasture	Introduced pasture
Dominant grasses	Kangaroo grass Poa	Poa Spear grass Red grass Wallaby grass	Wallaby grass Microlaena	Phalaris Cocksfoot Ryegrass Tall fescue
Rainfall	over 500mm	over 500mm	medium to high (over 650mm)	medium to high (over 650mm)
Grazing history	low to medium (and intermittent)	medium to high	medium to high	medium to high
Fertiliser rates	nil	medium 0.5 - 1kgP/DSE/ha	medium to high 1kgP/DSE/ha	medium to high 1-2kgP/DSE/ha
Carrying capacity (DSE/ha)	1-3	5 to 10	up to 12	up to 16
Herbage quality	low to medium	low to high	medium to high	medium to high
Suitable enterprises	wool production and animal breeding	wool production, animal breeding and slow animal growth	wool production, animal breeding and meat production	wool production, animal breeding and meat production

Conclusion

Native pastures can be managed for agriculture or conservation by establishing appropriate and realistic goals for the pasture type and then managing to meet these goals.

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References

Langford, C.M., Simpson, P.C, Garden, D.L., Eddy. D.A., Keys, M.J., Rehwinkel, R. and Johnston, W.H. (2004) *Managing Native Pastures for Agriculture and Conservation.* NSW Department of Primary Industries. 70pp.

Impact of alpacas on soil nutrient distribution in pastures

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Abstract

Alpacas establish communal latrine sites or dunghills. To determine the extent that alpacas move nutrients in paddocks three comparisons were made: centres of latrines were compared with a non-latrine control site 20 m away; to assess any nutrient leaching samples were taken at two depths: 0-10 cm and 10-30 cm and to assess the uniformity of nutrient distribution additional samples were taken from on the north, east, south and west sides within zones from the latrine centres. The accumulation of nutrients in the latrine sites was clearly detected, with a significant build-up seen in phosphorus (300%), nitrate nitrogen (235%), potassium (250%) and total soluble salts (160%). Soil acidity was also significantly affected in the centre of the latrine sites. The potential detrimental impact of the nutrient build up is discussed. Preliminary management options are discussed.

Key Words soil nutrients, phosphorus, nitrogen, potassium, latrines, dung hill, acidity

Introduction

Alpacas are becoming more prominent in farming systems within Australia, particularly in lifestyle areas that often have high natural amenity and environmental sensitivity. Alpacas establish communal sites for defecation and urination called latrine sites or dunghills. Latrine sites show signs of greater pasture growth, and alpacas avoid grazing them if possible. It is not known to what extent these latrine sites show a build-up of soil nutrients. The movement of nutrients within and out of a farming system can affect the efficiency and patterns of pasture growth, have serious environmental impacts particularly in waterways and is economically wasteful. The effect of alpacas on nutrient movement needs to be better understood so that effective management practices can be implemented. In the absence of objective data for alpacas, the present research was designed to provide objective data on the extent of nutrient movement to alpaca latrine sites.

Methods

Location and design

Alpacas were grazed at Attwood, located 18 km north-northwest of Melbourne. Alpacas grazed the site continuously from 1995 until sampled in 2005. Limited sheep grazing had also occurred for 3 years during this period.

To determine the extent that alpacas move nutrients in paddocks three comparisons were made:

1. Site: centres of latrines were compared (paired) with a non-latrine control site 20 m away (n = 9).
2. Depth: to assess any nutrient leaching samples were taken at two depths: 0-10 cm and 10-30 cm.
3. To assess the uniformity of nutrient distribution additional samples were taken from 4 sites on the north, east, south and west sides within zones spaced every 2.5 m, to 10 m from the latrine centres.

Sampling and testing

At each sample site 30 cores were taken with a tube-sampler and bulked. Samples were tested at the Victorian State Chemistry Laboratory, Werribee for: nitrogen, phosphorus as Olsen P, pH, total soluble salts (TSS), exchangeable cations (Ca, Mg, Na, K) and other nutrients. This report provides preliminary results. Analysis of variance was conducted following transformation of the data ($\log_{10}$) to detect the significance of site (centre vs control), depth and interactions. To assess the distribution of nutrients around the latrine sites graphs were prepared showing the variation in relative terms, with the centre site given the index value of 1.0. This approach negates the effect of variation between sites. Data from one sample, which was a statistical outlier arising from a sampling error, has been omitted.

Results

There were significant differences between sites in soil acidity (pH, centre vs control, P<0.001) and between depths (P<0.001) for pH (Table 1). On average pH values at the centre of latrine sites were 6% lower than for the control at 0-10 cm and 7% lower at 10-30 cm depth (Table 1).

Table 1: Backtransformed mean soil acidity and soil nutrient concentrations at the centre of alpaca latrine sites and at control sites for two soil depths (n=9).

	Centre Treatment		Control Treatment	
Depth	**0 cm-10 cm**	**10 cm-30 cm**	**0 cm-10 cm**	**10 cm-30 cm**
pH	4.97	5.44	5.28	5.87
Olsen P (mg/kg)	59	19	15	4.5
Nitrogen (NO_3-N mg/kg)	142	28	42	8
TSS (%w/w)	0.118	0.046	0.046	0.023
Exchangeable K (meq/100g)	1.52	0.63	0.44	0.26

There were significant differences between sites in total available phosphorus (Olsen P, centre vs control, $P=1.3 \times 10^{-5}$) and between depths ($P=4.8 \times 10^{-14}$) in Olsen P. On average Olsen P values at the centre of the latrine sites were 300% higher than for the control at both depths (Table 1). There were significant differences between sites in nitrogen as nitrate (centre vs control, P<0.001) and between depths (P<0.001) for nitrogen as nitrate (NO_3-N). On average NO_3-N values at the centre of latrine sites were 235% higher than for the control at both depths (Table 1).

There were significant differences between sites in total soluble salts (TSS, centre vs control, P<0.001) and between depths (P<0.001) in TSS. On average TSS values at the centre of latrine sites were 160% higher than for the control at 0-10 cm and 95% higher at 10-30 cm depth (Table 1). For exchangeable potassium (K) there were significant differences between sites (centre vs control, P<0.001) and between depths (P<0.001). On average exchangeable K values at the centre of latrine sites were 250% higher than for the control at 0-10 cm and 140% higher at 10-30 cm depth (Table 1).

Across both the north-south and the east-west axis of the latrines there was a clear trend that saw all nutrients experience a peak concentration with a downward gradient out in either direction from this peak. The peak was generally found in the centre treatment, with a few exceptions where the peak was in the first ring. The degree of the peak relative to the samples further from the centre varied between nutrients and the variation across the axis wasn't always smooth. The data for exchangeable K displayed the most uniform variation across the 0-10 cm horizon. Along both the north-south and the east-west axis K had the largest peak in the centre of the latrine sites and declined rapidly on each side of the latrine (Figure 1). pH saw the inverse to the general trend, with a decrease towards the centre.

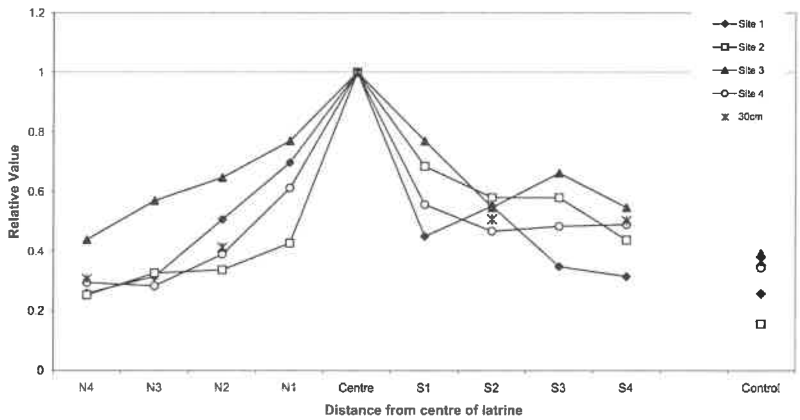

Figure 1: The relative change in exchangeable potassium in four alpaca latrine sites at Attwood, Victoria. Values are relative to the exchangeable potassium value at the centre of each latrine. The values are shown for various distances along the north-south axis from the centre of each latrine. The value for the control site is shown. Values are for the 0-10 cm depth unless indicated otherwise.

Discussion

The accumulation of nutrients in the latrine sites was clearly detected, with a significant build-up seen in phosphorus (300%), nitrate nitrogen (235%), potassium (250%) and total soluble salts (160%). Soil acidity was also significantly affected in the centre of the latrine sites. The levels of these nutrients found in the latrine sites were very high and would be able to sustain an extremely high level of growth, other factors not limiting.

Deficiencies

For a low input annual pasture, such as that found in the research site, the critical Olsen P concentration is close to 11 mg/kg (Gourley 1987). The levels found in the control sites (average of 14.7 mg/kg) were above this critically low value but continued translocation of phosphorus to latrine sites or exported out of the paddock by the removal of dung would lead to depressed pasture production in the longer term. Australian soils in general experience nitrogen deficiencies. Critical levels of available nitrogen have been found to vary greatly, from as low as 21 mg/kg up to 70 mg/kg. The values less than 35 mg/kg are more common for temperate annual pastures. The average nitrate level of 42 mg/kg found in control sites is generally above the critical levels.

Toxicity

In absolute terms, none of the nutrients measured in the centre treatments were found to be at potentially toxic levels for plants. Of concern for alpacas were the ratios of the exchangeable cations. Grass Tetany can occur when K/(Ca+Mg) is greater than 0.07-0.08. Values well above these were found at both depths in the centre treatments, with averages of 0.23 (0-10 cm) and 0.19 (10-30 cm). While this would not be of great concern owing to the alpacas selection away from latrine sites when pasture was abundant, when pasture is restricted the pasture at the latrine sites is consumed (McGregor unpublished data) with unknown affects on alpacas. The pH levels found in centre treatments in top 10 cm have potential to cause Al and Mn toxicity.

Leaching

Rates of leaching are linked to the solubility of a nutrient and the properties of the soil, such as texture affecting the adsorption of the nutrient and soil buffering capacity that affect rates of infiltration. The large increases in concentrations of nutrients found in the latrine sites will increase the rates of leaching. The leaching rate of phosphorus is typically very small in a normal situation owing to a relatively low solubility. The large increase (300%) in rates of available phosphorus in the 10-30 cm horizon in the centre treatments shows that a greater amount is moving down through the soil profile. Loss of nitrate through leaching is a common problem. Nitrate is very susceptible to leaching owing to its high solubility. The 230% increase in nitrate levels at the 10-30 cm depth show increased rates of nitrate down the soil profile. Potassium also saw an increase down the soil profile (140%) indicating increased rates of leaching.

Runoff

The soil at the research site will have a moderate to rapid infiltration rate, with a permeability in the range of 60-120 (mm/hour). This will mean that the rate of runoff of water in general will be low. The moderate slope may increase rates of runoff. The rate of runoff of an individual nutrient will depend upon its solubility into solution in the runoff water and the concentrations in which it is found in the surface soil trapped in the runoff. The profile for available phosphorus along the north-south axis (up and down the slope) showed increased levels not only in the centre, but down the slope of the paddock in treatments at two sites. There is an exponential relationship between levels of dissolved P in runoff and Olsen P. The increased levels found down the slope in site 2 and site 4 could be explained by runoff. Two potential explanations for this are: the latrine sites may have moved slightly over time; or that leaching and runoff effects are slower for some nutrients. Further analysis is required.

Soil acidity

The lower pH values found in the latrine sites are of concern. All treatments but the control treatment in the 10-30 cm profile can be classified as strongly acidic. Many species of plant, such as phalaris, lucerne, and medics are sensitive to and could suffer from increases in acidity owing to increases in aluminium availability. The levels of acidity found in the centre treatments were high for these pasture species. The measured acidity levels were marginal for subterranean clover and less than 'ideal' from most species.

Management implications and recommendations

While these results are preliminary it is clear that the combination of the large shifts in nutrients and the use of the latrine sites by alpacas could have a highly detrimental effect on both the rate of pasture growth and the botanical composition of any pasture that does grow. There is little value for valuable nutrients to be accumulating in latrine sites when they have greater economic value distributed over the pasture. Further, left unchecked, nutrient translocation to latrines will affect the botanical composition of the pasture and weed species are more likely to flourish at the latrine sites owing to the increases in acidity and nutrients as observed in the latrine sites eight years earlier (McGregor 2002).

Management practices need to be identified that target:
1). the build up of nutrients at latrine sites; 2). potential nutrient loses from the pasture system; 3). the environmental impacts of any nutrient loss; and 4). reduced quality of soil properties such as acidity.

At this time management practices will have to be reactive. Stopping the use of the same latrine sites would require a broad change in the animals' behaviour, which may be impossible to achieve. While getting the animals to use new latrine sites might be easy, stopping them from using established sites would be very difficult.

It is likely that the most cost-effective solution would be to redistribute the build-up of nutrients by grazing with sheep or cattle. Sheep will graze latrine sites in both the growing and non-growing seasons (McGregor 2002). Under higher stocking rates used in rotational grazing systems, sheep will distribute excreta uniformly over level paddocks. However sheep do form camps, particularly near vegetation or at higher elevations where nutrients will build up. Alpaca grazed at high stocking rates will graze latrine sites. Redistribution of the organic matter building up on the latrine site could be done mechanically, but would require machinery and labour and would need to be undertaken regularly to achieve any impact on nutrients within the soil horizon.

While it has been shown conclusively that there is a build-up of nutrient levels in the latrine sites, a long-term study into any changes in nutrient levels in the rest of the paddock would be required before a complete nutrient budget could be developed. This would be able to show any negative effects that alpaca behaviour has on the grazing system. There are numerous management and soil nutrient issues that need to be clarified. As the alpaca industry grows in Australia and large commercial fibre producing herds develop, management practices need to be developed for the specific needs of grazing alpacas. If alpacas are to continue to be seen as an environmental friendly alternative to traditional farming, management systems will need to be developed to prevent soil nutrient loss from grazed pastures.

Conclusion

Alpacas move nutrients into latrine sites and these movements occur over relatively short periods of time. Nutrients accumulated within latrine sites can be lost by leaching and runoff, increase soil acidity and have potential to increase weed growth and be toxic to animals.

References

Gourley CJP (1987). A revision of the model predicting pasture yield response from soil phosphorus levels in Superate. Technical Report 148. Department of Agriculture and Rural Affairs, Victoria.
McGregor BA (2002). Comparative productivity and grazing behaviour of Huacaya alpacas and Peppin Merino sheep grazed on annual pastures. Small Ruminant Research 44: 219-232.

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Impact of pasture on productivity and health

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Abstract
The movement of nutrients from the soil to plants and in turn animals is described along with the consequences of imbalances in this process. What can cause these imbalances and suggested solutions are also explored in the quest for optimum productivity and health.

Key words
Minerals, energy, protein, photosynthesis, rumen

Introduction
The soil is the plant's stomach similar to the role of the rumen in the ruminant. Plants can get carbon, nitrogen and oxygen from the atmosphere by respiration but most of the plants nutrients come from the soil. We can not get nutrients from steak without it being digested in our stomach and plants cannot get nutrients from organic residues like stubble without them first being decomposed. Micro-organisms are vital to the uptake of minerals in all biological systems and holistic nutrition requires attention to the well-being of the microflora in the soil, plant and animal.

Function of Mineral Nutrients in Plants
Plants require at least 13 essential elements that are normally absorbed from the soil. These together with carbon, hydrogen and oxygen that are absorbed from water and carbon dioxide make up the 16 essential elements that are required by all green plants. Table 1 shows that essential elements can have one or more functions within the plant (McLeod 2003). Some like nitrogen are required in large amounts for protein building materials in cells and is referred to as a macronutrient. Potassium is another macronutrient that is important for the osmotic balance of the plant. If elements are only found as part of an enzyme or function as enzyme activators, they are required in much smaller quantities and are referred to as micronutrients. Many of the trace elements or micronutrients have such functions and their levels in soil or their input as fertiliser are much smaller than the macronutrients for this reason.

Table 1: Major functions of plant nutrients and their content in dry matter at harvest

Macronutrient	*Function*	*Kg/t*
Nitrogen	Part of proteins, nucleic acids, enzymes and chlorophyll	16-40
Phosphorus	Part of nucleic acids, function in energy transfer	2-5
Potassium	Water balance, stomatal opening and enzyme activator	14-56
Calcium	Cell wall structure, membrane permeability	5-25
Magnesium	Part of chlorophyll, enzyme activator	2-9
Micronutrient	*Function*	*Gm/t*
Iron	Electron transfer in photosynthesis and respiration	50-250
Manganese	Photosynthesis, enzyme activator	20-500
Zinc	Part of enzymes, enzyme activator	25-150
Boron	Membrane stabilization, lignin synthesis	20-100
Copper	Electron carrier in photosynthesis, part of enzyme	5-20
Molybdenum	Enzyme constituent, nitrogen metabolism	0.2-1
Chlorine*	Involved in photosynthesis	0.3-1.2

* Chlorine content of plant is much higher than its requirement as a trace element and is usually in the range of 2-20 Kg/tonne. (McLeod 2003)

Soil mineral balance is responsible for balanced uptake of nutrients by plants and this has a direct impact on:

- Percentage of wastage in a crop
- Flavour
- Shelf life
- Control of plant nitrates
- Degree of wind damage
- Quality of produce

Albrecht (1996) referred to the two main food groups as "grow foods" (nitrogen/protein) and "go foods" (carbon/carbohydrates and fats). Unfortunately, the conventional model for feeding livestock fails to look at the **quality** of protein, (is it amino acids or urea-rich, non-protein nitrogen?) or the **quality** of the energy (is it starch only, or does it also include cellulose, hemi-cellulose, organic acids, lipids, sugar pectins, and beta-glucans?). If we can control plant nitrate levels then we control plant protein quality. Similarly, if we control plant nutrition and management, we can also control fruit waste, flavour and shelf life.

Photosynthesis

Photosynthesis requires a balanced supply of nutrients to ensure the production of quality protein, sugars, starch, pectins, cellulose, hemicellulose, fats and hormones by plants. The nutrient interactions discussed in the earlier paper "Soil composition and health impacts" indicated some of the potential impediments to this process. Other considerations are sunlight, moisture, soil structure, pests and diseases which will also impact on the ability of plants to function normally. The development of ryegrass staggers is an example of where suboptimal environmental conditions limit photosynthesis and predispose the ryegrass plant to develop excessive endophyte toxins. Grazing management can also play a major role in photosynthesis and therefore plant protein and energy levels as well as total dry matter production. The change in feed value with stage of plant growth is illustrated in Figure 1, and this is readily influenced by the pasture management strategies employed by the grazier.

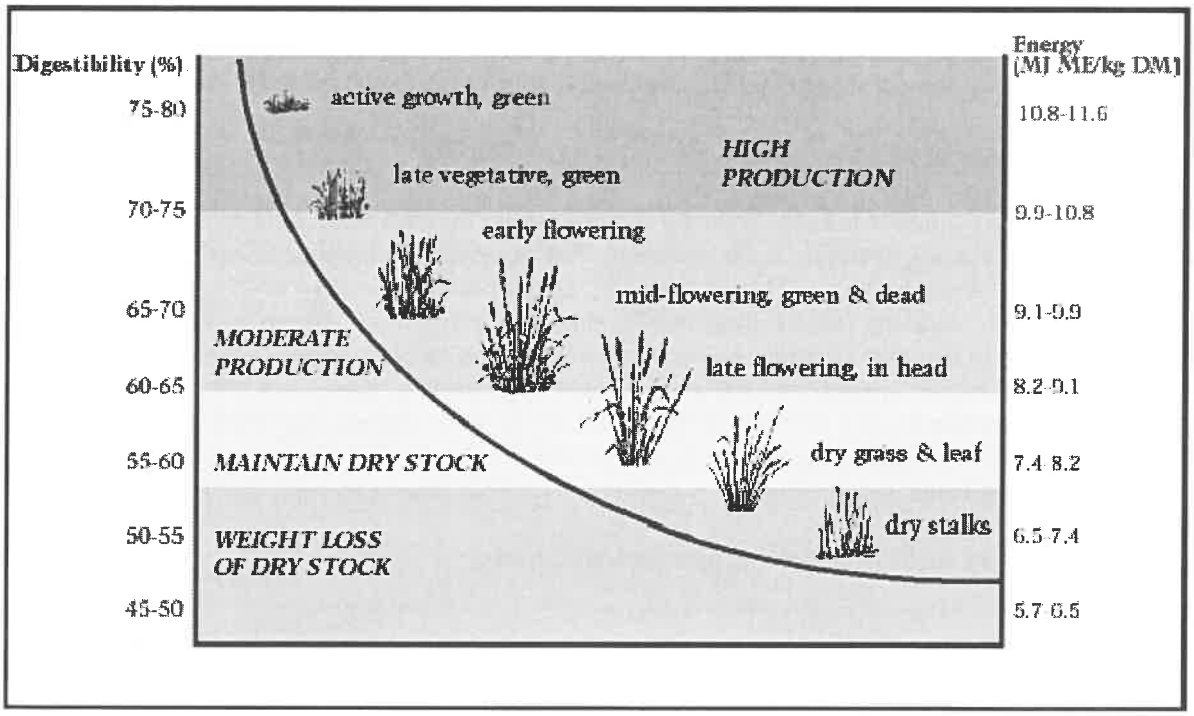

Figure 1: Plant digestibility and energy in relation to stage of growth and animal production requirements (Prograze 2003)

Grazing Management

A full explanation of the relative merits of alternative grazing management strategies in relation to animal and plant health and production can be found in the Meat and Livestock Australia EDGENetwork programs such as Prograze™ and LambCheque™. Grazing management has a direct impact on feed quality and quantity and an understanding of these influences is essential for every livestock grazier. Similarly, an understanding of the nutritional requirements of livestock at different stages of their reproductive cycle is imperative so that the livestock owner can best match this to the pasture growth rate curve for their environment. For discussion on these topics also refer to Prograze™ and LambCheque™. Matching the pasture growth curve to management strategies such as time of lambing has a profound effect on enterprise profitability and this will be explored by Scrivener in these proceedings.

Role of complementary feeding in animal nutrition

Complementary feeding is the provision of additional feed to complement the main diet or paddock feed on offer in order to meet the dietary needs of the animal. The aim is to provide nutrients that are deficient or to provide extra feed to improve stock performance. The term complement is used in preference to supplement as the intention is to make maximum use of the source of food ie grass, rather than replace it. It is an essential management tool, especially where seasonal conditions and/or management decisions have restricted the feed quality and/or quantity on offer for livestock.

Energy and protein balance

Protein is the most deficient nutrient during the dry months and energy is the limiting factor during periods of fresh growth. Therefore, feed high protein in the dry and save low protein feeds for winter. Note: barley straw is of little nutritional value, but can be the most valuable supplement during periods of cold weather. It increases rumination time, body heat and pasture utilisation. Don't waste it with a match!

Before complementary feeds are fed to stock, there are a few basics to understand. Understanding these basics can not only increase stock performance but also increase the value of your stored products. Many feeds are wasted due to:

- Poor timing of complementary feeding
- Misunderstanding animal requirements. Alpacas, cattle, ewes and lambs all have different daily needs.
- Lack of knowledge of the nutritional status of the various feeds.

A common finding among graziers is supplementary feeding where the additional feed provided has a similar composition to the feed already available in the paddock. For example, the feeding of lupin grain, lucerne or clover hay to stock on fresh pasture. This is likely to cause protein overload with potential disastrous consequences. This is replacing rather than aiding the consumption of the main diet. In contrast, complementary feeding in this circumstance would involve provision of high energy (with respect to protein) feed (e.g. oats, maize, maize silage), or low protein feed (e.g. barley straw, low protein pasture hay). Another example of complementary feeding is the provision of high protein supplements such as lupins, canola meal, peas, beans or lucerne hay to lambs or lactating ewes grazing dry pasture. Complementary feeding is summarised in Table 2.

Table 2: Complementary feeds to match various paddock feeds.

Available feed	*Potential issues*	*Complementary feed*
Winter pasture	High protein; high moisture; low fibre	Cereal straw, cereal grain
Lucerne pasture	Low energy	Cereal grain
Cereal stubble	Lack of grain; low protein grain/stubble	Cereal / legume grain
Fodder rape	Low fibre; iodine deficiency	Cereal straw; iodine suppl.
Dry pasture	Low energy; high fibre	Cereal / legume hay / silage

All stock need a balance of protein and energy in their daily diet and this varies with their physiological state, age and growth rate. If this balance is maintained then minerals and vitamins become less important. Table 3 shows the protein, energy and fibre content in common feed sources. Compare this to the protein and energy requirements of different classes of stock with respect to their physiological state, age and growth rate displayed in Table 4.

Table 3: Nutritional content of some common feeds*.

Feed	*Energy (ME in MJ/kg)*	*Protein (%CP)*	*Fibre (%NDF)*	*Digestibility (%)*
Grain:				
Wheat	13	13	19	85
Triticale	13	13	23	85
Barley	12	11	21	85
Oat	11	7 – 14	33	75
Lupin	13	28 – 33	22	85
Pasture:				
Short vegetative	12	20 – 35	30	85
Flowering	8.5	12	40	60
Dry stalks	5 - 8	1 – 8	40 - 80	35 - 55
Hay:				
Lucerne	9 - 11	8 – 28	35 - 65	60 - 77
Cereal	6.0 - 9.5	4 – 15	50 - 80	40 - 65
Grass	6.5 - 9.5	4 – 15	50 - 75	45 - 65
Clover	7.5 - 10.5	10 – 24	40 - 65	50 - 73
Cereal straw	5 - 8	1 – 4	40 - 80	35 - 55
Silage:				
Legume	7.5 - 10.5	12.5 - 25	45 - 55	50 - 73
Grass	7 - 10.5	7.5 – 25	40 - 75	50 - 73

CP = Crude Protein (% Nitrogen x 6.25)
ME = Metabolisable Energy in MJ/kg DM
NDF = Neutral Detergent Fibre (cellulose, hemicellulose & lignin fractions in fibre)
* *expressed on a dry matter per kg basis.* Ref: FeedTest™, Hamilton, Vic

Table 4: Examples of feed requirements for different classes of livestock*

Class of Stock	*Live weight kg*	*Dry Matter intake % LW/day*	*ME requirement MJ ME/day*	*CP requirement % of DM*	*Fibre NDF %*
Weaner (growing at 100 g/day)	30	4%	15	16	30
Dry adult (maintenance)	50	2%	9.3	8	60
Adult in late pregnancy	50	2.8%	14	14	45
Lactating adult	50	4.2%	19	14	30

* *Adapted from NRC (1985)*

The feed values in Table 3 are only provided as a guide. It is recommended that feed analyses be performed to establish the particular feed values for all feeds being considered for a ration, rather than rely on estimates.

Knowing the protein and energy content of stored feeds and matching them to the protein and energy needs of livestock enables reasonable balance to be achieved in the protein and energy in their daily diet. An example of the desirable balance between protein and energy intake for young stock is illustrated in Table 5

Table 5: Crude protein requirements of balanced rations for crias*

Energy Density of ration	*Cria live weight & CP % requirement*		
MJ/kg DM	*20 kg CP%*	*30 kg CP%*	*40 kg CP%*
13	19.3	16.1	13.8
12	17.5	14.7	12.9
11	15.7	13.3	11.9
10	14.0	11.9	10.8
9	12.4	10.6	9.6

* Assumes protein degradability in the rumen of 70%. *Ref: Bell, Shands & Hegarty*

A more accurate method of estimating actual Dry Matter Intake (DMI) can be calculated using the formula:

$$\text{DMI (kg)} = \text{LW} \times (120/\text{NDF})\%$$

This is used instead of the percentage estimates in Table 4, but assumes the Live Weight (LW) of the animal is known and a feed analysis has been performed on the feed to establish the Neutral Detergent Fibre (NDF).

Role of the rumen in animal nutrition

Figure 2 (Brunetti 2003) schematically illustrates the "eco-system" of a ruminant. It is critical to realise that 60% of the true protein in forage and 100% of the non-protein nitrogen (NPN) degrades into rumen ammonia. Soluble protein as ammonia provides adequate "grow foods" for rumen microbes. A build-up of rumen ammonia without a corresponding balance of soluble energy causes the ammonia to spill through the rumen wall, now becoming Blood Urea Nitrogen (BUN). This is a toxic substance and at high enough levels can kill stock. This is observed when stock are grazing actively growing pasture, crops, lucerne following a dry spell; or during winter or early spring; or when pastures are being irrigated. During these periods, pasture protein can be as high as 43%, but normally from 30 – 35%. BUN at elevated levels, over prolonged time, can cause illthrift and scouring, high infertility rates, udder health issues (eg mastitis), abortions, unthrifty neonates, retained foetal membranes, lameness, suppressed immunity with its consequences of disease etc. In addition, this toxic "protein" requires that the ruminant remove it from the blood stream utilizing an enzymatic cascade synthesized in the liver and kidneys. The result is excreted as urea or uric acid in the urine. Unfortunately, the labour to remove waste is stolen energy that would otherwise be used to put on weight, or produce milk. A "double whammy"!

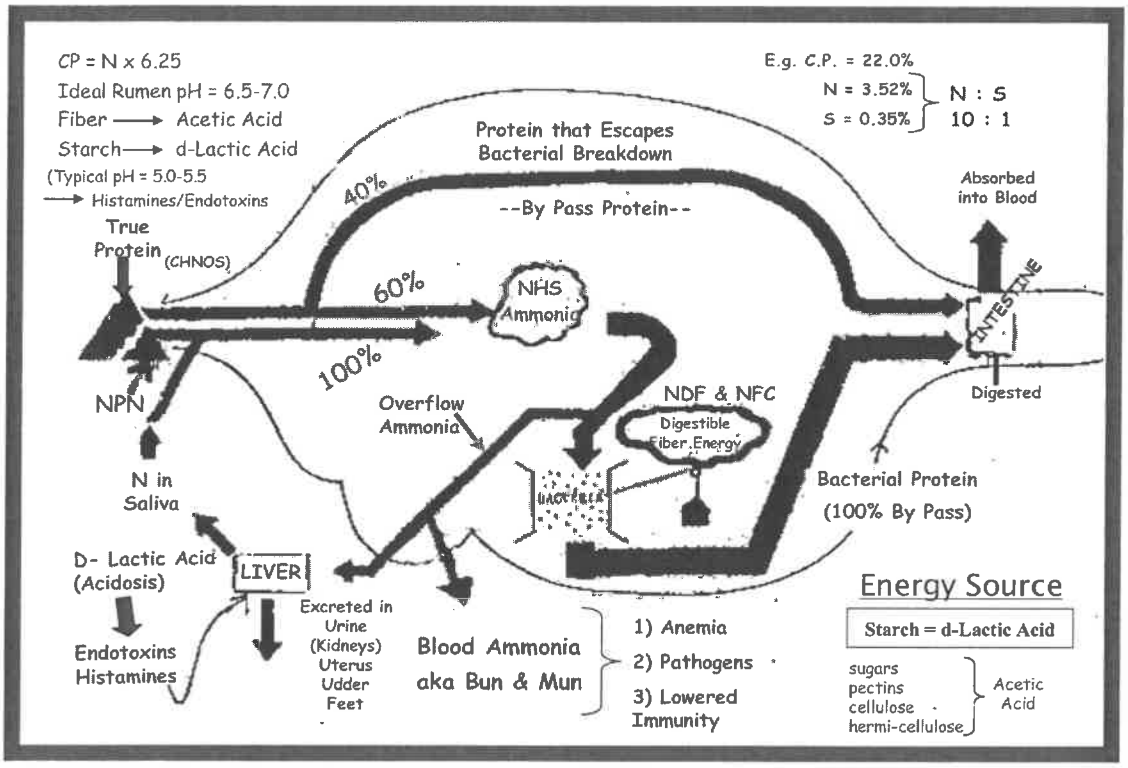

Figure 2: Schematic representation of the rumen "eco-system"

Excess protein negates pasture energy. For every 1 unit of surplus protein there is a loss of 0.18 MJ of ME. An example of daily protein and energy requirements of an adult and cria in a high quality fresh growing pasture is shown in Table 6. As a consequence of the 35% pasture protein, the net energy of the pasture available to promote growth or milk production is reduced from 11 MJ to 6 – 8 MJ / kg DM. This is a result of rumen organisms using the energy to degrade the surplus protein. The provision of barley straw in this instance would help to counter the effects of the high protein diet and to stimulate rumen fermentation.

Table 6: Example of daily protein and energy requirements of an adult and cria on a high quality fresh growing pasture.

	CP %		*Energy (MJ ME / kg DM)*	
	Cria	*Adult*	*Cria*	*Adult*
High protein pasture	35	35	11	11
Alpaca requirements	18	8	12	8
Surplus/Deficit	+17	+27	-1	+3
Net ME use to remove excess CP			(17 x 0.18) = 3.1	(27 x 0.18) = 4.9

Soluble plant carbohydrates are required to balance the "grow food/go food" equation. This is illustrated in Figure 9 and shows two primary groups. The first NDF group includes cellulose and hemi-cellulose making up the cell walls of plants. The second group of non-NDF carbohydrates are referred to as NFC and include organic acids, sugars, (mono and oligosaccharides), starch and Neutral Detergent Soluble Fibre (NDSF). NDSFs include fructans, pectins, galactans and β-glucans. Figure 9 shows that NFC consists of carbohydrates that are derived from both cell wall and cell contents. The reason for the overlap is that even though pectins, galactans and β-glucans are cell wall carbohydrates, they rapidly ferment in the rumen like other sugars and starches. However, they don't contribute to lactic acid production, but rather their fermentation is shut off in the presence of excess lactic acid lowering rumen pH.

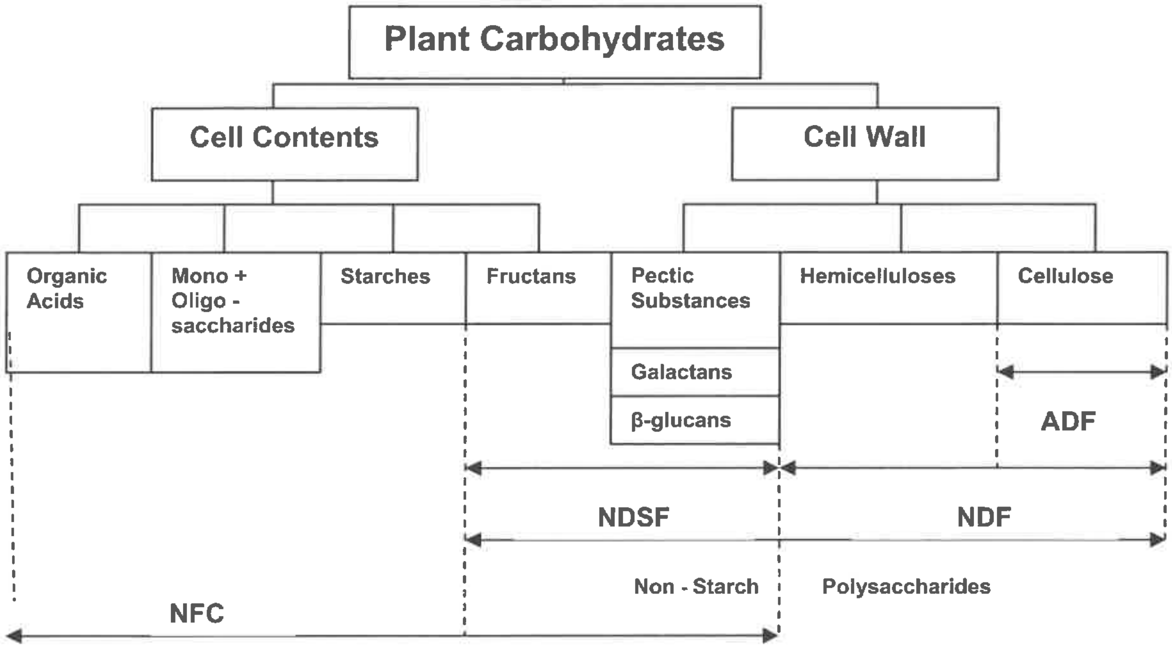

Figure 9: Components of plant carbohydrates

Rumen pH and acidosis

Up to 80% of a ruminant's energy can come from the three primary volatile fatty acids (VFAs): acetic, propionic and butyric acid. Fifty to sixty % of these VFAs will consist of acetic acid at rumen pH 6.5 – 7.0. As the pH drops in the rumen, acetic acid production decreases and is replaced by propionic and butyric acid. Another acid begins to appear at pH 6.0 which is a non-VFA lactic acid. Lactic acid is toxic to fibre digesting microbes and alters the rumen flora to become populated by microbes that thrive on substrate of starch rather than pectins and other fibres. The fermentation of the valuable, high-energy raw materials found in good forage (ie pectins, β-glucans, galactans, etc) are rendered unavailable at lower pHs, causing the grain (starch) to meet the energy deficit. Rumen bacteria do not grow when the pH level is below 6.0 and optimal growth is not achieved until the pH is above 6.5.

Rumen pH can fluctuate widely over a 24 hour period on total mixed rations as well as on lush pasture. When the pH is below 6.0 for much of that time, longevity of the animal is compromised due to lactic acid build-up and consequent metabolic (systemic) acidosis. The sequelae to chronic subclinical acidosis can be liver abscesses, immune suppression, adrenal stress, lameness, scouring, infertility, chronic udder problems and suppressed production.

Conclusion

In order to promote good production and health in livestock, it is in the interests of all stockowners to ensure balanced protein and energy intake. Changes in diet where grain is introduced or the type of grain or forage is changed needs to be done slowly to allow sufficient time for the appropriate rumen microbes to adapt to this change. Fundamentally, farmers need to adopt procedures to promote good mineralisation in soil and forage which in turn will encourage the formation of high quality protein and energy in the diets of ruminants. This combined with a basic understanding of ruminant nutrition and careful management should ensure minimal disruption to production and health.

References:

Albrecht WA (1996). The Albrecht Papers. Acres USA, Metairie, Louisiana USA
Bell AK, Shands CG and Hegarty RS (2003). *Grain finishing of lambs* MLA, North Sydney NSW
Brunetti J (2003). *The basics of animal nutrition* in Nutrition Farming Explained, Soil Therapy P/L, Eumundi Qld
FeedTest®(2004). Hamilton Vic
Glendinning JS (1990). Fertilizer Handbook, Incitec Ltd, Morningside Qld
Kinsey N & Walters C (1995). Hands on Agronomy. Acres USA, Metairie, Louisiana USA
LambCheque™ (2003). Meat and Livestock Australia, North Sydney NSW
McLeod BL (2003). Understanding Your Soils and Plants Workshop Manual, Aust Perry Ag Lab, Magill SA
NRC (1985). Nutrient Requirements of Domestic Animals, 6th ed, National Academy of Sciences, Washington, DC
Prograze™ (2003). Meat and Livestock Australia, North Sydney NSW

Opportunities for organic alpaca production

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Abstract

The market for organic food has been growing rapidly for most of the past twenty years, and although rates of growth have slowed slightly from the peak period around the turn of the century, organic agriculture is still the fastest growing sector of agriculture across the globe. Current areas of most rapid growth within the organic movement include livestock. Organic markets for fibre are the least developed area of the market, but there is potential for organic fibres, and the first export sales of organic wool for over ten years occurred in 2005.

Organic Standards for livestock include a requirement for organic feed, access to open range pasture, non-use of synthetic health products (except for limited use of vaccines) and high standards of general care and husbandry.

Keywords

Organic, biodynamic, certification, standards

Introduction

The market for organic food has been growing rapidly for most of the past twenty years, and although rates of growth have slowed slightly from the peak period around the turn of the century, organic agriculture is still the fastest growing sector of agriculture across the globe.

The fastest growing sectors of organic market currently, globally and in Australia, include alcoholic beverages (wine beer and spirits), processed product generally, and meat and livestock.

Organic livestock markets in Australia include dairy products, beef, sheep, eggs, poultry, aquaculture and wool. Australia has a larger area of certified organic land than any other country (larger than the next 10 countries combined), at about 12.1 million hectares. There are 1,832 certified organic producers in Australia, and probably several hundred more in the conversion process.

Australian organic market is currently estimated at $400–$450 million. The Australian organic export market is estimated to be worth $80 - $100 million per annum.

Recent organic wool exports from Australia occurred in 2005, after a break of about a decade since the first exports of biodynamic wool in the early 90's.

Organic fibre markets are less well established than edible products. However there are markets for organic livestock products, and most organic industry observers would believe that the history of ever broadening markets will continue and that this expansion will provide significant opportunities for organic fibre, including cotton, flax, hemp and wool, in the short-term future.

A recent search of the database of the two main organic certification bodies (CBs), NASAA and ACO, revealed no listing for alpaca. Some certified organic growers do keep alpaca, but may not have included them in their certification contract, due to lack of markets. Inclusion in the database is voluntary, so they may have also selected to be not listed, if they already have adequate markets for their alpaca products.

Organic growers tend to be involved in a variety of enterprises on each property, and are inclined to be involved in new and developing industries. In particular, cross grazing is a common feature of organic livestock management. Cross grazing is the use of more than one livestock type, to exploit the pasture species preferences of the various livestock types, to achieve more effective use of pasture and better weed control by grazing. It is therefore likely that many certified growers are using alpaca as a component of grazing or as companion animals for other livestock types, such as sheep.

Organic growing methods

Organic growing is a system of food production that does not use synthetic fertilizers and pesticides, or genetically modified organisms (GMOs). However organic growing is more than just not using certain chemical inputs. It involves a totally integrated management system to maintain fertility, pest management and productivity, while also achieving a high level of sustainability and production goals.

Good agricultural commonsense and old-fashioned 'cultural' methods are very important for organic growers, but they also benefit from scientific advancements and technological innovations.

Animal welfare is an important consideration in organic farming. Only free-range animals are permitted and permanent cages or permanent tethering is banned. Most of the feed component must come from pasture, with some allowance for exceptional circumstances such as declared drought conditions, when the CB may grant limited permission to apply 'Conversion to Organic' or conventional feed. There is a general allowance for 5% non-organic feed in Australian organic standards, but this is intended to cover feed supplements not available from certified organic sources, or incidental feeding, such as animals being moved down laneways or common areas.

Animals sold for organic carcass must have spent their entire lives as organic, starting in the third trimester of gestation. Livestock may be converted to organic for sale of wool or milk, which are regarded as 'annual crops', but these animals may not be sold for meat.

Natural health is maintained by mixed pasture grown on healthy organic soils, strategic feed supplements including grain products, minerals, molasses and cider vinegar. If animals require veterinary treatments, these may not be withheld, but animals so treated must be tagged and segregated from organic livestock markets. They may still produce organic annual crops (wool and milk) and organic offspring.

Organic certification

The health and environmental benefits of organic growing are available to anyone who adopts organic growing practices, but most organic growers find that they require 'certification' to obtain the market benefits of organic growing.

Certification protects both the genuine organic grower and consumers of organic food.

Certification is based on organic standards, which have been developed over the past twenty-five years. Two international organic standards exist, which, fortunately, are quite similar. The International Federation of Organic Agriculture Movements (IFOAM) has developed a 'private' standard and accreditation system, with input from its membership in over 100 countries. The United Nations Food and Agriculture Organization (FAO) CODEX Alimentarius Commission has also developed an organic standard. Most governments use the CODEX standard as a guideline for development of national organic standards. The IFOAM standard is used by the main private and not-for-profit certification organizations as a guideline for development of their organic standards.

A list of Australian CBs appears at the end of this paper. These organizations certify organic farms against a set of operating standards. For export purposes, these Standards and the certification procedures must comply with the *National Standard for Organic and Bio-Dynamic Produce* (the *National Standard*), published by the Australian Quarantine Inspection Service (AQIS). The CBs are accredited for export by AQIS and may issue export declarations for certified produce. There are no domestic regulations in place yet, although many wholesalers, retailers and consumers only purchase certified organic produce. The Organic Federation of Australia (OFA) has set in place a process to create a domestic standard using the Standards Australia system, but this is expected to take several years.

Organic certification requires that produce can be tracked all the way 'from paddock to plate'. Inspection of organic producers and handlers ensures that there is a complete audit chain that can prove organic produce has been grown, harvested, stored and transported in a way that protects the produce from contamination by synthetic chemicals or radiation. Organic produce therefore is sold almost exclusively through direct outlets or via certified organic wholesalers and retailers.

What is conversion to organic?

Organic Standards require a minimum "conversion period" of 3 years of consecutive organic management. Conversion is the process of change from a 'conventional' (non-organic) to organic system

The conversion period is required to achieve the following:

- Allow time for the breakdown of pesticide residues
- Allow time for the biological development of soil, i.e. soil ecology
- To allow for the development of a holistic farming system
- To permit a period of supervision of the farming system by the certification body (CB)
- To protect genuine organic producers and consumers from short-term profit seekers

What does the farmer do during conversion?

During the conversion period, farmers will:

- Develop a 'Conversion Plan'
- Develop an 'Organic Management Plan' (OMP) and appropriate record-keeping systems
- Submit to at 'pre-certification' and annual inspection by the CB
- Not sell produce with any certification claim for the first 12 months (pre-certification)
- Only sell produce with the Conversion' label for the next 24 months

What is an Organic Management Plan?

An OMP is a document that describes the farming system, including:

- The physical resources (area, land capability, biodiversity, capital improvements etc.)
- The farming activities (land use, seasonal routines, land preparation, sowing, weed control, harvesting etc.)
- The threats and pressures (pests, weeds, weather and climate, land class, neighbouring activities etc)
- Makes clear preventative measures (informing neighbours and clients, monitoring, record keeping, sanitation, constructing windbreaks etc)

The CB will make available a format or outline for producing an OMP.

Record keeping

Organic operators must maintain record systems that verify management is in accordance with organic standards.Records will include:

- Maps outlining land use, neighbouring land use and paddock subdivision (can be used to record rotation history too)
- Records of all purchased inputs including seed, fertilizer, pesticides, stock and stock feed
- Records of activities including sowing, spraying, drenching, harvesting etc
- Records of outputs including organic and non-organic sales

The CB will make available a format or outline for record keeping

First steps to going organic

Intending certified organic growers should obtain a copy of the National Standards or a certifier's standard and study them in detail to ascertain whether they can comply with the growing systems and record keeping procedures described in the Standards.

The next step is to speak to family members, other certified organic producers and CBs, to determine if the obligations can be met, and to select an appropriate CB.

Growers who apply for certification generally sign a statutory declaration that they have:

- Read and understood the Standard
- Are growing according to the Standard
- Intend to continue to grow according to the Standard
- Have provided accurate information concerning their growing practices.

What do you need to consider before converting to organic

- Do you have the appropriate knowledge? Do you know where to find out more? Do you know people who can help?
- Do you have the right tools and equipment? Will your enterprise change in nature, requiring new stock, equipment or fencing?
- Do you have enough labour and time? Will family and workers understand? Will organic require more labour in your situation?
- Do you have access to appropriate inputs, such as seed, stock feed orfertilizers etc?
- Do you have financial reserves to cover a reduced income during conversion? Do you know the costs and benefits of organic for your situation? How do you value non-financial reasons to go organic?
- Is your property disposed to organic because of low (or high) inputs, history and neighbouring land use?
- Is there a market for your products and can you produce them competitively?

Conclusion

There is potential for development of an organic alpaca industry in Australia, and organic methods will be used by some growers, regardless of the existence of an established market for their product.

Organic fibre is the least developed area of the organic marketplace at present, but there are signs of growth in the market for organic wool.

List of Australian certification bodies

Bio-Dynamic Research Institute
Powelltown Victoria 3797
Ph 03 59667333 Fax 03 59667433

Australian Certified Organic
PO Box 530 Level 1/766 Gympie Road
Chermside Qld 4032
Ph 07 3350 5716 Fax 07 3350 5996
http://www.australianorganic.com.au

Organic Growers of Australia Inc (formerly Organic Herb Growers of Australia Inc)
PO Box 6171 South Lismore, NSW 2480
Ph 02 66220100 Fax 02 66220900
www.organicherbs.org

National Association for Sustainable Agriculture (Australia) Ltd
PO Box 768 Stirling, South Australia 5152
Ph 08 83708455 Fax 08 83708381
enquiries@nasaa.com.au

Tasmanian Organic-Dynamic producers Co-operative
PO Box 434 Mowbray Heights, Tasmania 7248
Ph 03 63834039 Mob 0408 171 473

Organic Food Chain
PO Box 2390 Toowoomba, Queensland 4350
Ph 07 46372600 Fax 07 46967689

Safefoods Queensland
PO Box 440 Spring Hill
Queensland 4004
Ph 1800 300 815 Fax 07 32539810
info@safefood.qld.gov.au

Other contacts

Australian Quarantine Inspection Service (AQIS)
Ian Lyall
GPO Box 858 Canberra ACT 2601
Ph 02 6272 3933
www.aqis.gov.au
organic@aqis.gov.au

Organic Federation of Australia (OFA)
PO Box 166 Oakleigh South Vic 3167 Australia
Email: info@ofa.org.au

IFOAM
Charles-de-Gaulle-Str. 5, 53113 Bonn, Germany
Tel: +49-228-92650-10
Fax: +49-228-92650-99
Email: headoffice@ifoam.org
http://www.ifoam.org

References

Willer, Helga and Yussefi, Minou 2006. The World of Organic Agriculture: Statistics and Emerging Trends published by IFOAM and FIBL

A summary of the Australian organic industry and marketplace can be found at:
http://www.daff.gov.au/foodinfo *The Australian Organic Industry: A Summary*

Caring for Australian alpacas - preliminary data from the Monash University Alpaca Husbandry Survey

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Abstract
Controlled studies of the efficacy of different husbandry regimes for Australian alpacas require access to many more low-cost experimental animals than are presently available. An alternative means of exploring the value of different practices is to capture the expertise accumulated by individual alpaca carers. In this study we administered a comprehensive questionnaire, developed in consultation with numerous alpaca breeders, to members of the Australian Alpaca Association. Reported in this paper are preliminary data concerning how well-informed alpaca carers consider themselves to be and what resources they use to access alpaca care information. We also describe alpaca carer beliefs about their animals, the frequency with which alpaca carers engage in a number of common husbandry practices and the extent (if any) to which these practices are believed to cause distress to Australian alpacas.

Key Words
Alpaca, husbandry, welfare, health, carer beliefs

Introduction
A unique feature of the Australian alpaca industry, relative to comparable agricultural industries, is that alpacas are rarely farmed in large numbers by experienced stock persons. Instead, many alpaca owners are alternative lifestyle seekers, attracted to alpacas as a small business option or hobby. A challenge for the industry is to ensure that inexperienced alpaca owners are well informed about husbandry requirements and able to implement appropriate husbandry regimes, supported by guidelines developed on the basis of sound scientific data. A significant limiting factor in this respect is a lack of knowledge concerning basic husbandry requirements and the likely repercussions of not meeting these requirements on productivity and animal health and welfare. The instability of many South American countries means that limited research concerning alpaca breeding and husbandry has been conducted, with even less being reported in an easily accessible form. Research conducted in more developed nations has only recently begun, with an understandable early emphasis on reproduction, nutrition and veterinary issues. Since Australian conditions differ markedly from those encountered overseas, the applicability of this existing information is often unknown.

It is not feasible at present to study alpaca husbandry practices using the resource-intensive experimental methodologies employed by larger agricultural industries. An alternative approach is to consolidate the expertise accumulated by existing alpaca carers. In this study an alpaca husbandry questionnaire was developed in consultation with alpaca carers. Data from the questionnaire are used to address four questions in this preliminary paper. First, how well-informed about alpaca care do Australian alpaca carers perceive themselves to be and where do they go for information about how to care for their animals? Second, what beliefs do alpaca carers have about the husbandry requirements of the animals? Third, how often do most alpaca carers engage in routine husbandry tasks? Fourth, do alpaca carers consider any husbandry practices to be associated with a significant level of animal distress and how do they rate the overall welfare of their animals?

Methods
Participants
In this paper we report data collected from 172 members of the Australian Alpaca Association (AAA). Most respondents (71%) were female, the mean age being 54 yrs (SD 11 yrs, range 26-78 years). Participant experience with alpacas ranged from 6 months to 17 years (25% < 3 yrs, 25% = 3-6 yrs, 25% = 7-10 yrs and 25% > 10 yrs) and respondents had cared for between 1 and 1000 alpacas (25% < 12, 25% = 12-30, 25% = 31-70, 25% > 70). Almost all participants (99%) cared for alpacas that they owned, although a substantial

proportion also cared for alpacas either owned with business partners (23%) or agisted on their property (23%). Most participants described their alpaca enterprise as a small business (49.7%) or as either a major (26.9%) or minor (16%) hobby. While most (80.2%) reported that their alpacas were mainly used for breeding, those whose alpacas were used primarily for fleece production (15%) or as guards (2.9%), pets (4.1%) or lawnmowers (4.1%) were also represented. Most alpacas were kept on relatively small properties (25% < 2.5 hectares, 25% 2.5-5 hectares, 25% 5-12 hectares, 25% > 12 hectares). All AAA regions were represented, although over two thirds of the data reported in this paper came from Victorian members. Over two thirds of the sample (67.4%) cared for huacayas only. Very few participants (1.2%) cared exclusively for suris, with the remaining respondents having a small percentage of suri alpacas in their herd. Many of the participants (84.3%) reported that they were experienced at caring for animals other than alpacas.

Materials

The Monash University Alpaca Husbandry Survey was developed using a rigorous questionnaire development process. The area of interest was first developed in consultation with an advisory group from the Research and Development Subcommittee of the AAA. The initial survey was then repeatedly refined in consultation with independent focus groups drawn from diverse Victorian AAA regions. The final draft was reviewed by statistical and scientific advisors and revised to facilitate data analysis. The result was a ten page questionnaire comprising five sections. Section A consists of 18 questions collecting information about participants and their experience with alpacas. Section B consists of a series of 41 statements about alpaca care and husbandry requirements, with participants indicating the extent to which they agree or disagree with each statement using a five point Likert scale. Section C consists of eight questions probing various aspects of participants' feeding and management practices. Section D is applicable only to participants involved in breeding alpacas and includes eight questions about breeding and cria care. The final section, Section E, includes nine questions about alpaca health and welfare.

Procedure

AAA regional representatives throughout Australia were contacted by phone to request assistance in distributing the questionnaire. Those who agreed to participate were sent the required number of questionnaires to be distributed with region mail outs, accompanied by a reply paid envelope for direct, anonymous, return to the researchers. Because of differences in distribution dates, only a sub-sample of 172 questionnaires was available for analysis at the time of writing this paper, with Victorian alpaca owners being over-represented compared with other states. Additional information will be reported as it becomes available.

Results

In the first section of the questionnaire alpaca carers were asked how well informed about alpaca care they considered themselves to be, how easy they thought it would be to access information about a new husbandry or health problem and how often they accessed various sources of information about alpaca care. In general, alpaca carers believed themselves to be either moderately (48.8%) or extremely (30.4%) well informed about alpaca care. Only six participants (3.6%) believed themselves to be not well informed, with the remainder (20.8%) reporting themselves to be slightly well informed. Most also believed that they could probably (51.3%) or definitely (28.1%) find out how to deal effectively with a novel husbandry issue, although just over 20% were either unsure or thought it would be difficult to access appropriate information. The frequencies with which the participants accessed different sources of information about alpaca care are presented in Table 1. As can be seen from this table, most alpaca carers access a variety of sources of information, with common sense, personal experience and other alpaca owners being most commonly used, followed by alpaca industry publications and local veterinarians. Perhaps surprisingly, information about alpaca care from the AAA website, regional training days and AAA conferences was not widely used. Almost three quarters (73%) of the sample never or only sometimes accessed the AAA website and a similar proportion (75%) never or only sometimes accessed information from regional training days and events. Very few participants reported accessing private internet sites or chat rooms in order to access information about alpaca care.

Table 1: The frequency (%) with which Australian alpaca carers report accessing various sources of information about alpaca care

Information Source	Never	Sometimes	Often	Very Often	Extremely Often
Common sense	00	4.2	28.1	36.5	31.2
Personal experience	00	12.7	28.9	35.5	22.9
Other alpaca owners or breeders	1.2	28.0	28.6	29.8	12.4
Alpaca industry publications	3.6	43.0	32.1	15.8	5.5
Local veterinarian	10.1	42.9	17.9	20.8	8.3
Specialist camelid veterinarian	26.3	38.7	14.4	12.5	8.1
Alpaca shows	22.4	46.5	17.4	11.2	2.5
Private books	25.5	45.3	20.5	6.8	1.9
AAA website	31.3	41.7	16.0	6.1	4.9
AAA regional training days and events	28.1	46.9	14.4	8.7	1.9
Other agriculture publications	40.8	45.2	10.2	3.2	0.6
AAA conferences	47.5	33.1	15.0	3.1	1.3
Private internet sites and chat rooms	62.3	23.2	6.9	5.7	1.9

In Section B, respondents' beliefs about alpacas were examined. Table 2 presents a selection of items from this section and the frequency with which each response option was endorsed.

Table 2: The frequency (%) with which alpaca carers agreed or disagreed with statements about alpaca care and management

Statement	**Strongly Disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Alpacas are very resilient animals	0.6	7.3	11.6	64.0	16.5
Alpacas are more docile than other agricultural animals	0.6	17.5	24.1	51.2.	6.6
Alpacas are more easily managed than most agricultural animals	0.6	5.9	15.4	52.7	25.4
Alpacas are social animals that should be kept in pairs or groups	0.6	1.2	0.0	31.2	67.1
Alpacas can generally live on pasture alone	5.5	33.9	20.0	32.1	8.5
Pregnant alpacas require supplementary feeding at all times	2.4	20.0	13.3	46.1	18.2
Alpacas are susceptible to cold conditions after shearing	0.6	0.6	2.9	36.5	59.4
Alpacas require daily observation to ensure their health and wellbeing	0.6	18.2	15.9	42.4	22.9
Intestinal worms in alpacas should be monitored or treated regularly if they are **not** run with other livestock	0.0	12.9	13.5	53.5	20.0
Alpacas should be vaccinated against common diseases on a regular basis	0.0	5.9	6.5	41.8	45.9
Rye grass staggers is a health issue in alpacas in some areas of Australia	0.6	0.6	11.9	41.7	45.2
In some parts of Australia, alpacas are susceptible to vitamin D deficiency	0.0	0.6	7.1	48.8	43.5
In some parts of Australia, alpacas are susceptible to selenium deficiency	0.0	0.0	14.2	56.2	29.6
In some parts of Australia, liver fluke is a health problem for alpacas	0.0	1.2	37.8	44.5	16.5
In some parts of Australia, paralysis ticks are a health problem for alpacas	0.0	0.6	35.8	40.1	23.5
Alpacas toenails should be trimmed regularly	0.0	0.6	6.0	47.0	46.4
Most alpacas should have their teeth trimmed regularly	6.5	34.9	20.7	32.0	5.9

From Table 2 it can be seen that alpaca owners generally believe that their animals are resilient, docile and easy to manage. They are well informed about basic husbandry requirements like social contact, and are familiar with known health risks. Many carers disagreed with the statement that alpacas can generally live on pasture alone. A substantial proportion reported that pregnant alpacas, in particular, require supplementary feeding at all times.

In the third section of the questionnaire alpaca carers were asked how often they engaged in a number of routine husbandry tasks. Table 3 shows a selection of these variables and reports how many respondents engaged in each practice (at all), how often they were typically carried out, and the minimum and maximum intervals reported. All participants visually inspected their alpacas on a regular basis, most daily, and many also administered a daily or weekly mineral supplement. Many alpacas were physically inspected, body scored, and had their toenails inspected monthly, with other husbandry practices being typically conducted on a six monthly or annual basis, although the intervals were much longer (up to 5-6 years) for some respondents on some variables. Injectable vitamin D was used more frequently than oral vitamin D, with selenium supplementation (oral or injectable) being used by almost half the sample. Consistent with the belief (Table 2) that alpacas require supplementary feeding, when participants were asked (data not shown) whether they provided supplementary feed to most of their alpacas, 75% responded yes in times of good pasture, with the figure increasing to 98% in times of poor pasture. Most respondents also indicated that they provided supplementary feeds to 'special' groups of alpacas in their herds, including pregnant females, weanlings and stud males.

Table 3: Information about the frequency with which alpaca carers report engaging in a variety of husbandry practices

Activity	% of sample	Mode[1] (days)	Median[2] (days)	Min	Max
Visually inspect	100	1 day	1 day	.25 days	1 day
Physically inspect	98	1 month	1 month	1 day	2 years
Body score	89	1 month	1 month	1 day	3 years
Weigh	28	1 year	6 months	1 day	2 years
Inspect teeth	90	1 year	1 year	1 day	4 years
Inspect toenails	99	1 month	3 months	1 day	6 years
Faecal egg count sampling	30	1 year	1 year	2 months	5 years
Treat for internal parasites	75	6 months	6 months	7 days	4 years
Treat for external parasites	49	1 year	6 months	1 day	4 years
Vaccinate	95	6 months	6 months	1 month	2 years
Administer oral Vit D	19	6 months	3 months	1 day	1 year
Administer injectable Vit D	69	6 months	6 months	1 month	6 years
Administer oral selenium	25	6 months	3 months	1 day	1 year
Administer injectable selenium	21	1 year	1 year	2 months	4 years
Administer general mineral supplement	55	1 day	7 days	1 day	4 years
Treat for liver fluke	14	6 months	6 months	3 months	2 years

[1]Mode=most common response, [2]Median=midpoint of all responses

In the final section of the questionnaire alpaca carers were asked to rate the overall welfare of their animals and to identify the level and duration of distress associated with various husbandry and management practices. None of the participants reported that the welfare of their animals was poor or extremely poor. Most, on the contrary, believed that their alpacas experienced good (37.5%) or extremely good (61.3) welfare. No husbandry practices were identified as being extremely distressing or to cause distress for a prolonged duration (days). Husbandry practices identified as being associated with a moderate level of distress included shearing, weaning (for cria), restraint and administration of medication or supplements by injection. Those associated with a moderate duration of distress (minutes to hours) included weaning (for both cria and dam), changing social groups, shearing, restraint, castration and transport.

Conclusions

In this preliminary report we have identified that Australian alpaca carers consider themselves to be well-informed about husbandry requirements and that they access a variety of resources to obtain information, particularly other alpaca owners. They believe that their animals are easy to manage and appear well informed about basic husbandry requirements and known health risks. Most engage in a variety of husbandry practices on a regular basis and report that the welfare of their animals is either good or extremely good, with few routine practices believed to cause significant distress. This is encouraging information for those wanting to participate in the Australian alpaca industry. As additional data become available we will be able to investigate whether specific husbandry practices are associated with productivity and perceived health and welfare outcomes. Such information will assist in the continued development of a vibrant and successful industry.

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Holistic, compassionate, natural alpaca care.

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Keywords
Holistic and Compassionate.
Natural Pasture.
Diet and Health
Husbandry, Haltering and Mating.
Showing and Shearing.
Future breeding objectives.

Introduction
I would like to begin by saying that this is my first ever talk, I wrote a paper for the Tasmanian conference but chickened out about going to present same (also I do not enjoy flying) and have regretted it ever since. For the Alpacas sake I am here this year to fight their cause and spread the word, as someone needs to and I know I am swimming against the tide. I have no letters behind my name, only experience and results , a happy healthy herd of Alpacas.

Personally I do not like the word sustainability, as surely we have to improve our methods so that the land does not become more degraded and acid in Australia than it already is now. One way to do this is with that wonderful creature the Alpaca, the land is so fragile and they tread lightly, but we have to look after them properly.

My grandparents were Cornish farmers so I believe that the land is in my blood, my husband is Uruguayan, we both came out here in 1973/ 1974 respectively and of course are now both proudly Australian.

Our odyssey with Alpacas began in 1995 after seeing them in Peru on a trip there and Argentina and Uruguay in 1990. We were in Murrumbateman near Canberra, on 2 acres, so in 1997, 10 Alpacas (we had started with a pregnant girl and a wether) moved us to 64 acres, where we decided we definitely wanted to follow a natural regime. I would state here that this has worked for us and we are as organic as possible.

Methods
Holistic and Compassionate.
Holistic(not connected to religion), is just explained by treating everything as a whole, from the land up, through healthful husbandry, nutrition, mating, breeding practices and seeing that this wonderful creature is always treated with compassion.

Natural Pasture.
One should always try and buy the suitable farm , ours had been empty for two years before we moved in and has now been completely chemical free and super phosphate free for nine years. We do not spray weeds either, Heroides digs them out. We have native pasture, in the spring with many wild flowers and orchids, our land is part of the Southern Tablelands grassy ecosystem. Scattered with granite rocks, (these wear the Alpacas nails down naturally) the males love to stand on a rock and survey their females and the crias love running up and down them. We had the land tested and added the needed lime and dolomite, and we did seed the front paddocks with clover, fescue and rye, to have alternate feed in bad native grass years.

Recycled baths are water troughs and in them we put small lengths of copper pipe and zinc bolts to provide copper and zinc, which gradually leaches out. Be aware that after a while the bolts may become rusty and it is time to replace them. Alpaca drinking water is from the bore which is slightly salty and we do have a creek. They love to browse on our willows, poplars, pine trees and all the fruit tree leaves in the orchard and the honey locust or Robinia. We have put in a few tagasaste (tree lucerne) trees and a hedge of them completely covered in wire, which they love to nibble , especially the crias. One does have to be careful about poisonous plants but they are very discerning and will only eat the odd leaf, providing they have other choices.

Diet and Health.

The backbone of our system is the La Granja Mix, which consists of:-

Lucerne chaff Oaten chaff Livermol Seaweed meal Garlic powder Dolomite Barley (soaked in Apple Cider Vinegar) Yellow Sulphur Cracked Lupin seed Cracked Corn(in cold weather)Castlereagh Alpaca Pellets NO UREA.

Four or five handfuls of this mix are given once a day to every Alpaca and twice a day to lactating and pregnant mothers. They also like fruit, vegetables and some bread.

As we never vaccinate or drench it is very important that our Alpacas are kept very healthy with all the vitamins and minerals and a good diet. Apple Cider Vinegar and Garlic powder are for worm control and Cod Liver Oil and Vitamins ADE are given by mouth on a regular basis, every two or so months in winter and to the crias and the mothers after birth or if anyone is a little off colour. I really believe the knack is to keep them healthy and they will never get Johnnes or any other disease.

List of articles I keep in the Alpaca medicine cabinet.

Vitamin C (sodium ascorbate) This is used for healing wounds and muscles and after birth, as well as to replace the vitamin c levels after they have an antibiotic or for snake bite (we have not needed it for this) Vitamin C is given by mouth through a syringe- 100 mls at least. Do not worry you cannot give too much! I buy the powder and mix it with water.

Vitamin B12 and B15 or B complex. This is for illness or stress.

Bach Flower rescue Remedy, For shock or if new born crias are not doing well.

Mylantin, Ulcerguard or Slippery elm powder. For ulcers, stress or upset stomach.

Arnica Pills For healing.

Salty water or Orbenin. For eye infections or runny eyes. Check for seeds.

Olive Oil For floating seeds out of ears.

Honey and witch Hazel. For wounds, especially Manuka Honey.

Glucose. This is a good general energy boost.

Noni or Tahitian juice. This is fabulous stuff and I have saved many crias with it.

Yoghurt orYakult to re-grow gut flora.

Yellow Sulphur. Can be put down Alpaca backs 3times by3 weeks after shearing for lice

False Colostrum. ½ scoop DiVetalact, 1 teaspoon cod liver oil and 1 teaspoon seaweed meal .

Of course as stated before we swear by Apple Cider Vinegar, for worm control, general health and to relax uterine muscles before birth. Garlic Powder for worms and health.

Vitamins ADE and last but not least Cod Liver Oil, which builds strong bones and bodies, it also straightens legs and prevents knock knees. I grew up on it as a child and am none the worse for wear! Be sure to buy this in a dark container.

Our worst health experiences have been with intestinal blockage, symptoms are rolling on their side, groaning , sporadic kicking and not eating, it can be a Bezoar, which is a large pellet made up of dry matter and hair etc, in fact we found one after one Alpaca. passed it with the help of paraffin oil.

How we deal with it is, 100 mls of paraffin oil in one go and then dose up with Vitamin C, Noni, Vitamin ADE and Cod Liver Oil. Our young girl who had this is the first time I saw an Alpaca cry, this is too long a story to tell here but is written in my book. .

Most of our births have been fine, with only the odd little leg stuck back, I have long gloves and obstetric lubricant at the ready. One breech and two caesarians and a very bad birth with the cria head and legs turned right back. We have bottle fed a few crias and have saved some by working on them all day (one being Dama, daughter of Shanbrooke High Society) one of our best Alpacas and one I would never sell! We also raised an orphan(now 6 years old and the family pet) who cried like a baby for the first two nights. His special treat is to come into the garden every morning, when he wants to go back in the paddock, he knocks the shoes over in the porch to get my attention (who dare say Alpacas are not intelligent!) He also comes into the house and heads for my pot plants and fruit in the bowl.

I would say by far the largest killer of Alpacas is believed to be stress, from which they can develop ulcers. One of our studs hummed for a week for his companion (with whom he had grown up for 8 years) when he was sold, and a young male, who had seen his friend leave for a new home the day before, became spitty and screamy on the halter (never before known.) Mothers also grieve for their dead crias and should be left with them for quite a while and one of our old girls aborted her cria when she watched her grand daughter have a bad birth.

Husbandry, Mating and Haltering.

Besides trees we have shelters for all our creatures and I believe this is essential. A shearing shed and shelters of a roof and three sides, a lot of our shelters and fences are made from recycled materials as Heroides is a recycler with a passion! If it is cold and wet they dash for these and I would give them cracked corn in their food to warm their tummies as well. Most of the females run with AA (a gorgeous wether) at the back of the property, he protects his girls and is a gentle giant, even waiting for any stragglers.

Approximately two months before they give birth, two or more females are brought into the maternity paddock near the house, where I can monitor them, I am at home all the time. Mothers are brought in and crias to be weaned (7- 10 months) are left with the rest of the herd as this is less stressful for them. We can do this because we do not mate again in a hurry, the earliest would be one month and sometimes a few months or until the next season, we aim for spring and autumn births.. Maidens are at least 15 months and sometimes 2 years, depending on size and willingness to mate. Heroides finds he can tell if females are pregnant by pressing on their backs and orgling, this saves our studs a lot of frustration. Some of the older girls are like Jekyll and Hyde and will not let Heroides near them, when pregnant, strange how they know the gender thing! We mate them whilst the moon is waxing (growing) and we have a higher success rate of pregnancy then. All the studs are haltered and led over to the female, they are only allowed one mating a day. Haltering of crias is done from 3 or 4 days old with a very light Bungalook halter, our mothers do not object as they have been handled such a lot. Crias are also stroked on the neck a lot, not pulled but just haltered slowly and legs , feet and teats are felt to get them used to future handling. The halter is only just put on for the first few occasions.

I do feel it is very important to give a pain killer and local when the vet does a castration, NO rubber bands please.

Showing and Shearing.

We do not show, because it puts the Alpacas and us through too much stress, spending sometimes days in a tiny enclosure and being poked and patted on the head by children and I have seen too many Alpacas become ill or dehydrated in the summer to do this. Added to this is the stress of travel, sometimes causing ulcers and of course stress to the fleece and therefore easy breakage. Surely we could just show the fleeces.

We shear at the very end of November, when at La Granja it is not too hot or too cold, our shearer uses a table which we prefer, teeth and nails are attended to at the same time, including fighting teeth (just in case) as our studs run together and rarely fight. We get him to leave a top knot for protection from the sun and below the knee fleece for snake bite protection. Females are not shorn too near birth as sadly we lost twins through doing this. We have a very good shearer, who is very gentle with the Alpacas and does not nick them.

Future breeding objectives

To continue breeding for a gentle, fine fibred, good confirmation, beautiful, happy , coloured Alpaca. Certainly we seem to be headed in the right direction as we have a lot of gorgeous girls here and besides our other lovely studs have invested in a new Appaloosa boy. He is very nearly two, has recently been certified and at last shearing was 15 micron and 100% comfort factor.

Results

From following this natural regime, we have had very good results and only lost two elderly Alpacas, one over 18 years old of natural old age and an elderly stud of respiration pneumonia ,one young girl of blockage whom we could not save and a few crias at birth (twins and caesarian), we have never lost a mother. Not a bad tally in 11 years. All our Alpacas are very healthy and strong boned, glowing in all their colours and seem to be very happy, and as a bonus we have soft fine low micron fleece. A market to sell the Alpacas to like minded people is being developed, herbalists and homeopaths, although I hate selling my babies and always check prospective buyers very well, and send them off with loads of notes..

Conclusion

I was determined to give this talk as I would love to encourage more breeders to go down this path. I feel there is no need for all the chemicals we pump into the land and the Alpacas and they can be detrimental, At least ours have really pure systems, lovely confirmation and grow out well. I have written many articles for various publications and I am getting a lot of interest expressed by people. I have written too for the Alpaca magazine but have had articles knocked back lately, especially on my feelings about not eating Alpaca, anti Embryo Transfer etc, but I feel this is not right as there is room for everyone to express their opinion ,we are supposed to be a democracy

We really are very lucky to be part of this industry looking after this magical, spiritual creature.

Regarding Embryo Transfer as I write this I have had a request from a large breeder if I have any more Alpacas for sale as the ones I sold to him last year were in such good condition and excellent mothers and with plenty of milk, so he used them for that .It was a compliment in one way for our breeding methods, but in another way I was horrified as it is not natural and against my ethics.

Let me point out here I did not know they would be used for that and I spent all night thinking about the girls It is a catch 22 and you cannot control what happens to them after a sale and in many ways they will be looked after at this particular stud very well and also have masses of lovely green grass to eat where they have gone. Then there is the other side of the coin, I always keep in touch with people I sell Alpacas to and a local lady whom I rang last week had just taken one of the Alpacas to the vet because it was a little bit off colour (sold also last year) and it had been given 4 injections and sent home with more medication and I am sure if she had rung me all it needed was probably ADE and Cod Liver Oil. One injection was a steroid , how awful So what I am trying to say is as soon as they leave you they belong to someone else and there is no difference in either scenario. Most people will vaccinate immediately and drench, as they are frightened not to, and what must that do to their pure systems! I have to accept that, until we all become Holistic.!..

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Thank you for your kind attention. Thank you to Heroides without whom I could not breed Alpacas. I also owe a lot to Juliette de Bairacli Levys book The Complete Herbal Handbook for Farm and Stable, who writes about the New Forest near my birthplace, her book is my bible! Also Pat Coleby and all the little bits of advice we have gathered over the year, from various people and vets. However most of all I would like to thank the wonderful Alpaca..

Birthing and practical neonatal care

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Neonatal care commences at the time of birth. Responsible birthing practices can be achieved with forward planning which involves antenatal care of the pregnant female and assembling a first aid 'Cria Kit'.
The minimum recommended items are a digital thermometer, glucose, teats, bottles, mosquito forceps (used as a clamp for umbilical haemorrhage) and a cria coat.

The birthing of a cria is an exciting time and in most cases is trouble free.
By understanding what is normal at birthing, breeders can make calculated decisions should circumstances differ.
Knowing the last mating date gives some idea as to when birthing may occur, however, females mated on the same day seldom birth at the same time and up to 5 weeks variation in gestation has been recorded from matings performed on the one day.
The gestation period does not necessarily reflect on the weight and size of the cria at birth, and signs of dysmaturity ie a cria which is down on its pasterns, can be evident with full term cria.

Birthing

In many cases the pregnant female gives little indication that parturition is close. Udder development does not necessarily occur prior to the birth. Most females show few signs of discomfort, therefore the owner who is familiar with their female alpaca's temperament and habits, will recognise behavioural changes.

The following activities generally indicate that the first stage of labour has commenced :
Frequent trips to the dung pile
Restlessness or rolling
Murmuring
Standing or sitting alone
Tail extended when not near a dung pile
Sitting on one hip

The duration for the first stage of labour averages 1- 4 hours.
Should the above behaviour continue beyond this time, a veterinarian should be consulted.
The second stage of labour is much more apparent as the foetus has entered the birth canal and expulsion is obvious.
Most alpacas deliver in the standing position, sometimes sitting to take short rests during the process. Normal presentation is the head and front legs first.
Once the head, neck and front legs are fully extended, draining of fluid from the mouth of the cria may be seen. This is a natural process which aids in clearing the lungs of the cria.
Labour often slows at this point, and some females may walk about, graze or sit down prior to the delivery of the shoulders and chest.
Further draining may be visible as the cria hangs by its hind quarters before the final moment of birthing.
Do not be tempted to pull the cria out at this stage – gravity will do its job and there is a slight risk of umbilical haemorage by unnecessary intervention.
The final stage of birthing is the expulsion of the placenta. This should occur within 6 hours of birthing, but usually takes place within the first hour.
If the placenta has not been passed within 6 hours or an incomplete placenta is delivered, veterinary advice should be sought and oxytocin may be recommended.
Note: The placenta is not eaten by the mother and should be buried.
The majority of cria are born without intervention. Observe the birth from a distance, check the cria and mother, monitor progress but DO NOT INTRUDE.

Initial check of newborn

Be sure there is no haemorrhage from the umbilicus (navel) of the cria.
Run a thumb over lower gums to check for eruption of teeth and that there is no obstruction in mouth.
Note: If teeth are not erupted, regardless of the length of gestation, the cria must be treated as premature and special care will be needed.
10% Betadine may be sprayed on navel area, particularly if cria has been born in a dirty area or in a shed.
Monitor severely laboured breathing – postural drainage may be required. (see 'responses to problems of the neonate')
Check the sex of the cria and MOVE AWAY! Allow the mother to bond with the cria.
This initial inspection should not take longer than 30 seconds.
The cria is born covered by a clear membrane rather like glad wrap. There is no need to remove this as it is nature's insulator and it will disintegrate as cria wriggles.
The mother does not lick her cria clean but may 'kiss' around the nose and mouth and smell around the tail area, so try not to touch these areas as they are her 'scent identification'.
Some mothers pay little attention to the newborn until the placenta has been passed, so do not interfere excessively or the cria may not bond appropriately with the mother.

Normal progress of the neonate

Cria should be in the cush (sitting position) within 10 minutes
Cria should be standing within 2 hours after birth
Cria should be suckling by 4 hours after birth

Cria birth weights

5.5kg or less is very small and special care will be needed.
<6kg is small and should be weighed daily. Supplementary feeds may be necessary.
7.5-8kg is average weight.
8.5kg + is large. Some larger cria are sluggish and may need to be encouraged to move.

Normal feeding by the neonate

Within two hours the cria should be standing and attempting to locate the udder.
This is frustrating to watch as they often search around the chest, 'pop out' the other side, or try to reach the udder from between the back legs of the mother.
Be assured that if they seek they will find, and it seldom helps to assist at this time.
Cria feeds average two minutes.
A cria that is constantly suckling may not be getting enough milk, so recording weight is vital.
Healthy cria gain around 1- 1.5kg per week for the first four weeks
Less than 1kg gain per week is a problem and cria may need to be given supplementary feeds once or twice daily until appropriate gain is achieved.

Responses to problems of the neonate

Umbilical bleeding of cria post birthing:
This is an emergency and is more likely to occur following assisted births.
Clamp the cord using mosquito forceps. Do not move the cria until bleeding stops.

Laboured respiration:
If the cria has excessively laboured breathing, postural drainage may help.
Postural drainage is performed by holding the cria under one arm with its head hanging and legs pointing upwards.
Firmly tap the chest of the cria for 30 seconds to loosen any fluids in airways.
Lay cria down and observe. Repeat at 2 minute intervals if laboured respiration continues.
Note: This problem is more likely to occur when the mother has been in a seated position to deliver the cria.

Lying flat:
If the neonate is breathing but not attempting to wriggle or sit after 5 minutes, stimulate by briskly rubbing along spine for 30 seconds at three minute intervals. Postural drainage may also be beneficial.

Not attempting to stand within 1 hour:
If the neonate is sitting and appears healthy but is not making any attempt to stand after an hour, a mixture of 2 teaspoons of glucose powder in 60 mls of warm water will raise the blood sugar for approximately 1 hour, usually instigating activity.
Spinal stimulation as above should also encourage movement.
Record the rectal temperature of cria and take further action if a problem is indicated eg low temperature.
Normal temperature = 36.8c – 38.6c

Low temperature:
If a cria's temperature is below normal range, take immediate action.
Depending on the circumstances and severity of the situation, the options are:
1. Cria coat.
Towel dry the cria and prevent chill factor or loss of further warmth by using a cria coat.
Note: Lay the coat on the ground before placing on the cria. This allows the mother to familiarise with it. Do not cover the tail area with the coat as this is the scent identification area.
2. Bubble wrap is an excellent insulator to tuck around a frail cria.
3. Sit cria on a hot water bottle or electric blanket. The belly is the thermal window and core temperature will be raised by warming this area. Do not place the cria near a heater.
4. Give glucose using a pet nurser bottle with a marsupial teat. Gentle pressure will be needed if the cria has poor sucking reflex. Do not give milk to a cria with a low temperature. Glucose, plasma or electrolytes can be administered.

High temperature
This is likely to indicate infection. Although infrequent, infections can be fatal, so if a cria appears unwell and has an elevated temperature, do not delay to get help.
High temperatures can be temporarily reduced by immersing the cria in cool water, but the reason for elevated temperature must be found.

Cria unable to access colostrum:
Alpaca milk is best for alpacas. Colostrum, the first rich creamy milk the alpaca produces provides passive immunity for the cria. A cria that receives an inadequate amount of colostrum, is susceptible to infection. This occurs in premature cria or others that are unable to stand to suckle.
Milking the mother is difficult and very little colostrum is usually achieved, thus an alternative is necessary.
Plasma, processed from blood of alpacas and kept frozen, is a successful substitute. Plasma can be given orally, intravenously or intraperitonealy.
Know where the nearest source of plasma can be sourced.
Note: The oral route can only used in the first 12-24 hours.
Colostrum from other species is another option. Goat or sheep colostrum are most like alpaca.
Powdered colostrum from other species has been used with various levels of success.

Down on pasterns:
A cria that is down on pasterns (looks like flat feet) will benefit from supplementary feeding twice per day until feet become normal. The reason for supplementary feeding is that insufficient milk may be ingested by the cria, as it is harder for them to stand to feed. This problem usually resolves within a couple of days.

Constipation:
Occasionally on day 3 a cria is seen straining at the dung pile. This can often be relieved by inserting petroleum jelly in and around the anus. Should this not solve the problem, an enema may be necessary.

Diarrhoea
Diarrhoea can cause a cria to dehydrate rapidly. It is a rare occurrence, and a veterinarian should be consulted.
Note: Diarrhoea can be caused by overfeeding a cria that is being hand reared.

Antibiotics:
If a veterinarian prescribes an antibiotic for a cria, it is valuable to also give natural yoghurt to maintain the flora in the gut and reduce the risk of scouring. (diarrhoea)
20 mls twice a day orally, given by syringe is appropriate.

Prematurity in a cria means special care will be required.

Premature or Dysmature cria are recognized by all or some of the following:
Teeth not erupted
Floppy ears
Unable to stand or hold head up
Short gestation
Low birthweight – see above
Down on pasterns

Objectives of nursing a premature cria
Stablise temperature
Retain the bond with the mother
Develop a feeding regime which commences with plasma or colostrum

Helpful hints for nursing a premature cria
Record everything!
Measure all fluids and sterilise all equipment
Stabilise the temperature by warming or cooling the cria as required.
Record temperature three times a day. Contact the veterinarian if temperature is high!
Pack the cria with pillows to keep in a sitting position. Allow the neck to stretch forward if the cria is unable to hold it erect.
Massage legs and spine 3-4 times a day to aid circulation
Stretch the neck forward and chin up when feeding – think of normal feeding position
Assist cria to stand while being fed so it associates feeding with standing
Keep the mother near at all times– her murmuring can keep the cria alive

Conclusion

Greater detail on these and relevant subjects is available in the publication 'ABC for Alpaca Owners'. In most cases 'cria care' will only involve observing, enjoying and monitoring progress.
The miracle of birth will never lose its wonder and the excitement and the satisfaction of watching healthy cria develop and grow cannot be overstated.

References

ABC for Alpaca Owners by Dr Ewen McMillan B.V.Sc.(Hons) M.V.St. M.A.C.V.Sc. M.R.C.V.S and Carolyn Jinks, Benleigh Alpaca Stud, Victoria, Australia. Alpaca Publications Australia 2005

Alpaca nutritional requirements: Pregnancy and hepatic lipidosis

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Abstract
For an industry focused on reproductive performance, feeding and care of the pregnant alpaca is a critical management component. Metabolic nuances of camelids coupled with the unique metabolism of the fetal-placental unit require dietary modifications in all essential nutrients in order to meet daily needs and ensure a successful end to the pregnancy. Fetal growth is exponential with greatest gain occurring in the last 2 months of gestation. Higher dietary concentrations of energy and protein are needed in support of late pregnancy and to prevent development of hepatic lipidosis. A quality pregnancy diet is characterized by high quality forages and appropriately balanced supplements fed to maintain good intake. Body condition scoring, body weight measurements or blood analysis assessing energy balance are good determinants of nutritional status in monitoring success of your pregnancy feeding program.

Key Words
Nutrient requirements, pregnancy, hepatic lipidosis, feeding management, alpaca

Introduction
The most desirable outcome from a pregnancy is to have a healthy, vigorous cria, no health complications with the dam and successful rebreeding within 30 days. Nothing can be more frustrating for an owner after the long wait than to have something go wrong with their newborn cria, especially if the pregnancy was difficult to conceive. Even more disheartening is learning that something could have been done to prevent the problem during pregnancy.

Research with cattle and sheep has shown that nutrition during pregnancy influences colostrum quality and quantity, milk yield and composition, neonate viability and future fertility of the dam. These data reveal the critical nutritional issues that need to be addressed during pregnancy. The critical issues are: energy and protein balance relative to requirements and appropriate supplementation of minerals and fat-soluble vitamins. From a management standpoint, concerns such as level of intake, forage quality, body condition monitoring and environmental stressors must be considered. For an industry that is dependent upon sound reproduction, we have little data to guide us in the proper nutrition of our pregnant animals. Data specifically addressing pregnancy nutrition of alpacas and llamas are scarce at best. Because there is sufficient functional similarity of anatomy and physiology between camelids and other ruminants, extrapolation of basic concepts of pregnancy nutrition from other species can be applied to the alpaca and llama and will be the focus of this discussion.

Understanding Pregnancy Requirements
Nutrient requirements for the pregnant, nonlactating alpaca are only slightly higher than maintenance during early to mid gestation. The pregnant alpaca requires a defined amount of energy, protein (amino acids), minerals and vitamins to maintain normal body functions (e.g., maintenance) as well as support fetal development. Llamas were found to gain between 10 and 15 percent of their live weight at conception over the gestation period, with majority of weight gain (>60 percent) occurring during the last 2 months (Smith et al., 1992). This fetal growth pattern is similar to other species and suggests changing requirements as the pregnant alpaca progresses through the last 3 mo of gestation.

Following birthing, initiation of milk production results in a tremendous nutrient drain on the dam. When one compares daily requirements for glucose, amino acids, fatty acids and calcium for either a lactating or late pregnant cow, lactational requirements are 2.7, 2.0, 4.5 and 6.8 times greater than those needed for pregnancy, respectively (Bell, 1995). These differences represent changes in nutrient requirements over a period of only a few days and highlight the tremendous metabolic alterations necessary to adequately support lactation. If these metabolic changes are not effectively enacted, metabolic disease (i.e., hepatic lipidosis) and infertility problems may result. Maternal feed intake is depressed in all animals for a significant period of time prior to and following birthing. This results in inadequate nutrient intake to support milk production and rapid mobilization of nutrient reserves. If reserves have already been depleted during late pregnancy, milk production will be limited, thus compromising survivability of the cria. Under most management schemes, we attempt to breed alpacas within 30 days of birthing to establish next year's cria. Reproductive cycles and conception rates are highly sensitive to nutrient status. Depletion of energy reserves results in suppressed reproductive function.

Energy
Energy quantitatively is the most important nutrient and is derived from the metabolism of carbohydrates, fats and protein. Pregnancy energy requirement is a function of energy needs to support fetal, placental, uterine and mammary gland growth in addition to maintenance. Using sheep data, pregnancy energy requirements were modeled to estimate requirements at different months of gestation and expected birth weight (Figure 1; Van Saun, 2006a). Using these models, estimated pregnancy requirement at 8, 9 and 10 mo of gestation averaged 1.27, 1.55 and 1.92 times maintenance, respectively. These values are consistent with observations for other species. Additional concentrates or improving forage quality can account for increasing dietary energy delivery.

The fetus requires energy, primarily in the form of glucose and amino acids, to support growth. These nutrients are delivered via the maternal bloodstream to the uterus. The placenta, which encloses the fetus, is a physical barrier separating the fetus from maternal circulation. The primary functions of the placenta are nutrient uptake for metabolism and excretion of metabolic wastes. As a result of the number of cellular layers in the camelid placenta, similar to other ruminant animals, fatty acids and other lipid-based molecules do not cross the placenta (Battaglia and Meschia, 1988; Bell, 1995). Preventing fat from crossing the placenta allows the dam to shift her metabolism to utilizing fat as an energy substrate rather than glucose. This allows more glucose to be available to support the fetus.

During periods when the dam does not consume sufficient feed to meet nutrient needs, she will draw from her fat reserves to make up the energy difference. This is why the pregnant animal needs to have, at a minimum, moderate body condition throughout pregnancy; it is an energy reserve to draw upon. Unfortunately, the fetus has little flexibility in terms of available alternative metabolic fuels. There is no fat reserve in the fetus. Fetal glucose concentrations decline as a result of declining maternal concentrations during periods of nutritional deficiency. Growth of fetal sheep, as determined by crown-to-rump length measurements during pregnancy, was deterred or completely stopped during periods of induced maternal hypoglycemia during late pregnancy (Mellor and Matheson, 1979). Since fat, which is elevated in the dam during energy deficiency, cannot cross the placenta the fetus must utilize amino acids for energy. If environmental conditions or feed intake is more severely compromised, then excessive body fat will be mobilized predisposing the animal to hepatic lipidosis (see discussion below).

Protein (Amino Acids)
Protein nutrition of camelids is uncertain. A general impression suggests that the requirement is low based on forage resources in their native environment. Camelids, especially alpacas, are good browsers and can consume much higher quality diets than measured in specific forages found in their environment. Protein requirement has been estimated to be 3.5 g crude protein/kg $BW^{.75}$, which is a lower than that estimated for sheep or cattle (San Martin and Bryant, 1987). For an adult 70 kg alpaca, this would be equivalent to 84.7 g crude protein a day. Hospinal (1997) suggested a 68% increase in maintenance CP requirement to support pregnancy (2.38 g CP/kg $BW^{.75}$), totalling 5.88 g CP/kg $BW^{.75}$ for maintenance and pregnancy; equivalent to 142 g crude protein/day. Assuming an intake between 1.2 and 1.5% of body weight, recommended minimum dietary protein levels for maintenance and late gestation would be 80-100 g/kg and 100-120 g/kg, respectively.

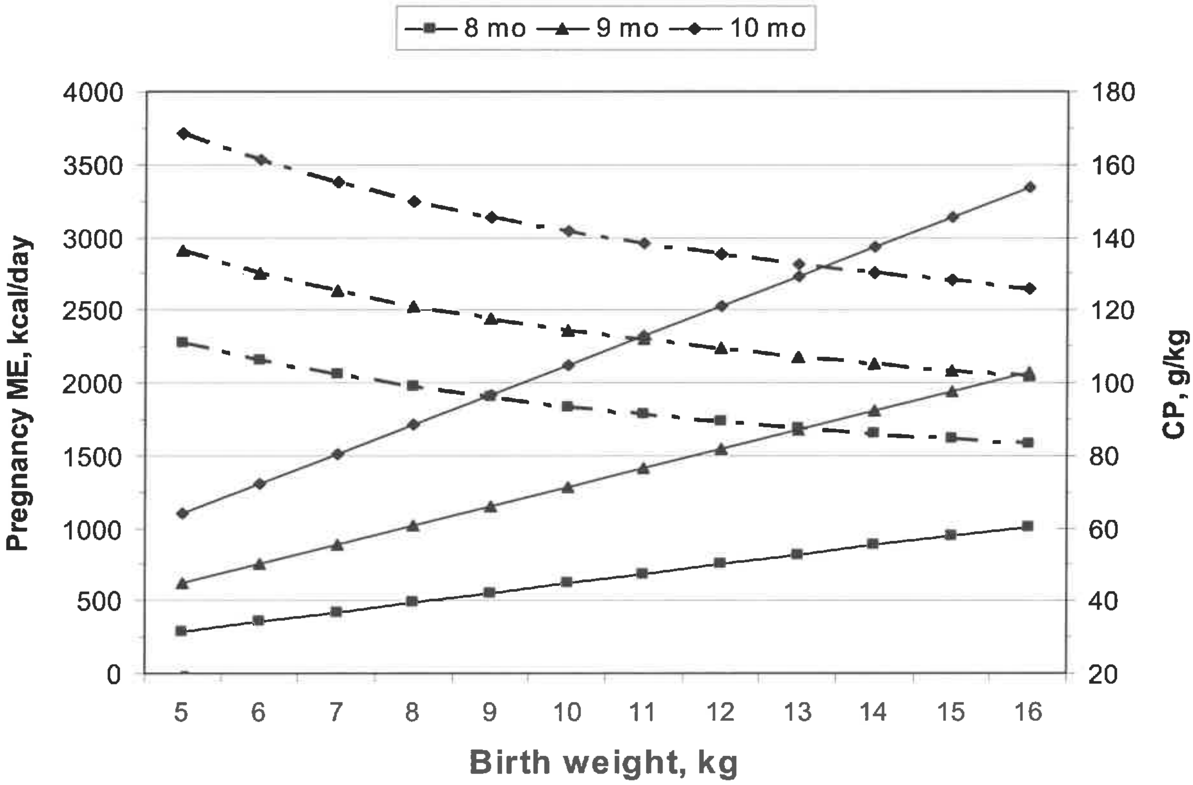

Figure 1: Dynamic models to predict metabolizable energy (ME, solid lines) and crude protein (CP, broken lines) requirements in support of pregnancy for last 3 months of gestation (Van Saun, 2006). Energy equivalents: 3000 kcal ME = 1 kg corn grain; 1500 kcal ME = 500 g corn. Dietary protein concentration assumes an intake of 1.5% of body weight.

An unresolved issue with camelid metabolism is the higher level of urea nitrogen (BUN) in their blood (19-25 vs. 7-12 mmol/l) compared to other ruminant animals (Van Saun, 2006a). Blood urea nitrogen concentration reflects protein level of the diet. Low protein diets result in low BUN, while high BUN is associated with high protein diets or excessive metabolic protein breakdown. Another metabolic oddity with camelids compared to ruminants is the higher blood glucose concentration (4.4-5.5 vs. 2.8-3.3 mmol/l). Like other ruminants, camelids do not absorb much dietary glucose as it usually is fermented in the foregut. Blood glucose is predominately derived from liver biosynthesis using precursors in the diet, namely propionate. Amino acids are also a good precursor for glucose synthesis. It is hypothesized that camelids oxidize a significant amount of amino acids to support their higher blood glucose concentration, which may account for their higher BUN concentrations (Van Saun, 2006a).

Protein requirement to support pregnancy includes the necessary amino acids needed to support fetal, placental, uterine and mammary development. With the typical fetal growth curve, significant protein needs to support pregnancy most likely occur during the last 3 mo of gestation, although data are needed to confirm this supposition. Additionally, amino acids are an important energy substrate in the fetus irrespective of nutritional status. In addition to their use as a fetal energy substrate, amino acids are necessary to support fetal growth. Maternal protein deficiency in late gestation seemingly has a greater impact on birth weight than does energy deficiency (Robinson, 1995). In contrast to glucose, fetal amino acid uptake is essentially unaffected by maternal nutrient status. A study using pregnant sheep showed amino acid oxidation to increase from 32 percent to 60 percent of total fetal oxygen consumption for diets either maintaining or restricting maternal nutrient intake throughout gestation, respectively (Faichney and White, 1987). These data clearly demonstrate that amino acids are essential fetal energy substrates, especially during periods of maternal under-nutrition, which places an additional protein utilization burden on the dam.

Maternal protein mobilization can maintain fairly normal fetal growth patterns during short periods of under-nutrition. Twin pregnant ewes fed an 8 percent crude protein diet had an 18 percent reduction in fetal weight compared to 12 and 15 percent crude protein diets, but were not different between the 12 and 15 percent crude protein diets (McNeill et al., 1997). These data suggest some capacity for the placenta to sustain amino acid delivery to the fetus, but it is not unlimited. However, there is no reserve storage of protein in the body. Where does this protein come from? Ewes receiving either 8 or 12 percent crude protein diets both lost maternal skeletal protein, whereas ewes on the 15 percent crude protein diet gained carcass protein mass. Mobilization of maternal skeletal protein ("labile protein") can explain why birth weight is not dramatically affected within reasonable variation in maternal nutritional status, at the expense of maternal protein mass. Severe or prolonged maternal protein under-nutrition can not only result in fetal growth retardation, but can also negatively impact newborn viability through decreased thermogenic capacity and reduced production of quality colostrum. Calves born to cows on restricted protein pregnancy diets had less ability to generate heat to keep warm compared to calves born to protein-adequate cows (Carstens et al., 1987). Prepartum losses in maternal nutrient reserves or body protein may have severe detrimental impacts on maternal health (predisposes to hepatic lipidosis), lactation and reproductive performance following parturition since these nutrient pools are critical to support early lactational nutrient losses. An alternative pregnancy model relating protein requirements to energy needs has been developed and suggests slightly higher protein requirements (Figure 1; Van Saun, 2006a).

Minerals and Vitamins

Macrominerals (calcium, phosphorus, magnesium, potassium, sodium, chloride) and microminerals (copper, iron, iodine, manganese, selenium, zinc) are transported across the placenta to support fetal growth and metabolism. During late gestation, calcium and phosphorus deposition into developing fetal bone accounts for an increased requirement for these minerals. In addition to the functional uses, most of these minerals are concentrated in the fetal liver to be used as a postnatal mineral reserve (Abdelrahman and Kincaid, 1993; Graham et al., 1994). Although milk contains high concentrations of calcium and phosphorus, it is deficient in most microminerals (Morin et al., 1995). Even appropriate supplementation of the lactating dam does not significantly increase the micromineral content of milk. The microminerals are not only required for normal growth and development of the cria, but are also essential to normal immune system function. The newborn cria relies on mineral storage in the liver to maintain normal body functions while on a predominant milk diet. Consumption of solid food, containing minerals and vitamins to augment liver stores, usually does not occur until two months of age or later. If liver mineral reserves are exhausted, immune function will be compromised, resulting in increased disease susceptibility as well as decreased growth rate. Proper supplementation of all minerals during pregnancy, more than during lactation, is essential for the normal development and viability of the fetus and newborn cria.

In contrast to minerals, fat-soluble vitamins A, D and E do not appreciably cross the placenta resulting in minimal liver reserves (Njeru et al., 1994). This means that the newborn cria is essentially devoid of these vitamins and susceptible to deficiency disease problems. The cria's primary source of vitamins A, D and E comes via colostrum ingestion, supplied from an adequately supplemented dam (Njeru et al., 1994). Colostrum contains a large amount of fat and concentrated fat-soluble vitamins. Milk also contains a reasonable amount of fat-soluble vitamins, again only if the dam is adequately supplemented. These relationships may explain why fall-born crias are most susceptible to rickets (Smith and Van Saun, 2001; Van Saun, 2006b). Maternal vitamin D concentrations decline during the fall and are lowest in winter without supplementation, thus compromising the cria's vitamin D status during the critical growth period. Colostrum also contains high concentrations of microminerals and protein in the form of immunoglobulins. Liver micromineral reserves can be augmented by colostrum consumption. Therefore, available neonatal nutrient reserves are the sum of placental transport and colostrum consumption, both of which are highly influenced by maternal nutrient status. These data strongly underscore the absolutely critical management practice of ensuring adequate colostrum consumption by the newborn to ensure passive antibody protection as well as micromineral and fat-soluble vitamin transfer.

Hepatic lipidosis and pregnancy

There are limited reports of hepatic lipidosis in llamas and alpacas in the literature; however, producer groups and practicing veterinarians have an increased interest in the pathogenesis of this disease process. A retrospective study of 31 histologically confirmed cases of hepatic lipidosis in llamas and alpacas submitted to Oregon State University Veterinary Diagnostic Laboratory revealed a predominately middle aged, pregnant or lactating female population to be affected (Tornquist et al., 1999). However 22.6% of the cases were male and age ranged from 5 months to 18 years. This is a very different demographics of affected animals compared to the disease in other ruminants. In these cases there was no significant association with any infectious, parasitic, or toxic causative agent. The most common factor documented in histories from these camelids was recent severe loss of appetite or weight loss. This period of not eating or weight loss varied from a couple of days to several weeks. Overweight, normal body condition and thin animals were all represented in the affected group. Biochemical measures associated with negative energy balance (NEFA), liver dysfunction (bile acids) and muscle damage were consistently elevated. Lipemia and ketonemia were not consistently associated with hepatic lipidosis in this retrospective study population compared to the two literature reports (Van Saun, 2006b). These data suggest similarities in the pathogenesis of hepatic lipidosis in camelids to other species and not just ruminants.

Since a history of recent anorexia or weight loss was the most common factor in the naturally occurring cases of camelid hepatic lipidosis, we attempted to create a model of this condition by limited feed restriction (Tornquist et al., 2001). The study has included lactating and non-lactating animals. All llamas in the study lost large amounts of body weight. About half developed hepatic lipidosis. No animals became depressed or recumbent. Blood tests showed the expected increases in liver enzymes in those that developed hepatic lipidosis, but not in those that simply lost weight. When nonesterified fatty acids (NEFA), a direct measure of negative energy balance, are elevated (>0.8 mmol/l), animals are at a high risk for hepatic lipidosis. These observations are important in telling us that our blood indicators of liver disease (bile acids) are relatively specific in camelids. When the affected camelids were returned to normal feed, we saw increases in weight, gradual changes in the blood values towards normal and the disappearance of fat from the livers based on biopsies. This was also a significant finding in that it showed that the condition is reversible when normal levels of nutrients and calories are consumed.

The key to preventing and treating this disease is increased understanding of the unique metabolic processes of camelids. The bottom line for prevention is to ensure adequate energy and protein intake, especially in pregnant and lactating females through good quality forage and appropriate supplementation (Van Saun, 2006b). Adequate energy and protein intake can be easily assessed by use of hands-on body condition scoring. Close monitoring of intake in sick animals is absolutely critical to prevent deaths.

Feeding management

Nutrition of the pregnant animal at all stages of pregnancy has been shown to influence viability of the newborn. Given the arguments made for increases in nutrient requirements over the course of pregnancy, the question follows; how does one accomplish this increase? There are two solutions to meeting increased nutrient needs - either increase feed intake or increase feed nutrient density. Expecting the late pregnant alpaca to consume more food may not be practical. During late pregnancy, the uterus expands and may physically limit intake. In addition, other metabolic or endocrine factors may decrease intake capacity. Environmental stresses also need to be considered, especially in light of the lack of tolerance to heat stress. Heat stress reduces feed intake and if prolonged, can result in severe negative energy balance with excessive fat mobilization. If intake does decline, appropriate modifications to nutrient density will be necessary to ensure adequate nutrient intake (Table 1). Without adjusting the feeding regimen, the alpaca will experience negative energy and protein balance, which could lead to rapid mobilization of fat reserves and subsequent hepatic lipidosis (e.g. fatty liver) and pregnancy toxemia (e.g. ketosis).

Forage quality is the most important factor to consider in addressing issues of intake capacity. Grass or alfalfa forages with high neutral detergent fiber (NDF) values are associated with low intake capacity. Fiber takes longer to ferment and fills the gastrointestinal tract preventing further feed intake. As either grass or alfalfa matures, its acid and neutral detergent fiber content will increase. Conversely, crude protein and energy content will decrease. At the same maturity, grass forages will have higher fiber and lower energy and protein values compared to alfalfa.

Feeding poorer quality forages to late pregnant animals is a disaster waiting to happen. Forages should be routinely tested or at least visually inspected to assess quality. Using higher quality forages or adding some grain to the diet can help increase dietary energy and protein density to compensate for reduced intake. In the spring or early summer, pregnant alpacas may not require much additional supplementation because of their high quality forages. The same is true for those alpacas grazing on irrigated pastures throughout the year. Pregnant alpacas eating mature grass hays will require energy and protein supplementation. This may come from substituting 25 to 50 percent of the grass hay with alfalfa hay depending upon quality. Cereal grains such as oats, corn, barley or their combination will provide additional energy, but minimal protein. Commercial supplements can provide both energy and protein; however, the high fiber products may not be appropriate. Review the feed tag and nutrient list to ensure that some cereal grains are present for energy and protein content is 14 percent or higher. In reading the ingredient list of a feed tag, a cereal grain like corn, barley or oats should be one of the first three ingredients listed. The amount of supplement to feed will depend upon forage quality and may range from 100 to more than 450 g/day. To achieve a dietary protein content of 120 g/kg while feeding an 100 g/kg protein grass hay, 550 g of a 140 g/kg protein supplement or 272 g of an 180 g/kg protein supplement would be required.

Forages contain some minerals, but in most areas of the country, forages are deficient in one or more minerals. Given the storage of minerals in the fetal liver during pregnancy, it would be good management practice to ensure that the pregnant dam is consuming adequate amounts of minerals. Relying on free choice intake of trace mineral salt products is not a good method because of their variable intake. Offering a fixed amount of an appropriately formulated mineral supplement would be the preferred method and would complement the use of a supplement to address energy and protein needs. One needs to review the mineral complement of commercial supplements to assess adequacy especially relative to microminerals (Van Saun, 1999).

Similar to the minerals, supplementation of the fat-soluble vitamins, especially vitamin D, is necessary during pregnancy to ensure adequate colostral transfer. Vitamins A and E are more than adequate in pasture, but may be limited in stored hay. Vitamin D is minimal in pasture and variable in hay. Most of the alpaca's vitamin D intake is dependent upon sunshine. Our research shows considerable seasonal variation in vitamin D status with highest values in the summer and very low values during the winter (Smith and Van Saun, 2001). Dark colored alpacas seem to have low vitamin D even during the summer. Vitamin D should be supplemented between 2,000 and 5,000 IU/day using a commercial mineral-vitamin product (Van Saun, 2003, 2006a). Vitamins A (4,000-6,000 IU/day) and E (30-100 IU/day) need to be supplemented if dried hay is being fed, but there is no need to supplement if there is good quality pasture.

Table 1: Suggested minimum dietary formulations for feeding pregnant alpacas (Van Saun, 2003; 2006).

Group	Feeding Plan	Dietary Guidelines
Pregnant females 1-8 months	Low requirements, but ensure no loss of body condition, adequate protein, minerals and vitamins	50 to 55% TDN, 8-10% Crude protein, 0.2-0.24% Ca, 0.12-0.2% P
Pregnant females 9-11 months	Moderate to high forage quality with supplement for additional mineral and vitamin needs	55 to 70% TDN, 10-12% Crude protein, 0.45-0.56% Ca, 0.28-0.33% P, [1,2]

[1]Requires higher amount of trace minerals and vitamins, preferably delivered by a supplement.
[2]Dietary energy and crude protein content may need to be increased further in late pregnancy if dry matter intake drops below 1.5 percent of body weight.

Assessing nutritional status

The single most important assessment of nutritional status in the pregnant alpaca is accomplished by body condition scoring. Body condition scoring is a method that subjectively grades alpacas by the amount of subcutaneous fat stores palpated over the lumbar vertebrae, shoulder and loin into categories covering physical states ranging from emaciated to obese (Hilton et al., 1998; Van Saun, 2003). Alpacas should have moderate body condition throughout pregnancy. Remember that the pregnant alpaca should gain between 9 and 13.6 kg during pregnancy to account for fetal growth. This energy reserve can then be mobilized in support of early lactation when intake is depressed. Overly fat alpacas have reduced intake and are more prone to fatty liver problems given their large, readily mobilized fat reserve (Van Saun, 2006b). Excessively thin animals have minimal reserves from which to draw to support early lactation or reproduction. Based on body condition, the nutritional program can be tailored to either increase or decrease supplements or forage quality to achieve the desired body condition. It would not be desirable to reduce energy intake too dramatically in an overly fat animal as this may lead to excessive fat mobilization and subsequent fatty liver problems. Ideally, one should continually monitor the body condition of their alpacas throughout the year and modify the nutritional program prior to mid or late pregnancy to achieve the desired body condition.

In addition to body condition monitoring, nutritional status can be evaluated using a number of laboratory tests of the blood. With specific metabolite analyses, one can evaluate nutritional status relative to energy balance, liver function and protein, mineral and vitamin status. However, blood analyses need to be carefully interpreted in light of the diet being consumed and underlying physiologic processes. Most macromineral blood concentrations are very tightly controlled by regulatory processes resulting in minimal concentration changes over a wide dietary input range. This minimizes their usefulness in diagnostic evaluations. Both microminerals and fat-soluble vitamins are stored in the liver, which helps to buffer nutritional insults and minimize changes in blood mineral or vitamin content. This storage however, confounds interpretation of the measured nutrient's concentration. Your veterinarian should be consulted relative to the usefulness and interpretation of blood nutrient analyses. Remember that blood analyses are only part of the diagnostic process and should not be the sole basis for nutritional management decisions.

Conclusions

Information pertaining to maternal and fetal metabolism and nutrient requirements during pregnancy has been presented. Although this information is not completely derived from alpaca research, it supports the contention that nutritional management of the pregnant alpaca can have tremendous impact on cria survivability and the reproductive capabilities of the dam. Clearly, more information specific to alpacas, especially a better understanding of nutrient requirements during pregnancy, is needed. There are many different ways to adequately feed the pregnant alpaca to minimize potential problems. Proper management includes implementing the following actions: 1). Monitor body condition to maintain moderate condition; 2). Assess forage quality and supplement appropriately; 3). Increase protein to at least 12 percent of total diet; 4). Adequately supplement all minerals with a palatable supplement; and 5). Supplement vitamin D and vitamins A and E if not on pasture. The quality of your available forage is primarily going to dictate the necessity and type of supplementation program needed. Feeding higher quality forage, adding some grain, or both may be necessary to maintain adequate energy intake by the pregnant alpaca. Properly addressing the nutrient needs of the pregnant alpaca increases the probability of a successful outcome for the cria and dam.

References

Abdelrahman, M. M. and R. L. Kincaid. 1993. Deposition of copper, manganese, zinc, and selenium in bovine fetal tissue at different stages of gestation. J Dairy Science 76:3588.

Battaglia, F. C., and G. Meschia. 1988. Fetal nutrition. Annual Reviews of Nutrition 8:43.

Bell, A. W. 1995. Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation, J Animal Science 73:2804-2819.

Carstens, G. E., D. E. Johnson, M. D. Holland, et al. 1987. Effects of prepartum protein nutrition and birth weight on basal metabolism in bovine neonates. J Animal Science 65:745.

Faichney, G. J., and G. A. White. 1987. Effects of maternal nutritional status on fetal and placental growth and on fetal urea synthesis in sheep. *Australian J Biologic Science* 40:365.

Graham, T. W., M. C. Thurmond, F. C. Mohr, et al. 1994. Relationships between maternal and fetal liver copper, iron, manganese, and zinc concentrations and fetal development in California Holstein dairy cows. J Veterinary Diagnostic Investigation 6:77.

Hilton, C. D., D. G. Pugh, J. C. Wright, et al. 1998. How to determine and when to use body weight estimates and condition scores in llamas. Veterinary Medicine 93(11):1015-1018.

Hospinal, R.S.(Ed), 1997. Capítulo IV. Nutrición y Alimentación de Alpacas, In: Produción de Camélidos Sudamericanos, Imprenta Rios, Huancayo, Peru, pp. 163-203.

McNeill, D. M., R. Slepetis, R. A. Ehrhardt, et al. 1997. Protein requirements of sheep in late pregnancy: Partitioning of nitrogen between gravid uterus and maternal tissues. J Anim Sci 75:809-816.

Mellor, D. J. and I. C. Matheson. 1979. Daily changes in the curved crown-rump length of individual sheep fetuses during the last 69 days of pregnancy and effects of different levels of maternal nutrition. *Quarterly J of Experimental Physiology* 64:119-131.

Morin, D. E., L. L. Rowan, W. L. Hurley, et al. 1995. Composition of milk from llamas in the United States. J Dairy Science 78:1713-1720.

Njeru, C. A., L. R. McDowell, N.S. Wilkinson, et al. 1994. Pre- and postpartum supplemental DL-alpha-tocopheryl acetate effects on placental and mammary vitamin E transfer in sheep, J Animal Science 72:1636-1640.

Robinson, J. J. Nutrition of the pregnant ewe: Effects on lamb viability and growth. In: Proceedings for Annual Meeting, Society for Theriogenology, pp. 283-291, Sept. 13-15, 1995.

San Martin, F.A., 1987. Comparative forage selectivity and nutrition of South American camelids and sheep. Texas Tech Univ, Lubbock, TX (PhD Dissertation), 146 pp.

Smith, B.B., Timm, K.I., Reed, P.J., 1992. Morphometric evaluation of growth in llamas (*Lama glama*) from birth to maturity. J. Am. Vet. Med. Assoc. 200(8):1095-1100.

Smith, B.B., Van Saun, R.J., 2001. Seasonal changes in serum calcium, phosphorus and vitamin D concentrations in llamas and alpacas. Am. J. Vet. Res. 62(8):1187-1193.

Tornquist, S.J., R.J. Van Saun, B.B. Smith, C.K. Cebra and S.P. Snyder. (1999). Histologically-confirmed hepatic lipidosis in llamas and alpacas: 31 Cases (1991-1997). Journal Am Veterinary Med Assoc 214(9):1368-1372.

Tornquist, SJ, Cebra, CK, Van Saun, RJ, Smith, BB. (2001). Metabolic changes and induction of hepatic lipidosis during feed restriction in llamas. American Journal Veterinary Research 62(7):1081-1087.

Van Saun, R. J. (1999). Understanding vitamin and mineral supplements for camelids: Reading between the lines. Alpaca Registry J 4(1):5-10.

Van Saun, R.J. (2003). Feeding the Alpaca (Vicugna pacos). In: Hoffman, E., ed., The Complete Alpaca Book, 2nd ed., Bonny Doon Press: Santa Cruz, CA.

Van Saun, R.J. (2006a). Nutrient requirements of South American camelids: A factorial approach. Small Ruminant Research 61(2-3):165-186.

Van Saun, R.J. (2006b). Nutritional diseases of South American camelids. Small Ruminant Research 61(2-3):153-164.

Breeding programs – Review of approaches in Australia

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Abstract
This paper discusses the range of genetic breeding programs which are available to Australian livestock industries. It presents a short history of genetic evaluation schemes and discusses the Australian Dairy Herd Improvement Scheme, BREEDPLAN for Beef Cattle, PIGBLUP, KIDPLAN, and the newly created Sheep Genetics Australia which combines wool and meat into one database. The paper concludes with an update on the Alpaca Across-Herd Genetic Evaluation (AGE) program and presents data on the traits measured to date.

Keywords
Genetics, BREEDPLAN, Australian Dairy Herd Improvement Scheme, PIGBLUP, KIDPLAN, AGE

Introduction
The major decision in any breeding program is to select which animals should be retained within the herd for breeding and to which sire or dam they should be mated. Historically such selection has been based on the visual assessment of the animal. In the mid twentieth century, breeding programs based on objectively selecting of animals based on measured traits was developed which have evolved into breeding programs based on genetic evaluation of these measured traits.

Phenotype and genotype are two commonly used terms in genetics and animal breeding. The physical appearance, what we see or measure is referred to as the phenotype of the animal whereas its genetic makeup is referred to as its genotype (Ponzoni 1993). Ponzoni (1993) and Tuckwell presented two papers at the 1993 AAA conference which provide a good background for the use of objective selection in alpacas. These papers covered the principles involved and how they may be applied.

The heritability of a trait is the proportion of phenotypic variation in a population that is attributable to genetic variation among individuals. Nicholas (1987) provides a table showing the heritabilities for most domestic animals and also is a reference on the use of breeding programs based on quantitative genetics.

This paper will discuss the genetic breeding programs for most of the livestock industries in Australia with particular emphasis on sheep breeding due to its emphasis on fibre production and its similarity to breeding Alpacas.

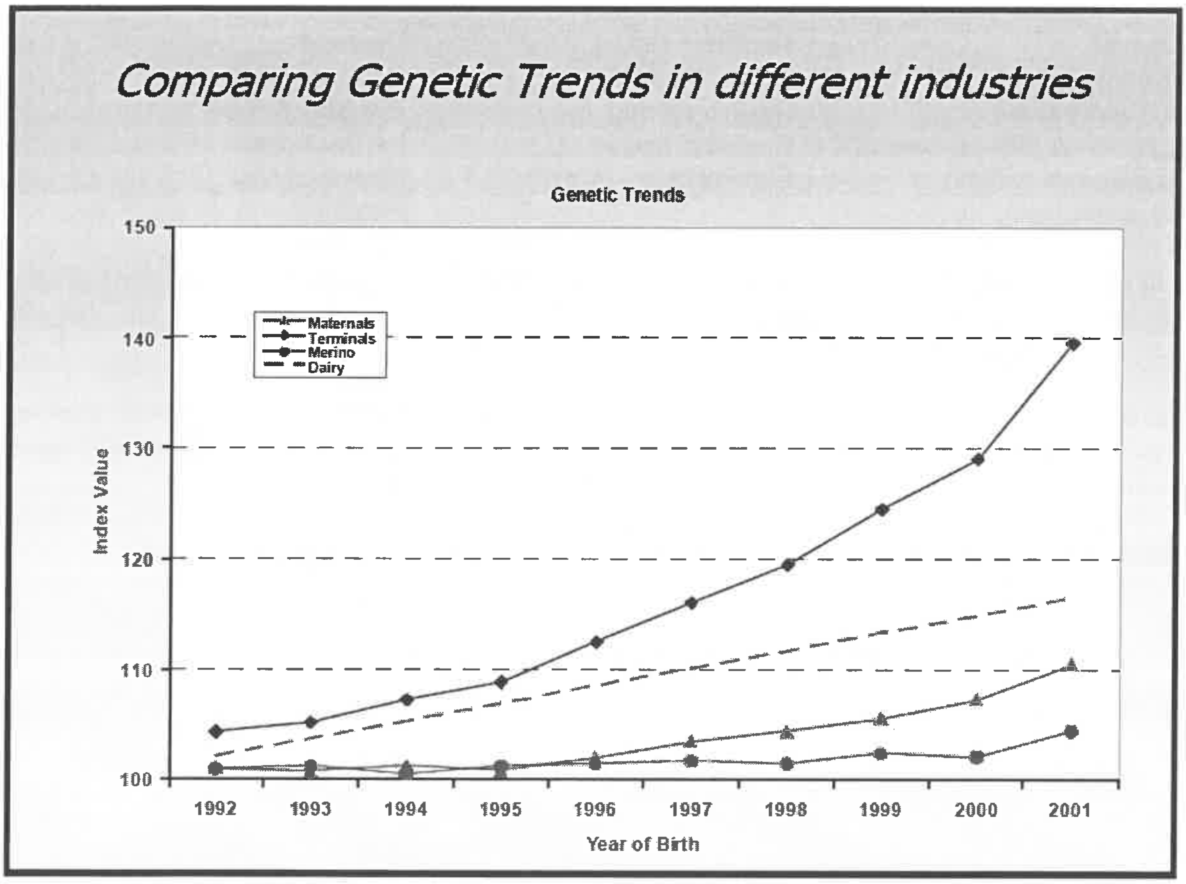
Breeding Programs
In commencing a breeding program there are two question which need to be answered before it can be commenced, these are; *Where should you aim*? and *How can you get there*? These questions will determine what the breeding program needs to be to answer these questions. For Alpacas this would require knowing where you want to be for Fibre Diameter (FD), Fleeceweight, Lustre, crimp, length, CV of FD, bodyweight, follicles per cm^2 and many more. Quantitative genetics allows the breeding objective to be achieved. Kinghorn et al (1991) summarises the breeding and selection options which are able to be used in sheep breeding.

Performance recording schemes was often the first step towards objective breeding programs which measured a character for selection, for example fleeceweight. However these schemes were really only assessing the phenotypic expression of the trait without any adjustment for age, dam age, birth type, sibling performance, sire or environment.

The development of computer technology has allowed Performance Recording Schemes to become true genetic evaluation schemes as the genetic merit of an animal can be calculated based not only on its own performance but also its relatives (sire, dam and siblings) whilst adjustment is made for environmental affects.

Most Genetic services are able to combine a number of traits into a single Index or Breeding Objective to assist breeders select animals.

The following graph shows the genetic trends which have been achieved across different industries over the period 192-2002.



From Werf (2004)

Industry Genetic Performance Schemes

Dairy Cattle

The dairy industry was one of the first to adopt performance recording schemes and the Australian Dairy Herd Improvement Scheme (ADHIS) is managed by the Australian Dairy Farmers Federation. Benefits from its operations flow through to all dairy farmers and through productivity improvement the entire community profits from this farmer managed operation. The A.D.H.I.S commenced in 1982 as a national genetic evaluation program (Jeffries 1991).

The ADHIS database contains records of about 8 million cows and 100,000 bulls dating from the 1970's. Since the inception of ABVs, genetic merit has increased by about 0.75% per year and accounted for about 30% of production gains.

The dairy industry almost exclusively uses semen for artificial insemination from bulls identified with superior production and other traits via the ADHIS. The main traits identified for dairy cows are milk, protein, fat, lactation length and ease of calving whilst the main traits identified for bulls were those identified for cows plus survival, conformation, milking speed, temperament, cell count, liveweight, workability and daughter fertility.

Further information can be found on the ADHIS website at www.adhis.com.au.

Beef Cattle

Performance recording of Australian beef cattle through the National Beef Recording Scheme started in 1972. BREEDPLAN commenced in 1985 as a within herd genetic evaluation scheme and expanded to an across herd evaluation in 1987 (Scheenberger et al 1991).

BREEDPLAN calculates Estimated Breeding Values (EBVs) for a range of traits including;

Weight	**Fertility**	**Carcase**
Birth weight	Scrotal Size	Carcase weight
200-day milk	Days to calving	Eye Muscle area
200, 400 & 600-day weight	Gestation length	Fat thickness
Mature cow weight	Calving ease	Meat Yield %
Feed efficiency		Marbling

Included in the calculation of EBVs are the animals own performance, the performance of known relatives, the heritability of each trait and the relationships between the traits ie; A world class genetic evaluation model, combining all traits in one analysis.

All breeds of beef cattle in Australia use BREEDPLAN. For most, the BREEDPLAN genetic evaluation system has been integrated with the respective breed association's pedigree system. Substantial genetic improvements for traits of commercial importance have been demonstrated.

Further information can be found on the BREEDPLAN website at http://breedplan.une.edu.au.

Pigs

The following information was obtained from the PIGBLUP website.

PIGBLUP is a PC based genetic evaluation system for pig, which analyses large data sets within minutes. PIGBLUP uses pedigree and performance date available from the breeders her recording system to derive EBVs for a number of performance and reproductive traits.

Since 2001, PIGBLUP has been the engine behind the National Pig Improvement program which provides across-herd EBVs for participating herds.

PIGBLUP calculates EBVs for:

Average Daily Gain
Feed Conversion Ratio
Gain in Test Period
Backfat (P2)
Carcase Muscle
Carcase Fat
% Lean Meat
Number Born Alive
21 Day Litter Weight
IGF1 trait (PrimeGRO)

The PIGBLUP system allows genetic and environmental trends to be graphically displayed which can be seen in the following two graphs.

Genetic Trends are an indication of the effectiveness of a breeding program and give valuable information to the user as to the direction in which the breeding program is headed which can be seen in *Figure 1*.

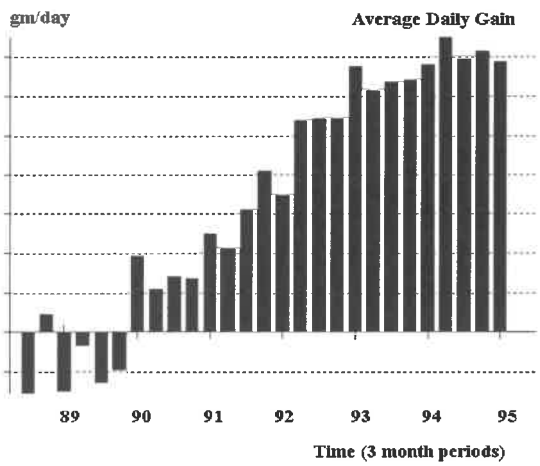


Figure 1: Genetic Trend for ADG (grams/day)

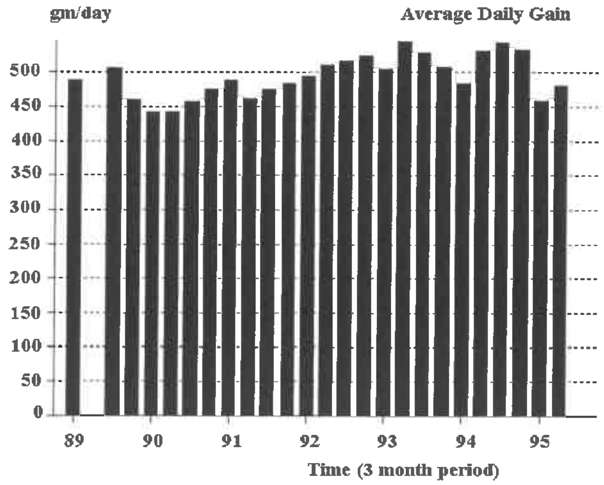


Figure 2: Environmental Trend for ADG (grams/day)

Environmental trends reflect changes in the environmental conditions in which the animals have performed. They also give an indication of the average production level across time. *Figure 2* shows the environmental trend in average daily gain during the same period of time as for the genetic trend in *Figure 1*.

Further information can be found on the PIGBLUP website at http://agbu.une.edu.au/pigs/pigblup/index1.php

Goats

Meat and Livestock Australia have launched KIDPLAN for the Boer and Meat Goat Industry.

By using pedigree and performance information, KIDPLAN provides simple, practical information on the values of an animal's genes for production, in the form of EBVs and specialised indexes.

KIDPLAN currently produces EBVs for a range of production traits including:

Weight
These are produced for the following weight/age classes:
- Birth weight
- Weaning weight (70-140 days of age)
- Maternal weaning weight (a measure of the milk and maternal value of the doe)
- Post-weaning weight (140-280 days of age)
- Yearling weight (280-400 days of age)
- Mature doe weight

Fat Depth
These describe the value of an animal's genes for fat depth at a constant weight.

Eye-Muscle Depth
These describe an animal's genetic merit for eye-muscle depth at constant weight.

Accuracy and Inbreeding
All KIDPLAN reports now come with accuracy and inbreeding levels for goats that have performance information in the KIDPLAN database.

Further information can be found on the PIGBLUP website at www.mla.com.au/kidplan/

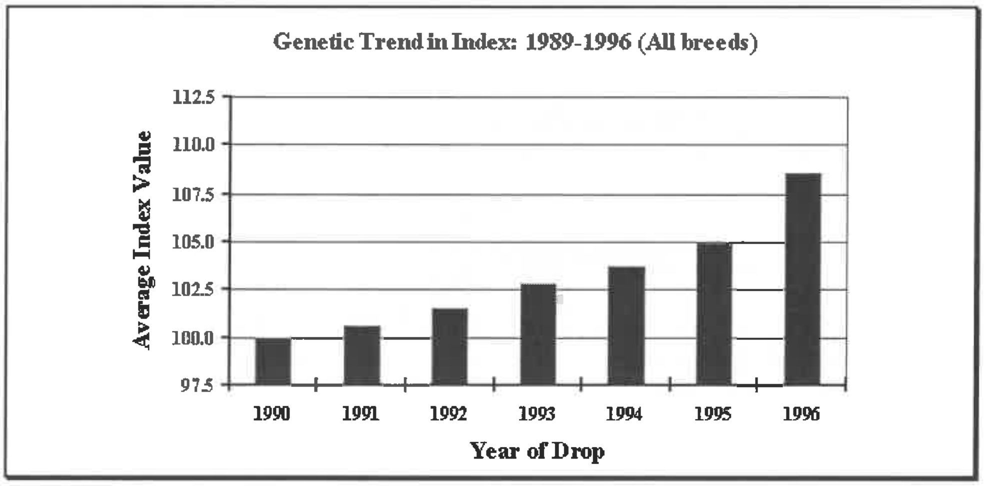
Sheep

When looking at breeding programs within the Australian Sheep Industry it must be remembered that these have traditionally been conducted with an emphasis on fibre or meat. For an analysis of the history of adoption of genetic evaluation and performance recording in the Australian wool sheep industry see Ponzoni (1994) whilst Banks (1995) presents the history of genetic selection via LAMBPLAN within the Australian lamb industry. Safari et al (2005) has recently reviewed the genetic parameters for a range of sheep production traits from estimates published over the period 1995-2005.

Sheep Genetics Australia (SGA) is a database which brings together objective genetic measurements for both wool and meat. SGA is a joint initiative of Australian Wool Innovation (AWI) and Meat and Livestock Australia (MLA).

a. Meat

NSW Agriculture introduced the Meat Sheep Testing Service in 1980 which measured liveweight and then in the mid 80's introduced fat measurement. After a period of evaluating the equipment, a National Performance Recording System was introduced in 1989 and called LAMBPLAN. LAMBPLAN has grown very rapidly in both the level of adoption and in the range and power of information. *Figure 3* demonstrates the genetic gain for the period 1989-1996 for all breeds for flocks using LAMBPLAN.



From Banks (1997)

Figure 3: Genetic improvement ~ increasing the productivity and product quality of Australian lamb.

Over 70% of rams from terminal breeds are bred in flocks which use LAMBPLAN.

b. Wool

Various state Departments of Agriculture operated performance recording services for wool traits from the 1970's. These schemes had a variety of names and initially only measured greasy fleece weight but over time various improvements have been made till now, where many traits are measured and reported with environmental differences being considered in the calculation.

In addition to the above Performance Recording Schemes there have been a number of other programs which have measured genetic merit, two of these were;

i. *Merino Central Test Sire Evaluation*

AWI funded sites across Australia with linkages between sites which allowed all sires to be compared. The results were published in a combined publication – Merino Superior Sires.

ii. Merino Bloodline Performance Package

This package is a tool for commercial Merino woolgrowers who want to identify the best options for their breeding objectives. The analysis takes out all environmental factors between the wether trials and years, allowing the genetic variation between bloodlines to be measured.

c. Sheep Genetics Australia (SGA)

SGA is the recently launched national genetic information and evaluation service for the meat and wool sectors of the sheep industry. SGA will calculate Australian Sheep Breeding Values (ASBVs) which will be delivered via MERINOSELECT and LAMBPLAN, which have been designated for the wool and prime lamb sectors respectively.

MERINOSELECT is for Merino ram breeders and commercial wool producers. It is the new brand name for Merino genetic information combining data from the current Merino schemes into a national system. LAMBPLAN continues as the brand name under which genetic information is delivered to terminal, maternal and dual purpose ram breeders and commercial lambs and sheep producers.

The SGA database will initially have records on around 100 million individual Merino sheep, and a similar number from the terminal and maternal sire breeds which reflects the data from more than 1000 flocks around Australia. This data has been drawn from the Merino Benchmark, LAMBPLAN, CSIRO Select Breeding Services, Merino Genetic Services, Australian Merino Sire Evaluation Association, Central Test Sire Evaluations databases and other independent providers.

There will be a wide range of ABVs reported to breeders and they will be available for the following core traits:

- wool
- growth
- carcase
- reproduction
- internal parasite resistance
- temperament.

Further information can be found on the SGA website at www.sheepgenetics.org.au/

Alpacas

The Alpaca Across-Herd Genetic Evaluation (AGE) commenced in 2004 and is jointly funded by NSW DPI, Rural Industries Research and Development Corporation (RIRDC).

Progress to date

- The first task of the project was to establish BLUP software so that data could be analysed and Alpaca AGE can be performed and reports sent to submitting breeders.
- In collaboration with alpaca breeders focus groups and the AAA AGE Working Party the traits to be evaluated were decided upon.
- AAA AGE Working Party has established the AGE database at ABRI (the major animal performance database provider in Australia). The AGE database was established along side the AAA pedigree database that has been successful managed by ABRI for several years.
- Promotional seminars were completed with seven seminars conducted in 2004 (Qld, NSW x 2, Victoria x 2, SA and WA). An additional seminar was held in NZ and this also acted as a stud breeders training workshop.
- An AGE Booklet has been developed to assist breeders to collect and submit data for analysis.
- A breeders Hands-On workshop was developed in 2005 and ten workshops conducted in 2005 (NSW = 5 (Including pilot), VIC=2, QLD, SA & WA = 1 each) with over 250 breeders having attended the workshops. The primary aim of the workshop was to take breeders through the AGE booklet so that at the end of the workshop they were able to collect and submit data to AGE.

Data Analysis

Three analyses have been conducted to date; February and November 2005, and February 2006.
485 animals from 28 studs were in the first analysis, 726 animals from 43 studs in the second and 1153 progeny from 64 studs were in the third analysis (1961 animals in 3rd analysis). New Zealand studs account for 45% of these studs.

The AGE Working Party has decided that analyses will be run in February, July and November each year.

a. Summary of Phenotypic values

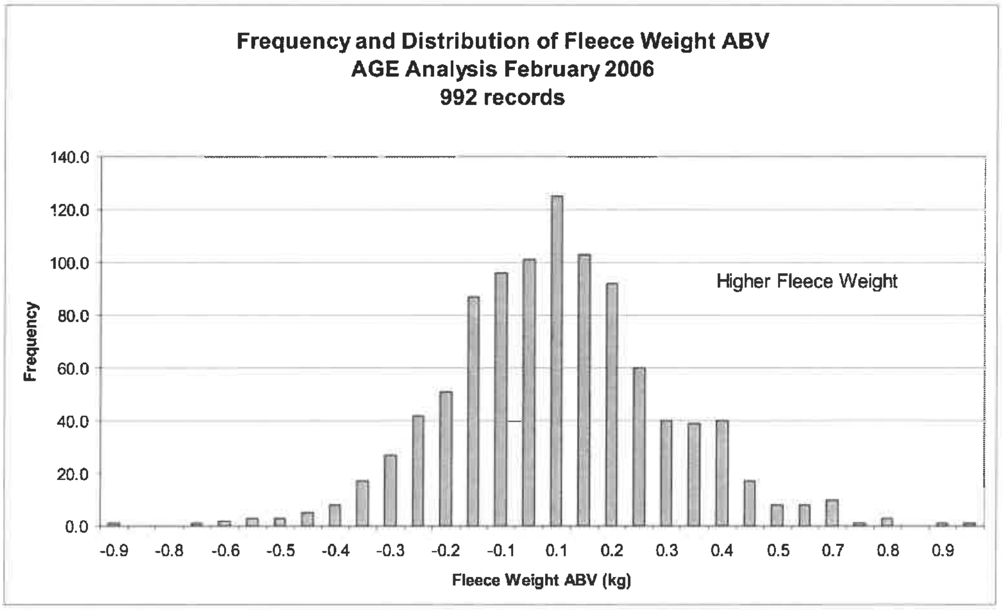
The average phenotypic values for the fibre traits were;

Greasy Fleece Weight	2.7 (kg)
Fibre Diameter	21.8 (µm)
Co-efficient of Variation	21.7 (%)
Bodyweight	50.2 (kg)
Staple Length	110.6 (mm)

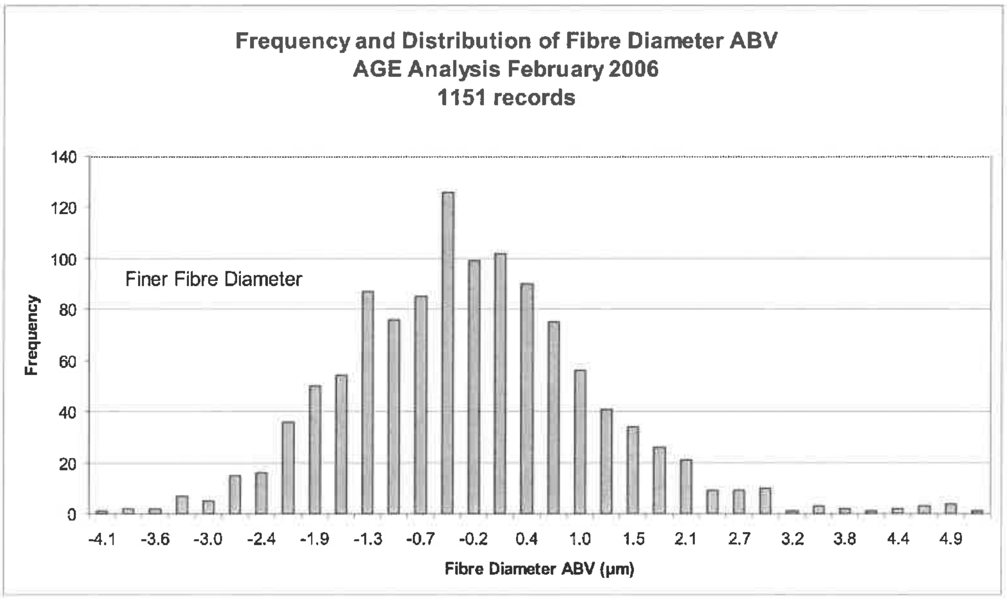
b. Breeding Values

The following graphs show the Alpaca Breeding Values for the above traits;

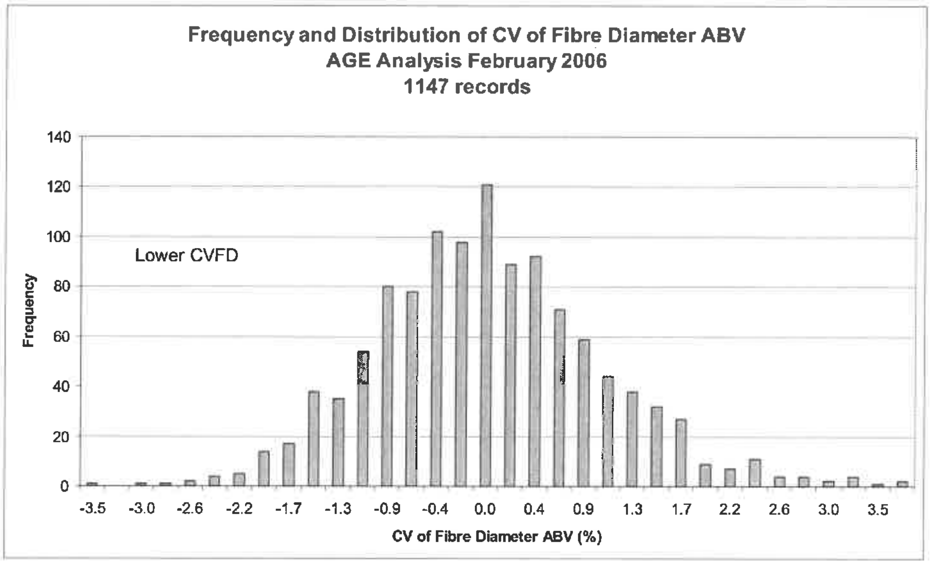
i. Fleeceweight



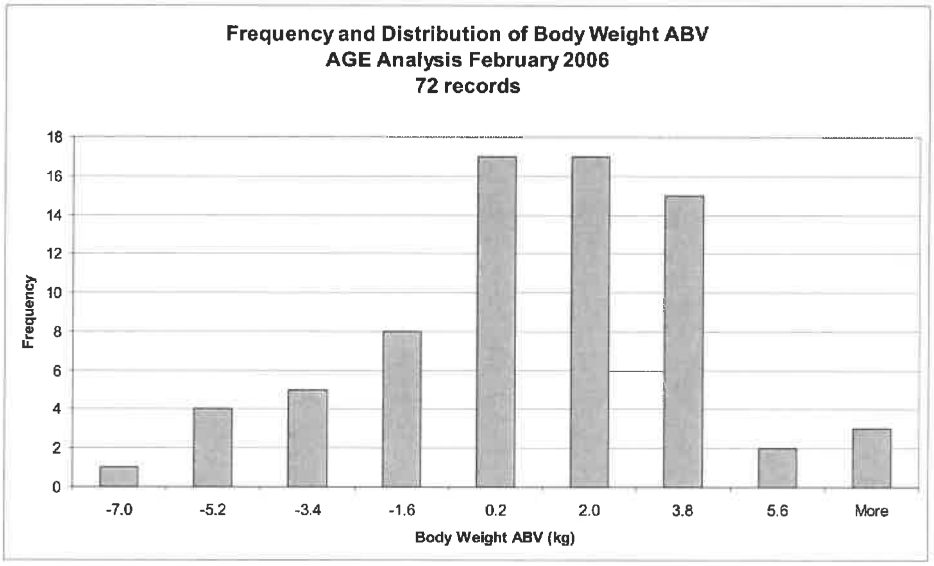
ii. Fibre Diameter



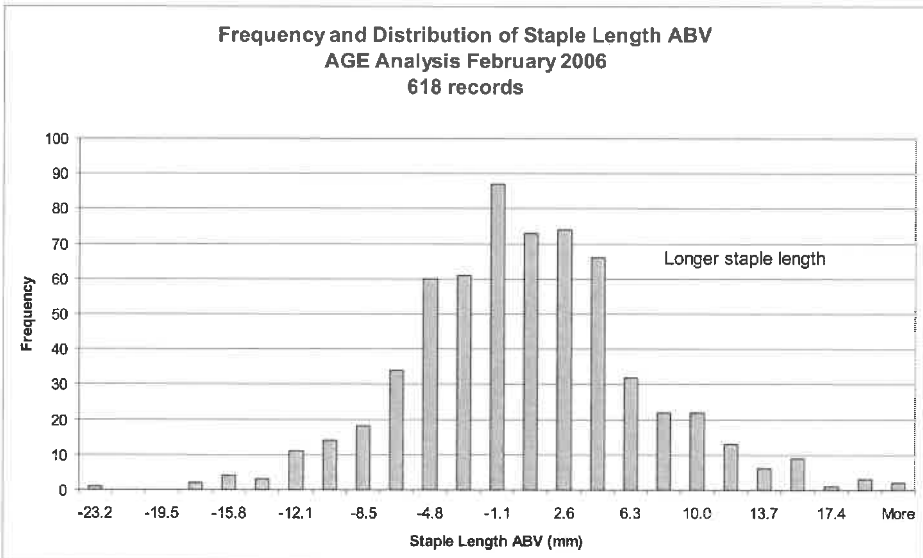
iii. CV of FD



iv. Bodyweight



v. Staple length



Conclusion

The Alpaca industry with its AGE program is well placed to make similar genetic gain to the other livestock industries in Australia. Progress gained will depend on breeders adopting and using the technology available to them.

Acknowledgements

Ie would like to acknowledge Johanne Taylor and Jennie Staples who have checked all the data and conducted the analysis for the AGE project.

References

Banks, R. (1995) Better Genetic Technology – Developments in the Australian Lamb Industry. *Proceedings of 11th Conference of the Australian Association of Animal Breeding and Genetics* Adelaide pp48-55

Banks, R. (1997) Genetic Improvement In The Lamb Industry For Increasing Global Competitiveness *Inaugural Lamb Industry Convention, August 1997*

Jeffries, M. (1991) Australian Dairy Herd Improvement Scheme Responding to Industry Needs. *Proceedings of 9th Conference of the Australian Association of Animal Breeding and Genetics* Melbourne pp444-447

Kinghorn, B.P., Rogan, I.M. and Davis,G.P. (1991) Breeding and Selection in *Australian Sheep and Wool Handbook* edit Cottle, D.J. Inkata Press pp 65-84

Nicholas, F.W. (1987) Veterinary Genetics. An Oxford Science Publication Published by Oxford University Press, NY 580pp

Ponzoni, R.W. (1993) Genetic Basis of Alpaca Improvement Programs in *Proceedings Alpaca Industry Seminar*, Roseworthy, SA.

Ponzoni, R.W. (1994)*Proceedings of the World Merino Conference Uruguay*, April 1994

Safari, E., Fogarty, NM. And Gilmore, A.R. (2005) A Review of genetic parameter estimates for wool, growth, meat and production traits in sheep. *Livestock Production Science* 92:271-289

Scheenberger, M., Tier, B. and Hammond, K. (1991) Introducing the third Generation BEEDPLAN and Group BREEDPLAN. *Proceedings of 9th Conference of the Australian Association of Animal Breeding and Genetics* Melbourne pp194-199

Tuckwell, C. (1993) The Application of Genetic Principles in the Selection of Alpacas for Breeding in *Proceedings Alpaca Industry Seminar*, Roseworthy, SA.

Werf van Der, J. (2004) Genetic Improvement in the Australian Dairy Industry *Vision 2004 Conference* organised by the Australian Dairy Herd Improvement

Mating management and embryo transfer in alpacas

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Abstract
A simple mating protocol for alpacas is described, based on the unique reproductive physiology of South American camelids. Females should be mated at 12 months of age, or 15-20 days post-partum. They should be presented to the male every 7 days thereafter for up to 3 matings to ensure conception occurs as rapidly as possible. Non-surgical, trans-cervical embryo collection and transfer is also described.

Key words
alpaca, reproduction, mating, pregnancy, embryo transfer

Mating strategy for your females
Camelids are often regarded as less fertile than other domestic livestock. This is not true! At least 50 % of matings between fertile machos and hembras result in pregnancy, comparable rates to sheep, cattle and goats. However, there is a tendency for alpaca owners to focus on females that fail to conceive because of their individual value and persevere with attempts to get them pregnant. This is in comparison with other domestic livestock where females that fail to conceive after 3 matings are removed from the gene pool by culling.

A simple mating protocol for alpacas includes:
- First breeding at 12 months of age (maiden) when reached 65 % of estimated mature body weight OR 15-20 days after unpacking if the delivery was straightforward and unassisted.
- Breed once when receptive.
- Spit-off at 7 days to check for ovulation. If receptive, ovulation did not occur and female should be mated again. If non-receptive at 7 days ....
- Spit-off at 14 days to check for pregnancy. If receptive, conception did not occur and female should be mated again. Non-receptivity indicates presence of elevated plasma progesterone and a corpus luteum .... And probably pregnancy.
- Spit-off regularly (every 2-4 weeks) until ultrasound pregnancy test at (30 and) 60 days post-joining to observe foetus and therefore confirm pregnancy status.
- Spit-off intermittently throughout gestation as there is a 5 % chance of foetal loss after 60-days gestation.

A female should be given three rounds of this mating management. Ninety percent of females will conceive. The remaining 10 % of females that fail to conceive should ideally be removed from the breeding pool to maximize fertility in the herd. Veterinary advice may be sought to investigate reasons for conception failure. Ensure dates and findings are recorded to assist with further reproductive investigations.

Reasons behind mating strategy
Understanding the reproductive biology of your females will lead to a better understanding of mating management on your farm.

Puberty
Alpacas do not exhibit clear signs of oestrus, as they are induced ovulators and it is therefore difficult to assess when they attain an age at which conception may occur (Bravo 1994). Evidence of sexual receptivity is based on submission to a male for mating. However, young females may exhibit receptive behaviour yet still be too young to conceive (Smith et al 1994). Ovarian follicular growth is usually initiated as early as 5 to 6 months of age (Bravo 1997). Nutrition is recognised as a major environmental factor that influences the onset of ovarian activity in young females. As a rule-of-thumb, females need to attain approximately 65 % of their mature weight in order to ensure a high likelihood of conception, whilst avoiding stunting and birthing difficulties (Smith et al 1994, Johnson 1989). In Peru, alpacas weighing at least 40 kg at 12 months of age were considered ready to reproduce (Novoa et al 1972). In Australia, this weight should be easily achievable by 12 months. Good nutrition after weaning together with monitoring of live weight and body condition score are essential for continued reproductive success.

Reproductive anatomy

Alpacas have a bicornuate uterus with a single cervix. The body of the uterus is approximately 3 cm long and 3 cm in diameter, and the two uterine horns each about 8 cm long. In alpacas that have had a cria the left uterine horn is usually larger than the right as about 98 % of all pregnancies occur in the left horn (Fernandez-Baca et al 1973). The uterus resembles the letter "Y" and the tips of the uterine horns are blunt and rounded. Each uterine horn terminates in an oviduct which joins the uterine horn to the ovarian bursa. The latter is a membrane that surrounds the ovary and 'captures' the egg (oocyte) at ovulation and directs it into the oviduct for fertilisation if the female has been mated. The ovaries are approximately 1cm x 1cm x 1.5cm (peanut-sized). The cervix is usually 2 cm long and the vagina is relatively long (15 to 20 cm) compared with ruminants of similar size (Sumar et al 1997).

Ovarian activity in the unmated, non-pregnant female

Female alpacas that have reached an age at which conception may occur, but which have not been exposed to a male (i.e. neither mated, nor in close proximity), exhibit regular cycles of ovarian follicular growth which has been described as follicular waves (Vaughan 2001). Follicle waves involve synchronous emergence of several follicles (2 to 3 mm diameter) which grow together to 4 to 5 mm in diameter. By an unknown mechanism, one follicle in the cohort becomes the 'dominant' follicle at an average diameter of 5 to 6 mm and this follicle continues to grow; the other follicles in the cohort undergo regression. The dominant follicle takes about 3 to 6 days to reach its mature size (7 to 12 mm diameter) and can remain at this size for 2 to 8 days. If mating does not occur, the dominant follicle undergoes spontaneous regression over 3 to 6 days and this is associated with emergence of the next follicular wave (Bravo et al 1989, Sumar 1983, Adams et al 1990, Vaughan 2001).

The interval between emergence of successive follicular waves varies from 12 to 22 days in alpacas (Vaughan 2001). New wave emergence interval varies within individual females and among different females. Waves of follicular growth continue in early pregnancy and during subsequent lactation (Adams et al 1990).

Ovarian follicular waves do not necessarily alternate between ovaries and large follicles are equally distributed between ovaries (Bravo et al 1989, Bravo et al 1990b, San-Martin et al 1968). As noted above, a follicular wave emerges as soon as the dominant follicles starts to regress which means that both the regressing and emerging dominant follicles can be visualised on the ovaries at the same time (Bravo et al 1990b).

If females do not have contact with a male, ovarian follicular waves continue and females can show long periods of receptivity (San-Martin et al 1968, England et al 1971). In ruminants, a growing dominant follicle secretes increased amounts of the hormone oestradiol, until it reaches a threshold concentration in blood at which point oestradiol induces oestrous behaviour. This scenario does not operate in alpaca and females are receptive to males throughout different phases of follicular growth, with occasional and intermittent periods of non-receptivity lasting 1 to 2 days as a new follicle wave develops (Johnson 1989, Sumar et al 1993). It appears that behavioural oestrus in females is associated more with the absence in blood of the hormone, progesterone, rather than fluctuations in blood concentrations of oestradiol (Adam et al 1989, Sumar et al 1988b). If a dominant follicle ovulates and forms a corpus luteum it secretes progesterone which is known as the 'hormone of pregnancy'. When females have blood progesterone concentrations of greater than 2 ng/mL they show strong rejection of males by spitting, kicking and running away (Adam et al 1989).

Alpacas are non-seasonal breeders. In South America, females are bred in summer when native pastures are green and plentiful; however, it was shown that ovarian follicular activity occurred throughout the year (Bravo et al 1989).

Mating and ovulation

A sexually receptive female may readily assume the copulation position when approached by a male, get close to a mating couple and adopt the copulation posture, or stand in proximity to a mating couple. Occasionally, some females mount other females (Fernandez-Baca et al 1970d). Copulation takes place in a sitting position and usually lasts 20 to 25 minutes, with a range of 5 to 65 minutes (England et al 1971). In a study of paddock matings, the average duration of copulation in alpaca herds varied based on animal interactions; males in herds without other males averaged 20 minutes compared with 15 minutes in herds with several males. Interruption/short duration of copulation in multi-sire herds was attributed to normal male territorial fighting, since males are vulnerable to attack during mating (Escobar, 1984). Males mating yearling females averaged 15 minutes compared with 22 minutes with multiparous females. During copulation, the male penetrates the cervix with his penis, and deposits semen into both uterine horns (Franco et al 1981).

Matings that occur in the absence of a dominant pre-ovulatory follicle do not induce ovulation, and conceptions do not occur. Matings that occur in the presence of a growing or mature follicle (≥ 6 mm diameter) result in ovulation (Bravo et al 1991b, Sumar et al 1993). Alpacas are known as induced-ovulators because females require coital stimulation for the egg to be released from the dominant follicle on the ovary. It is thought that neural stimuli from the mating process and an ovulation-inducing factor in the semen are transmitted to the brain (hypothalamus) of the female where they induce the release of gonadotrophin releasing hormone (GnRH). GnRH released from the base of the brain stimulates the anterior pituitary gland to secrete luteinising hormone (LH), which is transported in the blood to the ovaries where it stimulates ovulation of a dominant pre-ovulatory follicle (Fernandez-Baca et al 1970d, Bravo et al 1991b). The leg clasp of the male and his orgling sounds may contribute to neural stimulation of the brain to release GnRH (Bravo 1994).

Ovulation occurs in females approximately 30 hours after mating. Ten to 25 % of females with an 'ovulatory size' follicle on the ovary may fail to ovulate. (San-Martin et al 1968, Sumar 1985, Sumar et al 1993). With regard to the latter group of females, it was not established whether the 'ovulatory size' follicle was in the growing phase, static phase, or regressing phase. It is likely that in the majority of these cases the follicle was in the late-static or early- regressing phase and might not be expected to ovulate. Ovulations occur with equal frequency from both ovaries (Fernandez-Baca et al 1970b, d).

A corpus luteum (CL) develops at the site of ovulation on the ovary 3 to 5 days after mating (2 to 3 days after ovulation) and secretes progesterone. The CL reaches a maximum size of 10 to 15 mm and maximum progesterone secretion 8 to 9 days after mating. Progesterone secretion by the CL starts to decline about 9 to 11 days after mating. If conception does not occur, prostaglandin is released from the uterus and induces regression (luteolysis) of the CL (Fernandez-Baca et al 1970c, Adams et al 1989, Adams et al 1990, Adam et al 1992, Sumar et al 1991). Females return to sexual receptivity approximately 14 days after mating if a corpus luteum develops but conception does not occur.

Females not completely deprived of visual, auditory and olfactory stimuli from a male can also ovulate. Spontaneous ovulation without coital stimulation or direct male influence can occur in 5 to 15% of females; however, many recorded cases included some form of male contact (England et al 1969; Bravo et al 1989). Multiple ovulations occur in up to 10 % of natural matings (Fernandez-Baca 1993).

Pregnancy

The CL is the major source of progesterone throughout pregnancy and its presence is required to maintain pregnancy (Sumar 1988). Removal of the CL results in termination of pregnancy within 24 hours (Bravo 1994). Removal of the embryo induces CL regression 4 to 7 days later (Adam et al 1992). In pregnant females, a transient decline in blood concentration of progesterone occurs from Day 8 to 12 after mating, which coincides with the period of maternal recognition of pregnancy. The embryonic signal for maternal recognition of pregnancy must be transmitted as early as Day 10 after mating in order to 'rescue' the CL of pregnancy (Aba et al 1997). Thereafter, progesterone concentrations in blood increase and the diameter of the CL reaches a maximum of 10 to 19 mm around Day 21 of pregnancy (Adams et al 1991, Bravo et al 1993b). In alpacas, 98 % of pregnancies occur in the left uterine horn, even though the CL of pregnancy is found equally on the left or right ovary (Fernandez-Baca et al 1973, 1979). Therefore, embryos derived from ovulation of the right ovary migrate into the left uterine horn. Gestation length varies from 330 to 350 days and is usually longer in spring than autumn.

Early embryonic death is common in alpacas and in Australia, about 10 % of embryos (up to 50 % in other countries) may be lost in the first 60 days of pregnancy (Fernandez-Baca et al 1970b, Adams et al 1991, Adams 1997). Factors responsible for this high attrition rate are unknown but nutritional constraints, hormonal imbalance or chromosomal aberrations may be principle causes (Sumar et al 1997). Certification of pregnancy by a veterinarian should be performed about 2 months after the last known mating date.

Receptivity After Unpacking

The interval from parturition to resumption of ovarian follicular activity is about 5-7 days in South American camelids and females can be ready to ovulate by 10 days post-partum. The uterus only takes about 20 days to involute, probably because of the diffuse (microcotyledonary) nature of placentation.

Some owners have described difficulties in getting some females pregnant again if mated later than 3 or 4 weeks post-partum. These females generally conceive easily once their cria has been weaned. Explanations for this observation include:

- Females of other species of domestic livestock produce certain hormones during lactation that may reduce/inhibit ovarian function. This may also occur in camelids.
- Females reach peak lactation approximately 4 weeks post-partum. Lactation is the most metabolically demanding time for alpacas, and nutrients are diverted preferentially to the udder, possibly to the detriment of ovarian function.

Embryo transfer in alpacas

The reproductive physiology of alpacas differs to that of other domestic livestock and remains poorly understood, therefore hindering the direct transfer of artificial insemination (AI) and embryo transfer (ET) technologies from ruminants to alpacas. Generation intervals are relatively long in alpacas because males are slow to sexually mature and females exhibit an extended gestation (11.5 months), so conventional breeding results in slow genetic gain. The development of embryo transfer in alpacas in Australia is increasing the use of genetically superior animals.

Embryo transfer can rapidly increase numbers of crias born to superior females. For example, it is possible to transfer the genes from the top 10 % of an alpaca herd (donors) into the bottom 90 % of females (recipients). Embryo transfer also allows breeders to determine optimal male/female combinations as multiple sires may be used over the same female in one year. Embryo transfer will give smaller breeders access to elite genes through purchase of embryos and will allow for inter-farm/state/national movement of superior genetics.

Single ovulation versus multiple ovulation

Single-ovulation embryo transfer of alpacas does not require any hormonal treatment of donor females (Taylor *et al.* 2000). Donor females are mated once and flushed a week later. Follicle growth in the first 10 days after new wave emergence is consistent regardless of subsequent interwave interval (Vaughan *et al.* 2004), an observation integral to the success of single-embryo flushing of donor females every 10-12 days. More than 180 live births (50 % males, 50 % females) have occurred over the last 4 years in Australia, following single-embryo flushing performed by the author and Dr David Hopkins in numerous commercial alpaca herds. Donor females have since given birth to crias from matings performed soon after embryo flushing, indicating donor fertility was not interfered with during embryo collection.

Methods of multiple ovulation and embryo transfer (MOET or 'superovulation') are also being examined in alpacas in Australia and other countries. Both equine chorionic gonadotrophin and follicle stimulating hormone are currently being tested as agents to stimulate multiple ovulation. Techniques are producing an average of 3 embryos per flush (up to 21 embryos per individual) on most farms. Results have been less reliable on a some farms, presumably due to variations in alpaca fertility, nutrition, environment and management. The number of studies on MOET in camelids remains low and further refinement of existing protocols is continuing, to identify a MOET program that consistently yields an acceptable number of transferable embryos, and is associated with minimal risk of infertility to the elite donor female. Embryos have been yielded on many consecutive MOET programs in the last three years, without apparent effect on donor fertility as donor females have readily conceived within 2-4 weeks after their last MOET flush.

Preparation of donors and recipients

Females that are to be used as **donors** need to be reproductively sound (owners must resist the temptation of preparing females that have been difficult to get pregnant in the past), of superior genetic quality, have good conformation, and be free of all known inherited genetic disorders. Females that are to be used as embryo **recipients** must also be reproductively sound in order to optimise the chances of successful embryo implantation and birth of a cria. Demonstrated good mothering ability is an advantage. Females with physical and/or genetic abnormalities (carpal valgus, luxating patellae, fused toes, extra toes, wry face) can be used as recipients since these characteristics will not be transferred to the embryo and gestating foetus.

Attention to detail and thorough preparation of donor and recipient females and males is essential for successful embryo transfer. Four factors appear to be important for *all* alpacas participating in an ET program: normal fertility, body condition score 2.5 to 3 (out of 5), appropriate nutrition and selenium supplementation.

Embryo development in camelids
The embryos of camelids develop faster than in domestic ruminants and morulae have been recovered in the oviducts of llamas as early as 3 days after mating. The faster rate of embryo development in camelids is likely related to early maternal recognition of pregnancy, which needs to occur around Day 8 to 10 after mating to ensure persistence of the corpus luteum of pregnancy (Aba *et al.* 1997; Del Campo *et al.* 1995).
A week after mating, embryos have migrated to the uterus and are usually in the form of a hatched blastocyst. At this point, embryos are flushed from donor females. Ninety percent of embryos recovered between 6.0 and 7.5 days after ovulation had hatched from the zona pellucida, the protective coat around the outside of the oocyte and early embryo (Del Campo 1997; Bourke *et al.* 1992). The zona pellucida is protective to embryos during freezing and thawing procedures of cattle and sheep embryos.

Non-surgical, trans-cervical collection and transfer of embryos
This method involves the introduction of a Foley catheter through the cervix and placement of the catheter in the uterus. Medium is flushed through the catheter into the uterus, then allowed to drain, via gravity, into an embryo collection vessel. This method is relatively non-invasive and does not have the attendant risks of abdominal adhesions associated with surgical embryo collection. However, females with a narrow pelvis or excessive fat in their pelvis may not be suitable for non-surgical collection and there is also a risk of rectal trauma with this procedure. The author uses the non-surgical method of embryo collection from alpacas and llamas.

The retrieved fluid is examined under a dissecting microscope for embryos. After collection and washing, single embryos are loaded into small plastic straws similar to those used for artificial insemination and then placed transcervically (non-surgically) into the uterus of the recipient female. Pregnancy diagnosis using transrectal ultrasonography can be performed from approximately Day 25 after embryo transfer to assess pregnancy (Parraguez *et al.* 1997).

Future developments include the continued refinement of multiple ovulation protocols and the freezing of embryos to allow indefinite storage and easy transport of genetic material. Pregnancies have been achieved in camels (Skidmore *et al.* 2004) and llamas (Skidmore *et al.* 2004; Aller *et al.* 2002) following vitrification, thawing and transfer of embryos, but this success has not yet been translated to alpacas.

References
Available on request.

The continued development of artificial insemination technologies in alpacas

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Abstract

Artificial insemination is a tool which is widely used in animal breeding programs. At present the technology is not well developed in camelid species, but there is considerable interest in its application. Previous research aimed at improvement of artificial insemination (AI) in alpacas has had limited success owing to the vastly different reproductive physiology of camelids compared with other domestic species. Factors such as mating length and semen characteristics, particularly the low volume, low sperm concentration and viscous seminal plasma, have precluded the development of viable insemination and semen preservation methods. The Rural Industries Research and Development Council (RIRDC) has funded research into the development of AI in alpacas. This paper will discuss the importance of AI and our plans to improve this technology, including results from experiments where applicable.

Key Words

Artificial insemination, spermatozoa, cryopreservation

Introduction

The first successful attempt at artificial insemination (AI) was conducted in 1776 by Italian physiologist Spallanzani who inseminated a bitch producing three pups. The first lamb born in Australia from AI was in 1936 (Gunn 1936). Both the puppies and lamb were born from AI with fresh semen; since these early attempts there has been considerable effort in the development of semen preservation and AI technology. At present, fresh, chilled and frozen-thawed semen is used extensively for AI in animal breeding and production in Australia and throughout the world.

AI is available for most domestic animal species and some wildlife/companion animals. Breeders have the choice of inseminating females at a natural or synchronised oestrus with fresh, chilled and frozen-thawed semen. Fresh semen is normally extended (to increase the number of AI 'doses') and then inseminated within 1 - 3 hours of collection. Chilled semen is normally extended, cooled to 21, 15, or 4 °C (depending on the species) and kept for 1 – 7 days at this temperature prior to insemination. For freezing, semen is diluted with a cryodiluent (designed specifically to protect sperm during freezing and thawing), frozen and stored in liquid nitrogen until required. Frozen semen is then thawed and inseminated.

The type of oestrus and semen utilised are determined by the species, conditions and the breeder's preference. In species such as cattle and pigs where oestrus detection is easy and fairly reliable a natural oestrus may suffice. However for species such as alpacas who are induced ovulators, a synchronised oestrus would be more appropriate. The type of semen used also depends on the species. Ram and bull sperm are easy to freeze and are relatively tolerant of the freeze-thawing procedure; therefore sheep and cattle AI is based mainly on frozen-thawed sperm. Conversely, boar sperm is not as tolerant to freezing and thawing but remains viable for up to a week when chilled to 15 °C; thus the pig industry is based on AI with chilled semen.

Regardless of the type of AI performed there are a number of benefits including (modified from Evans and Maxwell, 1987):

- ***Increased rate of genetic gain*** - By rapid dissemination of desirable genetics as AI increases the number of offspring an elite male produces
- ***Easy transport of genetic material*** – It is cheaper to transport (or import) semen than the whole animal.
- ***Long-term storage of semen*** – Semen banks can be established and if frozen, semen can be used long after the death of a male.

- ***Increased efficiency of breeding*** – Subfertile males can be rapidly identified and eliminated from breeding programs.
- ***Reduction of elimination of the need to maintain males of farm*** – The cost and inconvenience of maintaining males is eliminated which is of benefit to small producers.
- ***Prevention and control of disease*** – AI eliminates male-female contact and therefore controls/prevents the spread of venereal and other diseases.
- ***Use of incapacitated males*** – Males can become injured/infirm which prevents them from mating females. However, AI can overcome this and allow his continued use for breeding.
- ***Use of other technology*** – AI is the foundation and allows incorporation of other technologies such as sperm sexing.

While the advantages of AI considerable there are also the potential for some disadvantages:

- ***Potential inbreeding*** – This may occur when the selection intensity is high particularly in small closed herds. Although AI also has the potential to increase the number of unrelated sires used (as frozen semen can be imported).
- ***Inaccurate breeding*** – This can occur when semen samples are not labeled correctly, accidental errors in inseminations may occur etc.
- ***Spread of disease*** - If sires have not been properly tested for venereal disease AI can potentially spread diseases faster than natural mating.
- ***Reduced fertility*** - AI can often result in lower pregnancy rates than natural mating particularly when oestrus is not properly synchronised or semen is handled incorrectly.
- ***Cost*** - There are costs associated with purchasing semen, hormone preparations, skilled labour and equipment.

At present AI technology is not commercially available for any camelid species. There is considerable interest in the development of this technology from camel and alpaca/llama breeders. There are a number of reasons why AI technology has not been developed in camelids. Camelid reproductive physiology is poorly understood and vastly different from that of other domestic, which has prevented the adaptation of existing methods from other domestic animal species. There have been several reviews of the reproductive physiology of male camelids (Brown 2000; Sumar 1996; Tibary and Vaughan, 2006). Rather than re-iterate the information contained in these publications, this paper will focus on the differences in reproductive physiology which are pertinant to the development of semen preservation and AI technology.

The fundamental differences between other domestic animals and alpacas are:

- ***Lower sperm production by camelids*** -
- ***Mating length*** - alpacas also mate for a longer length of time in sternal recumbancy
- ***Ejaculate characteristics*** - low volume, low sperm concentration and high viscosity.

Sperm production is a function of testis size and sperm production per gram of testicular tissue. Comparatively, Llama testes are small, accounting for 0.01 % of body weight, compared with an average of 0.02 – 0.5 % of body weight (Setchell, 1978). Testes size and therefore sperm production rates can be increased to some extent through nutrition. The feeding of lupins to rams increases testes weight independent of body weight, and every extra gram of testes produces 20 x 10^6 sperm per day (Evans and Maxwell 1987). Considerable research is required to elucidate the effects of nutrition on testis size, sperm production and other reproductive parameters.

The problems association with increased mating length in sternal recumbancy have been largely overcome. There have been a considerable number of studies examining the collection of semen from alpacas (reviewed by Vaughan et al., 2003). The majority of these studies have concluded that semen collection with an artificial vagina (AV) fitted inside a wooden mannequin covered in a tanned alpaca hide is the most suitable method. The AV and collecting container are kept warm by wrapping in a small electric blanket.

Ejaculates of low volume/sperm concentration do not pose much of a problem when protocols are established (as would be the case in commercial practice). Commercial ejaculates are diluted with 4 parts extender for every part of semen. However, during the development of semen preservation protocols it is often necessary to perform large experiments (which can detect synergistic effects of two or more factors) and an ejaculate of low volume cannot be split into enough aliquots to conduct such large experiments.

Furthermore, several large experiments are cheaper and faster to perform than numerous small experiments. The concentration of sperm in an ejaculate limits the number of AI doses that can be divided from each ejaculate, which is an important consideration for any AI program. While it is theoretically possible to manipulate the number of sperm a male produces (through nutrition etc) the research has not been conducted in alpacas.

While these factors can all be taken into consideration in commercial practice, the biggest hindrance to the development of semen preservation technology is the mucoid nature of the ejaculate. The viscosity makes semen samples hard to divide into aliquots, smear on slides (to assess integrity and viability) and dilute with extenders (heterogeneous mixing results in poor post-thawing motility). The seminal plasma also interferes with staining of the sperm making assessment of integrity and viability difficult. The viscous nature of the seminal plasma is a result of the presence of mucopolysaccharides (now referred to as glycosaminoglycans; GAGs) which are made up of 95 % long chain polysaccharides and 5 % protein. Histological staining of semen samples at our laboratory has confirmed that GAGs are present in the seminal plasma (unpublished data).

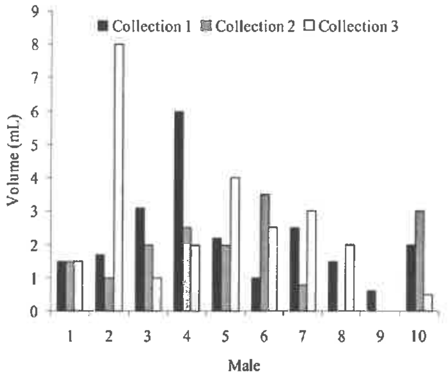
Given these constraints, our approach to the development of semen preservation and AI technology in alpacas was to divide the project into a number of stages (Table 1).

Table 1: The six stages, timeframe and methodologies used to develop semen preservation and AI in alpacas.

Stage	Timeframe	Methodologies
1. Obtaining and training of males for semen collection	July 2005 – January 2006	-Train males to mate with mannequin.
2. Improving the semen collection procedure	January 2006 – July 2006	-Determine the optimal collection procedure by investigating the different AV configurations, the presence of females and an extender during semen collection.
3. Developing protocols for general handling and laboratory assessment of alpaca sperm	January 2006 – July 2006	- Investigate enzymatic and mechanical methods for the removal of seminal plasma viscosity. - Determine the optimal centrifugation speed/time for washing and separation of sperm. - Develop stains for the determination of integrity and viability of alpaca sperm.
4. Developing liquid storage procedures for alpaca sperm	August 2006 – November 2006	-Determine the optimal extender, temperature and dilution rate for the storage of alpaca sperm -Investigate the effects of novel addatives (such as antioxidants) during the chilled storage of alpaca sperm.
5. Developing frozen storage procedures for alpaca sperm	November 2006 – March 2007	Determine the optimal frozen storage of alpaca sperm by investigating the optimal extender, cryoprotectant, freezing rate and packaging. Investigate the use of novel cryoprotectants in the freezing of alpaca sperm.
6. Optimising the artificial insemination procedure in alpacas.	March 2007 – July 2006	Determine optimal artificial insemination procedure by investigating sperm dose and sperm deposition site.

Stage I: Obtaining and training of males for semen collection

Our first step was to approach a number of alpaca breeders to donate males for semen collection. By December 2005, 16 males were housed at The University of Sydney's Animal Reproduction Unit at Cobbitty. After four weeks of training (n= 98 attempted collections), three males show consistent interest in the mannequin and will mate, two others will mate periodically and the remainder demonstrated little or no interest in the mannequin or real females. With continued training, all but one male have been trained to mate with the mannequin. We observed that some males take readily to mating with the mannequin while others require patient training. The latter males were placed in with a real female and allowed to mate. The mannequin was then introduced and slowly, over time, the males accepted the mannequin. During the training period we observed considerable variation between the males in semen volume and sperm concentration (Figure 1a and 1b respectively). This variation between males and within males (ejaculate variation) has been reported previously for alpacas (Vaughan et al., 2003).



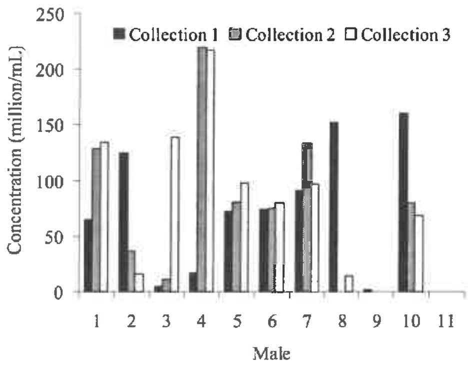


Figure 1a and *Figure 1b:* Variation between ejaculate volume and sperm concentration for three sequential ejaculates collected from 10 male alpacas.

Stage II: Improving the semen collection procedure

In this stage, experiments were devised to investigate the effects of re-designing the mannequin and the AV liners to mimic more closely the female reproductive tract, with the aim of increasing the quality and reducing the variability of collected semen. The specifications of the new mannequin were designed to reflect the external dimensions of live females (n=5), and to result in a posture similar to that at natural mating. The new mannequin also contained additional insulation to ensure that the temperature of the AV did not decrease during the collection process thereby permitting indoor and outdoor collections. The new mannequin was tested at the University's Reproduction Unit. Some males found the mannequin too high and too wide. However, the double insulation helped maintain the temperature of the AV during the collection period. Smaller versions of this mannequin have been constructed and are now used routinely.

Given the length of copulation, and the perceived effect of the design of the AV on the subsequent quality of semen, we decided to re-design the AV liner to include a vagina, cervix and uterus. The length of the liner was also increased from 40 cm to 51 cm and a three-ring cervix was included. Three designs for liners were created. The first was the straight liner used by Dr. Vaughan. The second was similar to the design of the first liner, but with the addition of a cervix. The third liner had a variable diameter and a cervix (Figure 2), taking into account the descriptions and dimensions of the female reproductive tract.

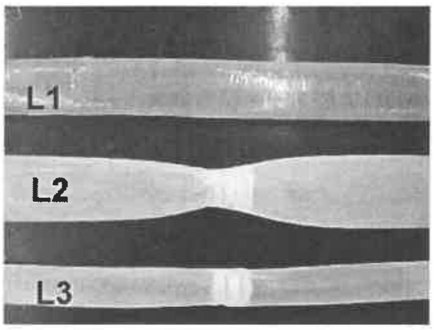


Figure 2: Three AV liner designs tested at The University of Sydney. All liners were made from silicone using an aluminum mould.

Initially liners were made from latex. However, the males would not continue mating with latex liners for more than 1-2 minutes and, in order to avoid any potential problems with the toxicity of latex liners, the decision was made to switch to silicone. To avoid potential toxicity problems owing to residues from the production process, medical grade silicone was used (Prosil 8®; Barnes Products Pty. Ltd.; Bankstown, NSW, Australia) and the liners were produced "in house" at The University of Sydney.

When the collections were made with the first liner (constant diameter, no cervix) the penis could be seen hitting the collection glass. When using the second liner (with the constant diameter and cervix) males appeared to mate without problems but no sperm were found in four of four collections. Males mating with the third liner showed discomfort and retrieved their penises from the AV, suggesting that the cervix did not adequately mimic that of a real female. The decision was then made to re-test the straight liner with a cervix fitted into the AV.

The next experiment was designed to determine the effects of the presence of females during semen collection.

The final experiment in this phase will be to test the benefits or otherwise of including extender in the semen collection container. During mating, which may take up to 20 minutes, the semen is exposed to air and additional oxygen due to frothing in the collection vessel. This is potentially detrimental to sperm survival owing to the development of reactive oxygen species causing lipid peroxidation and membrane damage. There has been some suggestion that the addition of extender, possibly containing antioxidants, to the collection container may improve semen quality and prolong sperm viability.

Stage III: Develop protocols for general handling and laboratory assessment of alpaca semen

Basic laboratory handling procedures and staining protocols are paramount to all experimental work and are not well established for alpaca semen. We have commenced research to determine the appropriate handling medium for alpaca sperm, and to modify protocols for staining alpaca sperm. Our current data suggests that Androhep® (Minitube, Germany) is a suitable medium for the general dilution and handling of alpaca sperm. Androhep is commercially available, cheap ($13 per litre) and has been used at the University for the processing and preservation of sheep, cattle, and pig semen.

Density gradient separation of the motile from the immotile sperm is another fundamental research technique. Camelid sperm do not progress through the standard 94/45 % Percoll®/ Puresperm® gradients, and we have determined that a 45/22.5% gradient is suitable for the separation of motile and immotile alpaca sperm. Further research is continuing to determine the optimal speed and time required for centrifugation of alpaca sperm.

Previous studies have used non-fluorescent stains (such as Hancock's stain) to examine sperm membrane integrity. FITC-PNA staining protocols (used to examine sperm membrane integrity) are currently being modified for use with alpaca sperm. Preliminary data suggests that the gelatinous seminal plasma interferes with the penetration of the stain into the sperm membranes. However, this stain is well suited to epididymal sperm. The determination of membrane integrity in ejaculated sperm is done using a Giemsa stain which is not affected by the presence of the seminal plasma.

The first of our viscosity removal experiments has been completed. The experiment investigated the addition of three enzymes (papain, trypsin and collagenase) at four concentrations (0.5, 1.0, 2.0 and 4.0 mg/ml) to the ejaculated semen. The motility of sperm after the addition of papain, collagenase and trypsin at four concentrations are presented in *Figure 3*. All enzymes reduced the viscosity of the seminal plasma. However, collagenase killed all sperm within 5 minutes of addition. Importantly, for the other enzymes, the sperm displayed strong forward progressive motility, rather than the usual oscillatory motility, within 2 -3 minutes of their addition.

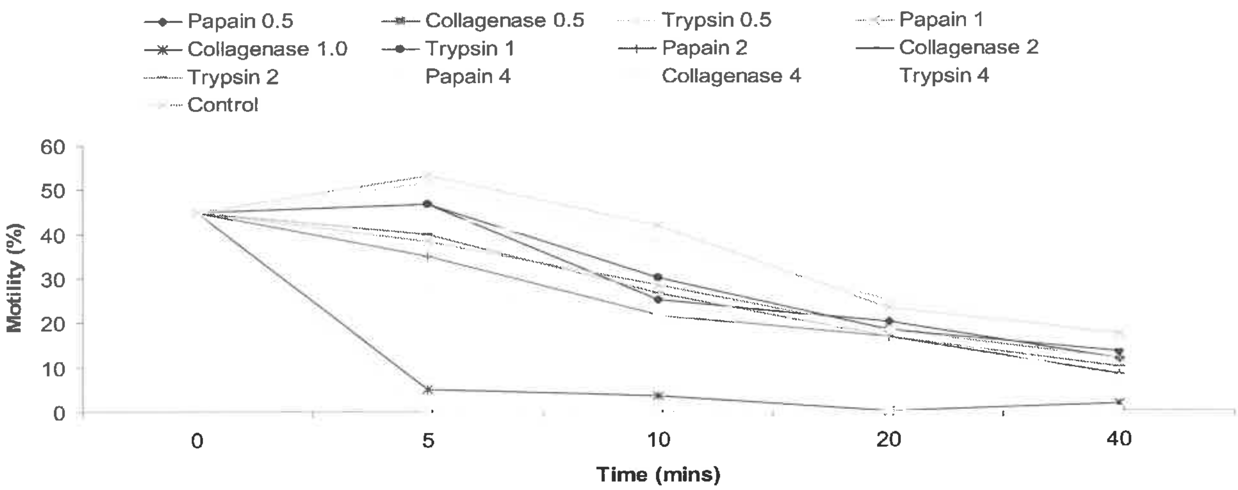


Figure 3: Motility of alpaca sperm 5, 10, 20 and 40 minutes after the addition of papain, trypsin and collagenase at 0.5, 1.0, 2.0 and 4.0 mg/mL.

Motility of sperm for all treatments (including the control) declined over time, as would be expected. The results of this experiment are particularly promising, as they provide a means of removing the gelatinous nature of the ejaculate while maintaining sperm motility. In the near future we will also be investigating several mechanical techniques such as centrifugation, spinning and passing semen through a needle for the removal of viscosity.

Stage IV: Develop protocols for liquid storage of alpaca semen

Several liquid storage experiments are planned to investigate the benefits of different diluents, storage temperatures, dilution rates, gaseous atmospheres and novel additives such as antioxidants. We have an experiment planned which will begin in a few weeks to compare five diluents as potential storage media (Androhep, Triladyl, Biladyl, Salamon's buffer and a lactose-based extender) and two different storage temperatures (4 and 15 °C).

Our preliminary data suggests that the transport of alpaca sperm in the seminal plasma at 37 °C is detrimental to their survival (0 % motile four hours post-collection). Transport at room temperature produced slightly better results (10 % motility at 12 hours post-collection) and dilution of alpaca sperm with Androhep® and storage at 15 °C increased longevity to around 24 hours.

Stage V: Develop protocols for frozen storage of alpaca semen

Several experiments will be conducted using both ejaculated and epididymal sperm to determine the optimal diluent (extender), cryoprotectant, freezing rate, and packaging for freezing alpaca sperm.

Epididymal sperm respond to freezing and thawing in the same manner as ejaculated sperm but they are not entrapped within the seminal plasma. For this reason they are an ideal model for ejaculated alpaca sperm. Before using epididymal sperm, we established a method of transporting the testes which would allow the sperm to remain viable. A number of trials were conducted using camel and alpaca testes and we now have a method that allows the recovery of sperm that are 60% motile 24 hours after castration.

A number of freezing experiments have been conducted using epididymal sperm. In the first experiment three freezing diluents were compared. Both the citrate and lactose diluents have been used previously for the freezing of alpaca and camel sperm, respectively. The Salamon's buffer is a Tris-based medium which is widely used for the freezing of ram semen. Best survival before freezing and post-thaw was obtained for sperm frozen in the lactose medium (*Figure 4*).

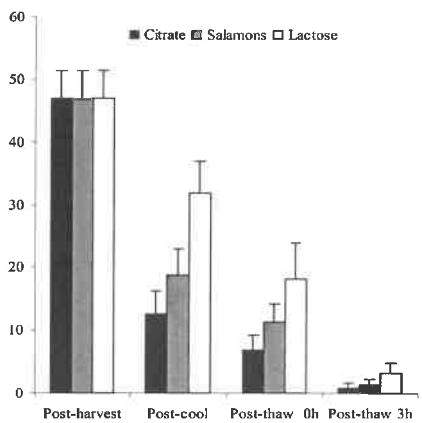


Figure 4: Motility of epididymal sperm at post-harvest, post-cool, post-thaw (0 h) and post-thaw (3h) after dilution in a citrate, Salamon's buffer or lactose diluent.

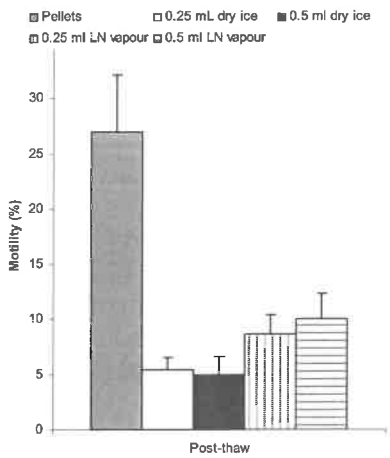


Figure 5: Motility of epididymal sperm post-thaw, after freezing in pellets, 0.25 or 0.5 mL straws on dry ice or over liquid nitrogen vapour.

For importing and exporting sperm straws are required. However for sperm to be used within Australia freezing in pellets is permitted. In a second experiment with epididymal sperm, the freezing of sperm in pellets or straws was investigated. By far the best post-thaw recovery of sperm was obtained after freezing in pellets (*Figure 5*).

The results from our experiments so far have demonstrated that epididymal sperm can be transported to for 24 h prior to freezing and still yield sperm which are 30 % motile after thawing.

Conclusion

Camelids have a vastly different reproductive physiology from other domestic and wildlife species. This precludes the adaptation of existing reproductive technologies to alpacas and other camelids. While the development of artificial reproductive technologies is underway in alpacas and there has been success in the preliminary development of a number of procedures, there is still considerable future research required before these technologies can be applied to full commercial AI and semen storage.

References

Brown BW (2000). A review of reproduction in South American Camelids. Animal Reproduction Science 58, 169-195.
Evans G, and Maxwell WMC (1987). Salamon's Artificial Insemination of Sheep and Goats. Butterworths, Sydney.
Gunn RMC (1936). Fertility in sheep. Artificial production of seminal ejaculation and the characters of the spermatozoa contained therein. Aust. CSIRO Bull. 94.
Setchel BP (1978). The Mammalian Testis. Elek Books Limited, London, UK.
Sumar JB (1996). Reproduction in llamas and alpacas. Animal Reproduction Science 42, 405-415.
Tibary A and Vaughan J (2006). Reproductive physiology and infertility in male South American camelids: A review and clinical observations. Small Ruminant Research 61, 283-298.
Vaughan J, Galloway D, and Hopkins D (2003). Artificial insemination in Alpacas (*Lama pacos*). Rural Industries Research and Development Corporation (RIRDC), Kingston, ACT.

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1. the most important thing to an alpaca is to feel safe;
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3. when alpacas run or otherwise behave instictively they do not think as well as when they feel safe and secure and can even be dangerously out of control;
4. the way people behave around alpacas can either make them feel safe or make them feel very nervous;
5. doing nothing except watching an alpaca, then moving slowly or trapping it are all behaviours that mimic stalking and push your alpaca's panic button;
6. allowing your alpaca to have a strucured area in which to move (a training pen), then entering the training pen with a plan in mind to structure the movement rather than stopping it will settle a nervous alpaca and encourage him to think and to stop.

Organising the movement in the training pen (or catch pen) keeps your alpaca calm and puts you in charge in a lowkey, non aggressive way. Trying to stop the movement physically or simply following along with whatever your alpaca does, unnerves your alpaca and sends the message that he/she gets to set the agenda. Alpacas are much happier when you lead the "dance" and you have to know how to dance or it feels terrible to try and follow.

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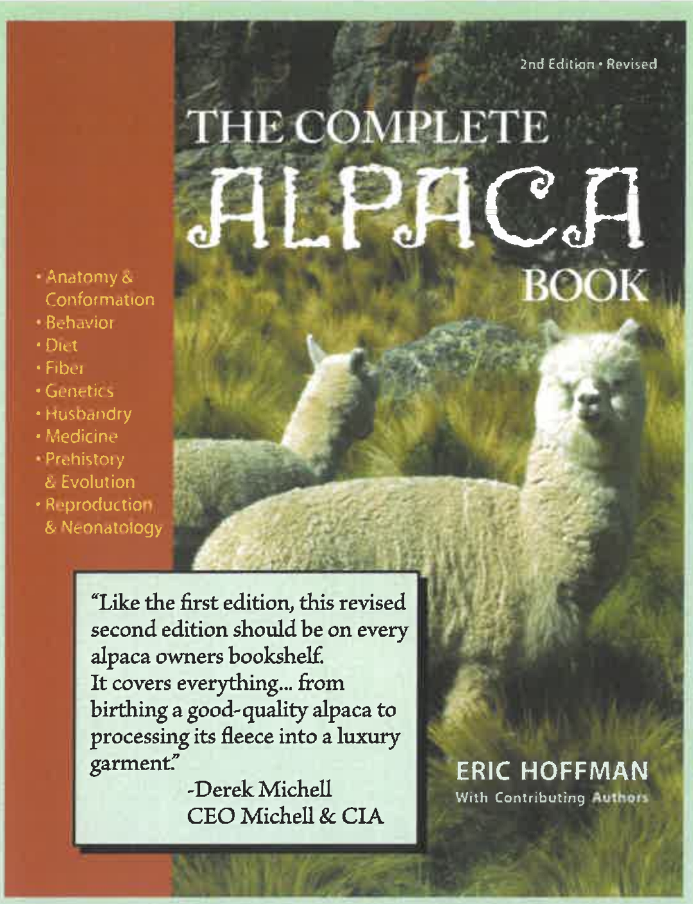
ALPACA HANDLING NOTES



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Alpaca, marketing, image, competition, implementation, strategy, niche.

Introduction
Marketing a business is an essential part of ensuring its ongoing success. It enables the owners of the business to communicate to, attract and retain clients. Marketing also allows the principals to differentiate themselves in an often-crowded market place. This applies to your alpaca farm business as well. This paper will explain the steps involved in developing a simple but effective marketing strategy for your business with particular emphasis on a niche marketing approach.

Why market?
As an alpaca breeder there is no necessity to market you alpacas or your alpaca farm. But this relegates your alpacas to expensive pets – though very cute.

Most breeders will see that effective marketing will impact their sales and contribute to the ongoing success of the wider alpaca industry.

Before looking at the process to develop a strategic marketing plan it is worthwhile to understand what is marketing in context of the alpaca industry.

What is marketing?
Marketing is the development of image / brand / product awareness through the use of media, presentations and displays. Marketing creates the environment in which you can sell.

With effective marketing, sales will follow. It is important to understand that marketing and sales are quite separate. Sales technique is a different issue all together to marketing.

Developing a Strategic Marketing Plan
The process to develop a strategic marketing plan follows a number of steps. As you work through these steps and clarify your vision for your alpaca business you should document your plan.

The steps involved in developing a marketing plan are:

- *Definition* - Define your farm's aims and product mix: speciality, niche
- *Image* - What will the "look" be for all marketing material?
- *Competition* - Understand the competition in your area of focus.
- *Spreading the message* - Develop options on how to get your message out.
- *Costs* - Establish the costs of the various options.
- *Implementation* - Map out what and when marketing activities will occur.
- *Measurement and review* – It is important to measure the success of your marketing activities and update your marketing strategy based on results, costs, competition and change of focus.

Let's look at each of these steps in a little more detail.

Definition

Before you do any marketing and spend any money, you need to define your point of difference.

- Why will people come to your farm?
- What is it you are offering?
- What is your product?

In developing your overall business strategy, a niche marketing strategy is worth considering. This is where you look at the market, your breeding objectives and establish a niche that you can command or dominate. This is far better than being a "me too" or a generalist. When you decide on your niche you may decide to modify your breeding objectives. Also, your breeding results may force you to modify your marketing niche.

Don't try to be something you are not.

Think - who is your target market? Who will want to buy and to whom do you want to sell? Market you business in areas in which you are comfortable and where you may have an advantage.

Some characteristics that can shape your niche are:

- Fleece type - suri, huacaya, crosses
- Colour – white, fawns, blacks, multi colours
- Quality – elite, quality, value for money, pet
- Clients – new breeders, existing breeders, export
- Source of stock – import, reseller, agent, breeder
- Scope of enterprise – animals, product, tourism, stud matings

Lets look at some examples of niches.

- A breeder of white and fawn suri, selling elite stock to existing and new breeders, while offering a range of imported suri males for external matings.
- A breeder and reseller of coloured huacayas to new breeders with some sales to existing breeders. Multiple sale focus by packaging and support services.
- A broad range of suri and huacaya, alpaca product shop on farm with visiting tourist busses.
- Breeder and reseller of pet quality animals in a range of colours to lifestyle property owners in your region.

Competition

In developing your niche in the market, you must understand what your competition is doing.

Competition is not a reason not to do something but the risks must be understood. Usually the greater the competition, the greater the marketing cost.

Refine your niche definition to create separation from your competition.

What is your point of difference and why should a client decide to buy from you?

Image

The style and overall image of all marketing material must be consistent. Consistency creates a greater impact due to people recalling your previous message. Use the same font, and general layout, colours etc.

The style should be carried through to your web site, brochures, farm / display signage, business cards, advertisements and uniforms.

The image must be clearly consistent with your niche and be appealing to your target market.

Spreading the Message

There are numerous ways to get your message out. Don't get confused by slick and glitz – just because a marketing item looks glossy and professional it does not mean it will work for you.

Key to your choice of method is to understand the demographics of the medium you propose to use. Aim to use media and displays that capture your target market at an effective cost.

Let's look at some options.

Print

Marketing material printed in magazines and papers can be very effective. Choose your publication carefully.

If your target market is new breeders - rural press and lifestyle magazines maybe an option.

To target existing breeders – "Alpacas on the Move" and "AAA Magazine" are obvious choices.

When choosing a publication, understand its "table life". How long do the readers retain the publication? A publication may be more expensive but retained for months, even years.

Brochures

Printed brochures to hand out at displays and to post to prospects are an inexpensive and effective marketing tool. Don't print too many as they may well be out of date before you get to use them. If you have a good quality printer at home you can even edit and print them yourself.

Displays

Displays are a good method of marketing your alpacas. Here you are able to target your approach through choice of location or event. The main benefit is the ability to get people to touch the animals. Shows are obviously a good display opportunity.

Other areas to consider are co-marketing with other businesses that are targeting similar demographics. Some co-marketing displays we have done are: wineries, vintage car displays, weekend /craft markets, alpaca product manufactures, schools, open garden displays, local government pet microchip days and rural shows.

Remember at these displays you are marketing, not trying to sell. Take your best display animals, well behaved and well prepared. Show your best and encourage farm visits. At these displays, keep it simple. Have the animals trained to eat pellets so it is easy for the public to feed the alpacas. If your focus is on suri, take suri. Your display must be consistent with the image you wish to build.

We have been at displays with other breeders who take a couple of older girls they wish to sell as their alpacas on display. The result is that the public think that this is the quality of their herd. The usual result is that people come to our farm to see what we have to offer instead.

Remember; don't try to sell at the display. Marketing at displays will produce more and larger sales at your farm. You are there to develop awareness in the mind of a potential client of your farm and animals and to begin to develop a relationship with this client, so that if and when they decide to purchase alpacas, they come to you.

Open Farm Days

These are of great value. People are often happier to visit your farm if it is a general invitation rather than just for them. When planning your open farm day, keep in mind your objectives. If you are marketing to new breeders to the industry, the last thing you want is established breeders taking up your time when you should be talking to you prospective clients. Marketing to existing breeders needs to be planned differently because their information needs are quite different.

If you want the day to be a success, the selection and placement of animals is critical, as this is going to tell your story.

The objective of the day should be to have the right people visit, not large numbers. Remember to get email addresses and make notes on the alpacas people are interested in as well as their level of interest for follow up.

At our open farm days we attract a small number of people. We have staff (the neighbors teenage children) to keep pens clean and organize the parking. Our focus needs to be on the client. We take photos of them with alpacas and we encourage clients to lead alpaca, thereby building a bond and establishing a mindset that this is possible for them.

On our previous farm we established a walking track so clients could take alpacas for a walk while we talked to another client. We email their photos, information and proposals so that the information beats them home. If they purchase alpacas on the day we email photos of their alpacas, for them to show friends and family.

We have our herd management software (HerdLogic) near the animals so visitors can review the genetics and health history on the alpacas they are interested in. This increases the clients' confidence as all information is disclosed and available. They are able to print details to take with them. This also gives them something to do if you get tied up with another client.

Coordinating open farm days with other farms in your area will increase attendance. The competition will ensure you keep your focus and people are more willing to visit as they have an excuse to leave if hey feel trapped as they need to visit the next farm.

Internet

This is an increasingly important method to market. It is comparatively inexpensive, and able to be updated quickly. It can also get out of date quickly. Maintenance of a web site requires a level of skill and time. Tuning search engines to find your site is also critical to its success.

Remember to quote your web address on all printed material and display signage.

Keep your website design consistent with all other media used to continue to reinforce your chosen message.

Electronic

Radio and TV is an expensive option. It also has significant obstacles. One of the key features of the alpacas is their look and feel. This is completely lost on radio.

Electronic media marketing is often based on high rotation - that is seeing the ad or image over and over. This makes it expensive but may be an option as part of a regional campaign.

Costs

Whether the business objective of your marketing strategy is to establish your identity or impact your profitability, you must understand the costs and control them. It is very easy, with ad hoc spending, to accumulate considerable expenses, which may not have the desired effect. The expense may have been better used in a high cost / high impact strategy.

Implementation

As you plan your strategy, document the steps and deadlines that are required to implement your program. Without a plan, deadlines slip.

Measurement and Review

As your marketing program commences, you need to measure its impact. Some simple measures are:

- Asking people who call or visit you where they heard about you
- Count the number of brochures taken at a display
- Count responses from mail-outs
- Count the number of visitors to an open farm day

You may notice that I have not suggested that you measure marketing success by the value of sales. Poor sales technique can destroy a good marketing campaign and good sales technique can hide a poor marketing campaign.

Also remember the time frame involved in the buying decision. How long did it take you to purchase your first animals? We find it can routinely be 12-24 months. Use this time to develop a relationship with this client.

Ethics

All marketing must be presented ethically.

All the representations you make must be correct and timely. Eg. Don't promote animals with old and out of date fleece results. When you publish fleece results, publish the date of the test. Use current photos.

As one of the objectives of the marketing strategy is to promote / build the industry, don't promote your business at the expense of another breeder. Denigrating another breeder is the quickest way to turn off new breeders.

Market positively not negatively. Eg, A part of Canchones business is outside matings. We never compare one of our stud males with a male owned by another breeder. In discussions we acknowledge our competitor's male in a positive way and compare one of our males to another one of our males.

Your business will be successful because of its good reputation.

All marketing should enhance your reputation. Remember your reputation is your greatest asset and both happy and unhappy clients will talk to their friends and family.

As an alpaca owner you are part of the alpaca community. In any community we all have community responsibilities. Marketing is a community responsibility. Remember we all need to act in a way to grow the industry as a whole. You will not always get the initial sale, but depending on how you act, you have a greater chance of getting subsequent and ongoing sales.

Conclusion

Your alpaca business can be both an enjoyable lifestyle and profitable business for you. All you need to do is approach your alpacas as a business and develop appropriate marketing strategies. The above information will help you to develop a niche marketing strategy based on your aims and abilities.

Fibre development - Creating a viable return

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Preamble

Ancient alpaca garment fragments recovered from the Inca Dynasty indicate a very high level of sophistication both in the quality of the fleece and the techniques used in manufacturing these garments. This has provided us with some indication as to the potential of these animals, and I think that it would be fair to say that in Australia in the last decade there has been a dramatic improvement in fleece quality and yield. Unfortunately this focus on breeding has not been matched with a coordinated industry programme for developing the appropriate infrastructure and understanding to create a viable fibre market.

To appreciate the limitations the industry is placing on itself, consider for a moment the affect on the industry, if fleece prices were increased substantially. Would this give rise to a greater acceptance from a wider farming sector? Would this give rise to improved demand for breeding stock and stud males. Would there be an increased level of investment in the industry? Consider also the future if fleece prices remain unchanged; how robust and large is the pet market?

From our own experience, I am aware that a properly thought out fibre model concentrating on industry participation can effectively create a "local" market price for alpaca fleece. I believe this involvement is critical for the future development of our industry. In the long term it is the Australasian experience with wool processing that will enable industry innovation to create alpaca products of a style and quality that are unique to this area.

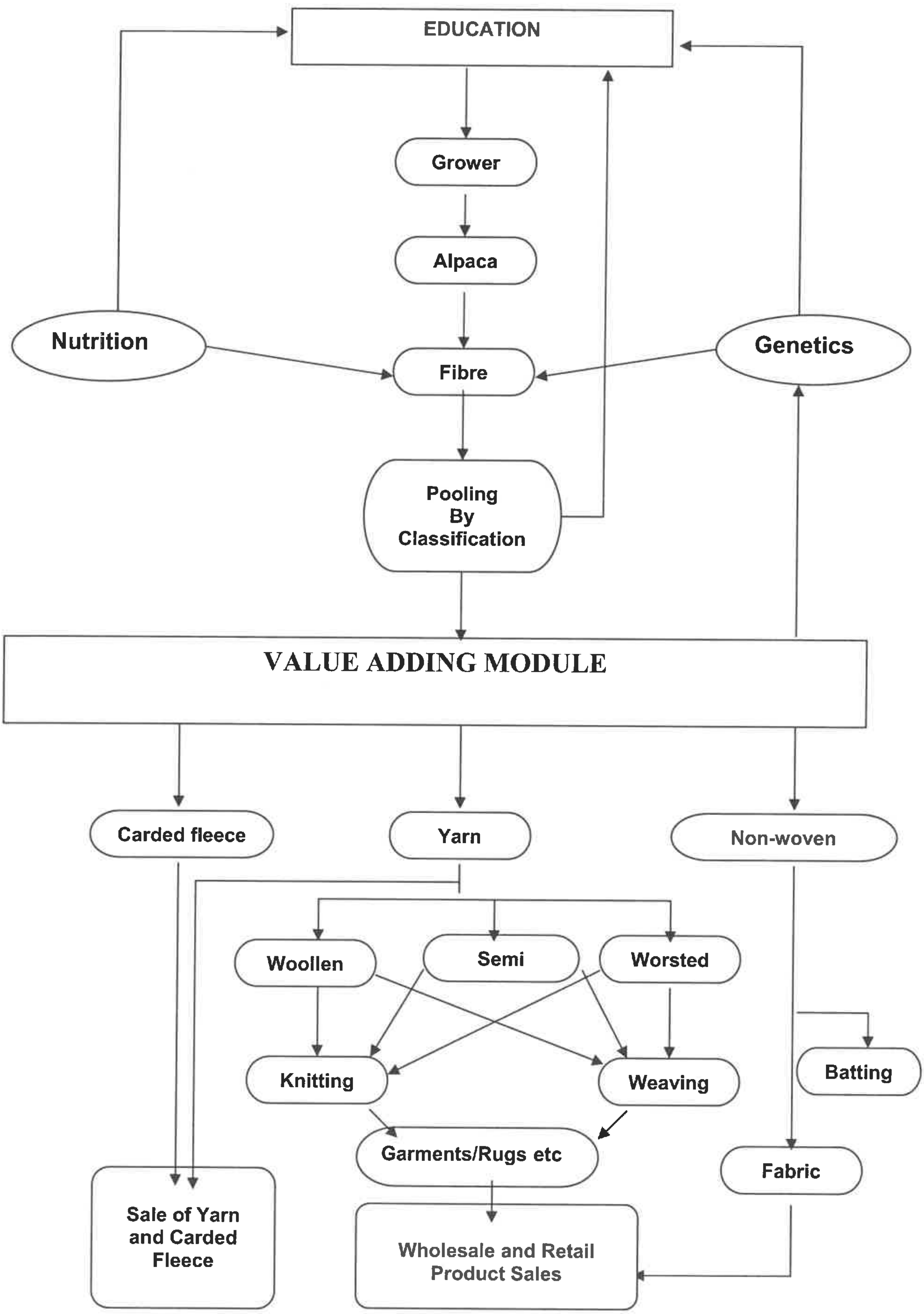
A brief look at the past:

As we are aware the bulk of alpaca fleece is grown in and around the altiplano. This may be provocative, but this picture reflects the standard of living of the average alpaca breeder who is living within the financial constraints imposed by the international prices paid for raw alpaca. These people have been locked into this standard of living for centuries, simply because of the price paid for alpaca fleece, meat etc.

Contrast this to those involved in the process of adding value to alpaca. Titus Salt was born in 1803. He had a thorough grounding in the wool industry, but it was his ability to innovate and adapt/build machinery to meet specific processing requirements that provided him with the resources to develop a vast alpaca processing business and social reform. In 1836 Titus purchased 16,000 Kg of unwanted alpaca fleece that had been sitting in the back of a warehouse simply because no one knew what to do with it. His skills really need to be acknowledged. This is a fibre that at this stage had not been processed mechanically. To complicate matters, it is recorded that some of the fibre had a staple length of 20-30 inches with the longest recorded as 36 inches. By 1840 his usage was 250,000 Kg and by 1852 it reached 1,000,000 Kg. In 1853 he opened a massive worsted mill "Saltaire" with 73,000 sqm of floor space, 3200 staff, 1200 looms and an output of 18 miles of alpaca cloth daily. I find it interesting that he accomplished all this in the time alpacas have been in Australia. Over the next 20 years he went on to develop "Saltaire" the village, which included high schools, hospitals and housing for 5000 people. All this was paid for from the profits from processing alpaca.

In more recent times, (around 1950) the Peruvians started processing their own alpaca fleeces. Today these Companies are large wealthy multi faceted operations.

Alpaca processing flow chart:



Developing an industry fibre model

This is a new industry- we have a clean slate. We can learn from similar industries but the responsibility and viability rests very much with us. We have chosen to invest in this industry and I believe we must take responsibility for it.

As an industry I believe we must;

- Be aware of the benefits of vertical integration.
- Invest in innovation and R & D to gain insight into the properties and processing of alpaca fibre.
- Learn to develop premium product.
- Develop a unique Australian or Australasian style and niche market.
- Develop a new concept of boutique processing to complement craft and commercial processing.
- Start small, learn and grow. Mistakes are easily overcome on a small scale.
- Provide an infrastructure that promotes investment, ownership and competition.
- Provide flexibility for breeders and processors to follow their aspirations.
- Understand clearly the role of the Association.
- Provide the educational resources to assist breeders.
- Provide the appropriate markets to trade alpaca fibre.

Developing the processing infrastructure

In providing this paper I have purposely refrained from commenting on the existing fibre policies. What we are looking at here is a more multi-faceted, more inclusive approach to processing alpaca that is capable of providing better returns that are effectively insulated from international prices. It is not a matter of replacing the existing structures but providing additional opportunities that reflect the diverse interests and ambitions of this industry. We need to look seriously at what resources are available for processing alpaca and what resources are not available, but would be beneficial to the industry. Whatever structure is contemplated the required infrastructure is similar.

- The development of a fibre model. *The industry needs to know where it is going.*
- An indication of the resources required. *Both financial and processing.*
- Education. *Fibre types, fibre skirting, grading and value adding opportunities.*
- Participation. *Developing hands on skills.*
- Understanding. *In respect to processing techniques and product development.*
- Innovation. *Both in respect to processing techniques and product development.*
- Development of unique product. *Unique alpaca.*
- Niche marketing that product.

Now would be a good time to suggest that it takes roughly $100/Kg to turn alpaca fleece into a knitted or woven garment. If we use 100,000 Kg as an indication of usable clip, the industry, strategic partners etc. need around $10m just to fund the manufacture of the product. This does not include the resources required to fund stockholding, debtors, R&D, marketing costs or the development of specific machinery (i.e. a scour, VM removal, dehairing etc.) that would assist in addressing processing problems specifically related to alpaca. As the manufacture of alpaca product requires these specialised processing operations it makes sense that these facilities are provided by this industry for the use of this industry.

Alpaca - The development of a point of difference

Currently the industry manufactures a range of garments most of which are blended with varying percentages of wool. I would suggest this does little for the development of this industry. If we want to develop alpaca as a unique product, we need to be developing our processing ability and manufacturing products that enhance the unique properties of alpaca. It is only in this way that the industry can develop a point of difference for alpaca. Blending should be done to achieve a structural result, not a cost, or processing consideration.

Similarly there are limitations imposed on the manufacture of product caused by the inherent nature of alpaca. Examples might be VM contamination of the fleece, guard hair, pilling of fine micron fibre, cockling or patterning of fine knitwear. Overcoming these traits immediately allows a unique point of difference.

Suggested properties of alpaca :	*Huacaya*	*Suri*
	Handle	Lustre
	Drape	Handle
	Tensile strength	Drape
	Medullation	Staple Length
	Lustre	Tensile strength
	Memory	Colour
	Hard wearing	Organic possibilities
	Staple length	
	Organic possibilities	

The Value Adding Ladder

This is a hypothetical exercise using a functional item of clothing to illustrate the different returns available depending on ones involvement.

The humble sock:	Costs	Returns	Difference
Stuff fleece under bed	Nil	Nil	Nil
Option 2.			
Sell fleece 1050kg at say $15.00/kg	Nil	$15,750	$15,750
Option 3.			
1050 Kg alpaca fleece @ $15.00 per Kg	$15,750		
elastine etc	1,400		
Wash, card, spin	24,000		
Manufacture 10,000 pr @ $2.00	20,000		
Labels	1,000		
Total production cost	$62,150		
Wholesale 10,000 pairs of socks @ $14.00 (ex GST)		$140,000	$77,850
Option 4.			
Retail ($28.00) 10,000 pairs of socks @ $25.45 (ex GST)		$254,500	$192,350

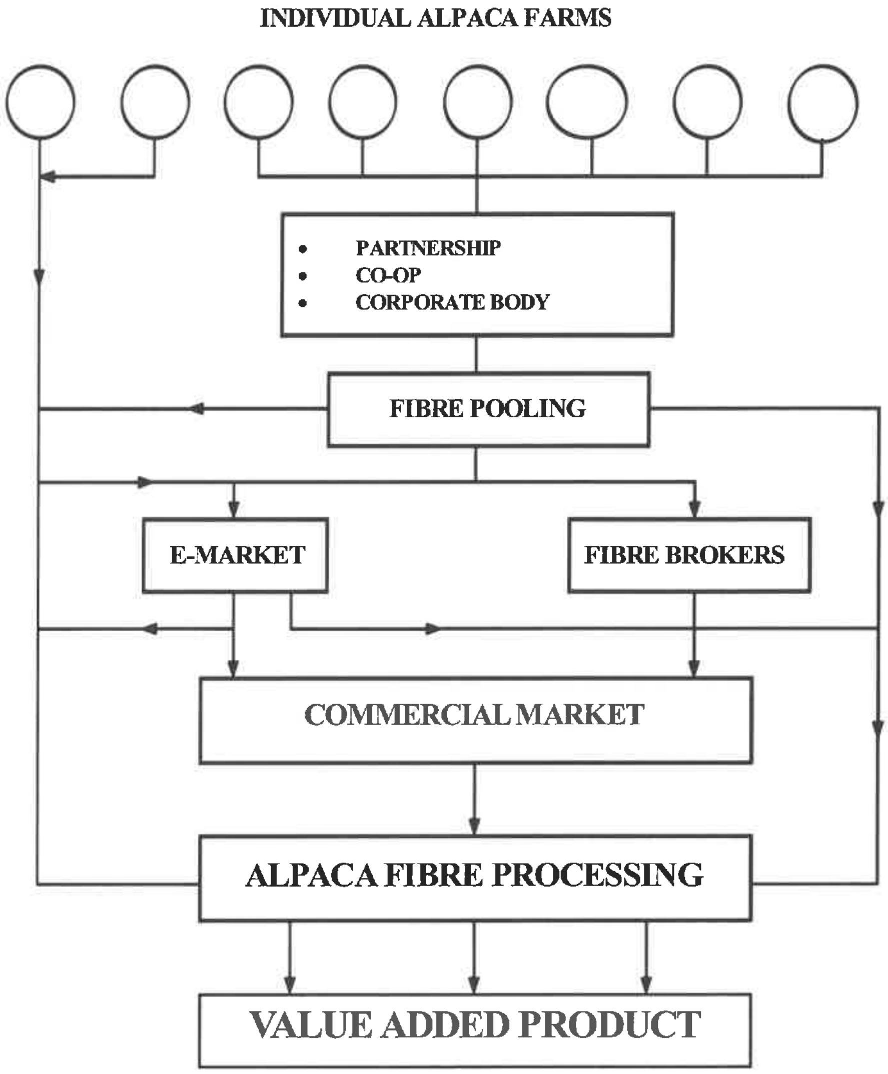
A guide to the gross retail return per kilogram for a range of garments

We have been manufacturing alpaca garments for ten years now and have built up an understanding of the gross retail return one is likely to gain from both the type of garment manufactured, and the type of stitch or weave utilised.

• Socks (as above)	$250 /Kg
• Double knit jersey	$360/ Kg
• 4 ply jersey	$400/Kg
• Boucle jersey	$400/ Kg
• 2 ply jersey	$780/ Kg
• Lacy triangular shawl	$1040/ Kg
• Crocheted scarf	$1750/ Kg
• Lacy Baby wear	$3000/ Kg

Obviously these figures are representative only, but adequately serve to illustrate a considerable variation in gross return per kilogram. Similarly costs to manufacture also vary, but the point of this illustration is to suggest that it would not be unreasonable to pay $100/Kg for top quality fine fleece to manufacture fine baby wear, whereas that is not an option for manufacturing socks and the heavier weight jerseys.

Trading alpaca fibre – What are the options



It is expected initially that the rates paid per kilo will vary considerably and this will tend to govern the preferred options. It is really about having the appropriate foundations in place to build on, in the future. You will note the existing facilities fit neatly within this flowchart. Again it is about adding to, rather than the replacement of existing facilities.

Scouring alpaca

Earlier I alluded to the fact that there were various processes within the traditional fibre processing systems that are less than adequate when it comes to processing alpaca. Scouring is a good example of this problem.

Wool is very much a commodity product and a modern scour is designed to process vast amounts of wool quickly and cheaply. The process is optimised for the removal of grease and to a lesser extent dirt. In contrast alpaca contains very little grease and the process should be aimed at the removal of dirt. By adding an additional process for the removal of vegetable matter prior to scouring would greatly enhance the end result. We also have the problem of small lots sizes, colour and colour contamination to content with, in respect to scouring alpaca. A good analogy is trying to run your car on two-stroke mix and wondering why you are not getting a good result. We are simply trying to use a system to do something that it was not designed for.

I was fortunate to be at Design Spun in Napier when they were processing Australian alpaca that had been scoured by the CSIRO. The fibre was in lumps and when you pulled it open it revealed a considerable amount of contamination. In other words there was problems with the opening of the fleece prior to scouring which meant the scour was only effective on the circumference of these lumps and the centres remained untouched. The residual grease content of this sample varied from .5% (ideal) to 2.5%(virtually straight off the animals back) and so instead of being a pleasure to process, the mill has a fight on its hands that is well illustrated in the next two photos. The extensive grease build up occurred after less than 20 minutes of operation.

Note in the photo on the left the top roller shows what it should look like, the bottom roller what it ended up like.

Conclusion

The development of the fibre sector is a process of evolvement. I would like to see the concept of this industry expanded so that premium product, rather than a bale of raw fleece, is seen as the desirable goal. At present the industry has no infrastructure in place to allow the development of a multi faceted approach to fibre development. **This is urgently needed**. Similarly proper planning will identify just what resources are required and also the benefits to the industry if these resources are provided from within this industry. The development of the fibre sector should be an exciting and rewarding time for those that wish to be involved.

Our garments on the catwalk at the 2005 AANZ National Expo

Marketing alpaca on a commercial scale using the fibre's competitive advantage

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The marketing of our wonderful fibre today, especially preparing for the future, will take many twists and turns as we strive to sell our fleece both nationally and internationally. The below paper gives you some insights into the workings of AAFL, presenting to you an overview of where we are up to, where the fleece comes from and what we have learnt up to now.

Current situation of Australian Alpaca Fleece Ltd

Australian Alpaca Fleece Ltd is currently working with 12 main organisations, both nationally and internationally, in the commercialisation of Australian alpaca fleece.

Creswick Woollen Mills

Creswick Woollen Mills is the home of luxurious natural fibre products designed in Australia to suit Australian conditions. The Company was founded in 1947 and is located in Creswick, 120kms from Melbourne, and is now the only coloured woollen spinning mill of its type in Australia.

Creswick Woollen Mills has devoted an enormous amount of R &D, time and money to establish the Australian alpaca woollen blanket and throw rug range as a mainstream upper end retail product. They are a major supplier to David Jones nationally as well as to many specialty stores around Australia.

Jo Sharp Pty Ltd

One of the most exciting events to happen to the Australian Alpaca industry in 2006 is the launch of the Jo Sharp alpaca hand knitting yarns. Jo Sharp currently produces an amazing range of hand knitting products, and is, without a doubt now, the most creative hand knitting label in Australia.

She has produced a fantastic pattern book, now on sale in Australia and the United States, including patterns especially designed for a wide range of alpaca knitted products.
Jo's company started in Western Australia in 1992, with its first collection being designed for David Jones, and has expanded over the years to not only selling her range througout Australia, but now to over 400 stores across America. Her pattern books have really become collector's items and they end up on coffee tables and design studios all around Australia.

Merino Gold Australia

Merino Gold, Australia's leading natural fibre knitwear specialist, has been working with Australian alpaca fleece for a number of years now, producing exceptionally beautiful and fashionable garments for men and women.

This initiative has continued and as well as their Australian operations Merino Gold is now making Australian alpaca garments in China, where they have manufacturing facilities. R & D has also continued with alpaca fibre now being blended with silk, cotton and wool.

Australian Carpet Makers

Australian Carpet Makers has been manufacturing mainly quality New Zealand wool products for over 100 years, and whilst the development of Australian alpaca carpets has not been easy, after two years of R & D, they have definitely struck the right formula.

Australian Carpet Makers currently produce a cut pile and "sisal look" 100% alpaca carpet. They are getting a huge amount of interest and support from designers, architects and the general public.

Kelly & Windsor Australia Pty Ltd
Since 2003, Kelly & Windsor has continued to launch new and innovative products based around their range of alpaca quilts, underblankets and pillows.

A combination of innovation, design, product development and market awareness has created a completely new range of unique and exclusive bedding products made from Australian alpaca fleece, which has significant potential in Australia and overseas markets for years to come.

This range now includes both 100% and blended alpaca bedding products under the labels of Alpaca Classic, Alpaca Gold, Alpaca Light and Alpaca Country. In particular, their extroadinary lightweight Alpaca Light quilts are uniquely suited to sleeping in warmer climate areas.

Design Spun (96) Ltd
With the recent demise of the Australian spinning industry and opportunities to spin yarn here, we have been fortunate to be able to spin yarn through Design Spun, which is situated in Napier, New Zealand.

They have perfected, through a lot of time, money and R & D, not only spinning but dyeing of alpaca yarns in many different textures and blends in hand knitting yarns, fine worsted yarns, boucles and brushed, which are used in both homewares and fashion.

Design Spun has become an important part of our business and we work closely with them to develop and introduce new yarn products for the future.

Zenger (Aust) Pty Ltd
One of our most recent partners, Zenger has joined with AAFL to develop the homeware and fashion wholesale area using Australian alpaca products. We are working with them to develop direct links with duty free stores around Australia as well as working directly with department stores in China on specific lines. It is particularly exciting to see the rapidly growing numbers of tourists from China keenly seeking out the range of alpaca quilts produced by Zenger in Australia to take home as gifts.

Zenger's wholesale arm covers quilts, underblankets, pillows, blankets, throw rugs, and women's and men's fashion products and accessories. Together we are developing lots of new products for the future and will end up with a complete range of Australian alpaca products, especially geared for export to China.

Pussyfoot Hosiery Pty Ltd
After many attempts to come up with the "right sock" that maintains both soft handle and performance, at long last we are producing this year, with the expertise of Pussyfoot Hosiery, a range of men's and women's dress and work socks in a blend of alpaca and super-wash wool.

This range will be available throughout Australia and overseas and we will be introducing in the future blends of alpaca/silk and alpaca/cotton. The yarn is currently spun in Peru and China.

Pussyfoot has great experience in the hosiery market, retailing their label through David Jones stores as well as the Hush Puppy label.

Hysport International Pty Ltd
We are developing a range of accessories with Hysport International, including beanies, gloves, scarves, shawls and baby blankets as well as fashion knitwear, which will be launched in the latter part of 2006. This range of merchandise will be produced from 100% fine Australian alpaca, spun and dyed in Peru.

The need to have products produced in Australia and with an Australian label is vital to our marketing; especially in the areas of export and duty free shopping, and Hysport International together with its "whole garment technology" offers flexibility and quick delivery that is well suited to our needs.

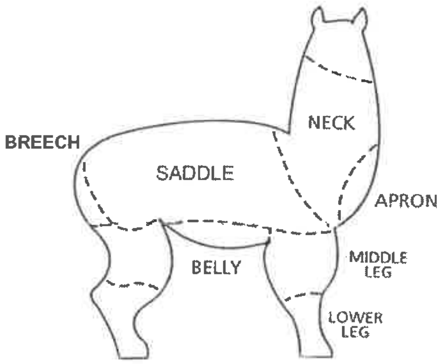
Masterweave Textiles Ltd
Situated in Masterton, New Zealand, Masterweave and AAFL have worked together successfully for a number of years to develop a range of throw rugs and scarves in a large variety of colours over brushed and boucle yarns.

These products have been very successfully marketed both nationally and internationally and currently we are unable to meet demand. The products created by Masterweave are produced in the full range of natural alpaca colours as well as now checked and striped designs.

Inca Group and Michell Group - Peru
With the world reality of manufacturing, we needed to have the ability to access products that are not available to be produced in Australia or New Zealand.

The Peru based Inca Group and Michell Group, who both have decades of expertise in producing, finishing and dyeing alpaca products and currently purchase some 70-80% of the world's alpaca clip, have been close allies in working with us to manufacture our Australian alpaca products. They have also supplied us with small quantities of yarns and tops made from Australian alpaca to develop the market both here and overseas.

Where the most common lines of fleece comes from on our animal (subject to quality of animals)



Saddle	huacaya and suri - all fleece lines
Neck	huacaya - all fleece lines, pieces, D length suri - all fleece lines, D length, pieces
Apron	huacaya - pieces, LCV, NCV suri - all fleece lines, pieces, D length, NCV
Middle leg	huacaya - pieces, LCV, NCV suri - D length, pieces, NCV
Lower leg	huacaya - LCV, NCV suri - D length, NCV
Belly	huacaya - LCV, NCV suri - D length, pieces, NCV
Britch	huacaya - all fleece lines, LCV, NCV suri - all fleece lines, D length, pieces, NCV

Products created from alpaca fleece

Homewares
quilts
underblankets
pillows
blankets
throw rugs
jacquard rugs
baby blankets
carpet
carpet rugs
cushion covers

Fashion
men's & women's fashion
men's & women's scarves
Shawls
Beanies
Gloves
ponchos
socks
fabric
coats
underwear

Other
hand knitting yarn
machine knitting yarn
inner soles
soft toys
tops
dehaired fleece
sliver

Australia's alpaca fleece availability and supply to AAFL, 2005/2006

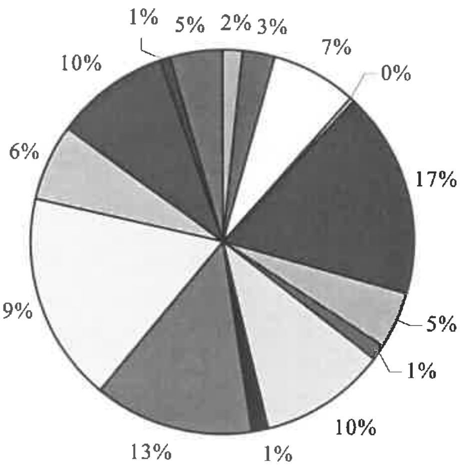
State	Registered alpacas	Approx. kg shorn	AAFL rec'd 2005/06
WA	5,360	10,720	4,280
SA	7,030	14,060	4,300
TAS	1,543	3,086	537
VIC	18,280	36,560	15,370
NSW	19,752	39,504	14,017
QLD	3,009	6,018	616

* Totals as at 20 June 2006
* Approx. kg shorn based on average 2kg per animal
* Multiply owned animals – 820 (1,640kg available fleece)
* Other fleece received by AAFL 05/06 – 1,861kg

- Aproxímate number of registered animals in Australia (as of 20/6/06) – 55,794
- Approximate fleece available in Australia, excluding non registered animals (based on 2kg per animal) – 111,588kg
- Total fleece received at AAFL (as of 20/6/06) – 40,979kg
- Anticipated fleece receival for AAFL 2005/2006 (classed) – 45,000kg +
- Approximate percentage received by AAFL per state (as of 20/6/06) –
  - WA 10%
  - SA 10%
  - TAS 1%
  - VIC 38%
  - NSW 34%
  - QLD 2%
  - Other 5%
- AAFL target for 2006/2007 – 65,000kg

Percentage of fleece received by AAFL for 2005/2006 per Region

2% - NSW Central Coast & Hunter
3% - NSW Central Western
7% - NSW Hawkesbury & Blue Mtns
0% - Sth QLD & Nth NSW
17% - NSW Southern
5% - NSW Syd, Coast & Highlands
1% - Queensland
10% - South Australia
1% - Tasmania
13% - VIC Central
19% - VIC Eastern
6% - VIC Western
10% - WA Central
1% - WA Southern
5% - Other



What AAFL have learned about the commercialisation of the Australian alpaca fleece industry

Global reality of manufacturing today

After spending considerable time working in and examining Australian and New Zealand manufacturing opportunities plus travelling extensively to Peru, Italy and China it became clear to me that if AAFL wanted to continue to advance the manufacturing of Australian alpaca in premium products, we needed to seek a balance of both local and offshore manufacturing.

A crucial ingredient to ensure that we were competitive with world standards was the need to draw our fleece prices back into line with current world prices. This gave us the opportunity of placing production at the best locations to obtain our requirements, whilst ensuring that our Australian customers were not disadvantaged by using Australian alpaca – or alternatively forced to buy their alpaca fleece cheaper overseas. In addition, our charter has always been not just to sell our fleece, but to value add to protect both our intellectual property and to enable an acceptable profit margin to be achieved.

Manufacturing in Australia is AAFL's number one priority, however we soon learned that the opportunities that now exist here, especially in the fine worsted area, were limited.

While China will certainly be a huge force in this area over the next few years they are currently concentrating their efforts on basic commodities with huge volumes, like wool, as opposed to boutique markets like our exotic fibre. And whilst I don't believe this will last very long, there is probably a two to three year timeframe before China becomes heavily involved with alpaca and other luxury fibres.

This window of opportunity fitted in with Peruvian capabilities, where we found we could sell them our scoured fleece and buy back products like yarn, accessories, men's and women's fashion and tops, made from Australian alpaca. This has given AAFL a whole new edge and flexibility with manufacturing and wholesale opportunities, hence joining the global loop:

- Australian alpaca, made in Peru, sold in China.
- Australian alpaca, made in Peru, sold in Australia and other countries.
- Australian alpaca, made in Australia, sold here and exported.
- Australian alpaca, made in New Zealand, sold in Australia and exported.

Why export overseas?

Currently the product range I described earlier is sold three main ways:

1. To traditional retail outlets, like David Jones, Myer, Harvey Norman and selected stores.
2. To duty free shops around Australia.
3. Through alpaca breeder owned specialty stores around Australia.

With the volatility of the Australian retail market with its constant ups and downs and taking into consideration our projected fleece production growth, AAFL has had to look further a field to develop our business.

In the medium to long term future we will not be able to cope with the steadily growing volume of fleece produced by only selling within the Australian market, especially at the premium end of the market. Looking abroad the Chinese middle class market represents strong opportunities for us. Not only do they have the potential to give us much needed sales but also production numbers, giving us needed manufacturing scale and efficiency.

Our AlpacaMark is our biggest asset and is now increasingly recognised around the world, being registered in a number of countries. It is pivotal to our marketing and promotion. Like fine Australian Merino wool, Australian alpaca fleece should be recognised as the best fleece in the world for fineness and handle and this is our goal.

Building the fleece industry for the future

Increasing value-adding to give the grower margins and dividends

There is a real need for the Australian alpaca industry to have control over its future expansion, especially in the area of fleece price and return to growers. Whilst we are all inevitably broadly tied to prevailing world alpaca fleece prices the ability to be able to return dividends to growers who support the fleece industry is vital to the success of the whole alpaca industry in Australia. To minimise costs that are passed on to the growers who supply fleece the costs of transport, shearing and classing must be closely controlled.

Overall whilst a continuing rise in fleece supply volumes will help this area, more needs to be achieved to make the fleece an additional bonus to the sale of an animal. AAFL is currently exploring a number of initiatives that will assist also.

Controlling our own destiny

Making money out of the sale of fleece without value adding, bearing in mind what our suppliers can purchase on the world market, is very difficult given Australia's labour costs. There is however, an opportunity to tier our value adding over a number of stages so contribution to gross profit can be achieved.

- Our own wholesaling.
- Value adding fleece before on selling
  - Scouring
  - Top making
  - Dehairing
  - Yarns, etc.
- Developing wholesale brands for other companies
- Supplying alpaca breeder's specialty shops around Australia
- A direct AAFL retail sale and product display outlet at Sunshine

By developing these areas AAFL should be able to be profitable provided there is an increase in fleece supply volume. This profit can then be passed back to the growers by way of dividends and as well as hopefully some improvement in the price paid for the fleece they have supplied, this should represent an improved return. However, an additional less understood tangible benefit applies to all AAA members, and that is that the ongoing viability of a national alpaca fleece industry forms one important leg underpinning the value of the stud industry in which I'm sure most members of my audience has a significant investment.

Ongoing R & D programs

Having the resources to continue to promote and support alpaca research and development programs is vital to the health and well-being of the alpaca industry, and from AAFL's perspective there is a particular need to consider the coloured fleeces that currently represent some 70% of the Australian clip. While it's clear from customer demand that the drive for white fleece will strongly continue, for many years to come there will be large quantities of fawns, browns, blacks and greys and all these will need to be catered for.

Also, as the suri clip grows, there will be more opportunities to develop this alpaca line and give it the exposure it deserves. Whilst this area does not give immediate returns financially, from AAFL's perspective, we recognise that it is vital for suri not to be overlooked or many opportunities will be missed.

Developing a marketing fund promoting the fibre's competitive edge

The marketing of the Australian AlpacaMark, as well as both Australian alpaca fleece and products made out of Australian alpaca all constitute vital cogs in the expansion of our industry. We are hopeful this year to set aside some dollars from every product we sell to be directed to marketing.

Over the last 10 years of the Australian Alpaca Co-operative Ltd and now AAFL very little has been spent on marketing promotion. In relation to the thousands of products that have been produced, the percentage spent on marketing is very small.

Marketing not only assists in selling our animals and fleece but most importantly assists in developing the external perception/awareness of our industry. We want to be perceived as a new, fast growing industry that is well organised, dynamic in its outlook and involved in the breeding and selling of end products that are positioned in the high quality luxury area of the market.

Overall we all want the alpaca industry to be seen as providing not only an enjoyable lifestyle opportunity but also as a financially rewarding venture offering good opportunities for investment. Without continued marketing by all those involved in our industry we will not be able to maintain the price of our animals or the demand for our fleece that we enjoy today.

Much has been written and discussed about the best way to market our industry and its products. Clearly there are many facets that contribute to the overall outcome, but I must say in conclusion that having quality products sold by upmarket retailers and being worn by Australians has been, I sincerely believe, one of the most important contributions to developing the perception and awareness of our wonderful alpacas.

Developing a 'Demand Driven' alpaca fibre industry

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Abstract
Market research indicates the supply of Australian alpaca fibre to the textile market is highly differentiated, irregular and too often, fails to meet consumer requirements. These issues are constraints to realizing market opportunities.

It can be argued that problems associated with the supply of Australian alpaca fibre can be resolved by pursuing 'demand driven' fibre production. Alpaca studs would play a critical role in this strategy

Key Words
Alpaca, fibre, demand driven industry, fibre marketing.

Introduction
The current state of herd build-up of Alpaca animals in Australia, places the industry at the cusp of moving from a 'lifestyle' based activity to becoming a commercial based industry that could play a significant role in supplying raw fibre to the global textile market or value added yarn direct to consumer markets.

Underpinning this transition, is a critical need to develop growers' awareness of the key market drivers for their fibre. This would enable volume production of 'demand driven' product, rather than irregular supply of highly differentiated fleece types.

Methods/Results
Australian Alpaca Fibre Testing conducted basic market research over the past three years in an attempt to estimate key price drivers for raw alpaca fibre. The research was based on market reports, anecdotal statements and detailed interviews with key position-holders within the alpaca textile industry.

While many of those questioned commented on how alpaca fibre's intrinsic attributes offered it substantial marketplace opportunities, a significant number indicated their frustration with an often highly differentiated and irregular supply of raw product that failed to meet their specifications.

It should be noted that many complimented the efforts of Australian Alpaca Fleece Limited, however, the problem appeared to be more related to the nature of alpaca fleece production in Australia.

A hint as to how this situation has evolved may be drawn from the results of a series of Q & A type surveys that reviewed growers' breeding and management strategies. These surveys have been conducted by AAFT during fibre workshops conducted over the past four years.

An approximate figure of 65% of alpaca breeders indicated they did not have clear breeding objectives when asked what type of fibre did they wish to produce. Of the 35 % who indicated a clear breeding objective for fibre type, about 80% of those could not justify their objectives by reference to an evaluation of market signals.

Perhaps another way of reporting the above figures is that less than less than 10% of the alpaca growers surveyed were producing fibre in a manner that could be described as 'consumer driven'. Over 90% produced fibre arguably based on their own personal tastes or of their fellow breeders rather than those who purchase and/or process their fibre.

Discussion

The potential risks to an industry that is not sensitive to its market signals cannot be overstated, particularly when supplying a highly competitive market such as textiles. It should be stressed that this principle applies equally to supplying consumer markets with value-added alpaca yarn.

Extensive surveys conducted by organizations such as IWTO (AWI Ltd, 2004 & Woolmark Co. 2005) have repeatedly shown that customers have now become conditioned to paying low prices for volume produced products; even for 'elite' or speciality products. The net result is lower price points throughout the supply chain with consequent slicing of profit margins.

To survive, those in the supply chain need to increase operating efficiencies through low risk processing of high volumes of known raw product. They need guaranteed supply of a large volume of product with exacting specifications.

The current supply of alpaca fibre does not fit this agenda. Again, this also applies in cases where alpaca growers engage in vertical integration ventures.

When volumes of suitable fleece type cannot be guaranteed, there is a substantial cost that has to be passed down the supply chain, back to growers in the form of price discounts for their fleeces.

On the positive side of the coin, developing a critical mass of fibre that satisfies market specifications can result in gains being passed to growers in the form of substantially increased fleece prices.

Conclusions

Conveying market signals to growers is not difficult. Seminars, workshops, market reports, information sheets and, of course, prices themselves can be effective methods for informing growers what fibre the market prefers, and presumably, is prepared to pay a premium for.

The real challenge is the substantial realignment of priorities by alpaca breeders. To become viable, the Australian alpaca industry needs to divert more attention towards producing fleeces that meet market demands.

It is at this point that alpaca studs play a pivotal and potentially rewarding role.

Major studs should be at the forefront of fibre market intelligence, offering their clients informed and accurate information that can support their commercial breeding programs. Studs might organise market information workshops, tours of mills or scour plants, maybe organise 'Bloodline Grower Groups' so that volumes of uniform fleece types can be produced and marketed under their own label.

If the wool industry can be used as an example, sheep studs that have pursued this strategy have, generally speaking, reaped price premiums for themselves as well as their wool producing clients, (The Land Newspaper, 29 June 2006).

The changes required are challenging, but rewarding. As stated at the beginning of this paper, the opportunities for alpaca fibre are substantial.

While some alpaca fleece types have little or no market value, there are those which are in very high demand. The opportunities for the alpaca industry rely on knowing which is which.

References

ABARE Outlook 2003 Fibres Outlook 2003 – 2008
Australian Alpaca Fleece Limited, 2006. Fleece Flyer 3
Australian Wool Innovation Limited (2003) Strategic Plan 2003 – 2008, June 2003.
Australian Wool Innovation Limited ans The Woolmark Company (2005) Review and Outlook for Fine Wool 2006
Future of the Textile and Fashion Industry. H Kuffner IWTO 2004
The Land Newspaper, 29 June 2006 'It's Egelabra or nothing' p 27.
The Woolmark Company, WoolXPress Elite Fibre Reports. 2005 to 2006

The affect of age, fleece weight, fibre diameter and live weight on the relative value of Australian alpaca fleeces

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Abstract
The impact of commercially important alpaca fibre production and quality attributes on the relative economic value of alpaca fibre production was investigated. Fleeces from five farms in southern Australia (n = 1100) were measured using mid side samples and standard tests and were assigned a relative economic value based on an analysis of market price data. The total relative economic value increased with increasing greasy fleece weight and with increasing saddle weight up 2.5 kg. Total relative economic value declined as mean fibre diameter increased above 23 µm, increasing live weight above 60 kg and with increasing age above 2 years for Huacaya and 3 years for Suri. The relative economic returns from fleece production of Huacaya and Suri breeds was similar. 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 and lighter animals. This work provides a method to assign an economic value to alpaca fleeces thus enabling animal selection based on international commercial economic values.

Key Words
Fibre diameter, fleece weight, fleece value, live weight, age, measurement

Introduction
In the 1980s and 1990s, alpacas were imported into Australia and New Zealand to establish a new animal fibre industry. Their productivity has been investigated in southern Australia (Hack et al., 1999) and New Zealand (Wuliji et al., 2000). Scientific analysis of Australian data has been presented on the most appropriate fleece sampling methods (Aylan-Parker and McGregor, 2002), the comparative productivity of Huacaya alpacas compared with Merino sheep (McGregor, 2002), sources of variation in fibre diameter attributes (McGregor and Bulter, 2004a), the inheritance of Suri phenotypes resulting from different crosses (Ponzoni et al., 1997) and the inheritance of alpaca fibre attributes in young Australian alpaca (Ponzoni et al., 1999). The Australian alpaca industry is evolving from the initial breeding phase of industry development to a more commercial industry with a greater focus on financial returns from fibre production.

With other animal fibres, such as wool and mohair, the major influence on fibre value is mean fibre diameter (Anon 2006a, McGregor and Butler 2004b). 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 changes with time. No data on the relative economic value of alpaca fibre production in Australia could be found. This paper attempts to quantify the changes in the relative economic value of alpaca production when various production and management attributes are manipulated by using real data from Australian alpacas and international fibre prices.

Methods
Fleece measurement
Data from 1100 fleeces from five farms in southern Australia (Hack et al., 1999) were collected from Huacaya and Suri alpacas. Prior to shearing all alpacas were weighed on live stock scales to the nearest 0.5 kg. At shearing, fleeces were separated into their components of saddle, neck and skirtings and weighed to the nearest 5 g. At shearing, mid side samples were taken on all animals and samples were tested for fibre diameter using the OFDA 100. For some of the animals all fleece components were also sampled and tested for fibre diameter. Full details of the test and sampling methods are found elsewhere (Aylan-Parker and McGregor 2002, McGregor 2006).

Fleece valuation

The relative economic value of each fleece has been determined using price data for white tops based on prices reported by the major international alpaca trader Alpha Tops (Figure 1, Anon 2006b). Using two complete price cycles (peak to peak) the mean relative price for each grade of alpaca fibre was calculated based on the area under each price curve over time. Data for the mean fibre diameter of each price grade has been supplied by Alpha Tops and confirmed by testing of sample tops. The relative price data has been 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 animal. 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.

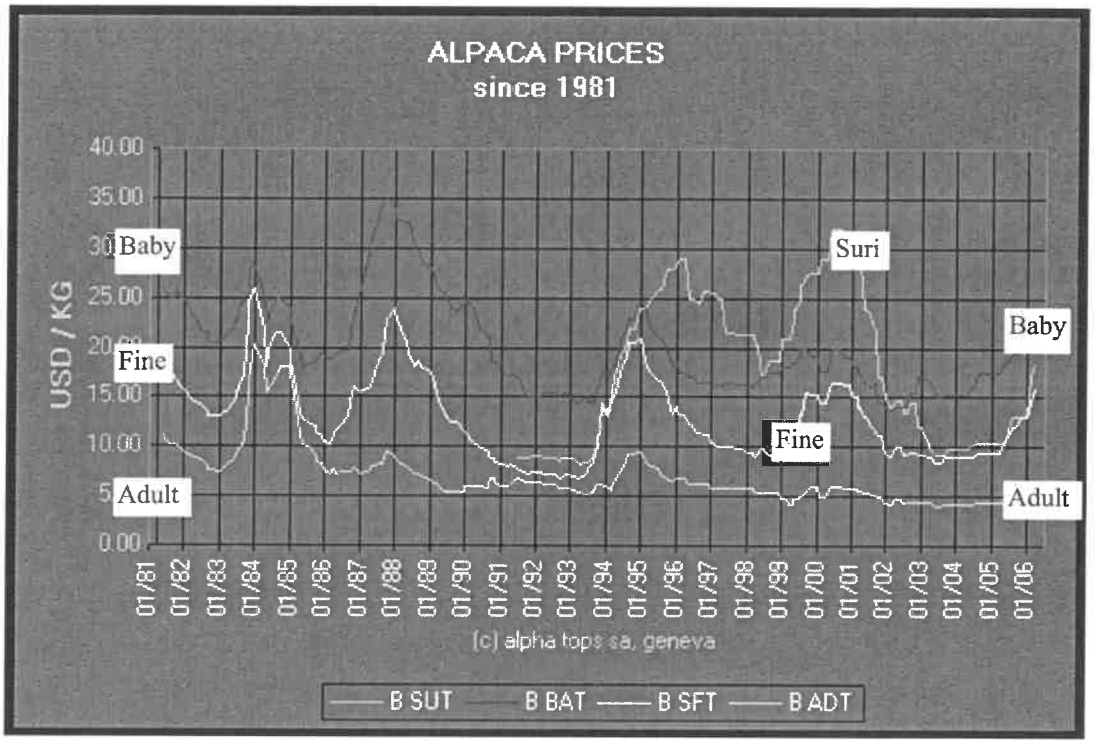

Figure 1: Alpaca prices for the period 1981 to 2006 for different grades (BSUT suri fibre, BBAT baby alpaca, BSFT fine alpaca, BADT adult alpaca) based on Alpha Tops data (Anon 2006b)

The relative economic value for a fleece was then determined by:
1). Multiplying the weight (kg) of each component by the relative value predicted by placing the measured or determined 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 has been applied to all fibre coarser than 34.0 µm (17 units/kg). Colour has not been taken into account, all fibre has been assumed to be white. Suri fibre values have been increased by 10% relative to Huacaya (Vinella, 1993) which approximates the market for the period 1995 to 2002 (Figure 1). 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 set of alpacas (Aylan-Parker and McGregor 2002). For this analysis the mid side was taken as 1.5 □m finer than the saddle.

Results and discussion

Relative economic value of alpaca fibre

The relative value of alpaca fibre related to the MFD is shown in Figure 2. The data indicate an average decline in price of 11% per 1 □m increase in fibre diameter up to 26 □m. Above 26 □m the average decline in price was 5% per 1 □m increase in fibre diameter. Fibre of 32 □m 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:

1. For MSMFD values 22.0 to 26.0 μm; RELVAL = - 10.9 x (MSMFD + 1.5) + 339.8;
2. For MSMFD values 26.1 to 34.0 μm; RELVAL = - 4.933 x (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.

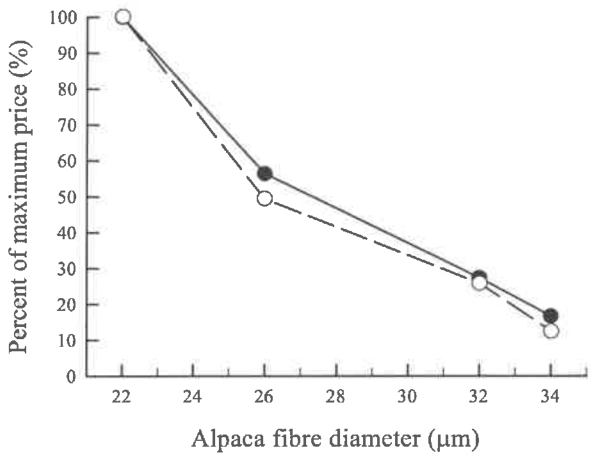

Figure 2: The effect of alpaca fibre diameter on the relative price of white alpaca tops over the 10 year period 1985 to 1995 (●) and during the price cycle troughs in 1986, 1991 and 1992 (O).

The shape of the price/fibre diameter curve is generally similar to that seen with wool and mohair. This is not surprising as the physical properties of alpaca, wool and mohair that affect textile performance are identical. For example, Swinburn et al. (1995) found that increasing alpaca fibre diameter significantly increased the prickliness and reduced the softness of alpaca blend knitwear.

Relative economic value of Australian alpaca fleeces

The total relative economic value increased with increasing fleece weight (Figure 3a) and with increasing weight of the saddle up to a saddle weight of about 2.5 kg (Figure 3b). 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 3c). Total relative economic value declined with increasing live weight above 60 kg (Figure 3d) and with increasing age above 2 years for Huacaya and 3 years for Suri (Figure 3e).

Generally 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 appears to be the case under current international market conditions (Figure 1) 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 (see Hack et al. 1999, McGregor 2006), the greatest driver for increased economic value was reducing mean fibre diameter.

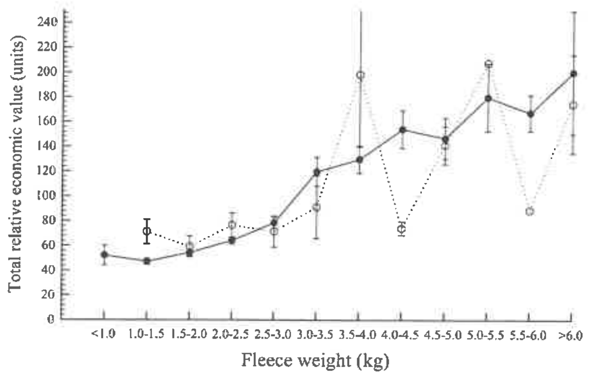

Figure 3a.

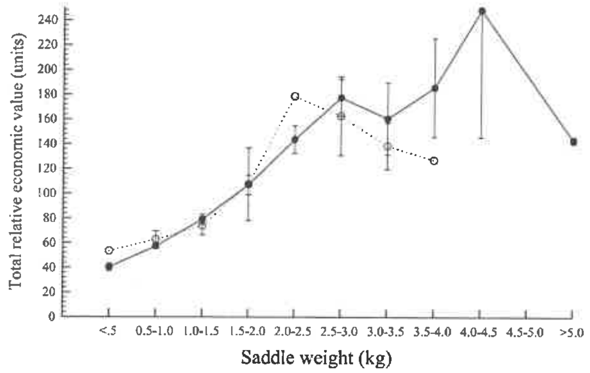

Figure 3b.

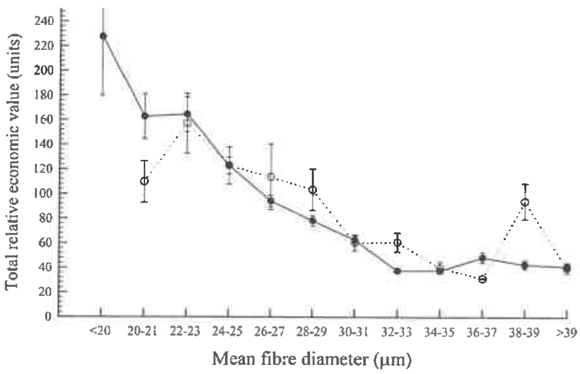

Figure 3c.

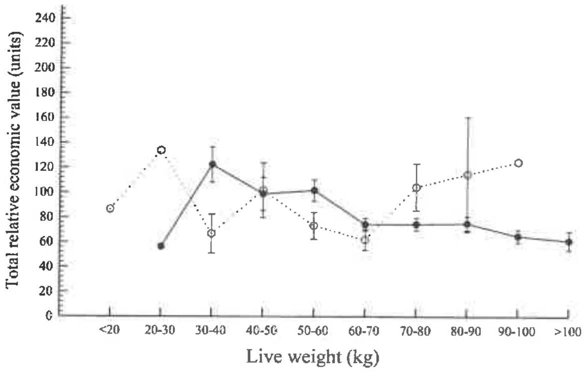

Figure 3d.

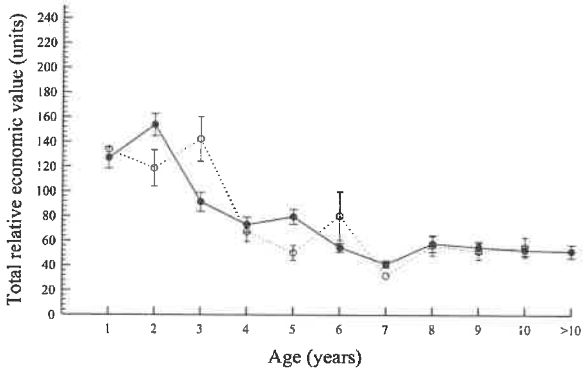

Figure 3e.

Figure 3: 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.

Using the economic values in selection programs

The relative economic values determined in this work can be used to evaluate the economic value of individual animals in breeding programs such as the AGE program. As Figure 3e shows, 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. This reduction in economic value will be minimised or eliminated if breeders can substantially reduce fibre diameter blowout (McGregor and Butler 2004a).

Fibre diameter 'blowout'

The term 'micron blowout' is commonly used in the wool industry to describe the increase in mean fibre diameter with age that is not due to short lived environmental influences. Depending on the property, 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 ± 7.5 µm (McGregor and Butler 2004a). Thus it has been 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 repeatable animal to animal variation is such 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, as indicated by the repeatable animal correlation of 0.5 years of age and slope being only 0.363. 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 of huge differences in 'micron blowout' is confirmed, beyond any reasonable doubt, by this research with Australian alpacas. This is clearly one of the most important issues that needs addressing within the Australian alpaca industry.

Conclusion

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 and lighter animals. This work provides a method to assign an economic value to alpaca fleeces thus enabling animal selection based on international commercial economic values.

References

Anonymous (2006a). Woolcheque, wool diameter. Australian Wool Innovations, Sydney.

www.woolcheque.com.au/LivePage.aspx?pageId=44

Anonymous (2006b). Market information, alpaca prices 1981 to 2006. Alpha Tops sa, Geneva.

www.alphatops.com/index3.htm

Aylan-Parker J and McGregor BA (2002). Optimising sampling techniques and estimating sampling variance of fleece quality attributes in Alpacas. Small Ruminant Research 44: 53-64.

Hack W, McGregor B, Ponzoni R, Judson G, Carmicheal I and Hubbard D (1999). Australian alpaca fibre: improving productivity and marketing. Rural Industries Research and Development Corporation Research Paper No. 99/140. RIRDC, Barton, ACT.

McGregor BA (2002). Comparative productivity and grazing behaviour of Huacaya alpacas and Peppin Merino sheep grazed on annual pastures. Small Ruminant Research 44: 219-232.

McGregor BA (2006). Production, attributes and relative value of alpaca fleeces in southern Australia and implications for industry development, Small Ruminant Research 61: 93-111.

McGregor BA and Butler KL (2004). Sources of variation in fibre diameter attributes of Australian alpacas and implications for fleece evaluation and animal selection. Australian Journal of Agricultural Research 55: 433-442.

McGregor BA and Butler KL (2004). Contribution of objective and subjective attributes to the variation in commercial value of Australian mohair and implications for mohair production, genetic improvement and mohair marketing. Australian Journal of Agricultural Research 55: 1283-1298.

Ponzoni RW, Hubbard DJ, Kenyon RV, Tuckwell CD, McGregor BA, Howse A, Carmichael I and Judson GJ (1997). Phenotypes resulting from Huacaya by Huacaya, Suri by Huacaya and Suri by Suri alpaca crossings. Proceedings of the Association for the Advancement of Animal Breeding and Genetics 12: 136-139.

Ponzoni RW, Grimson RJ, Hill JA, Hubbard DJ, McGregor BA, Howse A, Carmichael I and Judson GJ (1999). The inheritance of and associations among some production traits in young Australian alpacas. Proceedings of the Association for the Advancement of Animal Breeding and Genetics 13: 468-471.

Swinburn DJ MacK, Liang RM and Niven BE (1995). Development of alpaca and alpaca/wool blend knitwear fabrics. Proceedings 9th International Wool Textile Research Conference 2: 536-544.

Wuliji T, Davis GH, Dodds KG, Turner PR, Andrews RN and Bruce GD (2000). Production performance, repeatability and heritability estimates for liveweight, fleece weight and fiber characteristics of alpaca in New Zealand. Small Ruminant Research 37: 189-201.

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Finding the niche in the global market

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Abstract
Since the 1980's the market for alpacas has expanded from South America to encompass countries across North America, Australasia, Europe and Africa. To be able to sell in these emerging markets you need to identify what overseas breeders are looking for, and why they would want to buy from you. You also need to understand what some of the pitfalls are. This paper takes you through my particular journey, and raises questions that you will need to answer if you wish to find your niche in this global market place.

Keywords
Overseas markets, research, contacts, breeding

Is there a Global Market?
Yes, most definitely!

Up until the 1980's, the alpaca industry was mainly the providence of South America, with the alpaca population of approximately 3 million split between Peru, Bolivia, Chile and Argentina. At around this time, the interest from small breeders around the world started to develop, and more than twenty years on the market for alpacas is now well established in North America, Australasia, Europe, and Africa.

Table 1: Estimated world population gathered from data available on the internet.

Country	Alpaca Population
Peru	2,500,000
Bolivia	500,000
USA	70,000
Australia	70,000
Chile	50,000
Canada	14,000
UK	14,000
NZ	4,000
Germany	2,000
Switzerland	1,600
South Africa	600
France	500
Italy	400
Ireland	200

Outside of South America, Australia and USA are the two dominant markets, with the industry still in the establishment phase in the rest of the world. Looking at the figures for Australia, 70,000 starts to feel like a large number, but when you compare this with the established wool industry, were the current number of merino sheep in Australia is 97.5 million, you can see we still have a long way to go.

However, compared to the other alpaca markets Australia has a well established industry that is able to provide a diverse pool of breeding stock, whether breeders are interested in colours, fibre, fleece types etc.

Why would overseas breeders be interested in Australian alpacas?
There are a number of factors. These include:-

- Disease free status i.e. FMD etc
- Availability & costs
- Quality livestock due to rigorous breeding programmes

This has seen Australia over the last few years exporting alpacas to New Zealand, South Africa, Europe and the UK.

How did I get involved in exporting alpacas?
My first export sale was as a result of being contacted directly by an agent buying on behalf of overseas buyers. I was recommended by others in the industry that I had developed relationships with through attending the various local and major interstate shows. It also helped that I have been able to compete successfully at these shows, and have quality animals available to offer. My first animal to be exported had won a Supreme Championship at a local show, and is now enjoying life in Scotland.

Figure 1: Beringya Downs Kara exported to United Kingdom.

Finding my niche
Having made my first sale overseas, I started researching what overseas buyers were looking for through surfing the internet, and talking to contacts I had made with breeders both in Australia and overseas. I found that many of them have no preconceptions about the Australian alpaca market place but were looking for proven bloodlines and avidly followed the show results.

Since I started in the industry over 13 years ago, I have always had a strong view of what I wanted to breed for, and have consistently adhered to this in my breeding programme. In my case I have concentrated on particular bloodlines, particularly Highlander and El Dorado, as well as with very select males that I believe are making an impact with their progeny on the Australian show circuit. Following this approach I have had reasonable success at both the local and interstate shows and therefore my stud name features regularly.

I have also ensured that I have maintained and further developed contacts with overseas breeders. The Royal shows and especially our Australian National show, where there are a number of overseas visitors is very important. This strategy has seen me being contacted by overseas buyers who have been particularly interested in my breeding. These buyers have done their research, and followed the Australian show results, having a good idea of what they are looking for. I have developed my own website, and have been able to direct buyers to view the alpacas that I have available, as well as their ancestry and show results. Through this I have then been able to offer them alpacas with generations of proven family history.

What has the result been for me?
Although only a small breeder, over the last three years I have managed to make sales to England, Scotland, Germany and New Zealand. This has not only helped to promote my stud in the global market place, it has also given me the opportunity to further develop contacts and relationships with breeders around the world.

I have had the personal satisfaction of seeing my breeding promoted in other countries, and have seen this as a confirmation of my breeding programme.

It hasn't happened overnight but with a lot of passion, and time and effort, it has started to pay off.

What are some of the pitfalls?

You must have quality stock with good conformation. Generally they want your best which you may have otherwise wanted to keep for your own ongoing breeding programme.

Most countries that you are exporting to have rigorous screening standards, and will not accept animals that fail to conform.

You will need to meet the Australian quarantine standards. If an animal fails quarantine, you may have lost the sale.

Sale contracts have to be highly specified, and if issues arise, handling these over long distance will be difficult.

Where do you start?

You need to identify what will work for you. What will make you stand out?

Research and understand what overseas buyers are looking for. There is no point breeding for a particular characteristic that the rest of the world has never heard of. On the other hand there could be markets for superfine alpacas or a particular colour or even size.

Identify the market that you wish to sell to. Your breeding programme should then support this.

Develop contacts – make sure you are known. I do this through attending shows, as well as getting involved in other events. You may prefer other options for your marketing strategy eg advertising in journals, sponsoring events etc.

In Summary

There is a global market, with the alpaca industry developing in a range of countries within Europe, as well as more locally in countries such as New Zealand and South Africa.

The industry has come a long way in the past thirty years, with new breeders overseas looking for quality animals to build their herds and establish their reputations.

To be able to sell consistently overseas you need to do your research and identify what market niche you wish to fill. Once you have decided on this, you need to maintain your goal. Don't expect results overnight, it takes hard work and time to develop not only your reputation and contacts, but also your stock of alpacas for sale.

References

Alpaca Information – www.alpacaseller.com
Mike Safley (2004). The Alpaca Market in 2018 (www.ideal-alpaca.com)
Dr Alex Ball (2004). Vic Country Hour Summary – Monday 17/05/2004 (www.abc.net.au)
Joanne Rothque (2006). Australian Alpaca Newsletter No.53 June 2006

Research and Development of the Australian Alpaca Industry

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Abstract
This paper explains the current context of research and development of the Australian alpaca industry. It describes the structure and key processes and procedures, the context in which the key decisions are made, how projects are managed, the characteristics of the industry that contribute to its research success, and the main purpose and objectives of the R&D Subcommittee.

Key Words
Research and development, R&D Subcommittee, research projects, research investment, industry resources.

Introduction
In 1989, a year after the importation of the first alpaca on which today's alpaca industry is founded, and only months before the Australian Alpaca Association Inc. was registered, Richard J Mahoney, CEO of Monsanto during late 1980s, advised organisations and industries that if they desire to be on the cutting edge they must not just prioritise research and development, but be fully and wholly committed to the concept of "R&D isn't part of the strategy, R&D *is* the strategy" (Ellis 1989 p.66). In reflection of this philosophy, the R&D Subcommittee has established structure, procedures and processes to manage the R&D of the industry, to support researchers, and to attract potential researchers and patrons to invest in the alpaca industry.

Structure
During recent times the R&D Subcommittee of the Australian alpaca industry has taken some significant steps to design and implement appropriate structures that will enable the industry to maximise research opportunities, support ongoing projects, and use resources effectively and efficiently.

This existing structure works well for the current needs. R&D is managed by the Chairperson of the R&D portfolio, who also sits on the National Committee. The five-person R&D Subcommittee, accountable through the Chairperson, develops structure; establishes and upholds protocols, process and procedures; supports research activity in-progress; manages the resources that are currently available; and plans for the future needs of R&D activity.

Each Subcommittee member sits on one or more research project working parties. The purpose of these working parties is to provide support to Association-accepted projects by assisting in the provision of whatever resources may be required.

R&D research can result in outcomes that have financial value. For the sole purpose of protecting this intellectual property, confidentiality of projects and of contract negotiations, and holding research contracts between the Association and researchers, an R&D company, Australian Alpaca Research Propriety Limited (AARPL), has been established. This Company is wholly owned by the Association.

Whilst this structure is not complicated it is quite sophisticated when compared with the R&D strategies of other primary industries.

Resource management
Decision making pertaining to R&D not only accommodates the current needs of the industry, but also the availability of resources, the predicted future industry needs, plus the demands and needs of industry stakeholders and the wider environment including government. Furthermore, as the industry resources are owned by the members, in essence decisions must accommodate their needs. All of these aspects can make

decision making complex and challenging, particularly given that the R&D of the industry is being managed entirely by volunteers.

R&D has the second largest budget allocated to portfolios but this is quite inadequate to fully fund the research that is necessary if alpaca has a commercial future in this country. We are dependant on universities and other research institutions being attracted to alpaca research, seeing it as a viable alternative compared with other options, and on funding sources such as Rural Industries Research and Development Corporation (RIRDC).

The management of resources is about much more than budget allocation. Resources that are available include the enthusiasm and the wide range of expertise that is available in the membership, the skills of the loyal and dedicated Association staff, and the innovative and creative ideas that come from outside and inside the industry. Another resource is the reputation and credibility of the industry, as a viable primary industry in which investments are likely to produce worthwhile outcomes, and as an industry that has integrity in the community, in the commercial world, and in the research community. If we want to attract serious research into which people outside our industry invest their money, their efforts and expertise, and their reputations, we must be serious about our industry and about research.

Success of the Association R&D is largely due to two characteristics of the alpaca industry. One is the attitude of many of the members toward research. Not only do these members appreciate that the industry's future is very dependent on the gaining of greater knowledge of the animal and of fleece processing, but they are also willing to participate in this research. Associated with this attitude is the wide range of knowledge, skills, and abilities they give to these undertakings. Both these attributes place the alpaca industry in a unique position, giving it an immeasurable advantage, within the Australian rural industry sector.

The other characteristic is that the industry is represented by a single desk – the Australian Alpaca Association. The industry speaks to outsiders as one voice, one representative, which gives confidence and the assurance that the Association and AARPL have the authority and represents the majority of industry, with understanding of the industry context and its needs. Furthermore, the industry's resources are centrally focused and thus can be used to affect worthwhile outcomes.

Project management

Each research project relevant to the alpaca industry fits into one of three categories. There are those that are being undertaken quite independently of the AAA. They have been initiated to meet the needs of the researcher or those of the industry as perceived by others independent of AAA R&D. In the second category are projects that have been independently initiated and are not being driven from within the industry, but are seen by the R&D Subcommittee to meet industry needs and thus willing to provide in-kind and maybe even some financial assistance. The third category is those projects that address specific industry priorities or needs. They may, or may not, have been initiated by the Association, are driven by the R&D Subcommittee and attract financial and other supports, from the AARPL.

We strongly encourage those who are interested in undertaking alpaca-associated research to plan and design their projects to fit into the second or third categories. By working in collaboration with the industry researchers can achieve outcomes that not only meet their own objectives, but also assist the industry. Furthermore, these researchers are advantaged by having industry support available to them, some details of which are provided below, including a working party, the makeup of which is determined by both the researcher and the Association.

All alpaca researchers are encouraged to register their projects with AARPL, even if they wish to remain independent, and do not require or seek any assistance. Confidentiality is assured, and by us having knowledge of all projects we can alert researchers to situations such as duplication, which wastes resources and reduces the merit and significance of outcomes, and assistance that could be of value. Furthermore, we may be able to make suggestions that could enhance the value of the project.

The purpose of the R&D Subcommittee is to meet the research and development needs of the industry, by providing the means by which knowledge of alpaca and associated industry issues can be increased. Thus, its objectives are to:

- Encourage research activity that is value to the alpaca industry;
- Protect AAA-owned intellectual property;
- Protect those members of the AAA who participate in research activity;
- Ensure that the information they provide is kept confidential;
- Ensure that their efforts are invested in research that is sound, ethical and aims to produce beneficial outcomes;
- Establish the alpaca industry as a good industry in which to target:
  (1) research activity, as:
    - The industry provides active support to researchers, including:
      - Topic suggestions that align with industry needs;
      - A working party for each project, the members of which are selected to suit the needs of the particular project, provides whatever support is required;
      - Appropriate mentoring and access to expert advise;
      - Relevant contact introductions and networking;
      - Reference letters to support scholarship and finance applications;
      - Finance and in-kind assistance;
      - Links to breeders and other relevant personnel within the industry who are eager to assist research;
    - Research outcomes benefit the industry as the industry knows and clearly articulates its needs;
    - Those projects that are supported are known to be scientifically sound, as Association has established a reputation for only supporting research that is such;

  (2) research investment, as:
    - Research activity is driven by the industry, not researchers, therefore the outcomes do benefit the industry;
    - The industry supports research projects with a range of strategies, and thus enhances the rate of success;
    - The methodology of accepted projects is ethical and sound;
    - The projects accepted by the Association are value for money.
- Strengthen and reinforce within the industry a culture that values R&D, and an appreciation of what is required for R&D to be successful and beneficial for the industry.

Whilst these management strategies encourage and support formal research projects, the industry must also recognise and appreciate the amount of knowledge that is being gained as breeders, faced with specific problems, take initiatives and try new strategies, thus adding to the knowledge capital of the industry. The outcomes of these ingenuities creep silently into the culture and just become 'common knowledge', yet they are invaluable.

Future opportunities

During the forthcoming year, in addition to continuing to support local research, the Subcommittee will attempt to further build the relationships we have established with researchers overseas to develop collaborative projects on issues that are pertinent to alpaca, regardless of their location. During the inaugural International Camelid Conference held recently the Camelid Research Foundation was established. Unfortunately the AAA does not have representation on this, as it is likely to be a very rich source of funding with the Arabs being involved.

Also, we have initiated preliminary strategies to develop research that cuts across other species. Some of diseases and problems experienced by alpaca are also found in other animals, for example, staggers. The initiatives taken by the members of the staggers working party have created the potential for our industry to drive across-species research on problems-in-common. Not only could such initiatives address our particular problems, but they also enable us to tap into sources of funding available to other, more established, primary industries. Furthermore, they can contribute to developing the alpaca industry as one that is serious about being a legitimate primary industry, going about its business in a professional way, and accepting responsibility for its own future.

Conclusion

The value of today's industry, including the value of animals, is largely determined by the perception of its future. Potential and current investors must believe that it has a viable future, not just in the short-term, but long-term. It is quite evident that for the alpaca industry to be a legitimate primary industry current farming practises and management strategies are not feasible. There must be some major changes, and these are significantly dependant on its research and development. Whilst it has the structure, policies and procedures that enable some R&D to occur, for any expansion of R&D there must be strong support and encouragement from the decision-makers and recognition of the value of innovative strategies.

References

Ellis J E 1989. Why Monsanto is plunking down its chips on R&D. *Business Week* August 21.

Sustainable parasite control - Integrated parasite management (IPM)

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Key Words
parasite, resistance, residues, control, *refugia*, quarantine

Introduction
Integrated Parasite Management (IPM) is an approach to parasite control that utilises a range of chemical and non-chemical control strategies in combination (an approach borrowed from the Integrated Pest Management strategies used in cropping systems). Well-designed and managed integrated control programmes suppress parasite populations to a level that is minimising economic losses as well as preventing animals from suffering clinical disease. The various elements that can be employed are discussed below. Each element should be considered in relation to its impacts on all the parasite species that are of concern and also its effect on other management activities and farm productivity and profitability.

Parasite Resistant / Resilient Stock
Stock that are resistant to parasites will carry fewer parasites than other stock, whereas resilient stock will carry just as many parasites while suffering fewer negative impacts. For instance, *Bos indicus* breeds (e.g. Brahman) will carry fewer cattle ticks than *Bos taurus* (British and European) breeds (i.e. resistance), whereas they will carry just as many buffalo flies while showing fewer effects (i.e. resilience). This strategy is most easily applied by running breeds that are resistant / resilient to the parasites in a particular area. There is, however, variability within breeds and even within herds with a similar genetic background. Producers can introduce sires that have been tested for their resistance / resilience. They can also actively select for resistance / resilience within their own animals by culling animals that are carrying large parasite burdens or are performing poorly in the presence of parasites. This approach is rarely viable in isolation because heavy selection for resistance in animals is often counteracted by not allowing heavy selection for production traits. Selection for resilience is less likely to have a negative impact on production traits, but significant economic losses can occur in the early stages as animals suffer from the parasite burdens they are carrying.

Pasture Management
Parasite burdens in animals can, in many cases, be limited by preventing continued infection from contaminated pastures. In some cases this can be achieved by modifying or isolating particular microhabitats. For example, the drainage or fencing of wet areas can prevent infection with liver and stomach flukes. In many cases, however, the parasites are distributed throughout the pastures and management must be aimed at the spelling or renovation of entire pastures. Unfortunately, many parasites survive for long periods (over 6 months) in pastures when conditions are suitable, so spelling must be balanced against the nutritional values of pastures left ungrazed for certain lengths of time. Rotational grazing where sheep, cattle and/or horses are grazed in paddocks alternately can overcome this to some extent, but care must be taken because some parasites can cross-infect between different host species. Pasture renovation (including burning or ploughing) can kill parasite larvae and intermediate hosts (e.g. the pasture mite intermediate hosts of tapeworms), but is costly and often impractical.

The length of time that animals can safely graze a paddock can be maximised by minimising the rate of parasite contamination. This can be achieved by the strategic use of chemical treatments to prevent parasite numbers from getting out of hand, particularly where young stock, which are likely to carry the highest parasite burdens, are concerned. It can also be aided by minimising the build up of dung in the pasture. Dung provides a safe habitat for roundworm larvae and a breeding place for flies. By breaking down faecal deposits (either physically using harrows or by encouraging the activities of dung beetles), the dung is spread out and buried. It becomes dry and exposed to sunlight making it unsuitable for the survival of parasite larvae. Do not harrow pastures during wet weather though, as this would have the opposite effect of spreading active infective parasite larvae.

Nutrition

The ability of animals to mount an immune response is closely linked to their nutritional status. Animals in poor condition are unable to mount an effective immune response to parasites. Similarly, animals suffering from a deficiency of a particular element such as Cobalt (leading to a vitamin B12 deficiency) or Selenium can have a compromised immune system. Supplementary feeding can be used when pasture feed is poor to ensure that animals can mount a good immune response, particularly since infection rates can be high in dry conditions because the animals are feeding close to the ground. Supplementation of particular elements should only be employed in areas of known deficiency.

Vaccination

Vaccination is a key element in the control of many diseases. Vaccines are designed to prime the animal's immune system so that it recognises the disease organism and immediately mounts an immune response. In most cases, vaccination does not prevent the animal from acquiring the disease, but prevents the disease from progressing to a dangerous level. Unfortunately, there are few parasite vaccines available for use in ruminants. Some live parasite vaccines (those that use live organisms to infect the animal) are available, but are restricted to the protozoan parasites that cause tick fever. No killed parasite vaccines (those that use entire organisms that have been killed or extracts thereof) are available. Only one subunit vaccine (which uses a part of the organism produced artificially) is available. It is used to control the cattle tick, but requires repeated use to maintain effective immunity. Vaccination is, for the moment, of limited value in parasite control simply because of a lack of vaccines.

However, vaccinating against other diseases is a sound practice and will also indirectly control parasitic diseases by keeping animals strong and healthy.

Biological Control Agents

Biological control agents are animals or organisms that naturally control the parasite through predation, parasitism or disease. If applied in artificially large numbers, they can effectively reduce the parasite population to very low levels. Although examples like predatory mites are widespread in the horticultural industry, the only example in the livestock industries is the use of dung beetles for the control of flies and, to a lesser extent, roundworms. Much research is currently underway looking at a variety of organisms that may prove suitable. The most promising are fungi that can be applied to animals to infect and kill ticks and flies or applied to pasture to capture and kill roundworm larvae in the dung and soil.

Parasite Traps

Traps generally rely on the behaviour of parasites to catch and kill them. They are usually only effective when the targeted parasites are highly mobile. Sheep blowfly traps lure the flies into the holding container using a chemical attractant. In contrast, buffalo fly traps utilise the change from light to dark or brushing fingers to dislodge the flies, which then travel towards the sunlight and become trapped. The use of traps is restricted mostly because of practicality. For instance, cattle must go through a buffalo fly trap twice a day to get good control of the fly. This cannot be achieved unless animals have a single source of water or another attractant (e.g. supplement licks) that can be fenced off and will be visited regularly by the animals.

Strategic Chemical Control

This final element of IPM will be the focus of the conference talk. The audience will be encouraged to ask as many questions as possible.

Chemical treatments should be used strategically to suppress parasite numbers before they become a problem rather than to try to fix a problem that has already occurred. Once animals are clearly diseased their production has already been reduced by 10-20%. Chemicals should be used wisely: the correct chemical should be applied in the correct way, at the correct dose, at the correct time. Chemical products should be chosen according to which parasites need to be controlled (do not use a broad spectrum product when a single parasite needs to be controlled and a narrow spectrum is available) and the resistance status of the property. It is essential that the efficacy of chemicals be monitored on an ongoing basis to ensure that they are working appropriately and that unseen parasite problems are not occurring. Chemical use should be minimised (i.e. do not treat if it is not needed), but parasite populations should not go unchecked because treating too late will often result in high levels of pasture contamination and high infection rates that require repeated treatments. This then results in the use of more chemical than otherwise would have been required, greater losses in production, and more residues in commodities.

The concept of parasites kept *in refugia*, the strict application of quarantine principles and the use of combination antiparasitic products form the basis of modern strategic chemical control, aiming at minimising the development of chemical resistance in parasites.

Conclusion

The key to Integrated Parasite Management is to avoid relying on chemical control alone. No new chemical classes are being brought onto the large animal market in the near future. Many of the existing products are being lost to resistance problems. Unless effective non-chemical controls are implemented and chemicals are used in a way that sustains their continued efficacy, parasite problems will make livestock production unprofitable.

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Vitamin D and phosphorus interrelationships in alpacas

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Abstract
A rickets syndrome of young growing crias characterized by stunted growth, shifting leg lameness and angular limb deformities has been described. Initially low blood phosphorus was implicated in the etiology, but later studies showed vitamin D deficiency to be the primary inciting agent. Subsequent studies have characterized the interrelationship between vitamin D and phosphorus in the nutrition of the alpaca. Vitamin D plays an important role in the overall regulation of phosphorus homeostasis. Information extrapolated from other species was used to generate prediction models to estimate phosphorus requirements for various life stages. Vitamin D requirements, based on supplementation trials, are higher for alpacas compared to other species.

Keywords
Vitamin D, phosphorus, nutritional requirements, rickets, alpaca

Introduction
Abnormal bone growth is a commonly diagnosed problem in young growing animals of all domestic species and is usually related to nutritional deficiencies of calcium (Ca), phosphorus (P) or vitamin D. A rickets syndrome in juvenile llamas and alpacas characterized by a shifting leg lameness and enlargement of the joints, most noticeably the carpus, has been described. Affected crias have variably shown a slowed growth rate, reluctance to move and kyphosis. Radiographic evidence of abnormal growth plates and low serum P concentrations were consistent with a diagnosis of rickets. The Camelid Research Group at Oregon State University had investigated the role of vitamin D in hypophosphatemic rickets over a period from 1993 to 1999. We completed five studies dealing with various aspects of etiology, treatment and prevention of this syndrome. This presentation will provide an overview of vitamin D and P metabolism in the alpaca and describe their interrelationship relative to the pathogenesis of hypophosphatemic rickets.

Role of vitamin D
In our first study we defined the role of vitamin D in the hypophosphatemic rickets syndrome. Twenty clinically affected and 10 age and sex matched non-clinical control llamas and alpacas from 9 farms were compared (Van Saun et al. 1996). While serum Ca concentrations did not differ between clinical and non-clinical groups, serum P concentrations in the control group (2.9 ± 0.3 mmol/l) were higher than in the clinical group (1.1 ± 0.06 mmol/l). This was consistent with the original disease syndrome description by Fowler (1990, 1991). Serum vitamin D (25-hydroxy vitamin D) concentrations in the control (83.2 ± 20.2 nmol/l) and clinical (7.4 ± 1.9 nmol/l) groups differed, supporting the hypothesis that insufficient vitamin D_3 production played an important role in the development of rickets in the llama and alpaca. Vitamin D concentrations and month of birth accounted for nearly 60% of the variation in serum P concentrations.

Another aspect of this study was showing that vitamin D supplementation alone could improve P status. Ten clinical animals were subsequently treated with either parenteral or oral gel forms of vitamin D. Calcium, P and vitamin D concentrations were measured before and after treatment. The data in Table 1 show significant increases in both P and vitamin D concentrations with treatment. These results then set the stage for subsequent studies determining an appropriate treatment and prevention protocols.

Study Conclusions:
Vitamin D deficiency, and not dietary P deficiency directly, induces low serum P concentration in growing llamas and alpacas resulting in a hypophosphatemic syndrome. Supplementation of vitamin D can increase both vitamin D and P status and correct deficiencies associated with the disease process.

Table 1: Mean serum concentrations of calcium, phosphorus and vitamin D in paired samples obtained from 10 rickets-affected camelids before and after treatment with a vitamin D supplement.

Serum Parameter	Time Relative to Treatment		
	Before	After	Reference
Calcium, mmol/l	2.4 ± 0.06	2.5 ± 0.22	2.1 – 2.7
Phosphorus, mmol/l	1.16 ± 0.13	2.9 ± 0.16	1.6 – 2.9
Vitamin D, nmol/l	5.9 ± 1.4	259.9 ± 53.6	> 75

Seasonality Effects

Both owners and veterinarians reported a seasonal incidence of this problem with cases being diagnosed primarily between November and March in the Northern Hemisphere. This observation fits well with the finding of low vitamin D as the causative agent. Vitamin D requirements of the animal are met by either dietary supplementation or synthesis in the skin by the animal. We hypothesized that insufficient sunlight during the winter months resulted in decreased vitamin D production by the animal. This is not a unique situation to alpacas, but has been documented in sheep in both northern and southern hemispheres during winter and summer seasons, respectively.

In the second study, serum Ca, P and vitamin D concentrations in 30 llamas and alpacas were measured at monthly intervals for 12 months (Smith and Van Saun, 2001). Analysis of samples collected over 12 months showed no seasonal change in serum Ca concentrations. In contrast, P and vitamin D concentrations declined significantly during the winter months. Highest vitamin D concentrations were seen through the summer months peaking in September. An interesting secondary finding was that vitamin D concentrations increased following shearing. This observation would suggest that the fleece blocks out much of the sun's rays. Similarly, we found that coat color also impacts potential for vitamin D synthesis. Two jet black alpacas never showed any increase in serum vitamin D concentration compared to white or cream coated individuals. The severity of the decline in vitamin D concentrations was most pronounced in the youngest animals with mean P and vitamin D concentrations decreasing to 50% and 10% of the peak summer values, respectively. These results support the hypothesis that vitamin D and serum P concentrations vary significantly as a function of season.

These results have important implications for the management of Fall-born crias (Northern Hemisphere). Observations suggest that Fall-born crias are most susceptible to this syndrome. This observation makes sense in that Fall-born crias never obtain any vitamin D reserves from summer sunshine. In contrast Spring-born crias store vitamin D during the summer and enter the winter with these reserves. Also Fall-born crias will be attempting to achieve their most rapid growth rate during the time of lowest vitamin D and P concentrations compared to Spring-born crias.

Study Conclusions

Serum vitamin D and consequently serum P concentrations vary according to season with lowest values during the winter months. Fall-born crias will need to be carefully managed and vitamin D supplemented to prevent the rickets syndrome.

Phosphorus and vitamin D metabolism and requirements

Metabolism of Ca and P is intertwined with vitamin D. Specific actions of the active form of vitamin D (1,25 dihydroxycholecalciferol) are mediated by the presence or absence of the counter-regulatory hormones parathormone (PTH) and calcitonin (CT). There is a dynamic balance between dietary ingestion and absorption of Ca and P from the intestines, resorption or deposition in the bone, recycling of P via the saliva and elimination of Ca and P via the urine, feces and milk. Vitamin D is of central importance in Ca and P metabolism having a direct effect on the rate of intestinal absorption, bone deposition and urinary loss. Of particular importance is the role of vitamin D in stimulating intestinal absorption and decreasing urinary losses of Ca and P. Without sufficient vitamin D activity, intestinal absorption efficiency of dietary P is greatly diminished. Renal excretion of P is a minor regulatory pathway in ruminants compared to the recycling of P in the digestive tract through saliva (Horst, 1986). Reduced intestinal absorption of P resulting from vitamin D inadequacy would potentially result in greater losses of endogenous P from salivary recycling, thus, inducing a hypophosphatemic condition.

In the two studies cited above, statistical relationships between Ca, P and vitamin D concentrations and other factors were determined. In healthy crias, serum P concentration was influenced by month and chronologic age ($P < 0.0004$) with a tendency for 25-OH-D_3 concentration ($P < 0.07$) to influence P concentration. Serum 25-OH-D_3 concentration was influenced by month ($P < 0.0001$), chronologic age ($P < 0.0004$) and month of birth ($P < 0.006$). The seemingly high serum P concentrations for the clinically normal llamas and alpacas (mean, 2.9 mmol/l) were consistent with the observations that mean serum inorganic P concentration in healthy crias decreased from more than 2.9 mmol/l to 1.9 mmol/l during the first 12 months of life (Smith et al., 1999). In clinically affected crias, vitamin D was highly associated with serum P concentration. Vitamin D concentration (adjusted r^2, 0.44; $P < 0.0001$) and month of birth (adjusted r^2, 0.12; $P < 0.01$) were the only independent variables that significantly contributed to the overall model (r^2, 0.56; $P < 0.0001$) in predicting serum P concentration (Van Saun et al., 1996).

Since serum P concentration is influenced, but not totally controlled, by vitamin D, it is important to ensure adequate provision of both essential nutrients in the daily diet for alpacas. The National Research Council (NRC) is a scientific body in the US commissioned to study nutrient recommendations for various animal species. A new report is currently being published that will address nutrient requirements for small ruminant species, including llamas and alpacas. Due to a paucity of studies directly addressing llama and alpaca nutrient requirements, most recommendations are based on extrapolated data modified to fit camelid physiology (Van Saun, 2006). Table 2 provides current minimal recommendations for P requirements for various life stage alpacas. At present there is no data to provide insight into bioavailability of dietary P sources, so these data reflect total dietary P intakes.

Table 2: Suggested minimal llama and alpaca phosphorus requirements for differing physiologic states.

Averaged Requirement[1]	Extrapolated Requirement			
	Daily Intake[2]	Diet[3]	Group[4]	Comment
26 mg/kg BW	1.6 - 4.2 g/d	0.17 - 0.21	M	Total requirement
75 mg/kg BW		0.27 - 0.38	G (1-12 mo)	Daily intake will vary by body weight; Dietary concentration for total requirement
42 mg/kg BW		0.21 - 0.28	G (12-36 mo)	
0.15 g/kg Fetus	0.9 - 2.4 g/d	0.28 - 0.33	P	Add intake amount to maintenance; Dietary concentration for total requirement
1.7 g/kg Milk	1.3 - 4.25 g/d	0.32 - 0.45	L	

[1]Extrapolated from nutrient requirements for beef cattle (NRC, 1996), sheep (NRC, 1985) and goats (NRC, 1981).
[2]Estimated daily requirement based on a range of adult body weights from 60 to 160 kg. Pregnancy and lactation intake requirements based on a range of 6 to 16 kg fetal weight and 0.75 to 2.5 kg milk production, respectively. Values are in addition to maintenance for total requirement.
[3]Dietary concentration (g/100 g) on dry matter (DM) basis for total requirement. Nutrient density calculations based on an assumed range of DM intake between 1.25 and 1.5% of body weight (maintenance and pregnancy) and 2.0 and 2.75% of body weight (lactation).
[4]Physiologic states of maintenance (M), growth (G), lactation (L) and pregnancy (P) for which the requirement is defined.

Vitamin D requirements are less clear, even though a feeding trial has been completed (Van Saun, unpublished data). Most NRC reports for ruminant species suggest a minimal vitamin D requirement of 6.6 IU/kg body weight for all physiologic states; equivalent to 400-480 IU/kg total diet dry matter for llamas and alpacas. This value is based on older studies and an endpoint of maintaining blood vitamin D concentrations just above those associated with clinical rickets. One might question this as an appropriate reference given our current understanding of other biological roles for vitamin D, primarily with immune function. However, this recommendation assumed animals would be receiving sufficient sunlight for endogenous vitamin D production. Fleece cover and coloration may limit the availability of sunlight, thus reducing endogenous vitamin D production in camelids, especially when sunlight intensity may be seasonally diminished. A preliminary study addressing oral supplementation of vitamin D in camelids suggested a much higher requirement to maintain rickets-protective serum vitamin D concentration (Van Saun, unpublished data). Data from this study suggested a vitamin D dietary supplementation rate of 30 IU/kg body weight. This higher rate should be targeted to growing crias and reproductively active females. This supplementation rate is equivalent to a total dietary concentration of 2000-2400 IU/kg dry matter or 1800-4800 IU/day for adult animals. Obviously this recommendation is much higher than that for other ruminant species and needs to be further validated. No toxicity problems arose during the duration of the study and many commercial alpaca farms in the US are feeding this level of vitamin D or slightly higher without any problems and more importantly, good success in preventing rickets problems.

Conclusions

Based on available research data, vitamin D plays a pivotal role in both Ca and P homeostasis in alpacas, similar to that of other species. Because of their fleece cover, greater potential exists for inadequate skin production of vitamin D from sunshine, especially during the winter months (Northern Hemisphere), thus inducing a deficient state. As the fermentation vat develops in the growing cria, more P is recycled through C-1 via salvia. Vitamin D status will determine the efficiency in which intestinal P is reabsorbed. In situations of vitamin D deficiency, blood P concentrations are associated with vitamin D status. In contrast, blood P concentration is not associated with vitamin D when sufficient. Recommendations for adequate amounts of P and vitamin D in the diet were made.

References

Fowler, ME. (1990). Rickets in llamas and alpacas. Llamas 4(2):92-95.

Fowler, ME. (1992). Rickets in alpacas. Alpacas (Fall):10-13.

Horst, RL. Regulation of calcium and phosphorus homeostatsis in the dairy cow. *J Dairy Sci* 1986;69:604-616.

National Research Council. (1981). Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries, National Academy Press, Washington, D.C., 91 pp.

National Research Council. (1985). Nutrient Requirements of Sheep, Sixth revised edition, National Academy Press, Washington, D.C., 99 pp.

National Research Council. (1996). Nutrient Requirements of Beef Cattle, Seventh revised edition, National Academy Press, Washington, D.C., 242 pp.

Smith, BB, Van Saun, RJ, Reed, PJ, Craig, AM, Youngberg, A. (1998). Normal blood mineral and vitamin E concentrations in the llama (*Lama glama*). American Journal Veterinary Research 59(8):1063-1070.

Smith, BB, Van Saun, RJ. (2001). Seasonal changes in serum calcium, phosphorus and vitamin D concentrations in llamas and alpacas. American Journal Veterinary Research 62(8):1187-1193.

Van Saun, RJ, Smith, BB, Watrous, BJ. (1996). Evaluation of vitamin D status in llamas and alpacas with hypophosphatemic rickets. Journal of the American Veterinary Medical Association 209:1128-1133.

Van Saun, R.J. (2006). Nutrient requirements of South American camelids: A factorial approach. Small Ruminant Research 61(2/3):165-186.

A survey of 'staggers' observed in Australian alpaca herds

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Abstract

To collect evidence of the distribution, frequency and severity of staggers, the Australian Alpaca Association (AAA) commissioned a survey of producers selected at random from their membership list. The survey addressed the number and type of animals affected (cria *vs* adult, suri *vs* huacaya) over the past three years. Neurotoxic signs were recorded, as well as other effects that can be associated with perennial ryegrass toxicosis (PRGT) such as ill-thrift, heat stress, failure to conceive and neo-natal losses – effects that may apply to more of the herd than those exhibiting the typical neurotoxic signs. Information about the cost and method of treating animals with these signs was collected.

Twenty three percent of 105 randomly selected alpaca producers across Australia reported observing staggers in their herds in the past three years (2004–2006). 76% of producers with perennial ryegrass pasture and 48% of producers with phalaris pastures reported staggers. Of the total number of animals owned by respondents, 3% were reported to have exhibited signs of staggers. The average estimated reported cost to treat staggers was $96 per affected animal per year (including medication, treatment, feed, and labour costs). Herds containing at least one staggers-affected animal had a higher incidence of subclinical effects. Weanlings were much more likely to exhibit staggers than adult alpaca. The need for animal production research to quantify the limitations posed by grass toxins is discussed.

Introduction

A number of plant species can cause neurotoxic disorders with signs such as staggers in grazing animals. In Australia, Perennial Ryegrass Toxicosis (PRGT) is the most common of such problems. It is a condition that can be fatal and is known to occur in sheep, cattle, horses, deer, alpaca and many other herbivores (Miles et al., 1998, Reed & Cummins, 2003). PRGT is commonly known as "staggers", and is associated with ingestion of perennial ryegrass (*Lolium perenne*) infected with the microscopic fungus *Neotyphodium lolii* (Miles et al., 1998, Mackintosh & Orr, 1993). This endophytic fungus produces toxins, some of which have a neurological effect on the animals, causing the staggering symptoms. The ryegrass and the fungus have a symbiotic relationship. Toxins are mainly produced by the endophyte during late spring to early autumn (Holmes et al., 1999). Other causes of staggering symptoms may be associated with the ingestion of other grasses. The most common are annual ryegrass (*Lolium rigidum*), paspalum (*Paspalum dilatatum*) and phalaris (*Phalaris aquatica*) (Miles et al., 1998). A study with dairy cattle in South Australia has shown that herd milk production was reduced by 14% in autumn although only one cow showed signs of staggering (Valentine et al. 1993). Other "sub-clinical" effects including heat stress, lowered fertility, ill-thrift and scouring have been recorded in controlled experiments where sheep or cattle have been grazed on perennial ryegrass with or without the toxin-producing fungus (e.g. Easton et al. 1996, Fletcher et al. 1999, Keogh and Blackwell 2001).

The aim of this study was to summarise observations from a random sample of alpaca breeders throughout Australia in order to estimate the prevalence and severity of the staggers condition.

Method

A survey questionnaire was developed containing questions about a range of factors associated with staggers to elicit relevant observations from alpaca breeders. The voluntary survey was conducted by telephone and the identity of respondents was protected at all times. Lists of members for survey contact were generated at random from all states in Australia from the 2005 Australian Alpaca Association breeders' directory using

JMP statistical software (version 5.01, SAS Institute). Four lists, each comprising 100 members, were prepared and at least two attempts to contact each listed member was made before moving on to the next list. The survey responses were recorded in a spreadsheet for collation and analysis. The sample size lower limit (92) was selected in order to achieve a 95 percent confidence limit at a 10 percent confidence interval. Each survey was identified only by a number.

The survey involved a standard sequence of questions. Firstly, the breeder was asked if they knew what was meant by "staggers", and if they had ever observed it in alpacas or seen any video recordings of the condition. If they were not familiar with staggers, then a brief explanation and description of the condition was given. Then they were asked what animal species were present on the farm and if the breeder had ever seen staggers in their own animals (and if so, then in which species). Next, the number of alpacas on the farm was recorded for each of the years 2004, 2005 and 2006, further classified by type (huacaya or suri) and, for farms where staggers was observed, by age (cria, weanling and adult). Then, a list of possible clinical and sub-clinical signs and symptoms was read to the breeder. These symptoms were crowding into dams and panting in cool weather, reduced fertility, unexplained early cria deaths, loss of pregnancy, failure to thrive and scouring. Respondents were asked to indicate whether or not they had observed any of these in any of their animals. This question was asked whether or not the breeder had observed staggers in their herd.

For farms where staggers was observed, further information was collected. The onset and duration of symptoms of staggers was noted for each year. Any remedial action taken by the breeder was recorded, including veterinary intervention, home medication and management. Respondents were also asked to make an estimate of the costs of both clinical and subclinical effects, being the cost of treatment and management or loss of productivity. Finally, some information about the pasture was recorded for all farms surveyed, where respondents were asked to estimate the incidence and percentage of four grass species in their pasture. Rainfall data (average annual) was taken from official records retained at the Australian Bureau of Meteorology (http://www.bom.gov.au/climate/map/climate_avgs/clim_avg1.shtml, accessed 5 June 2005) by searching for records for the nearest weather station to the location as indicated by the postcode for the farm location (http://www1.auspost.com.au/postcodes/, accessed 5 June 2006) that was supplied by the survey respondent. Data were analysed using Excel (Microsoft), JMP (SAS Institute), SYSTAT and SPSS (SPSS).

Results

In total 105 members of the AAA completed the survey. Those farms that reported at least one animal with the clinical symptoms of staggers (in any year between 2004 and 2006) were classified as 'affected' farms. Eighty respondents (76.4%) reported no staggers in their herds while 25 (23.6%) reported that they did have animals with staggers. The incidence of affected farms by state is shown in Table 1.

Table 1: Total farms surveyed and number of farms reporting staggers by state.

State	No. of farms surveyed	No. of affected farms	% of farms affected in State+	% of farms affected in survey#
Queensland	4	0	0	0
New South Wales	37	2	5.4	1.9
Victoria	34	15	44.0	14.0
Tasmania	3	2	66.0	1.9
South Australia	16	6	38.0	5.7
Western Australia	11	0	0	0
All	**105**	**25**	--	**24.0**

+ Indicates percent of farms affected out of number of farms in the state.
# Indicates percent of farms affected out of total number of farms surveyed.

The number of animals affected and unaffected in each state and for each year of 2004-2006 is shown in Table 2. The only states in which staggers was reported and in which data were significant were New South Wales, Victoria and South Australia. No survey respondents in Queensland or Western Australia reported staggers. However, the number of members surveyed was very low in Queensland (4), which makes it difficult to draw any conclusions as to the existence of staggers-affected alpacas in that state. Tasmania had a very high frequency of herds affected with staggers (2 out of 3 respondents), however, the total number is too low to be statistically significant and therefore were not included in the comparison analysis by state as the results could be misleading. The average number of animals that were observed to have been affected as a percentage of the total number of animals represented by the survey was 3.2%.

Table 2: Number of animals affected and unaffected by staggers within each state for which sufficient data is available.

	2004		2005		2006	
State	**Unaffected**	**Affected#**	**Unaffected**	**Affected**	**Unaffected**	**Affected**
New South Wales	1387	19 (1.4)	1334	18 (1.3)	1087	23 (2.1)
Victoria	815	17 (2.2)	774	35 (4.5)	688	27 (3.9)
South Australia	282	18 (6.4)	355	34 (9.6)	204	31 (15.0)
All	2484	54 (2.2)	2463	87 (3.5)	1979	81 (4.1)

The numbers in parentheses are the percentage of affected animals of the total of animals in the state.

Seventy six percent of affected farms identified perennial ryegrass as present in their pastures. The mean coverage of this grass was 40% on the affected farms. The next most common species present on affected farms was phalaris. The grass types observed in pastures in both affected and unaffected farms, as well as the average percent of pasture covered by each grass type are shown in Table 3.

Table 3: Percentage of farms recording the presence of various species of grasses in their pasture and the average estimate of pasture covered with grass species.

	% of farms with grass#		% of pasture covered with grass*	
Grass Types	***Affected***	***Unaffected***	***Affected***	***Unaffected***
Perennial Rye	76	36	40	15
Annual Rye	24	23	18	19
Phalaris	48	19	29	11
Paspalum	24	26	5	9

Numbers are the percent of affected (or unaffected) farms that reported the presence of the grass.
* Numbers are the percent of coverage of that grass that an affected (or unaffected) farm reported.

The onset and duration of symptoms in herds affected with staggers varied considerably. Onset of symptoms was reported in all months of the year, with a prevalence of onset in January and February, as shown in Figure 1. The average duration of symptoms was three and a half months; however the range of duration was from one week to one year, indicating high variance in this observation as shown in *Figure 2*.

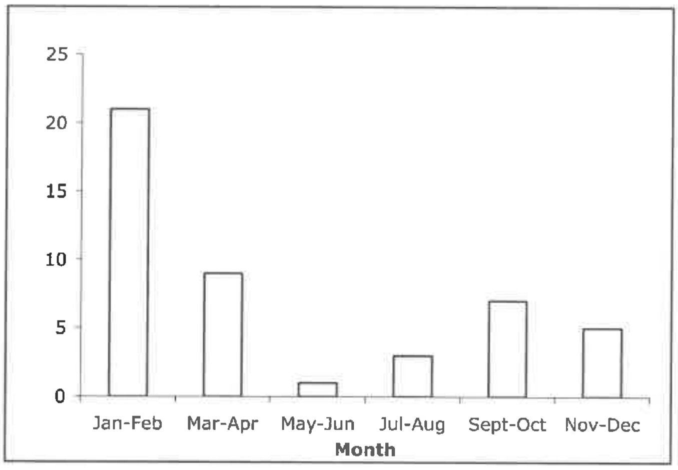

Figure 1: month when staggers symptoms were first seen (2004-2006). The number of farms that reported onset of symptoms in a given month is shown on the y-axis. For some farms, month of onset was different in each of the three years.

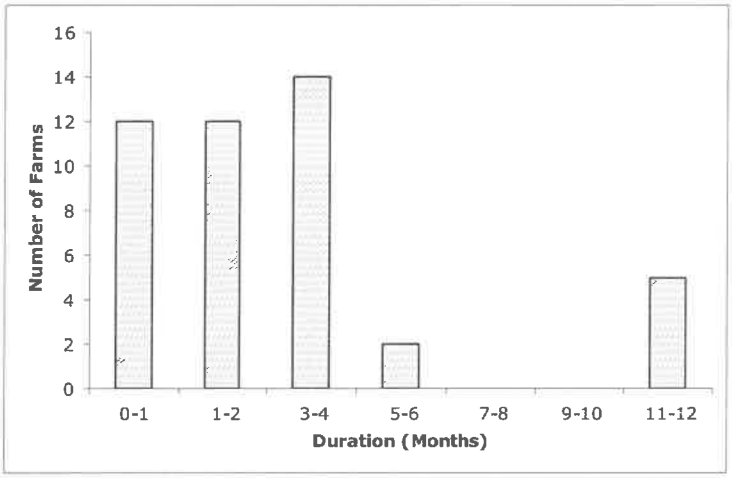

Figure 2: Duration of staggers symptoms (in months) over the three years. The number of farms that reported duration of symptoms for a given number of months is shown on the y-axis. For some farms, duration of symptoms was different in each of the three years.

There was a clear difference in occurrence of staggers between adults, weanlings and cria. The distribution of animals according to age in the affected, exposed and unaffected animals over the three years is shown in Table 4. Over the three years, 21% of weanlings on exposed farms were affected although they represented only 14% of the alpaca on those farms. The distribution of unaffected, exposed and affected animals with regard to type (i.e. huacaya or suri) is shown in Table 5.

Table 4: Age distribution of affected animals.

	2006				2005				2004			
	Total	**C^**	**W+**	**A#**	**Total**	**C**	**W**	**A**	**Total**	**C**	**W**	**A**
Unaffected	3972	--	852 (21)°	3120 (79)	3932	--	872 (22)	3060 (78)	2978	--	634 (21)	2344 (79)
Exposed*	929	75 (8)	162 (17)	692 (74)	927	81 (9)	172 (19)	674 (73)	1521	126 (8)	145 (10)	1250 (82)
Affected	55	4 (7)	31 (56)	20 (36)	88	5 (6)	36 (41)	47 (53)	99	24 (24)	32 (32)	43 (43)

* Exposed animals are those present on farms with at least one staggers affected animal.
^ Cria (no data for unaffected farms)
+ Weanlings
# Adults
°Numbers in parenthesis are the number of animals of that age group as a percent of total animals for each of the categories Unaffected, Exposed or Affected.

Table 5: Incidence of affected animals by type.

	2006			2005			2004		
	Total	**Huacaya**	**Suri**	**Total**	**Huacaya**	**Suri**	**Total**	**Huacaya**	**Suri**
Unaffected	1989	1753 (88)#	233 (12)	1966	1752 (89)	214 (11)	1489	1329 (89)	160 (11)
Exposed*	931	881 (95)	50 (5)	921	895 (97)	26 (3)	833	797 (96)	36 (4)
Affected	55	53 (96)	2 (4)	88	85 (97)	3 (3)	99	96 (97)	3 (3)

*Exposed animals are unaffected animals present on farms with at least one staggers affected animal.
Numbers in parenthesis are the number of animals of that type as a percent of total animals for each of the categories Unaffected, Exposed or Affected.

In describing the symptoms observed, 100% of respondents with affected alpaca reported in-coordination in animals with staggers, 92% head tremors, 84% tripping or staggering, 32% spasms and 28% reported stock down in the paddock. There was an average estimated cost of AUD$96 per year per animal affected with staggers. With regards to remedial action taken by the producers, 68% administered home medication and management and 32% employed veterinary intervention at some stage. The affected farms showed a markedly higher occurrence of sub-clinical signs and symptoms compared to unaffected farms (Table 6).

Table 6: Proportion of herds where possible sub-clinical signs were observed (%).

	Crowding	Panting	Lowered fertility	Early cria deaths	Loss of pregnancy	Ill-thrift	Scouring
Unaffected	3.7	3.7	9.9	18.5	23.5	12.3	6.2
Affected	20.0	20.0	28.0	36.0	44.0	52.0	12.0

In order to examine any effects of rainfall on the occurrence of staggers, the average rainfall was compared for affected and unaffected farms in each state where staggers was seen using the Student t-test. The average rainfall on affected farms was significantly higher on farms that were affected by staggers in both South Australia and New South Wales but not in Victoria (Table 7).

Table 7: Average annual rainfall (in mm) for affected and unaffected farms by state for those with statistically relevant data.

State	Affected	Unaffected	p
NSW	1101	777	0.025
VIC	814	802	0.873
QLD	-	1321	
SA	743	594	0.006
WA	-	691	

The effect of rainfall on the species of grasses reported was also investigated (Table 8). The main effect of rainfall was on the occurrence of annual ryegrass, which was restricted to lower rainfall areas which also varied collinearly with lower incidence of staggers. This suggests that annual ryegrass toxicity (ARGT) is not likely to have been being misdiagnosed as PRGT.

Table 8: Average rainfall for the observation of presence or absence of various grass species, and the statistical significance of the effect.

	Perennial ryegrass	Annual ryegrass	Phalaris	Paspalum
Absent	768 mm	819 mm	776 mm	803 mm
Present	821 mm	708 mm	842 mm	761 mm
Significance of rainfall effect?	No	Yes (p = 0.003)	Yes (p = 0.051)	No

Discussion

The results of this survey indicate that staggers is a condition that does occur frequently in alpacas in Australia, with an average of 24% of farms nationwide being affected by the condition. The proportion of total number of animals that developed staggers was 3%. However, it is possible that this number may be an underestimate because of inexperience in recognizing the signs and symptoms of staggers. Within the farms where staggers was reported, 9.3% of the animals in those herds developed staggers. As might be expected, Victoria and Tasmania, where perennial ryegrass is widely naturalised, showed a high incidence of staggers. However, the number of farms surveyed in Tasmania was too low to gain statistical significance. South Australia was also severely affected (37% of farms reported animals with staggers). While no affected farms were reported in Western Australia or Queensland, the low numbers of farms surveyed mean that it cannot be assumed that staggers is absent from those States.

There was a statistically significant ($p < 0.001$) positive correlation between the presence of perennial ryegrass (PRG) and the occurrence of staggers (Table 3). Seventy six percent of affected farms reported the presence of PRG compared with only 36% of unaffected farms. Phalaris was the next most important grass, being associated with 48% of affected farms versus 19% of unaffected farms ($p < 0.001$). The amount of the grass present in the pastures was also significant, where affected farms had a large amount of pasture consisting of PRG and phalaris when compared to the unaffected farms. However, the presence, *per se* of PRG and phalaris was not in itself diagnostic of staggers, nor proof of a causative effect, because large numbers of farms with these two grasses did not report staggers (Table 3). The data were estimates made by the various, perhaps untrained respondents and cannot be assumed to be consistent and accurate. Of those animals known to have been exposed to pastures containing PRG, 5.9% developed staggers symptoms (Table 4). Interestingly, these data are consistent with those of an earlier smaller scale survey (Reed and Cummings, 2003) that estimated that, when exposed to pastures containing PRG, around 5–10% of alpacas develop clinical signs of toxicoses for up to 3 months of the year.

The month of onset and duration of staggers symptoms varied, but January and February were the most common months for onset. As was determined by **ref, the endophyte *N. lolii* will produce more of the staggers-causing toxin when the plant is stressed (e.g. excessive heat or drought), and this will most likely occur during the dry season. Thus we would expect to see a higher number of animals with onset of staggers symptoms during that part of the year. The duration of the clinical symptoms varied greatly, and most often lasted 3 to 4 months, however, a sizable proportion (20% of the 25 farms that were affected — two in SA and three in Victoria) reported symptoms as lasting for 12 months of the year. Such extended duration of staggers was also noted in the survey of southern Victorian alpaca but has not been observed in sheep and cattle. This might suggest that alpaca may be relatively low in tolerance to perennial ryegrass toxins.

It appears that weanlings are more susceptible to staggers than adults, (Table 4), which is an interesting observation for which there is no confirmed explanation. Further research should be conducted to elucidate the cause of this observation. The survey also found that there was no significant difference in the susceptibility to staggers between suri and huacaya.

When asked about the symptoms that affected alpaca displayed, all breeders reported incoordination, most also saw tremor of the head and tripping or staggering. A smaller percentage reported spasms or having stock down in the paddocks. It is possible that these more serious symptoms were not as commonly observed because – in contrast to extensively grazed sheep - the animals were removed from pasture and treated at the first signs of staggers, preventing further progression of toxicosis. The subclinical signs — heat stress, lowered fertility, ill-thrift, etc. — were 6 to 80% more prevalent in affected herds than in unaffected herds. This indicates that the loss of productivity and subsequent costs from staggers may be much higher than can be estimated from the numbers of clinically affected animals. This is supported by work showing that the estimated cost per head of sub-clinical and speculative effects in sheep is as high as 62% of the total (Lean, 2005). Therefore, elucidation of this cost requires research, for example, by conductinig controlled experiments to measure intake and liveweight gain on perennial ryegrass both with and without toxin-producing endophyte.

Previous work has indicated that rainfall may play a role in the occurrence of staggers because it determines the type of pastures that are able to grow (ref), however our data did not support this. Affected farms in Victoria and South Australia, have slightly elevated average rainfall when compared with unaffected farms. Whilst this effect was statistically significant in SA ($p = 0.006$), this was not the case for Victoria ($p = 0.873$). The limitation of the rainfall data for this study was that the information was obtained on a postcode basis, not a direct rainfall from the farm. Any future studies should endeavour to obtain more precise rainfall data to allow the effect of this variable to be clarified.

Conclusion

The survey provides evidence that clinical staggers is a costly problem for alpacas and is most prevalent where alpaca are grazing perennial ryegrass. Also, there may be serious sub-clinical effects of exposure to pasture-borne toxins. Perennial ryegrass appears to be the grass species most commonly associated with staggers but phalaris was also implicated. Research is needed to ascertain the best management practices for affected alpaca. It must also be established if, as with sheep, it is possible to breed alpacas that are resistant to implicated pasture toxins.

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References

Easton, H.S., Lane, G.A., Tapper, B.A., Keogh, R.G., Cooper, B.M., Blackwell, M., Anderson, M. and Fletcher, L.R. (1996) Ryegrass endophyte-related heat stress in cattle. Proceedings of the New Zealand Grassland Association, vol 57, pp 37-41.

Fletcher, L.R., Sutherland, B.L. and Fletcher, C.G. (1999) The impact of endophyte in the health and productivity of sheep grazing ryegrass-based pastures. Ryegrass endophyte: an essential New Zealand symbiosis. Proceedings of a New Zealand Grassland Association symposium, Palmerston North, NZ, pp 11-18.

Holmes, L., Frame, N., Frame, R., Deff, J., & Lewis, G. (1999) Suspected tremorgenic mycotoxicosis(ryegrass staggers) in alpacas (*Llama pacos*) in the UK. *The Veterinary Record* 145, 462-463

Keogh, R.G. and Blackwell, M.B. (2001) A three-year investigation of the performance of spring calving diary cows grazing ryegrass-based pastures of high or low endophyte toxin status in Northland. Proceedings of the New Zealand Grassland Association, Palmerston North NZ, vol 63, pp 209-214.

Lean, G.R. (2005) Impact on sheep production of perennial ryegrass toxicosis. Proceedings of a symposium "Perennial ryegrass toxicosis in Australia" Attwood, Victoria.

Mackintosh, C. & Orr, M. (1993) Ryegrass staggers in alpacas? *Veterinary Record* 132, 120

Miles, C., Menna, M., Jacobs, S., Garthwaite, I., Lane, G., Prestidge, R., Marshall, S., Wilkinson, H., Schardl, C., Ball, O., & Latch, G. (1998) Endophytic fungi in indigenous Australasian grasses associated with toxicity in livestock. *Applied and Environmental Microbiology* 42, 601-606

Reed, K. & Cummins, L. (2003) Incidence of perennial ryegrass staggers among alpaca in Southern Victoria. Australian Alpaca Association western Victorian region newsletter, Issue 50, pp 15-17.

Valentine, S.C., Bartsch B.D. and Carroll P.D. (1993). Production and composition of milk by dairy cattle grazing high and low endophyte cultivars of perennial ryegrass. 138 - 141. In Hume, D.E et al (ed.) Proc. 2nd International Symposium Acremonium/grass Interactions. Palmerston North. 4-6 February 1993. AgResearch, Palmerston North,

Dental Malocclusions in Australian alpacas

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Keywords
alpaca, teeth, malocclusion, dental, tooth, incisor

Introduction
As in other animals, the mouth is the first stage of the digestive tract. A correctly balanced, well functioning mouth allows the efficient prehension and mastication of food essential for the overall health and wellbeing of the animal. Good teeth play an important role in this process. Dental disorders are not only painful for the animal, (to which many humans can relate) but left untreated will have a detrimental effect in many areas including body weight, fibre quality and the ability to reproduce.
Australian breeders try to maximize the lifespan of their alpacas. This means that dental disorders that are present in young animals are likely to become problematic with the animal's increasing age.
This paper will provide an overview of basic dental anatomy and identify the most common malocclusions observed in Australian animals. There will also be a brief outline of a Case Study.

Dental Anatomy
Alpaca teeth develop and grow below the gums, being fed by blood vessels and nerves housed in the pulp chamber. The teeth erupt through the gums and start to wear as soon as they meet the dental pad or opposing teeth. The teeth keep erupting through the gums at the rate at which they are worn. How quickly the teeth wear is dependent largely upon the type of feed we give them, inherent dental quality and occlusion of the teeth (Fowler, 1999, p.13).

Alpacas have two sets of teeth in their lifetime. The first teeth, known as deciduous or baby teeth, are temporary and are replaced between two and four years of age with permanent teeth. An adult male has 30-32 permanent teeth and an adult female the same or less, as not all females develop fighting teeth.

There are four types of teeth found in the alpaca: incisors, canines, premolars and molars (*Figure 1A* and *Figure 1B*).

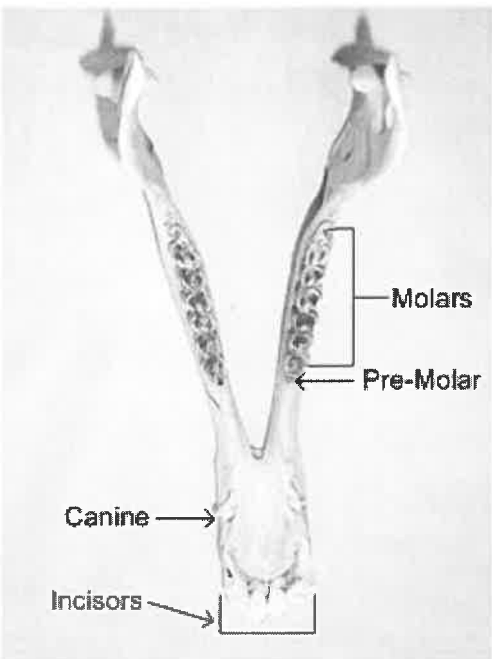

Figure 1A: Lower jaw teeth position

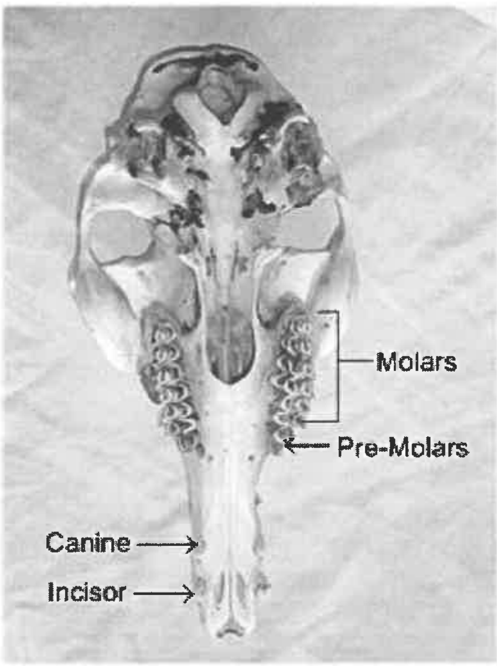

Figure 1B: Upper jaw teeth position

There are six incisors in the lower jaw (mandible) at the front of the mouth of an alpaca (*Figure 2*). The incisors of an alpaca are designed to fit snugly with the dental pad of the upper jaw. Incisors are used for cutting grass.

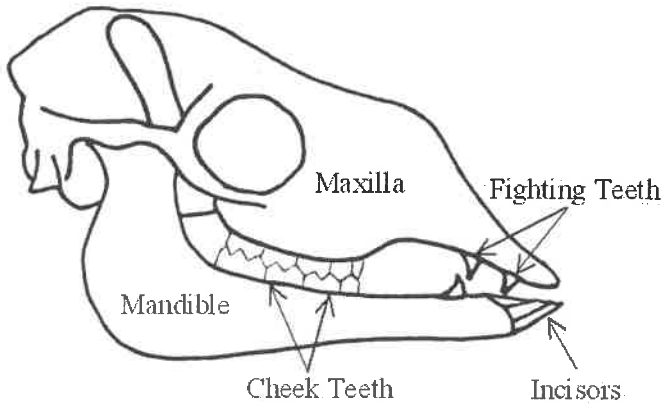

Figure 2: Alpaca skull showing positioning of teeth

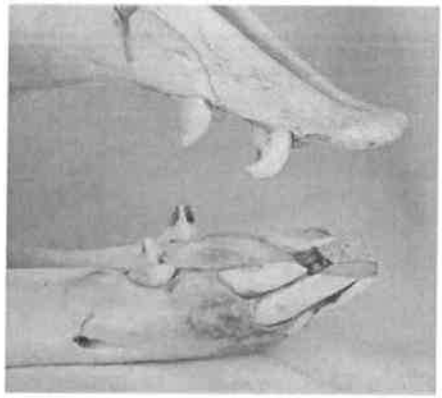

Figure 3: Well developed fighting teeth

There are three pairs of fighting teeth, two pairs in the upper jaw and one pair in the lower jaw (*Figure 2*). Males generally have large, well developed fighting teeth (*Figure 3*) designed to rip and tear, causing serious damage to their opponent during fights for supremacy. Fighting teeth do not always erupt in females and if they do they are usually much smaller.

At the back of the mouth in both the upper and lower jaws are the premolars and molars, usually referred to as the cheek teeth (*Figure 2*). The cheek teeth are arranged so the upper and lower arcades (rows of teeth) mesh together to produce an efficient grinding surface. These teeth do all the hard work grinding the food to a consistency suitable for swallowing.

What Are Malocclusions?

The meeting of the lower teeth with the upper teeth and dental pad is called occlusion. If for some reason they don't meet together correctly it is called malocclusion. As the teeth continue to erupt for most of an alpaca's life, overgrowth occurs when a tooth doesn't meet another tooth in occlusion and wear down. The wear will be uneven and malocclusions such as hooks and ramps will form.

Undershot Jaw

This is one of the most common malocclusions, and one of the easiest to identify as the incisors can often be seen protruding through the lips (*Figure 4*).

Figure 4: Overgrown incisors

Figure 5: Overshot Jaw

Overshot Jaw

This is not quite so obvious but it is an equally serious malocclusion. The incisors bite against the roof of the mouth, not the front of the dental pad (*Figure 5*).

Retained Incisors

Sometimes we see alpacas with two sets of incisors (*Figure 6*). The deciduous teeth have not fallen out as they should have as the new teeth have grown. The retention of the deciduous teeth may prevent the permanent teeth from occluding with the dental pad correctly and should be removed.

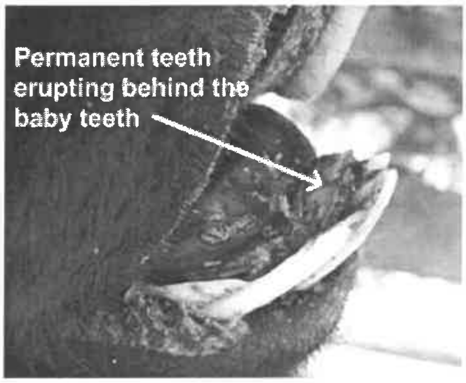

Figure 6: Retained Incisors

Ramps and Hooks

Ramps and hooks occur if the cheek teeth are not aligned correctly. The part of the tooth that is not being worn down may become long enough to dig into the opposite gum, causing significant pain whilst chewing.

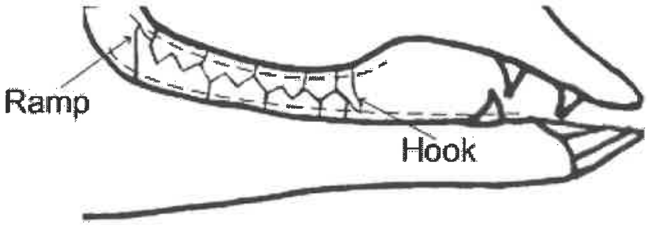

Figure 7: Hook and Ramp shown digging into gum line (dotted line)

Protuberant Teeth

If an alpaca has lost a tooth or had it extracted for some reason, the tooth in the opposing jaw will not have anything to wear against. The result will be an over-long or protuberant tooth. The protuberant tooth can become so long that it can penetrate the gum where the opposite tooth used to sit.

Wavy Mouth

Wavy mouth is the uneven wearing of the cheek teeth creating a roller coaster effect on the grinding surface of the teeth.

The Effects of Malocclusions

Malocclusions cause varying degrees of discomfort or pain to the animal. While times are good and food is plentiful the discomfort may not seem so obvious. When times are tougher, for example during times of drought or other health related issues, dental anomalies become more pronounced.

Overlong incisors, overshot and undershot jaws all make the intake of food more difficult. As cheek teeth malocclusions develop, chewing becomes more difficult and painful.

Identifying Dental Health Problems

These are the more common signs of dental problems that we should all be aware of:

- Loss of body condition, especially if the other animals are doing well in the same environment
- A reluctance to eat, accompanied by obvious pain on chewing
- Feed spillage from the mouth whilst chewing
- Undigested food in droppings

- Swelling around the jaw area
- Nasal discharge
- Unhappy demeanour

Watch your animals, noticing how they eat. Do they chew evenly on both sides of their mouth? Regular observation can identify small problems before they become major challenges. Animal age, characteristics, seasonal conditions, varying types of feed and regional soil variations can all have an impact on what type of dental disorders, if any, may present and when.

Case Study, "Bangles"

I would like to give an example of how animal observation led to the diagnosis and successful treatment of one of my own animals, a 3 year old female named "Bangles". This case in fact was the catalyst for my interest and eventual entry into the practice of Alpaca Dentistry.

Bangles was feeding a cria, living on good grass, and despite having access to extra rations was losing weight and in fact was becoming alarmingly thin. All the other nursing mothers and their cria were doing well in the same environment. In an attempt to reverse the weight loss, Bangles was being fed hay and I also introduced extra supplements in chaff and pellets without success. Apart from the weight loss I noticed other symptoms:

- Obvious pain on chewing.
- Not finishing her rations.
- Did not like being touched around the head.

Having had horses all of my life I realised that these symptoms needed the attention of a dentist. I was referred to a dentist who was treating alpacas and on inspection it was found that Bangles had a rotten tooth. This tooth was duly extracted.

I was amazed at how quickly Bangles improved. Her whole demeanour changed and within one hour she had resumed eating and within three weeks she had regained most of her lost weight. Bangles has needed subsequent treatment in the form of an additional extraction of a loose tooth, and regular trimming of the protuberant teeth from the opposite jaw that no longer occludes correctly due to these extractions. With regular dental maintenance, Bangles will continue to be a healthy, productive animal.

Conclusion

Correct mouth function provides for the efficient processing of food nutrients that are vital to the health, performance and efficiency of an alpaca. Dental disorders in the form of malocclusions can occur during the life of the animal, and present themselves in a wide variety of ways.

An understanding of these disorders, identification of the varying types and appropriate treatment is required to restore optimal mouth function. As breeders strive to maximize reproduction from their older animals, dental health care plays an important role in the management of Australian alpaca herds.

References

Fowler, M.E., 1999. Health Care of the Geriatric Alpaca. *Alpacas Australia, Issue 44 Winter 2004, p. 12-14.*

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An Introduction to linebreeding alpacas

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Introduction

A breeding plan of some description is a necessity for every alpaca breeder that is serious about herd improvement. Without a plan, breeders will produce alpacas that are most likely, of the average quality, of the national herd. There will be the few exceptions that are either outstanding or very poor. However, relying on a random combination of genes leads to assorted results. A carefully considered breeding plan is a wise investment by reducing the odds on what genetic material is passed on to the next generation. At this point it is worth remembering that physical science is not an exact science. While total control is not obtainable, predictability may be increased through a scientific approach and a sound breeding plan.

Line breeding is common practice among most domesticated and indeed undomesticated animals throughout the world. There are even specific references in the Bible explaining how some races were established. A small number of alpaca breeders have ventured down the path of linebreeding, however, the topic linebreeding is relatively uncharted territory in the Australian Alpaca industry. This paper will attempt to provide an overview of the key considerations and implications for a linebreeding program.

The effect of linebreeding

By definition linebreeding is a concentration of the genes of a specific ancestor or ancestors through their appearance multiple times in a pedigree. Inbreeding is similar but involves the breeding of very close relatives. While the difference between linebreeding and inbreeding is highly debatable, for the purposes of this paper, linebreeding will be achieving an inbreeding coefficient no greater than 12.5%. Up to 25% inbreeding coefficient can be achieved by mating a sire back to his daughter or full sister to full brother. However, while I would consider this to be inbreeding, the difference between linebreeding and inbreeding is interpretation. In fact it can quite easily be argued that linebreeding is inbreeding, but to a lesser extent. Examples of inbreeding and linebreeding various animals such as dogs, cattle and horses are able to provide us with the benefit of years of experience and knowledge that we can apply to alpaca breeding programs.

The main aim or purpose of linebreeding is to develop consistency and uniformity within a herd or breed. Bill Robbins states, “Linebreeding is the system by which practically all lasting improvements in livestock have come about” [1]. This can be clearly observed within dog breeding where we now have many different types of dog that breed true to type, which probably all originated from a dog much like a wolf. In some cases livestock or animal breeders have developed a strain within a particular breed through linebreeding. By concentrating the genes of an ancestor or ancestors with specific recognizable traits it is possible to develop a strain within a breed that might one day be recognized as a breed itself. Suri and Huacaya alpacas which have clearly recognized standards may well be examples of this within the camelid family. Eric Hoffman states, “There is only one species of alpaca and the two coat types are often referred to as breeds” [2]. Linebreeding may be used like a tool in the breeder’s toolkit to stamp in particular traits and recognizable features that are of high priority to your breeding program. Whether it is a particular frame, fleece, or other distinguishing feature, linebreeding has the potential to set particular characteristics in a homozygous form to develop a strain within a breed that will show uniformity and consistency. An alpaca has 37 chromosome pairs, inheriting 37 from the dam and 37 from the sire. If the two genes an alpaca carries for a particular trait on a chromosome pair are the same it is said to be homozygous for that trait and will pass on that genetic information to its progeny. “Because inbreeding causes an increase in the proportion of like genes (good or bad, recessive or dominant), the inbred animal's reproductive cells will be more uniform in their genetic makeup. When this uniformity involves a relatively large number of dominant genes, the progeny of that individual will uniformly display the dominant characteristics of that parent”[3].

Every breeder should recognize the value of setting desirable characteristics by increasing homozygosity. Breeders should also beware of setting undesirable characteristics and this highlights the importance of selection and out crossing which will be explained in detail later.

Inbreeding coefficient

When attempting to fix desired traits through linebreeding it is useful to have an understanding of Galton's Law of ancestral heredity and Wright's inbreeding coefficient to fully appreciate ancestral influence.
Galton's ancestral law states that the two parents contribute between them on average half of the total genetic make up of the offspring, the four grand parents a quarter and great grand parents one eighth. Galton's Law recognizes and estimates the hereditary influences that are not expressed in an individual but are capable of being passed on to the next generation. An individual alpaca will pass on a different combination of genes to each offspring and therefore, while very useful in estimating genetic influence, Galton's Law is in fact an estimation of the proportional influence.

Table 1: Galton's Law expressed mathematically.

1/4 SIRE	1/16 G. SIRE	1/64 G. G. SIRE	1/128
			1/128
		1/64 G. G. DAM	1/128
			1/128
	1/16 G. DAM	1/64 G. G. SIRE	1/128
			1/128
		1/64 G. G. DAM	1/128
			1/128
1/4 DAM	1/16 G. SIRE	1/64 G. G. SIRE	1/128
			1/128
		1/64 G. G. DAM	1/128
			1/128
	1/16 G. DAM	1/64 G. G. SIRE	1/128
			1/128
		1/64 G. G. DAM	1/128
			1/128
½	*1/4*	*1/8*	*1/16*

Galton's Law expressed mathematically shows proportional genetic contribution.

From Table 1, it becomes clear that the influence of an outstanding great grand sire will have little influence. However, if the great grand sire appears in three or four of the four possible positions in the pedigree, his influence would be considerable.

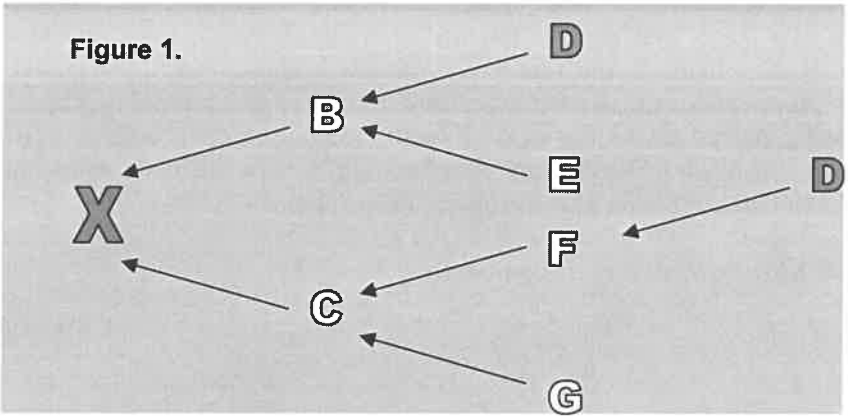
Wright's inbreeding coefficient is a measure of pedigree relationship and estimates the probability that both genes of a pair in an individual are identical (homozygous) by decent.
For example;
Sire & daughter or full brother & full sister = 25%
Sire & granddaughter or brother & half sister = 12.5%
Aunt & nephew or uncle & niece = 12.5%
Full first cousins = 6.25%
Half first cousins = 3.125%
It is relatively easy to calculate the inbreeding coefficient of one ancestor which appears twice in a pedigree. The cumulative effect of multiple appearances in a pedigree by an ancestor or multiple ancestors has a far greater genetic influence and is more difficult to calculate.

Wright's formula for inbreeding coefficient devised in 1922 is expressed as;

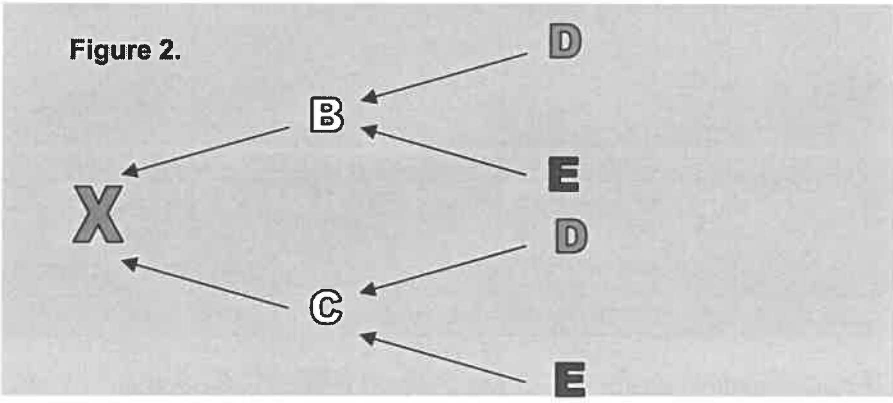
$$F_X = \sum [(1/2)^{n+n'+1} (1 + F_A)]$$

F_X = the inbreeding coefficient of animal X.
(1/2) = fraction of an individual alpacas genetic material that is passed on to its progeny.
n = the number of generations between animal B and the common ancestor.
n' = the number of generations between animal C and the common ancestor.
+1 = is added to n and n' to account for the additional generation between animal X and its parents.
F_A = the inbreeding coefficient of the common ancestor.

The following example demonstrates the use of the formula in use;



$F_X = \sum [(1/2)^{n+n'+1} (1 + F_A)] = \sum [(1/2)^{1+2+1} (1 + 0)] = 0.0625 = 6.25\%$ inbreeding coefficient



$F_X = \sum [(1/2)^{1+1+1} (1 + 0)] + [(1/2)^{1+1+1} (1 + 0)] = 0.25 = 25\%$ inbreeding coefficient

However, when calculating the inbreeding coefficient in Figure 2, if ancestor D already has an inbreeding coefficient of 0.125 or 12.5% then the calculations would be as follows;

$F_X = \sum [(1/2)^{1+1+1} (1 + 0.125)] + [(1/2)^{1+1+1} (1 + 0)] = 0.265 = 26.5\%$ inbreeding coefficient

In a practical sense this means alpaca X has 26.5% likelihood of carrying genes for a particular trait by descent from the common ancestor.

In this situation the use of pedigree tracking software that automatically calculates inbreeding coefficients quickly becomes very useful. By using appropriate software a breeder may identify and track the influence of various ancestors over dozens of generations. Some pedigree tracking software allows the recording of various features or traits. This is particularly useful, providing the breeder with the facility to easily identify and trace the influence or source of a particular trait (good or bad) within their herd.

Disadvantages of inbreeding

There are some obvious advantages and gains to be made through planned linebreeding. However it is the problems associated with severe inbreeding which deters some breeders from considering the role of linebreeding within their herd. The main disadvantages of inbreeding are; reducing the gene pool, decrease in hybrid vigor, inbreeding depression and the appearance of genetic faults. Reducing the gene pool is seen by some as an advantage and others as a disadvantage. On one hand the concentrating of specific genes is very useful in developing alpacas that are uniform and consistent in appearance. On the other hand it could be argued that by concentrating specific genes, we are losing others that might have an important influence that we have not yet identified. Inbreeding depression or decreasing hybrid vigor can cause lack of fertility, higher mortality rates, smaller framed alpacas, congenital defects, reduced resistance to disease and infection. Genetic faults are possibly the biggest obstacle with inbreeding and are often cited as the reason some breeders steer clear of linebreeding. Recessive genes that are responsible for faults are either present or not present in a particular alpaca. However, except for sex linked genes, recessive genes must be present in duplicate (one from sire and one from dam) for the effect to be revealed. The practice of linebreeding will more likely reveal undesirable genes through visible faults exhibited in an alpaca. While many consider this to be a disadvantage, others would see this as an opportunity to identify alpacas that carry defective genes and remove them from the breeding program. A breeder could eventually create a strain that is free from that genetic defect. Through continual outcrossing, the expression of undesirable genes can be masked and faults or defect may be hidden in an alpaca's genetic make up and not visible in its phenotype. In this situation recessive, defective gene causing faults could be propagated in the carrier state and widely dispersed in the Australian alpaca population. With current research into alpaca DNA genome mapping, it may soon be possible to identify particular faulty genes in alpacas. The defective gene carrying alpaca could then be withdrawn from a breeding program. This DNA technology breakthrough could prove to be very useful to the linebreeder enabling screening of breeding stock at selection stage before recessive faulty genes can be spread.

Selection and culling

Selection has a major role to play in any breeding program and has great influence in future generations. It is usually not appropriate to choose a stud male for instance based on a superb fleece or fantastic conformation or a good looking head, in isolation to other traits. Decisions about selection and culling for a breeding program should be, as far as possible made based on analysis of data gained through objective measurement and in line with overall breeding goals. It is possible to place a value on particular traits that are important to your own breeding objectives and score each trait to determine an Estimated Breeding Value (EBV) for each alpaca in your program. The Across herd Genetic Evaluation program (AGE) can be a useful source of data when calculating EBVs. In calculating EBV's, it is important that they match your own breeding objective and include all traits that you identify to be important. In this way it is easier to measure improvement and make large genetic gains through appropriate selection. It is easy to be influenced by the success of currents fads, but to achieve uniformity within a herd a breeder must stick to breeding objectives and selection criteria.

It has been suggested that the phenotype (the genetic make up of an alpaca as shown or evident by its appearance) of an alpaca is the result of it genotype (the true genetic make up of an alpaca regardless of its outward visible appearance) and its environment (quality of feed, trace elements, climate conditions, etc, etc.)

P = G + E. In fact some would argue that; Phenotype = Genotype30% + Environment 70%.

Chris Tuckwell states, "Animals that have identical genetic merit can have divergent phenotypes. An animal's phenotype is predominantly (at least 60%) determined by its environment" [4].

If this is true, then how do you select animals for a breeding program when 70 % of what you see is in fact the product of the environment? A great number of breeders, including myself, have used particular stud males with no progeny and very limited pedigree, based on its outstanding phenotype. Sometimes a male will be highly prepotent for a particular trait and pass on that trait in the majority of cases. In other circumstances the male may be highly unpredictable throwing progeny of varying, conformation, colour or fleece style. By using a stud male with some degree of linebreeding a breeder is able to increase the odds of producing progeny that display the required traits. The pedigree data contained on the IAR database is a very valuable source of information that should be studied carefully and considered with other selection criteria.

Culling works hand in hand with selection in a breeding program and is equally important. Culling may be achieved through a number of means such as; not breeding from particular alpacas, using females that exhibit undesirable traits as recipients for embryo transfer recipients, castrating males that do not match breeding objectives, etc, ect. A breeder that is willing to remove animals from a breeding program that do not match the breeding objective will achieve whole herd genetic gain quickly. While the breeder that retains below standard animals in a breeding program compromises the rate of whole herd improvement. In some cases it may be prudent to split a group of females into two groups being "breeding seed stock" and "embryo recipients" in order to maximize whole herd genetic improvement.

Outcrossing / purpose and process

When a breeder is not happy with the alpaca they have produced outcrossing is frequently used to bring in different genes and reduce homozygosity. By breeding to an unrelated line new genes and new traits are immediately brought into the mix. The new genes can also increase hybrid vigor and address any areas affected by inbreeding depression in one generation. If your goal is to maintain consistency and uniformity it is a good idea to outcross to an unrelated line that also has some degree of linebreeding while also exhibiting the traits you desire. Uniformity within a herd can still be maintained when crossing two lines that have some degree of linebreeding, however, these uniform alpacas are unlikely to produce uniform and consistent progeny. Therefore it is important to either continue breeding back to the original line or continue with the new line to maintain uniformity and consistency in future generations.

Prepotency

Prepotency is a measure of the likelihood that an alpaca carries genes in a homozygous form and passes one on to each of the offspring. An example of this is a homozygous Suri male alpaca mated with a Huacaya dam to produce a Suri offspring. The Suri male would be considered to be highly prepotent in its ability to throw Suri progeny. An alpaca could be considered prepotent for a variety of traits such as, super fine fleece, high fleece weight, a particular colour coat or blue eyes. Linebreeding, by reducing the variety of genes, increases an alpaca's prepotency to produce consistent quality offspring. Alpacas that are prepotent for, selected, desired traits should be of more value than the average.

Marketing and value of bloodlines

I believe that in the near future, quality, linebred alpacas will be more highly valued than an alpaca of similar quality with no common ancestor due to their increased likelihood of passing on visible traits. That is; "What you see is what you get". A serious breeder should value an alpaca whose phenotype and genotype closely match and therefore provide a higher level of reliability in passing on desired traits. The days of purchasing a particular alpaca with an unknown pedigree, based simply on its phenotype (physical appearance) are numbered. Breeders will become reluctant to invest heavily in what may be a Pandora's Box with the genetic diversity to produce virtually anything.

Developing a breeding plan that suits you

Every Alpaca breeder should have a well established breeding plan or clear direction. Every breeder should be able to justify their choice of sires and the combination of ancestors appearing in the pedigree of a particular alpaca they breed. Dr Jay Lush states, "The more superior a breeder's herd or flock is to the average merit of its breed, the more reason he has to practice linebreeding to his very best animals or the very best of the recent ancestors" [5]. I predict that in the next ten years various alpaca studs will emerge, producing alpacas that may be identified as a strain within the breed. For example one stud will be known for consistently producing alpacas with extremely long staple length fleeces while another may be identified by the shape of their alpaca's heads. Some will consistently produce animals that are highly desired and sought after due to market influences at the time. Others will go relatively unnoticed until the current fad matches the phenotype of their herd. However this will depend on selection decisions made now based on the best and most accurate information available at the time. Maintaining consistency with selection is difficult, but can be rewarded with uniformity and consistency among progeny.

Linebreeding should not be looked at as the answer to producing the perfect alpaca. Equally, it would be shortsighted to dismiss it as being not viable or not useful. Dr Pierre Baychelier states, "There are advantages and disadvantages in the use of inbreeding and outbreeding in domestic animal reproduction. Both approaches complement each other and when used rationally can help breeders progress in their genetic gain" [6]. Linebreeding will most likely be used by many breeders in the alpaca industry as a tool to complement other breeding systems. Linebreeding is a long term process requiring careful planning and selection, and patience for success.

References

1. Bill Robbins (2004), 'Evolving the Australian Alpaca' AAA Conference 2004 Proceedings.
2. Eric Hoffman (2004), 'Ancestral Beginnings of the Alpaca' AAA Conference 2004 Proceedings.
3. Dale Vogt, Helen A. Swartz and John Massey (1993) G02911 Inbreeding: Its Meaning, Uses and Effects on Farm Animals. Department of Animal Sciences. University of Missouri-Columbia.

4. Chris Tuckwell (2002), Considerations for Designing an Alpaca Breeding Programme, Rural Industry Developments Pty Ltd.
5. Dr. Jay Lush (1945), Animal Breeding Plans, Iowa State College Press.
6. Dr Pierre Baychelier (2004), 'Are you afraid of inbreeding?' Issue 43 Alpacas Australia magazine.

Acknowledgements and further reading

1. Lents, J.H. (1991), The Basis of Linebreeding.
2. Safley M. (1998), Pure Blood part 1, Issue 25 Alpacas Australia magazine.
3. Safley M. (1999), Pure Blood part 2, Issue 26 Alpacas Australia magazine.
4. Safley M. (1999), Pure Blood part 3, Issue 27 Alpacas Australia magazine.
5. Tuckwell C. (2002), Considerations for Designing an Alpaca Breeding Programme, Rural Industry Developments Pty Ltd.
6. Jarvis Dr W. C. (2004), Basic Genetics for the Alpaca Breeder, The International Alpaca Handbook.
7. Jarvis Dr W. C. (2004), Introduction to Genetics of Improving Alpacas, The International Alpaca Handbook.
8. Bourdon B. (1997), Understanding Animal Breeding, Prentice Hall.
9. Dale Vogt, Helen A. Swartz and John Massey (1993) G02911 Inbreeding: Its Meaning, Uses and Effects on Farm Animals. Department of Animal Sciences. University of Missouri-Columbia.

Colour review 2006

Elizabeth Paul

Abstract

One of the major problems for the alpaca industry in terms of understanding the genetics of colour inheritance, has been the use of descriptive terms for fleece colour. This paper aims to give a more accurate definition of the genetic patterns involved, and to present a review of the types and proportions of different colours within the Australasian herd. Pigmentation in both skin and fibre is primarily a protective mechanism against excess ultraviolet light. The type and arrangement of pigment granules are determined by various gene series. The final coat pattern is determined largely by the relationship between those series. The mating results have been drawn from the AAA herd book database. The majority of progeny are fawn or brown. The results clearly indicate that white, although the preferred commercial colour, is regularly produced only from white x white matings. Blacks and greys remain rare to very rare colours. The production of a commercial white herd, will depend on the number of white females available.

Key Words

alpaca, pigment, genetics, patterns, mating results.

Introduction

Alpacas, as mammals, are assumed to carry the same genetic equipment to produce pigment as other mammals, and therefore the colour patterns should equate to those seen in other mammals.
A brief explanation of how and why pigmentation is produced in the animal will be presented. The genetic series thought to be involved, and the basic patterns will be also be briefly discussed.

The progeny results from AAAHerd Books 1-13 have been condensed and graphed to show the relative proportions of matings between colours, and also the progeny results. Only results between two registered parents were included. Progeny results where only one parent was recorded, were not included. Alpaca importations later than 1993 were also not included.

The Herd Book data has a number of limitations, including misinterpretations of colours against the AAA Colour Chart. More importantly, since the Colour Chart is a perceptual device created to class fibre in bin lots, the colours registered bear little relation to the actual genetic colour patterns. For convenience, however, the colours have been described as designated by the AAA colour chart, ie white, fawn, brown, black, rosegrey and silvergrey.

Pigmentation

Production of pigment is a protective device, to counteract the effects of too much ultraviolet light, which can cause skin damage. It has a secondary role in producing different colour patterns between species, and also has a role in social behaviour within a species. Young ones may have a different pattern than their elders for easy recognition by other members of a group. Patterns may also play a similar role in sexual recognition or attraction, or signalling of danger.

Pigment is a derivative of the amino acid tyrosine. There are two colours available for mammals, yellow, or phaeomelanin and black or eumelanin. Yellow pigment occurs as large round golden balls, sometimes joined in long strings. Black pigment granules are ovoid, smaller, and sometimes occur in pairs. Yellow pigment is responsible for most shades of fawn, tan or red based browns. There is another derivative of black called liver or chocolate.

Pigment granules are produced by special cells, called melanocytes, which are derived from the neural crest area of the developing embryo. They migrate through the surface of the embryo at an early stage of development, to reach all parts of the body. This occurs within a genetically pre determined time frame. The cells lodge at the base of hair follicles, and insert granules into the developing hair fibre as it grows out of the follicle. The type, number and arrangement of granules within fibres is under genetic and sometimes environmental control. Any delay in the migration may cause an area of non-pigmentation ie white, but other events, such as injury or day length, can also cause permanent or temporary white patches or coat.

Genetic Series

There are at least three series of genes which interact with each other, to produce the final coat pattern. These are Extension, Agouti and black/brown locus. The Extension locus has a full dominant dark allele, a neutral and a full recessive light allele, ie the final coat colour is either fully dark, or fully light. Both the dominant and the homozygous recessive alleles, override the Agouti series. The neutral allele of Extension, when present as the dominant allele at the Extension locus, allows alleles of the Agouti series to be expressed.

Agouti alleles are characterised by the expression of both yellow and black pigment in the same coat. The most recessive allele in the Agouti series also allows for full expression of dark colour. The most dominant Agouti allele will be the lightest expression of that series. Full black colour will only be expressed, by the presence of at least one Extension dominant dark allele; or alternatively, with homozygous Agouti recessive dark alleles combined with at least one Extension neutral allele, as the dominant allele at the Extension locus.

It is important to realise that each alpaca carries all three series of alleles, Agouti, Extension and Black. The final expression of colour and pattern will be determined by the interaction between the three series.

Patterns

Different colour patterns in larger mammals are achieved by different arrangements of the pigment within the same hair or across the coat. Agouti in small mammals such as wild mice, rats and rabbits is expressed as a grizzled grey coat, with bands of both black and yellow pigment in the same fibre. Guard hair is usually a uniform black.

In larger or domestic animals, the Agouti pattern is more likely to be expressed as bay, where the animal has a redbrown body or blanket, and the extremities, known as the points, are black eg the mane, tail and lower legs in horses. The wild guanaco is a reddish yellow colour over its body but has a grey face and black lower leg stripes. It is, in effect, a light bay pattern.

The presence of homozygous recessive Extension alleles, will suppress the production of black pigment and allow the animal to develop a full yellow coat. This is called a recessive red, as illustrated by a chestnut horse.

Brown as a genetic colour, requires the change from the dominant black allele at the black locus, B to the homozygous recessive form bb. This changes all the eumelanin pigment from black to brown. It is more common in smaller mammals such as dogs. Chocolate or liver colour is a feature of some breeds, as in chocolate Labradors. The dog has a chocolate or liver coloured coat, lighter eyes, brown toenails, and brown or pale pads. There will be no black on it, as all of the eumelanin will be in the brown form.
Most fawn and brown alpacas are exhibiting an agouti or bay pattern, since most of them have both yellow and black pigment expressed in the same coat. The amount of black may be extensive, or greatly reduced to just black eyelashes, black guard hair on the ears or along the back of the neck, or black toenails and footpads. See P 4. Dark brown alpacas with more extensive black, and most black alpacas, are likely to be at the lower end of the Agouti series, rather than Extension dominant dark animals.

Grey, roan and white markings such as tuxedo are most obvious when overlaid on a coloured animal.
Multi is traditionally used to indicate an alpaca with a large amount of white on it, (more than a third) plus other colours. It has been replaced in show material with the word Fancy, to cover other alpacas with unusual patterns.

White as a solid colour can be arrived at by a number of different genetic pathways, including dominant white, diluting genes, combinations, and albino. White alpacas may need to be differentiated, on the basis of their foot and eye colour, in order to establish a true-breeding white herd for commercial purposes. True pink eyed albino has not been recorded in alpacas

Results

The colour breakdown of the original herd, assessed from AAA Herd Book 1, of approximately 7000 alpacas, was as follows: White 18%; Fawn; 16%; Brown 30%; Black 13%; Greys 12% and Multi 11%. A comparison between the progeny results of AAA Herd Books 2 and 13, indicates that production of white progeny has more than doubled, from 15% to over 30%, over the ten year span 1995 to 2005. Production of fawn progeny increased slightly from 25% to 32%, while brown progeny declined from 34% to 15%. Black progeny declined from about 16% to 12% and greys, always the rarest colour, from about 10% to 6%.

Both the proportions and progeny results of approximately 56,000 matings between registered alpacas, in Herd Books 2-13, are presented in Fig 1. 22 % of matings are W x W, which also produces the highest number of white progeny, at about 70%. White progeny are rarely produced from two coloured parents. White x black produces neither colour as a clear dominant, but usually some shade of fawn or brown, in other words a bay. Greys are usually only produced from a mating involving at least one grey parent.

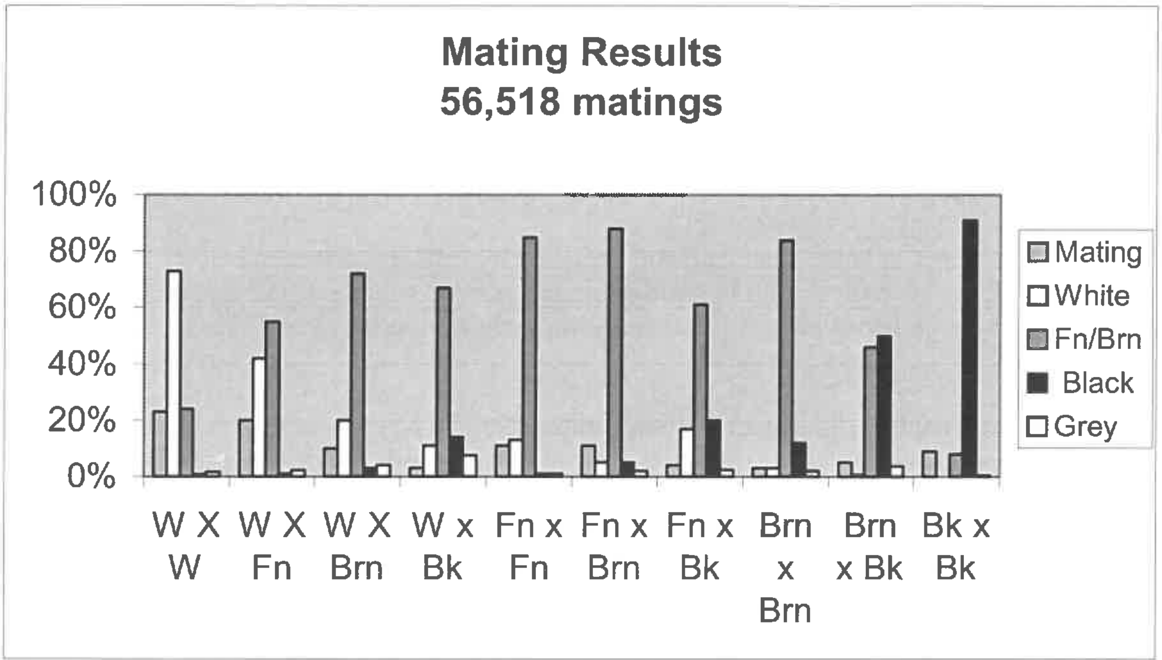


Figure 1: Illustrates the proportions of mating type (blue) and progeny colour results across the Australasian herd. Results drawn from AAA herd books 2-13.

The current colour status of approximately 3900 certified males is: 40% white; 29% fawn; 7 % brown; 14% black; and 10% grey sires.
The results of all matings from Herd Books 2-13, covering approximately 63,000 mating results with both parents recorded, are: 28% white; 32% fawn; 20% brown; 14% black; 3% each of rose and silver grey. Overall, the most likely result from any mating is a bay of some shade.

For all herd books, approximately 2/3 of all progeny registered are female.

Discussion

Since there are more white sires than any other colour, it would be reasonable to expect that the Australasian herd could be rapidly turned into a white commercial herd, simply by using white males to mate with all colours of females. However, from the mating results, it can be clearly seen that neither white nor black appear to be dominant colours in their own right. Mating White to Black produces mostly fawn or brown progeny, with few blacks and even fewer whites. One explanation is that the black parent contributes one Extension neutral allele to the progeny genotype, while the white parent can only contribute a more recessive allele from the Extension locus. This combination then allows for the expression of whatever dominant Agouti genes have been contributed by the white parent (since the black parent can only contribute the most recessive allele in Agouti). This results in a large proportion of bay progeny.

Conclusions

Approximately 72% of the registered progeny in the Australasian herd are coloured, 50% of which are some shade of fawn or brown, in other words, they are genetically bay. For all colours, 2/3 of progeny registered are female. Blacks and greys remain rare to very rare colours. Overall, there has been a 20% increase in the number of white progeny registered between 1995 and 2005. However, since white does not appear to be a dominant colour, the growth of a commercial white herd is likely to be limited by the number of white females available for W x W matings.

References

AAA Herd Books Volumes 1-13 incl, published by the AAA., in conjunction with ABRI, Uni of New England, NSW.

Draper, Judith. "Horse Breeds of the World" Sebastian Kelly, Oxford. Anness Publishing Limited, London. 1997

Hart, Ken. " The Dominant White allele is the Top Dominant allele in the Agouti Series", presented to the University of Western Australia in November 2001.

Little, C.L. "The Inheritance of Coat Colour in Dogs." Fifth Edition, Howell Book House, New York. 1973

Searle, A.G."Comparative Genetics of Coat Colour in Mammals". Logos Press Limited, London 1968.

Sponenberg, Dr P. "Some Educated Guesses on Colour Genetics of Alpacas'
The Alpaca Registry Journal Vol 1V. No 1. Spring 2001.

Paul, E. 'The Alpaca Colour Key" Nov 2002.

The future of DNA technologies in apaca breeding

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Key Words
DNA, genetic testing, molecular markers

Introduction
DNA technology reaches into our lives more and more every year, from astonishing breakthroughs in human disease diagnosis and prevention, to concerns over GM food. To date the alpaca industry has felt relatively little impact from DNA technology. However, as will be outlined in this paper, scientists are already beginning to apply DNA technology to alpaca issues.

There are three fundamental ways in which DNA technologies can impact on the breeding program of any production animal species. These are: basic research, diagnosis of infectious diseases, and production/ health genetics. By incorporating the outcomes of these processes into their breeding program, alpaca breeders will be able to produce healthy, quality animals, with better quality fibre, at lower cost.

Where are we now?
A) Basic Research
Basic scientific research might appear to be irrelevant in the real world. However, without the fundamental knowledge that basic research provides, useful, practical advancements cannot be made.

i) DNA Markers
DNA markers are one of the basic tools of molecular research. They allow the researcher to divide the genome into manageable sections. If the location of a marker on a chromosome is known, it can be used to "map" the location of genes that control desired (or undesired) traits. Even when the exact chromosomal location of a marker is unknown (as is often the case), it can still be used to provide information about the inheritance of a trait. For example, if a marker occurs close enough to a gene that controls a trait, the marker can be used as an indicator of the status of an animal for that trait, even when we don't know where on the genome that gene lies. In order to be able to use markers effectively, there must be enough of them so that all parts of the genome have representatives. For example, there are two minimal mapping sets of markers for the canine genome, comprising 172 and 327 markers respectively (Richman *et al.* 2001, Clark *et al.* 2004). These can be used to narrow the focus of a search for a gene, but then more detailed (i.e. dense) sets of markers must be used to pin-point the gene or genes being sought. There are fewer than 100 published alpaca DNA markers (Lang *et al.* 1996, McPartlan, *et al.* 1998, Penedo *et al.* 1998, Obreque *et al.* 1998, Penedo *et al.* 1999a and b, Obreque *et al.* 1999, Sarno *et al.* 2000, Mariasegaram *et al.* 2002), therefore there are not enough markers for a dense alpaca marker map. There are, however enough markers for parentage testing, and this service is offered by the Veterinary Genetics Laboratory at the University of California, Davis.

ii) Genome Mapping
Warren Johnson from Maryland in the US has almost completed a radiation hybrid map of the alpaca genome (funded by ARF and MAF). This map can be likened to a street directory of the genome. Where the streets are the DNA strand and the buildings are the genes. His laboratory has "mapped" a set of markers to the genome. This is like knowing where all the hospitals in the world are. It doesn't tell you what is in between the hospitals, but if you find out that where you want to be is somewhere between two given hospitals, the search area is much narrower.

iii) Evolution of the species
In perhaps the most valuable piece of DNA research on alpacas to date, a team of scientists from the UK and Peru have used DNA markers to study the evolutionary history and relationships between alpacas, llamas, vicuna and guanacos (Kadwell *et al.* 2001). They found that contrary to what had previously been believed,

alpacas are not descended from guanacos, but are descended from vicuna. This research led to the re-classification of alpacas from the genus Lama into the genus Vicugna. The scientific name of alpacas is now *Vicugna pacos* (formerly *Lama pacos*). Results of relationship analyses obtained using another type of DNA marker (maternally inherited mitochondrial DNA) were more ambiguous, indicating that while llamas have only guanaco markers, alpacas have a mixture of guanaco and vicuna markers. This fundamental knowledge was not accessible without DNA analysis, because the skeletal characteristics of the four species are too similar, and because archaeological specimens aren't well preserved (Bahn 1994).

B) Infectious Disease Diagnosis

Diagnosis of infectious disease using DNA technologies can reduce the time taken to obtain a result from weeks to hours. In cases of acute outbreaks, accurate and fast diagnosis can mean the difference between stopping an outbreak, or dealing with a serious ongoing problem. Faster, more accurate diagnoses also increase the chance of survival of affected animals.

i) Johne's Disease

Diagnosis of Johne's disease (i.e. infection by *Mycobacterium avium* subsp. *paratuberculosis*) is traditionally done by faecal culture (Buergelt *et al.* 2004), which can take up to eight weeks. Since 1995 PCR methods have been used to increase the speed of reporting, but the methods still involve initial faecal culture (e.g. Millar *et al.* 1995, Englund *et al.* 1999, Djonne *et al.*, 2003). In 2006 a group from Slovakia reported a PCR test directly from blood that reduced reporting time to days instead of weeks (Bhide *et al.* 2006).

ii) West Nile Virus, Eastern Equine Encephalitis, Bovine Viral Diarrhea Virus

Although none of these viruses are something that Australian alpaca breeders need to be immediately concerned with, they serve as examples of the successful application of DNA technologies for the alpaca breeder. All use a fast, sensitive, and reliable method called RT-PCR to detect viral particles from blood or post-mortem samples (Vodkin *et al.* 1993, Goyal *et al.* 2002, Yaeger *et al.* 2004). The existence of these tests allows for much better biosecurity in that all animals coming into Australia can be checked for these diseases, thus preventing entry of the disease into the country.

C) Production and Health Genetics

Whilst most of us would resist the instigation of wholesale job selection for human children based on their DNA profile (like in the movie GATACA) the same resistance doesn't exist for production animals. Indeed, selection of genetically superior stock already takes place, it is simply done on phenotype not genotype. The advantages of being able to DNA-test a new-borne cria to determine whether it would be best suited for fine fibre or carpet fibre production, whether it would be best kept as a flock guardian or breeding animal, and whether it has any resistances that would make it suitable for faming in a particular geographical region, cannot be underestimated. Unfortunately, at present there are no DNA tests available for production traits, nor for health related traits, in alpacas.

Where do we want to be in 20 years time?

Given sufficient funds, research time, and appropriate samples from alpacas huge genetic advancements can be achieved within 20 years. Below is a list of achievable goals for alpaca research. Some of the goals are relatively easy to achieve, while others will not be reached in 20 years without a lot of effort and money.

A) Basic Research

- i) Full genome sequence
- ii) High density panel of markers, and minimal marker sets for linkage studies

B) Infectious Disease Diagnosis

Hopefully nothing will be needed, but if so, a PCR test from a blood or faecal sample would be ideal.

C) Production and Health Genetics

Tests to predict or indicate genetic potential for:

- i) Fibre characteristics: e.g. micron, handle, lustre, density.
- ii) Potential colours
- iii) Fecundity/ fertility

iv) Safe/ effective twinning
v) Resistance to disease (e.g. parasites or staggers)
vi) Absence of defects (e.g. choanal atresia, wry face, atresia ani)

How do we get to where we want to be?

The following research projects are all working towards achieving the goals listed in the previous section.

A) Basic Research

i) Full genome sequence

It is unlikely that the alpaca industry would be able to independently raise the required US$4-10 million cash required to finance the sequencing of the entire alpaca genome. Therefore, the importance of such information on a global scale (economically and environmentally) must be emphasised, so that the alpaca is one of the species that is selected as a candidate for sequencing by the large sequencing consortiums. However, until the alpaca sequence is complete, the completed genomes of similar species can be used to great effect by employing comparative genomics. Comparative genomics involves matching the sequences of the most closely related species for which data is known. Then parts of the sequence that do not differ between these species are identified and used to isolate the same gene from alpacas.

ii) High density marker panel.

It is important to continue with marker discovery research, and such research is already underway. The alpaca genome mapping project funded by the Morris Animal Foundation has discovered over 400 new markers (W. Johnson, personal communication). Another small-scale project recently funded by the Morris Animal Foundation, which is being undertaken in our laboratory, aims to find between one and two hundred more markers by the end of 2007.

B) Infectious Disease Diagnosis

The best way to deal with potential disease outbreaks is to be proactive. Any new diseases that affect sheep, cattle, goats or horses need to be watched carefully to determine their potential impact on the alpaca industry.

C) Production and Health Genetics

Comparative genomics will be critical in developing tests for desired or undesired traits. There are already a variety of DNA tests available for production traits in species such as sheep, cattle, horses and pigs. In total there are 77 traits or disorders listed on "Online Mendelian Inheritance in Animals" (Nicholas 2006) for which the molecular basis of the trait is known (33 in cattle, 11 in pigs, 12 in horses, 14 in sheep, and 7 in goats). It is reasonable to assume that the gene or genes that cause a trait in these species may be the same gene in alpacas, because genes for basic functions do not differ significantly between related species. Therefore, we may be able to use information about the cause of a trait in sheep or cattle to identify the causative mutation in alpacas, without having to undergo lengthy and expensive association studies.

i) Coat colour

There are at least three laboratories researching coat colour genes in alpacas using genetic information from cattle, horses, dogs and mice. The Italian group have cloned the alpaca TYRP1 gene (responsible for albinism in cattle) (Castrignano 2003) but, no analyses of polymorphisms within that gene have been published (C. Renieri, personal communication). The American group are looking at two genes, MC1R (responsible for chestnut in horses, gold in Golden Retrievers, dominant black in sheep) and ASIP (responsible for multiple phenotypes in mice). According to a conference abstract published last year they have identified polymorphisms in the MC1R gene. However no further information is available as to whether those polymorphisms are linked to particular phenotypes (Ensminger *et al.* 2005). In our laboratory, we are studying two genes, MC1R and SILV (responsible for merle in dogs), in order to try to find polymorphisms that relate to the fawn and grey phenotypes respectively. Both genes have been cloned, and comparison of the sequence of each gene from various animals is underway.

ii) Coat type

The Alpaca Research Foundation has awarded a grant to Andrew Merriwether for a feasibility study to find out if the markers used by the mapping group (i.e. Johnsons group) would be useful for full scale studies to find the gene that causes the difference between suri and huacaya coat types. The expected completion date for the feasibility study is the end of 2006.

iii) Fibre quality

The evolution research by Kadwell and colleagues (2001) showed us that alpacas are descended from vicuna rather than guanaco. Use of those markers also allowed the researchers to determine the "purity" of the alpacas and llamas in their research population. It was found that up to 80% of the alpacas carried some llama/guanaco markers. Use of such markers might enable breeders to select from their herds those animals that have less llama/guanaco influence, and hence have greater genetic potential for quality fibre. Research is ongoing on the potential application of these markers (M. Bruford, personal communication).

Summary

While DNA testing of alpacas (other than for parentage) is currently non-existent, use of information from related species will accelerate the rate of discovery of genes in alpacas that are responsible for desired traits.

References

Bahn P.G. (1994) Nature 367: 511-512.
Buergelt C.D., Donovan G.A. and Williams J.E., (2004) Int. J. Appl. Res. Vet. Med. 2 (2): 130–134.
Castrignano F., Antonini M., Misiti S. Cristofanelli S. and Renieri C. (2001) In: Gerken M. and Renieri C. Progress in South American Camelid Research. Wageningen. EAAP publ. No. 105: 207-210.
Clark L.A., Tsai K.L., Steiner J.M., Williams D.A., Guerra T., Ostrander E.A., Galibert F. and Murphy K.E. (2004) Genomics. 84(3): 550-4.
Djonne B., Jensen M.R., Grant I.R. and Holstad G. (2003) Vet. Microbiol. 20 (92): 135–143.
Englund S., Ballagi-Pordany A., Bolske G. and Johansson K.E. (1999) Diagn. Microbiol. Infect. Dis. 33: 163–171.
Ensminger A.L., Gray K. and Campbell E.M.G (2005) PAGX111, Poster abstract 633: Other species.
Goyal S.M., Bouljihad M., Haugerud S. and Ridpath J.F. (2002) J. Vet. Dign. Invest. 14(6): 523-525.
Kadwell M., Fernandez M., Stanley H.F., Baldi R., Wheeler J.C., Roasadio R. and Bruford M.W. (2001) Proc. R. Soc. Lond. B 268:2575-2584.
Lang KD, Wang Y, Plante Y. (1996) Anim Genet. 27(4):293.
Mariasegaram M, Pullenayegum S, Jahabar Ali M, Shah RS, Penedo MC, Wernery U, Sasse J. (2002) Anim Genet. 33(5):385-7.
McPartlan HC, Matthews ME, Robinson NA. (1998) Anim Genet. 29(2):158-9.
Millar D.S., Withey S.J., Tizard M.L., Ford J.G. and Hermon-Taylor J. (1995) Anal. Biochem. 10 (226): 325–330.
Nicholas F. Last updated 15/06/2006 Online Mendelian Inheritance in Animals http://omia.angis.org.au/
Obreque V, Coogle L, Henney PJ, Bailey E, Mancilla R, Garcia-Huidobro J, Hinrichsen P, Cothran EG. (1998) Anim Genet. 29(6):461-2.
Obreque V, Mancilla R, Garcia-Huidobro J, Cothran EG, Hinrichsen P. (1999) Anim Genet. 30(5):397-8.
Penedo MC, Caetano AR, Cordova KI. (1998) Anim Genet. 29(5):411-2.
Penedo MC, Caetano AR, Cordova K. (1999a) Anim Genet. 30(2):166-7.
Penedo MC, Caetano AR, Cordova KI. (1999b) Anim Genet. 30(5):399.
Richman M., Mellersh C. S., André C., Galibert F. and Ostrander. (2001) *J. Biochem. Biophys. Methods* **47:** 137–149
Sarno RJ, David VA, Franklin WL, O'Brien SJ, Johnson WE. (2000) Mol Ecol. 9(11):1922-4.
Vodkin M.H., McLaughlin G.L., Day J.F., Shope R.E. and Novak R.J. (1993) Am. J. Trop. Med. Hyg. 49(6): 772-776.
Yaeger M., Yoon K.J., Schwartz K. and Berkland L. (2004) J. Vet. Diagn. Invest. 16(1): 64-66.

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The impact of the National Livestock Identification System on the alpaca industry

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Introduction

The National Livestock Identification System (NLIS) is now Australia's system for permanent, whole-of-life identification and traceability of livestock.

The alpaca industry will be expected to participate in NLIS for biosecurity purposes and to provide quality assurance in the marketplace. NLIS can also lessen the social and financial impact of an exotic disease outbreak and provide assistance to alpaca breeders in the management of their alpacas.

NLIS is not a system of tags, databases, technology and forms, but rather a traceability system which uses those tools to achieve its goals.

History of the NLIS

In the 1960s Australia carried out a cattle Brucellosis and Tuberculosis testing and eradication campaign. To assist with this, a traceability system was set up based on an identification number which was unique for every farm. This was the basis for what is known as the "tail tag".

The stimulus for the development of the NLIS came as a result of a number of international food safety scares including Europe's Bovine Spongiform Encephalopathy (BSE) detections, E.coli problems in Japan and the United States of America (USA), and chemical residue incidents.

During the 1990's, market demands for traceability of livestock, particularly by the European Union, (EU) drove the need for individual animal identification and the development of the NLIS database.

In 1999 in order to retain access to the European Union (EU) market, NLIS was introduced into the cattle industry on a voluntary basis. By 2005, the National Livestock Identification System was compulsory for cattle using an individual animal identification system. For sheep and goats born after 1st January 2006 a compulsory flock system has been introduced. The pig industry is now also actively progressing towards an identification system and other livestock industries are expected to follow in time. Most of our competitor countries have introduced, or are in the process of introducing, comprehensive traceability requirements for their livestock industries.

The benefits of the NLIS

Biosecurity

Biosecurity is a general term for the measures which are used to protect our farms and the country as a whole from the entry and spread of unwanted pests and diseases. The performance standards the NLIS supports will help maintain the high level of biosecurity Australia enjoys.

Quality assurance

Every purchaser of a product including livestock wants the assurance they are buying something of the highest standard. Alpaca purchasers have sometimes discovered too late there is a hidden health risk only to be told "You didn't ask". The NLIS and the tools it uses help to overcome some of these issues.

Market assurance

The NLIS will improve our ability to maintain access to markets. The product quality standards set by the European Union are usually higher than for most other countries and often on introduction seem almost unattainable, but they are the demands of the customer. Some diseases cross species, meaning a disease in alpacas could jeopardise the export of any livestock or associated products to the E.U. or elsewhere. With its perceived "clean and green" image, Australia's good management of diseases and chemical residues will help maintain that reputation and keep our livestock industries at the forefront of domestic and export markets.

Quality and market assurance criteria apply for over the fence transactions just as much as for the export market. No alpaca breeder can afford not to protect their local, intrastate, interstate or overseas markets. The NLIS is the system to help every breeder/owner achieve that goal.

Ownership assurance
Under the NLIS, all stock must carry identification (usually an ear tag) with the relevant property identification code (PIC) before moving off property. PIC identification of all livestock is recommended to assist in tracing ownership of straying and stolen animals. This identification is crucial in times of natural disaster when fences have been destroyed.

Social and economic benefits
A recent Commonwealth government study* estimated the overall economic loss as a result of an FMD outbreak to be between $2 billion and $13 billion. NLIS will not prevent a disease outbreak, however it can reduce the financial and social impact of a disease epidemic due to improved identification and traceability capabilities (MLA 2003). This impact has been repeated many times during the implementation and enforcement of the Ovine Johnes eradication scheme and overseas with FMD and BSE outbreaks. These incidents have identified the need to be able to trace individual and companion animals accurately and rapidly throughout their lives.

On-farm management
Depending on the type of identification device adopted by the industry, getting the most benefit from technology compatible with NLIS depends on how it is implemented in a farm business. Through the optional integration of readers, scales and management software programs, the benefits can be improved management and breeding decisions, less paperwork and time saved through automated data collection and better individual animal data accuracy. (Rendell 2005) Benefits of this technology could flow onto the show circuit.

The Australian Alpaca Association and NLIS – alpaca
In 2004, the Australian Alpaca Association in its current and future objectives outlined its plan to investigate the feasibility of taking the alpaca industry into NLIS. The AAA set up the NLIS – Alpaca Working Group (NLIS-AWG) to research NLIS.
The NLIS – alpaca Working Group had the following objectives:
- Collection of relevant NLIS information
- Investigate tagging systems to recommend appropriate tags for alpacas
- Consider whether the IAR numbering system and brass ear tagging can be incorporated into NLIS requirements, such as using existing IAR numbering.
- Recommend costing for NLIS implementation and researching areas for financial support.
- If appropriate and authorised, develop a timetable for implementation of NLIS practices into the alpaca industry (AAA 2004)

After a year of preliminary research by individual group members, a meeting was held in March 2006 with representatives of the (Australian) Department of Agriculture, Fisheries and Forestry, Victorian Department of Primary Industries, ear tag and bolus manufacturers and stud stock agents. A report and recommendations from this meeting were tabled at the June 2006 meeting of the AAA National Committee (AAA NatCom). This resulted in the NatCom passing motions to apply for federal funding for the purpose of employing a consultant to establish a business plan for the implementation of NLIS to the Australian alpaca industry. (AAA NatCom 2006)

The National Traceability Performance Standards.
In the USA, three weeks after a BSE outbreak, only 14 of 81 cattle had been traced due to an inadequate system. From Table 1 it can be seen that the standards for tracing livestock are high. The NLIS is the means of reaching these standards which are deemed necessary for the quick and accurate traceability of livestock for biosecurity and market assurance.

Table1: National Traceability Performance Standards (Animal Health Australia 2006)

Applicable to all FMD susceptible livestock species[1]	
1.1	Within 24 hours of the relevant CVO[2] being notified[3], it must be possible to determine the location(s)[4] where a specified animal was resident during the previous 30 days.
1.2	Within 24 hours it must be also possible to determine the location(s)[4] where all susceptible animals that resided concurrently and/or subsequently on any of the properties on which a specified animal has resided in the last 30 days.
2.1 - 2.3 **Applicable to cattle only**[5]	
Applicable to all FMD susceptible livestock species except cattle (lifetime traceability excluding the preceding 30 days - addressed by 1.1 and 1.2 above)	
3.1	Within 14 days of the relevant CVO[2] being notified[3], it must be possible to determine all locations[4] where a specified animal has been resident during its life.
3.2	Within 21 days of the relevant CVO[2] being notified[3], it must also be possible to determine the location[4] of all susceptible animals that resided concurrently with a specified animal at any time during the specified animal's life.

Notes:
1. For the purposes of these Standards, 'FMD susceptible species' means cattle, sheep, goats, and domesticated buffalo, deer, pigs, camels and camelids.
2. 'The relevant CVO' means the State or Territory Chief Veterinary Officer, or their delegate, in the jurisdiction where the specified animal is located or has been traced to.
3. For the purposes of these Standards, the term 'notified' means the relevant CVO is aware of an incident that required tracing.
4. 'Location' means any definable parcel of land including (but not limited to): any parcel of land with a Property Identification Code, travelling stock routes, saleyards, abattoirs, feedlots, live export collection depots, show grounds, Crown land and transport staging depots.
5. Given the risks posed by BSE, it was considered appropriate to establish separate Standards for cattle.

The traceability system

Property Identification Code (PIC)

The basis of the NLIS is the property identification code (PIC). Under NLIS it will be a requirement that all properties on which livestock (alpacas, buffalo, cattle, deer, goats, pigs and sheep) are run to be registered; this will assist in locating properties if there is an exotic disease outbreak or a natural disaster. This registration will be irrespective of how many animals are run on the property. It is just as important for the property with only one animal running on it to be registered as the property with thousands of stock running on it. Alpaca breeders registering for Q – Alpaca are now required to provide a relevant Property Identification Code.

The AAA NatCom has on the recommendation of the NLIS-alpaca WG passed a motion "That the AAA actively encourages all members to obtain a Property Identification Code (PIC) from the relevant State authority". (AAA 2006) In most states this is the Department of Primary Industries or Agriculture. In New South Wales a PIC is obtainable from the RLPB. Under NLIS, properties **must** have a PIC number prior to the movement or sale of animals. This is not negotiable. NO PIC – NO SALE. Requirements for a PIC vary from state to state and whether mandatory or voluntary, registration figures show little correlation. The high number in South Australia is due to extensive promotion at a government level. PIC compared to AAA registrations varies considerably. (Table 2) To be ready for NLIS, every alpaca property owner is encouraged to apply to their relevant state authority now for a PIC if they do not already possess one.

Table 2: Alpaca property registrations per state compared with AAA property registrations. Data as at 30th April 2006 (Rendell D. 2006)

State	Registration requirements (alpaca)	PICs registered with alpacas	AAA property registrations	% of AAA property registrations
Tasmania	voluntary	1	112	0.9
Victoria	voluntary	378	1214	31.1
New South Wales	not required	Not available	1276	Not available
Western Australia	mandatory	193	409	33.7
Queensland	voluntary	Not available	383	Not available
South Australia	voluntary to 30.6.06 mandatory from 1.7.06	374	438	85.4

Identification - tagging

One objective of the NLIS – alpaca Working Group is to investigate tagging systems and attempt to rationalise tags and numbering for alpacas. Other identification methods will need to be considered but tagging currently appears to be the best option. Whichever option is chosen, it first must meet the standards for reading and retention of identification technology set by the NLIS Standards Committee. This will involve research and testing of available types and brands of devices on a herd basis in alpacas. Conformity to existing technology will be a key factor in the type of tag chosen.

There are currently several tagging options:

- Plain tag. (Mob based) In this case the tag bears the PIC number only. This is the method set for the sheep industry and is suitable for mob movements but is not as useful as individual animal identification for tracing animals from property to property in the case of a long term disease or residue problem
- Plain tag (individual animal with a database) In this case the tag bears the PIC number on one side and a unique animal number on the other. This system results in too many recording errors and restrictions and is not used elsewhere for traceability. Better technology makes it almost redundant for individual identification.
- Radio Frequency Identification Device (RFID) or Electronic Identification Device (EID). This device can come in the form of a tag, microchip under the skin or as a rumen bolus which is inserted orally to remain in the gut of an animal for life. Each device contains a microchip encoded with a unique number linked to the PIC of the property of origin. Livestock are tagged with the device only once in their life. Electronic identification tags allow for manual reading or the automation of reading the device and transferring the information. The automated method is highly accurate, whereas visual identification systems have high labour requirements for reading the devices, the accuracy of recording the numbers is low and transcribing and transferring data to a database or for on-farm management is more difficult. The electronic tag and bolus are the methods of identification used by the cattle industry and could be optional in the sheep industry. Evidence indicates that alpacas do not retain a bolus in the rumen.

Database

A central database is integral for use with RFID's and reaching the performance standards required of the industry. The NLIS database for cattle was developed by Meat and Livestock Australia. This database contains a register of all of the NLIS devices produced, animal movements and animal and property status. It can be accessed by all authorised sectors of the industry. The alpaca industry through the AAA has an existing database in the form of the International Alpaca Register operated by Agricultural Business Research Institute. Databases will need to be researched on the basis of cost of setup and operation, conformity with other industries and access by authorised users.

National Vendor Declaration

National Vendor Declarations (NVD's) provide a mechanism for the transfer of information on the history of livestock consigned for sale. They allow producers to declare any residue and treatment status of their livestock and, where required, the property disease status. National Vendor declarations already exist for cattle and sheep, with waybills and transport forms already in use in some states for other livestock. NVD's are linked to livestock consignments by the PIC.

Legislation for NLIS

The legislation governing the control of stock diseases comes under various state acts. Even though there may not be legislative requirements in place for alpacas, this would not be difficult to overcome by including alpacas with other species. Nationally NLIS is brought about by agreement of the Primary Industries Ministerial Council, made up of the respective state Ministers for Agriculture.

Funding

The alpaca industry is responsible for the setting up of NLIS – alpaca and is expected to meet the cost. In the lead up to the October 2004 election the Federal Government pledged to spend $20million on NLIS. $15million of this has gone to the cattle industry, $2.5 million to the sheep and goat industries and $1.2 million to the pig industry. This leaves $1.3 million to be shared among other livestock industries including alpaca. The AAA is seeking to access some of this funding through the expected appointment of a consultant to set up a business plan for the implementation of NLIS by the alpaca industry (NLIS – alpaca working group 2006)

The alpaca industry itself will have to provide some funding for NLIS, particularly for the eventual upkeep of a database if electronic identification devices are used. How these funds will be sourced is to be determined but every endeavour will be made to keep owner's costs to a minimum without sacrificing the industry's commitment to the National Traceability Performance standards and NLIS.

Timeline

The NLIS - alpaca working group has not determined any timeline for the introduction of NLIS. Experience in other industries indicates that implementation takes longer than expected and the system could take a few years to develop with every effort being made to meet the expectations of markets and other livestock industries.

Summary

GET YOUR PIC or confirm that you have one.

The Australian alpaca industry has no driving need of the National Livestock Identification System. The government will not force NLIS upon the alpaca industry. The industry though, through the National Traceability Performance Standards, does have a responsibility to its participants and to other livestock industries. It will be the livestock industries who will apply pressure to the alpaca industry to conform. NLIS brings assurance of product quality, markets and ownership. An identification system will not prevent a disease or residue problem, but it will greatly reduce the financial and social impact due to the enhanced traceability of alpacas with the opportunity of improved herd management.

References

Rendell D. (2005) The alpaca industry and the National Livestock Identification System. Paper Presented to the South Australian Alpaca Advisory Group forum. April 2005

Meat and Livestock Australia (2003) Brochure "How do I participate"

Rendell D. 2005 'Why NLIS is valuable' SA Beef Field Days P 14

Rendell D. 2006 "NLIS" Report. SA Alpaca Advisory Group Newsletter April 2006 p3

Australian Alpaca Association NLIS Working Group. 2006 Report to NatCom 3rd June 2006

Australian Alpaca Association Business Plan 2004-2005 Current and future objectives, sub-Committees, NLIS Working Group.

AAA Natcom 2006, minutes of Natcom meeting (unconfirmed) 3rd-4th June 2006

Animal Health Australia. 2006 National Livestock Identification System www.animalhealthaustralia.com.au/programs/adsp/nlis/nlis_home.cfm Accessed 30th April 2006

Rendell D. 2006 'NLIS for alpacas'. 'PowerPoint' presentation to AAG forum, April 2005. Slide 4&5

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Basic introduction of biosecurity programs for alpaca farms

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Abstract
Isolation has given Australia a distinct edge in global primary industries, as its produce is relatively free of disease. Likewise, an isolated farm is less likely to be subject to disease. Biodiversity endeavours to protect a farm by lessening the opportunity for disease to enter the farm, and to limit its impact should it enter. A diversity program of a medium sized alpaca, horse and cattle farm is described. A general maintenance-level program is not complex and is easy to establish and maintain. Should a specific threat exist, this low-level program can be tightened to further lessen opportunities for contamination.

Key Words
biosecurity, infectious disease,

Introduction
Today, Australia's primary industries are highly competitive, globally and domestically. In global markets Australia has a valuable competitive edge, as it is clean from disease as a consequence of our relative isolation. Whilst Australian farm animals are not subject to many of the diseases experienced in other countries, there is potential for infectious diseases to destroy complete herds, and even an industry. To retain that competitive edge we should be ensure that we minimise the impact of disease, should it occur.

Domestically, it is in the interests of farmers to devise strategies to minimise the risk of disease entering their farms, and to curtail its impact, should it enter.

Biosecurity should be as aspect of every farm's management. A program for a farm of low or medium risk is based on the very basic principles of creating and maintaining a boundary and of risk assessment. The aim of this paper is to demonstrate that biosecurity management is not complex by describing the facilities and management of a particular property.

'Turrabunna' is a 60 acre farm situated on the Kooweerup swamp, south-east of Melbourne, the home of approximately 40 steers and 40 alpaca, plus 2 dogs, four horses, 2 humans and countless wildlife.

The purpose of biosecurity is to minimise the opportunity for the animals on a property to be contaminated by disease. The aim is to adopt management practices that minimise the importation of infectious agents onto the farm, by establishing and maintaining a boundary around the property, by structure and procedures. I predict that, at some time in the future, all farms will be encouraged, and may eventually be made, to develop such a program. Those farms on the MAP and in Q-Alpaca should already have such in place. This is not difficult, and does not require any great expertise.

The following is the way by which the program for Turrabunna was established and is being upheld.

Microorganisms do not make their way onto a property on their own. They are carried on by something, or someone. They are carried by faeces, saliva and other body fluids, on the skin and hair, on clothing, on vehicles and equipment, on the wind and in water. It could be said that the ideal is a program that either denies access or fully de-contaminates all these. However, depending on the circumstances, the benefits may not be worthy of the effort nor the expense, and not be practical. Furthermore, some strategies may be detrimental to the business.

Another aspect of management is assessment of risk. What contaminants exist in the environment? How dangerous are they to the animals on the property? What strategies are required to keep them off the property? Do these justify the possible consequences? Also, does the denial of exposure reduce the natural resistance of the farm animals, and thus expose them to greater risk when they are exposed on their departure from the property?

There are two programs that can be established: a permanent program to which all must adhere at all times; and a program that can be quickly activated should the need arise.

The following account describes the strategies undertaken at 'Turrabunna'.

Two types of barriers were established – passive and active. Passive barriers include fencing and water-flow prevention. Once they are in place they must be regularly inspected and maintained.

Animals outside the property can contaminate through a fence by faeces and saliva being windblown, and by direct contact with our stock. The solution is to double fence to all roads and neighbours, with a gap between the fences of several meters between the two. The planting of trees and shrubs in the gap between the two fences will further lessen the chances of contamination.

Another external carrier of contaminants is water. There are several strategies that can be used to prevent water from flowing from outside onto the property. It can be captured in closed drains; channelled away from the property by levy banks; filtered through several meters of sand; or soaked up by thick vegetation. The total catchment area of all dams must be within the property perimeters.

'Turrabunna' has no gates on the property boundary that cannot be monitored. All gates onto the farm are from the house area. Each gate carries a sign that states that behind the gate is a quarantine area and all entry must be supervised.

These are the passive strategies. The active strategies are designed to prevent the people, machinery, equipment, and animals, that have legitimate access, from bringing contaminants onto the property.

Complete de-contamination all personnel coming onto the property would involve full wash-down showers and change of clothing. During times of which no emergency animal disease outbreak the risk of our and most visitors' clothing carrying contaminants that are dangerous is judged to be low. Therefore the de-contamination of ourselves and most visitors is confined to footwear. Either boots that are only used on the property are supplied, or visitors' are asked to walk through a footbath containing the phenol-based solution.

The most effective disinfectants are formaldehyde and aldehyde-based products (Wolfgang, date unknown), but we found that the solution we were using caused our visitors' footwear to fall apart. Furthermore, these products can be very severe on animals – they are used for embalming. Therefore, as the phenols have been found to be good disinfectants against bacteria and have some impact against fungi and virus (Wolfgang, date unknown), we believe that this is adequate for our current requirements.

Vets and others who work with farm animals either wear clean overalls or they are supplied.

Access to the property of machinery and equipment is minimised. That which must go through the gates is de-contaminated by a phenol-based solution, following the full wash-down of that which has been on other farm property. The de-contamination is the spraying of wheels and under-carriage of vehicles, and of those parts of equipment that may have been in touch with the ground or other animals.

The general policy is that animals that come onto the property are held in quarantine yards, once cleaned for any possible faeces. They are thoroughly checked for skin diseases, drenched against internal parasites, and their general demeanour and health monitored until their cleanliness and good health has been established. This may take several days or could be two to three weeks if a disease is suspected. During this time these animals use separate feed and water containers, and prior to and after all feeding, husbandry and handling we de-contaminate by changing overalls, changing or dipping boots, and washing hands. Animals exempt of being subject to this complete regime are those that are taken off the property temporarily for shows, displays, and matings. Their facilities when off-farm are kept separate from those of other animals, and as clean as possible, and on their return these animals are cleaned for any possible faeces prior to being taken through to the farm area.

A further consideration is the vulnerability of the farm's animals themselves to disease. Animals that are completely isolated from disease are more vulnerable as their immune systems are not given the opportunity to develop. Therefore, if these animals are taken off the property and exposed to disease they are much more likely to succumb. The ideal is to prevent disease from being brought onto the property, yet enable our animals to develop their own innate resistance.

Furthermore, those animals that are in good health, are well maintained, kept in sound farming conditions, and are not stressed will be less likely to succumb to disease. Maintenance includes regular vaccinations, strategies such as adequate drenching, and a balanced diet that it appropriate for each animal's individual needs. Sound farming conditions include facilities that allow for adequate exercise, grazed on well-maintained pastures that are not over-stocked, adequate shelter, are cross-grazed with other species that do not carry the same parasites, are frequently rotated through fresh paddocks, and are kept with other animals with which they are compatible and thus are not pushed off feed or bullied. As psychological stress increases susceptibility to disease, appropriate handling facilities and methods are also imperative. This includes general handling and training.

Cleanliness is also important. Troughs and feed containers should be kept clean and in good order.

Some industries are known to regularly administer antibiotics to all animals as a tool to enhance resistance (as opposed to specific use to fight infection). It is our opinion that this use of antibiotics and some other chemicals is irresponsible. It is now evident that bacteria that threaten both farm animals and humans are developing resistance to many antibiotics.

Risk management is also relevant when an animal becomes ill. Unless the problem is known to not be infectious the infected animal(s) should be immediately separated from the others. However, if only one animal is involved separation may induce further stress which could inhibit its recovery. Therefore, assessment of the options' consequences has to be made.

Early detection, diagnosis and treatment are other important factors. This involves knowledge of animals' 'normal' behaviour and demeanour, and general condition, frequent and regular monitoring, and the keeping of a farm diary, into which all observations as well as regular husbandry activity such as vaccinations and entered.

We have two methods of disposal of dead bodies. A knackery is close by. As there are several strips of granitic sand, and we have the equipment to dig deep pits, burial is the other option. On-farm burial is only possible when the cause of death has been clearly established and was not infectious.

There are several weaknesses of this program. For example, no strategy exists for de-contamination of the farm's dogs, who come and go. However, their sole access is through the gates, all of which face onto the house area, that could be said to be a 'neutral' area, as no farm animals are housed there, and any faeces that may spill from animal transports, the occurrence of which is rare, are immediately picked up. Should the dogs come from the road they travel through this neutral area before entering the farm. Furthermore, all vehicles that travel on the road have travelled in excess of 1 km following any possible contamination caused by driving through animal faeces from another farm, therefore the contaminants on the road are minimal. Whilst this is not ideal, it is believed to be adequate in the current environment.

Turrabunna is also the home of wildlife, such as bandicoots, possums, wombats and prolific birds including water birds, as well as foxes. All these break the current biosecurity as they go about their lives between properties. Whilst this risk could be reduced by very expensive measures, it is not considered a worthwhile investment and would be very difficult to establish and maintain.

Whilst it is recognised that our biosecurity management could be tighter, it is important that the strategies in use are sufficiently straightforward that there is no temptation to take shortcuts. They should be sufficiently easy to undertake that they become immersed in the everyday farming activities.

This is the bio-security program for 'Turrabunna'. It is low-key, designed for the environment of south-east Victoria, in times of no known infectious disease outbreak. It has not been complicated to set up, nor to manage.

As stated above, an important aspect of a biosecurity program is risk assessment. The current program is assessed as suited to the present environment, but it is recognised that in the event of an infectious disease outbreak additional measures would need to be introduced.

References

Wolfgang, DR (date unknown). 'Biosecurity' *Veterinary Science Information* College of Agricultural Sciences, Penn State. http://vetextension.psu.edu/resources/pdf/biosecurity/BiosecurityIRS.pdf Accessed 10 June 2006.

Sustainable alpaca farming - setting up your farm Environmental Management System

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Abstract
Environmental Management Systems have been used for many years in a range of industries. Their application to agriculture is more recent and has been the subject of various studies, government policies and incentive schemes. While the alpaca industry grapples with how the apply EMS to alpaca farming, considering our diverse membership and geography, individuals can prepare and implement a simple EMS or Environmental Action plan for their property. This will allow them to identify the most significant issues relevant to their property and put in place management programs to address them.

This paper gives a basic step-by-step process for preparing a Farm EMS. Examples and further details will be available during the oral presentation and Poster Session.

Key Words
Environmental Management Systems, environmental issues, risk assessment, monitoring, implementation, review.

Introduction
As with all agricultural pursuits, alpaca farming has the potential to impact on the environment in a multitude of ways. How we manage the alpaca industry will determine the extent of such impacts and the sustainability of alpaca farming on agricultural land. In particular, many alpaca farms are located on the edges of urban areas and are often intensively farmed on small acreage. This creates the potential for conflicts with other land users, neighbours, Council bylaws and impact via theft or dog attack.

There are legal, ethical and financial reasons for ensuring our activities do not cause environmental harm, meet environmental and planning laws and do not cause damage or nuisance to neighbours.

This paper gives an outline of how individual farmers can set up a simple Environmental Management Plan for their alpaca farm.

Environmental Management Systems
What is an EMS?
An 'environmental management system' (EMS) is a systematic approach to assist any enterprise to identify and manage its impacts on the environment, while providing opportunities for improved business performance. As an integrated business management tool, an EMS can effectively complement and build on other existing activities such as property management planning, best management practices, codes of practice and quality assurance schemes. EMS provides a management framework based on a simple `plan, do, check and review' cycle that achieves continuous improvement. A manager uses the system to identify environmental impacts and legal responsibilities, then implements and reviews changes and improvements in a structured way.

Why Adopt an EMS?
The reasons for adopting an EMS vary between enterprises, landholders and communities. These may include the need to:
- improve business efficiencies;
- become more sustainable;
- meet Council requirements;
- reduce environmental and financial risks;
- differentiate products in the marketplace;
- maintain or improve access to markets and natural resources;

- maintain or improve the natural resource asset base of the farm enterprise;
- meet catchment and/or regional strategies; and
- meet the expectations of neighbours and the community.

Guiding principles
The following principles have been developed for EMS in Australian agriculture:
- voluntary and industry and/or community led;
- link competitiveness and natural resource management;
- able to be combined and integrated with existing business management activities wherever possible;
- simple, cost effective, user-friendly, able to be phased in at any level with clear benefits to the adopting enterprise;
- adaptable and allow for continuous improvement; and
- consistent with internationally recognised systems (such as ISO 14001) and capable of independent audit (NRMMC 2002).

How to Prepare an EMS
The tasks involved in preparing an EMS are:
1. Prepare an Environment Policy
2. Describe the Farm Environment - opportunities and constraints
3. Review Legal Requirements and other Guidelines
4. Identify Environmental Issues, Impacts and Risks
5. Prepare and Implement Environmental Management Plans to address issues
6. Monitor and measure performance
7. Report and review EMS

This is shown diagrammatically in *Figure 1.*

These tasks are outlined in more detail below.

Figure 1: The EMS Approach

Step 1: Environment Policy
An Environment Policy outlines the environmental objectives and targets for the farm and should be appropriate to the nature, scale and environmental impacts of the activities undertaken on the farm. In addition, the policy must:
- acknowledge compliance with legislation as a minimum;
- show commitment to continual improvement of the EMS and prevention of pollution; and
- address environmental sustainability.

The development and implementation of the Environment Policy requires the following commitments:
- agreement by the owners/managers of the farm to abide by the Environment Policy;

- allocation of time and dollars to implement it; and
- active review and reporting.

Step 2: Describe Farm Environment

Briefly describe the farm environment, including natural resources, soil types, climate and farming history. Outline the major issues confronting your use of the property (eg. urban encroachment, salinity) and the goals or opportunities you see for the future (eg. wildlife conservation, organic farming, tourism).

Step 3: Review Legal Requirements

Identify the environmental legislation that applies to your farm/area. Be familiar with your responsibilities under State Environmental legislation. Also review how your property fits within Regional Catchment Management or Landcare Regions. Approach government and community groups for assistance and input into your farm EMS.

Step 4: Identify Environmental Issues, Impacts and Risks

The activities of the farm or enterprise should be investigated to identify the issues and impacts of each activity. Issues for alpaca farms may include those such as listed in Table 1. These should be listed and then a risk assessment undertaken to prioritise each issue according to risk (see Table 2 below).

Table 1: An example of a table to identify environmental issues, impacts and risks for an alpaca farm.

Activity	Issue	Impact	Risk
Chemical use and storage • Veterinary Chemicals • Pesticide use • Storage facilities • Fuels and oils	off-label use of chemicals unnecessary use of drenches spills withholding periods	animal health soil contamination drench resistance pesticide residues occupational health and safety	
Pasture Management	manure disposal animal rotation stocking rates pasture species access to significant vegetation	water contamination erosion invasion of weed species habitat destruction odour/dust soil compaction	
Stock Management • Feed storage • Drinking water • Shelter • Riparian zones • Rotations	contaminated feed access to water courses siting and type of shelter siting of fences and gates animal rotation/set stocking	animal health stream bank erosion soil compaction water contamination habitat destruction	

Table 2: Risk Assessment

PRIORITY RATING	LEVEL OF RISK	ACTION REQUIRED
High	Extremely Significant Environmental Risk	Procedures and Programs MUST be put in place
Moderate	Significant Environmental Risk	Procedures and Programs SHOULD be put in place
Significant	Some Environmental Risk present	Procedures and Programs should be considered
Low	Very Minor Environmental Risk	Does not warrant Programs

Step 5: Prepare and Implement Environmental Management Plans

Prepare an Environmental Management Plan (EMP) initially for those high priority issues. Give a commitment and timeframe for preparing EMPs for issues rated moderate and for deciding on issues rated significant.

An EMP will include:

- Objective
- Policy
- Performance Targets
- Obligations
- Responsibilities
- Procedures
- Reporting
- Commencement
- Consultation
- References
- Review Date

For effective implementation, you should develop the capabilities and support mechanisms necessary to achieve your environmental policy, objectives and targets. These include:

- documenting what you do and how you do it;
- monitoring the effectiveness of your actions and whether you are meeting your targets;
- undertake training where available;
- ensuring communication with regional and local authorities, community groups and neighbours is maintained - ask them to read and comment on your EMS;
- setting a timetable for meeting targets and reviewing this regularly; and
- obtaining feedback from regional and local authorities, community groups, neighbours and other stakeholders on the effectiveness of your EMS.

Step 6: Monitor and Measure Performance

Once the system is in place, you should measure, monitor and evaluate your environmental performance. Documented procedures to ensure that measurements are accurate and recorded should be put in place. When performance targets are not met, corrective actions should be identified and implemented when required. All such actions should be recorded.

Step 7: Report and review EMS

You should regularly add to and upgrade your farm EMS, with the objective of improving overall environmental performance.

You should review the Environment Policy, targets, objectives and the EMS effectiveness regularly and in response to external changes such as changes in legislation, land use or market requirements.

References and Further Reading

Carruthers, G. (2005) Adoption of Environmental Management Systems in Agriculture: An analysis of 40 Case Studies. Report to RIRDC from NSW Agriculture

Commonwealth of Australia (1992) National Strategy for Ecologically Sustainable Development, December 1992

Department of Primary Industries (Vic) (undated) Beginners Guide to Environmental Management Systems in Agriculture.

Department of Primary Industries (Vic) (2004) Environmental Requirements for Victoria Farmers Booklet 1-6.

Department of Sustainability and Environment (Vic) (2005) Environmental management in Agriculture: Work Sheet Series 1-8.

Merrell, John (2002) Alpacas and Sustainable Agriculture. Gateway Farms Alpacas website

NGO Sustainable Agriculture Treaty 1992 (US)

NRMMC (2002) Australia's National Framework for Environmental Management Systems in Agriculture, Natural Resource Management Ministerial Council, October 2002.

Queensland Farmers Federation (1998) The Environmental Code of Practice for Agriculture

RIRDC (2004) Eco-Range: Market-Oriented Environmental Certification for Rangeland Pastoral Industries.

RIRDC (2005) Environmental Management Systems in the Yarra Valley.

SCARM (Standing Committee on Agriculture and Resource Management) 1998, *Sustainable agriculture: assessing Australia's recent performance.* A report to SCARM of the national collaborative project on indicators for sustainable agriculture, SCARM Technical Report 70, CSIRO Publishing, Melbourne.

Standards Australia (1996) Australian/New Zealand Standard: Environmental management systems - Specification with guidance for use. AS/NZ ISO 14001:1996

Poster abstract

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The role of objective and subjective measurements on the market value of mohair and implications for alpaca

This recent analysis of over 1000 lots of mohair was published in the leading Australian Journal of Agricultural Research. The work is relevant to alpaca producers as it shows that the prices of speciality fibres such as mohair (and alpaca by implication) are predictable, are based on important measurable attributes and that prices for speciality fibres are not all myth and magic. It also demonstrates that certain traits have no or little market value and therefore presents a challenge to sections of the breeding industry. This paper is a must for those who seek to establish a long-term alpaca fibre industry in Australia.

Poster abstract

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Effect of alpaca age on testes growth and development, sperm production and post-thaw sperm survival: preliminary results.

Alpacas have a naturally low reproductive rate and long generation interval. Male alpacas reach sexual maturity between the ages of 2 and 3 years[1], and are selected for breeding at 3 years with testes length of ≥ 3 cm[1]. Selecting males for breeding based on testis size at 14 months of age may result in the use of males with superior sperm production[1] and increased pregnancy rates after natural mating. The current project aims to examine the growth and development of alpaca testes, and to identify possible relationships between age and testis size (length and width), testis development, sperm concentration and post-harvest and post-thaw motility.

Testes and epididymides were collected at castration from male alpacas (n=18) with an average age of 19.4 ± 0.9 months (range 10 – 25 months). Testes were measured (length and width) and sperm extracted from the epididymides and pellet-frozen[2]. Sperm concentration and motility were assessed post-harvest (pre-freeze) and post-thaw. Testicular development was assessed histologically. Briefly, whole testes were fixed in 10 % buffered formalin and processed through ethanol and xylol before embedding in paraffin wax. Tissue was sectioned at 5 µm, mounted and stained with Whitlock's Haematoxylin and alcohol eosin. Correlation and regression analyses were calculated using Genstat.

Average testis length and width was 3.5 ± 0.2 cm and 2.4 ± 0.1 cm, respectively. Sperm concentration was 55.1 ± 18.1 $x10^6$ per mL but this varied considerably between males (range: 0 – 265 x 10^6 per mL). Post-harvest motility was 23.7 ± 5.8 % and post-thaw motility was 12.1 ± 4.2 %. Alpaca age was highly related to both testes length (P = 0.0039), and testes width (P = 0.0094). Testis length and width were highly related (P = 0.0021). There was no relationship between age and sperm concentration, pre-freeze or post-thaw motility. Testis length was not related to sperm concentration (P>0.05).

These results demonstrate the relationship between alpaca age and testis growth (length and width). Interestingly, there was no relationship between age and testis development or sperm concentration. Motile sperm were harvested from a 15 month male, while three males over 20 months of age produced no sperm suggesting individual variation in testicular development and timing of sperm production. Selecting males with testes length ≥ 3 cm does not provide a reliable indicator of sperm production. Further research is required to elucidate the patterns of testicular growth and development in male alpacas, and to determine the optimal breeding age, and testis size of male alpacas. *Supported by RIRDC and the Australian Alpaca Association.*

[1]Galloway 2000. Proc. Aust. Alpaca. Ass. 1:21-23
[2]Morton et al. 2006. Proc. European Soc. Dom. Anim. Reprod. (submitted)

Poster abstract

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A comparison of three diluents for the cryopreservation of epididymal alpaca sperm

There have been few reports of successful cryopreservation of epididymal alpaca semen. The aim of this study was to evaluate cryosurvival of epididymal alpaca sperm in three freezing diluents. Sperm were harvested by mincing the epididymides of males (n=9) after castration, and swimming out into Androhep (AH; Minitube, Germany) for 30 min. Sperm suspensions were centrifuged (300g; 10 min), the pellet resuspended in 1.5 mL AH and further diluted 1:1 with Citrate (Sodium citrate-glucose-20% egg yolk-glycerol; Bravo et al, 2000, Theriogenology, 62, 173-193), Lactose (11 % Lactose-20% egg yolk-glycerol-1.5% SDS), or 1:2 Tris (Tris-citric acid-glucose-20% egg yolk-glycerol) diluents (final glycerol 3 %). Sperm were cooled to 4°C over 2h and pellets frozen on dry ice. Motility and acrosome integrity (FITC-PNA) were recorded after harvest, cooling, and at 0 and 3 h post-thaw (37°C). After harvesting, motility was 46.9±4.5 % and acrosome integrity was 90.6±1.5 %. After cooling, motility was 12.5±3.8 %, 31.9±5.1 % and 18.8±4.1 % for Citrate, Lactose and Tris diluents respectively. Post-thaw motility at 0 and 3 h was significantly higher for sperm frozen in Lactose (18.1±5.7 % and 3.1±1.7 %) than Citrate (6.8±2.3 % and 0.9±0.64 %) and Tris (11.3±3.0 % and 1.4±0.8 %) diluents. Acrosome integrity was similar for all groups after cooling (86.4 - 92.4 %) and freeze-thawing (0h: 79.0 - 83.4 %; 3h: 75.0 - 79.0 %). This study demonstrates that Lactose results in better cryosurvival of epididymal alpaca sperm than Citrate or Tris diluent. *Supported by RIRDC and AAA.*

Poster abstract

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Preliminary development of sperm sexing technology in alpacas (*Lama pacos*)

The separation of sperm into X- and Y-chromosome bearing populations by flow cytometry ('sperm sexing') is an emerging reproductive technology. Sperm sexing has been used to produce offspring and embryos of a pre-determined sex in a number of domestic animal species in conjunction with artificial insemination (AI) and in vitro fertilisation (IVF; Maxwell et al. 2004. Anim. Reprod. Sci. 82-83, 79-95). Sex-sorted sperm are commercially available in cattle and horses, but the technology has yet to be developed for Camelids. The aims of this study were to i) determine the DNA difference between the X- and Y-bearing sperm in alpacas, ii) optimize the optimal Hoescht 33342 (H33342) staining concentration for the flow cytometric separation of X and Y alpaca sperm nuclei and iii) separate alpaca sperm into high purity (> 90%) populations bearing the X- and Y-chromosome.

Ejaculates were collected from 5 males (n=4 ejaculates per male) using an artificial vagina inside a mannequin and prepared for sex sorting. Briefly, sperm tails were removed by sonication (to aid in orientation), the nuclei were diluted to 100 x 10^6 mL^{-1} with Androhep (AH; Minitube, Germany) and incubated with H33342 stain (4, 6, 8, or 10 µL mL^{-1}) for 60 mins (38°C). Sperm nuclei were then separated into X- and Y-chromosome bearing populations using a high speed cell sorter (SX-MoFlo®; DakoCytomation Inc., Fort Collins, Co, USA). Purity of the separated populations was determined by resort analysis. Data for the proportion of oriented sperm (those able to be sorted), flow (passage of sperm through the machine) and sort rates (speed of separation of sperm into X- and Y-populations) were analysed by ANOVA and means compared using least significant differences (LSD).

There was no significant difference in the proportion of sperm nuclei correctly oriented (43.3 ± 3.9, 46.4 ± 3.7, 44.5 ± 4.0, and 51.1 ± 2.5 %), flow (9400 ± 658, 9336 ± 632, 10214 ± 915 and 10120 ± 763 sperm $second^{-1}$) or sort rates (1381 ± 160, 1386 ± 123, 1371 ± 133 and 1379 ± 127 sperm $second^{-1}$) for sperm nuclei stained with 4, 6, 8, and 10 µL mL^{-1} H3342, respectively. The DNA difference between the X- and Y-chromosome bearing sperm in alpacas was 3.8 ± 0.06 %, and the average purity of the separated X- and Y-sperm nuclei populations was 96.6 ± 0.7 % and 96.1 ± 1.1 %, respectively.

These results represent the first application of sperm sexing technology in alpacas and demonstrate that alpaca sperm nuclei can be successfully separated into high purity X and Y populations. Further research is required to optimize preparation and sorting procedures before the technique could be combined with AI or IVF for the production of pre-sexed alpaca offspring. *Supported by Rural Industries Research and Development Council.*

Poster abstract

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Cryopreservation of epididymal alpaca sperm in pellets and straws frozen on dry ice or in liquid nitrogen vapour.

Alpaca ejaculates contain a highly viscous seminal plasma which traps sperm and makes handling, dilution and cryopreservation difficult. As a consequence, the protocol for the cryopreservation of alpaca sperm is not well established. The use of epididymal sperm avoids the viscous seminal plasma and provides a model for establishing protocols for the cryopreservation of ejaculated semen. Epididymal sperm can also be used to establish gene banks for endangered camelids and deceased males of high genetic value. Despite this, there are limited reports on the frozen storage of epididymal alpaca sperm[1,2] and the development of freeze and thawing protocols are still in their early stages.

Epididymides and testes were obtained from males after castration and transported to the laboratory (approx. 6 h). Sperm were recovered by mincing the epididymides with a scalpel and allowed to swim out for 30 mins into Androhep (AH; Minitube, Germany). Sperm were frozen using a modified Westendorf method[3] with a cooling extender (11 % lactose supplemented with 20 % egg yolk) and a freezing extender consisting of cooling extender supplemented with 9 % glycerol and 1.5 % sodium dodecyl sulfate. Briefly, sperm suspensions were centrifuged (300 *g*; 10 mins), the pellet resuspended to a final volume of 2 mL with cooling extender and cooled to 4°C over 2 hours (-0.14°C/min). Cooled sperm were further diluted with 1.0 mL freezing extender and frozen as pellets (250 µL) on dry ice, or loaded into 0.25 mL or 0.5 mL straws and frozen on dry ice or in liquid nitrogen vapour (10 cm above liquid nitrogen for 10 mins then at 2 cm for 5 mins). Motility and acrosome integrity (FITC-PNA) were recorded after sperm harvest, cooling and at 0 and 3 h post-thaw (35°C). Statistically significant differences were determined by ANOVA and means compared using LSD.

Sperm motility after harvest was 37.5 ± 11 % and was similar after cooling to 4°C. Motility immediately (0 h) post-thaw was higher for sperm frozen as pellets (27.5 ± 8.5 %), than in 0.25 mL (6.3 ± 2.4 %) or 0.5 mL (6.3 ± 4.7 %) straws (on dry ice), or 0.25 mL (10.0±3.5%) and 0.5 mL (11.7 ± 4.4 %) straws (in liquid nitrogen vapour). Motility at 3 h post-thaw was similar between groups (<5 %). Acrosome integrity was similar immediately after harvest and cooling to 4°C (89.3 ± 3.8 %) and did not differ between groups at 0h (range: 81.0 - 91.0 %) and 3 h (range: 78.3 - 83.0 %) post-thaw.

Pellet freezing resulted in superior motility compared with 0.25 and 0.5 mL straws frozen either on dry ice or in liquid nitrogen vapour. Immediately post-thaw pellet frozen sperm retained most of their original motility, but motility declined by 3 hours post-thaw. While these results are encouraging, further research aimed at improving the post-thaw motility and longevity of epididymal alpaca sperm is required. *Supported by Rural Industries Research and Development Corporation (RIRDC) and Australian Alpaca Association (AAA).*

[1]Bravo *et al.* 2000. Proc. Int. Congress. Anim. Reprod. 2:92.
[2]Morton *et al.* 2006. Proc. European. Soc. Dom. Anim. Reprod. (submitted).
[3]Bathgate *et al.* 2006. Reprod. Domest. Anim. 41:68-73. *6.*

Poster abstract

Elizabeth Paul

Vitamin D and Phosphate Requirements in Alpacas – One Breeder's Observations.

Vitamin D helps prevent a low phosphate condition called rickets. The correlation between serum levels of vitamin D and phosphate is so close that the level of phosphate is considered a good indication of the level of vitamin D. However, the results of various studies have indicated that this correlation differs seasonally, and quite markedly, in alpacas.

The aim of this presentation is to explore the relationship between vitamin D and phosphate in alpacas from this perspective, by reviewing and combining the results of these studies to provide a clearer annual picture of events.

A secondary aim is to offer an explanation as to why alpacas are more affected by this condition than other large domestic animals. Alpacas have evolved a unique blood system to enable them to live in high altitude, low oxygen conditions. One reason could be that they require extra phosphate, (and therefore extra vitamin D), to maintain this blood system.

Poster abstract

Jorge Luis Reyna

The application of reproductive technologies in alpaca breeding programs in Australia

The main objective of this paper is to discuss our current knowledge in AI and ET, and its impact on genetic improvement programs. Genetic gain in alpacas is slow, as males reach puberty at one-three years, gestation is long (11.5 months) and there are a limited number of offspring from females over their whole reproductive life. Current limitations of AI include the lack of a reliable technique to collect sperm due to the length of copulation, the unique mucoid character of the sperm, low concentration and motility of the spermatozoa, and the lack of techniques to store sperm in chilled or frozen form. In the case of embryo transfer techniques, several papers have described different superovulatory treatments with variable responses. One of the limitations in this area is the number of females which need to be allocated to different treatments to achieve statistical significance.

Research is being conducted in our laboratory to improve on current techniques for collecting sperm using a mannequin (dummy female) and an alpaca artificial reproductive tract (AART), testing liquefaction of sperm with novel enzymes and also several protocols for chilling/freezing sperm. In the case of ET, 3 different protocols using a combination of hormones (FSH and LH) in a single/multiple dose are being tested, taking into account synchronisation of ovarian follicular waves.

Results show that the design of the AART is critical to obtaining good quality of ejaculates from trained males. Sperm processing techniques to liquefy the sperm and extend it for AI purposes have been achieved satisfactorily. In the case of ET, a single FSH injection with a "long effect vehicle" has been shown to produce equal ovarian responses in females primed with progestagens for 7 days. In conclusion, several field trials need to be performed with a large group of animals to test our findings. We believe these techniques will be available for alpaca breeders in Australia within a year's time.

Poster abstract

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Embryo transfer in alpacas

The development of artificial breeding technologies in alpacas will increase the use and allow more economic movement of genetically superior animals nationally and internationally. Generation intervals are relatively long in alpacas because males are slow to sexually mature and females exhibit an extended gestation (11.5 months), so conventional breeding results in slow genetic gain. Assisted breeding technologies are being used to improve wool quality more rapidly than would otherwise be possible by natural mating in industries such as Merino sheep and Angora goats. However, the reproductive physiology of alpacas differs to that of other domestic livestock and remains poorly understood, therefore hindering the direct transfer of artificial insemination (AI) and embryo transfer (ET) technologies from ruminants to alpacas.

The understanding of ovarian function in alpacas has been instrumental in the success of developing non-surgical, transcervical single and multiple ovulation ET in alpacas. The author has produced more than 700 alpaca pregnancies using ET in Australia and will discuss animal preparation, embryo transfer technology and results from the last 3 years of work.

Poster abstract

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The potential of visible and near infrared spectroscopy as a rapid tool to analyse Alpaca fibre characteristics.

Abstract
Visible (VIS) and near infrared (NIR) reflectance spectroscopy is a rapid and non-destructive technique that has found many applications in assessing the quality of agricultural commodities, including wool. In this study, VIS-NIR spectroscopy combined with multivariate data analysis was investigated for its feasibility in predicting a range of fibre characteristics in raw Alpaca fibre samples. Mid-side samples (n=149) were taken from alpacas of a range of colours and ages at shearing time over four years and subsequently analysed for fibre characteristics using traditional laboratory testing methods and also by VIS-NIR spectroscopy. In addition, total fleece weight (kg) and staple length (mm) was measured. Fibre characteristics measured included, mean fibre diameter and standard deviation (and coefficient of variation), spin fineness, curvature degree (and standard deviation), comfort factor, medullation percentage (by weight and number in white samples only) using the OFDA2000 method sourced from commercial service providers. Samples were scanned in a large cuvette using a NIRSystems 6500 monochromator instrument in reflectance mode in the VIS and NIR regions (400 to 2500 nm). Partial least square (PLS) regression was used to develop a number of calibration models between the spectral and reference data. Mathematical pre-treatment of the spectra (second derivative) as well as various combinations of wavelength range were used during model development. The best calibration model was found using the NIR region for the prediction of mean fibre diameter which had a coefficient of determination in cross-validation (R^2) of 0.85 with a standard error of prediction of 3.0 micron. The value for the residual predictive value, RPD (ratio of standard deviation to the root mean square of the standard error of cross validation (RMSECV)) was 1.9 meaning that the technique has promise as a semi-quantitative method for screening purposes. Other workers [1] have found that fibre diameter in greasy wool samples was poorly predicted with NIR, while clean wool showed good relationships. The lack of grease in alpaca samples suggests that the technique might find ready application as a rapid measurement technique for preliminary classing of shorn fleeces or, if used directly on the animal, the technology might offer an objective tool to assist in the selection of animals in breeding programs or shows.

References
1. Cozzolino, D; Montossi, F; San, Julian R. The use of visible (VIS) and near infrared (NIR) reflectance spectroscopy to predict fibre diameter in both clean and greasy wool. Animal Science 80 (3): 333-338, 2005.

Key Words
alpaca fibre, mean fibre diameter, spectroscopy