FIBRE PRODUCTION AND SHEEP BREEDING IN SOUTH AMERICA

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SUMMARY

The production of wool and other fibres, in particular those produced by camelids (special fibres) in South America is reviewed. The two main production systems, namely commercial and smallholding are described, including their geographic locations. Wool is by far the main animal fibre produced in South America with a volume of 143 million kg (greasy) followed by the alpaca fibre with 4 million kg.

Sheep breeding programs in the four South American countries with the largest sheep populations are summarized. Argentina and Uruguay have the most developed sheep genetic improvement programs. Their evolution from the beginning in the 1970's until now is reviewed, including a description of the present programs.

INTRODUCTION

The South American sub-continent covers a range of environments in which sheep, goats and South American domestic camelids (llama and alpaca) produce meat, fibre, milk and skins for a large number of farmers, contributing substantially to their livelihoods and to the national economies. Given the variety of ecological and socio-economical conditions it is difficult to generalize on production areas, production systems and breeding practices. Sheep are most common in the vast temperate rangelands and deserts of the south, while goats are more common towards the north-east of the subcontinent, and camelids are largely found along the Central Andean region. Sheep are for the most part dual purpose (wool-meat) whereas goats are bred for meat and camelids are multipurpose. Dairying with small ruminants is not common in South America. Notable exceptions to this general description are hair-sheep in the northeast of Brazil, bred for meat and skins, and Angora goats and criollo goats in southern Argentina which besides meat produce mohair and cashmere.

Wool is by far the most important animal fibre in South America, but other fibres, usually called "special fibres" like alpaca, llama, and mohair are also produced in large quantities. In addition, vicuña, guanaco, angora (produced by rabbits), silk and cashmere fibres have great potential for development but at present the amount of fibre produced is still low (Table 1).

Table 1. Production of wool and other animal fibres in South America.

Species	Animal Population	Fibre	Fibre Production (kg, greasy)
Sheep	57,500,000	Wool	143,700,000
Alpaca	3,503,774	Alpaca	4,055,595
Llama	4,080,596	Llama	3,342,866
Angora goat	550,000	Mohair	825,000
Vicuña	319,547	Vicuña	5,580
Guanaco	577,697	Guanaco	1,500

Source: Cardellino and Mueller (2008), Quispe *et al*. (2009).

SHEEP PRODUCING AREAS

The main sheep production areas in South America are shown in Map 1. Three main sheep areas can be distinguished. The largest one, indicated as wool producing sheep area, includes the majority of Argentina, southern Chile, Uruguay and southern Brazil. In that area, wool or dual purpose sheep breeds predominate, mainly derived from the Merino. The second area, the criollo sheep region, includes the northern part of Argentina, and the Andean Altiplano regions of Bolivia and Perú. There is a third area, specifically a dry region in northeastern Brazil, where woolless hair sheep are raised basically for meat and skins.

Map 1. Sheep producing areas of South America.

SHEEP PRODUCTION SYSTEMS

Two major sheep production systems can be distinguished: commercial and smallholder. Commercial systems include farmers with a variety of flock sizes depending on the region, but oriented mainly to the production of wool and meat for the market. The main areas of these production systems in Argentina include the regions of Patagonia (dry and cold, Merino and Corriedale), Mesopotamia (mixed cattle-sheep farming, Corriedale and Polwarth) and the Pampas (mixed cropping-sheep farming, Corriedale, Romney Marsh and Lincoln) with about 50,000 growers. Uruguay, with 38,000 growers in mixed farms with beef cattle, run mainly dual-purpose sheep (Corriedale 60% and Merino 25%). Brazil, with 40,000 growers running mixed farms are located mainly in the southern region, with a predominance of dual-purpose sheep. In Chile there are about 60,000 growers. The Patagonian region in Chile contains 60% of the total sheep population in the country, consisting of dual purpose sheep breeds on medium to large farms.

Table 2 shows that commercial production systems comprise some 60% of total sheep numbers and account for 85% of the wool produced. It also can be seen that most wool marketed is fine or medium. It is estimated that about one third of coarse wool and camelid fibres produced by smallholders are not marketed and is instead used in the household or transformed and sold with aggregate value as handcrafts.

Table 2. Sheep population and wool production in South American countries (2008).

Country	N° sheep (mill)	Prod. System	Fine < 24.5 mic	Medium 24.6 – 32.5 mic	Coarse/Criollo > 32.5 mic	Wool Production (mkg, greasy)
Argentina	16.0	commercial/ smallholders	40.3	22.7	2.0	65.0
Uruguay	10.4	commercial	12.0	27.0	2.0	41.0
Chile	3.9	commercial	0.2	10.8	0.2	11.2
Brazil	3.5	commercial	1.0	8.5	1	10.5
Perú	14.7	smallholders	0	5.0	7	12.0
Bolivia	9.0	smallholders	0	0	4	4.0
Total	57.5		53.5	74.0	16.2	143.7

Source: Cardellino, RC. based on FLA, SUL, ODEPA, IICA, IWTO.

The second sheep production system is the smallholder system which corresponds to low input, low productivity small farms with subsistence economies. Flock size is small, 20-40 head and usually mixed with goats or camelids. Sheep are of the criollo type (derived from the original sheep introduced by the Spanish settlers) or non-defined criollo crosses. Main areas where these types of production systems can be found include: the Altiplano of Bolivia, a region at 3000-4500 metres above sea level (masl), involving mostly native communities; the Sierra Central Region of Peru and the area north of the Titicaca Lake, with 43% of very small producers and 32% of peasant communities. The Altiplano sheep production systems extend to the northwest of Argentina (Tempelman and Cardellino 2007).

SHEEP BREEDING PROGRAMS

Argentina. As in other countries of South America, Spanish sheep were introduced into Argentina soon after the discovery. In the early 19th century these populations called “criollos” were upgraded to Saxon, Negrete and Rambouillet Merinos aiming for a better carcass and finer wool. Selection within the resulting genetic pool gave origin to the Argentine Merino. By the end of that century an active European mutton market and the advent of cold-storage plants and ships encouraged the use of the large British Lincoln and Romney Marsh breeds. Both breeds were used for crossing and upgrading. In the 1930s the decreasing demand for sheep meat and increasing wool prices were responsible for the preference of Australian Merinos, Polwarths and Corriedales which were imported from Australia and New Zealand.

Within breed improvement was initiated by pioneer breeders who later associated into Breed Societies and implemented pedigree registration following British Flock Book rules. These Societies are largely responsible for the present genetic structure, production level and genetic improvement rate of most breeds. Today a hierarchical genetic structure characterize Argentine sheep breeds.

Performance recording started in the 1960s, heavily influenced by Australian scientists such as Helen Newton Turner and Brian Jefferies who visited and worked in Argentina as consultants for a FAO funded Patagonian Sheep Production project run by the National Institute for Agricultural Technology (INTA). Following their advice, a fleece testing laboratory was constructed and objective fleece testing was promoted. A performance testing scheme was implemented in 1970 as a selection aid for Merino and Corriedale ram breeders in Patagonia. In 1990 the program

developed into the National Sheep Evaluation Service (PROVINO) based on a joint agreement between INTA and several breed societies. Initially the program provided within contemporary group breeding values and sire-summaries.

In 1991 Central Progeny Testing (CPT) of sires started in the Merino breed followed by Corriedale, Romney Marsh and Polwarth. Particularly successful is the Merino CPT scheme which is still operating. Interestingly the Merino CPT scheme often includes show champions and imported sires on invitation. It has to be remembered that major Argentine Merino studs regularly import rams or their semen from Australia. Amongst the imports are Australian show champions including supreme champions (see for example Top Sire 2005). Several of these studs furnish PROVINO with pedigree information allowing the calculation of within flock BLUP of expected progeny differences (EPDs). Since 2006 the accumulated data from these studs and those from the CPT sites are merged enabling across flock evaluations which are published by the Argentinean Merino Breeders Association (see sire evaluation results at AACM 2009).

Thus, at present PROVINO provides two types of genetic evaluations: within flock EPDs and across flock EPDs. At the end of the 2007/2008 production year, PROVINO evaluated about 16,000 ram hoggets from a total of 176 farms and ranked 236 Merino sires. These figures highlight that selection procedures are still largely based on visual inspection only. An important step towards the use of objective measurements was taken by the Argentine Merino Breed Society with its "Pure Registered Merino" program based on identification of rams performing above average (on breeder chosen PROVINO index) in its contemporary group and visually accepted by an authorized classer.

A further important development has been the enforcement of a "National Sheep Recovery Law" in 2001, which provides state funds for stock recovery, farm infrastructure, feed production, breeding plans, large scale sheep health programs, AI projects, semen imports and central progeny testing.

Brazil. Brazil has around 14 million sheep concentrated in two main regions: South (wool sheep) with 33% and Northeast (hair sheep) with 56% of the total population. In the southern region temperate and subtropical climate predominates. Sheep improvement began with the absorption of mixed criollo flocks of Spanish origin (mainly Churro) by traditional wool and meat sheep breeds (Merino, Polwarth, Corriedale, Romney Marsh and Hampshire Down), followed by 50 years of visual selection by breed standards. In 1942 the Brazilian Sheep Breeders Association (ARCO) was created.

In 1978 the Sheep Genetic Improvement Program (PROMOVI), based on objective measurement of wool traits, was initiated and remained officially active from 1981 to 1995. The importation of meat breeds (Ile-de-France, Suffolk and Texel) increased in the 1990s. From 1995 to 2000 ARCO implemented the Central Performance Test for meat breed lambs and a Performance Test on farms. Since 2000 no objective evaluations that could serve as basis for sheep genetic improvement programs have been carried out in this region (Cardellino 2009).

Semi-arid conditions predominate in the Northeast region of Brazil. Hairy sheep originated from African and Caribbean stocks and resulted in well defined naturalized breeds (Santa Ines, Morada Nova, Rabo Largo and Cariri). Since 2002 a research institute in Paraiba State (EMEPA) and the sheep national centre in Ceara State (EMBRAPA) have conducted feedlot performance testing in Santa Ines males. Other initiatives are the Genetic Improvement Program for Goats and Meat Sheep (GENECOC) by EMBRAPA and the Genetic Improvement Program for Santa Ines breed by the University of Sao Paulo.

All current programs have a very low level of participation by sheep breeders, especially studs. In an expanding market, these breeders obtain good prices for their sheep stock (rams, hoggets and ewes) based only on visual selection and aggressive marketing. In 2008 EMBRAPA proposed the

development of a Research Network for Sheep Genetic Improvement with the participation of its research units, universities and state research organizations. It is being currently developed under a service contract with ARCO and aims at establishing a national sheep genetic improvement scheme with enough versatility to include all breeds of wool and hair sheep in both main sheep producing regions of the country (Benítez *et al*. 2008).

Chile. At present there are no regional or national sheep breeding programs operating. In the Chilean Patagonia, where most of the sheep are concentrated, a cooperative nucleus breeding scheme in the Corriedale breed was set up in the 1980s supported by the National Institute of Agricultural Research (INIA). More recently a number of breeds were introduced and evaluated, including Dohne Merino, Poll Dorset, Suffolk and East Friesian. (R. Lira 2009, pers.comm). Breed improvement relies heavily on conventional procedures, including visual classing of replacement candidates and promotion of show champions. Nevertheless Corriedale rams have ranked high in progeny tests including New Zealand and Argentinean sires (Mueller *et al*. 2007).

Peru. The sheep population in Peru is estimated to be 14 million head, 85% of which is run by peasant communities, and belong to the criollo breed and their non-planned crosses (W. Vivanco 2009 pers.comm.). The remaining 15% correspond to Corriedale and Junín (a local breed based on the Corriedale, Polwarth and Panamá breeds), and are in the hands of communal cooperatives and private farmers. There are no well structured and organized sheep breeding programs in the country, nor performance recording systems and genetic evaluations. Large scale improvement programs have been successfully implemented with support of the University of La Molina (Mueller *et a*l. 2002). Recently, the Dohne Merino and the East Friesian have been introduced.

Uruguay. The predominant breeds in Uruguay are Corriedale, Merino and Polwarth, which represent 60, 20 and 10 per cent of the national sheep flock, respectively. These breeds can be defined as multi- purpose in the sense that they generate income from the sale of wool and sheep meat (surplus offspring and cast for age animals), forcing breeders to consider several traits in their selection programmes. Traditionally, wool has been the main product of the system. However in recent years, the importance of sheep meat (lambs and mutton) has increased significantly. The breeding structure of sheep industry in Uruguay follows in general the common hierarchical pattern with “top”, and “multiplier” studs. Flock size in studs is large enough to allow effective “within flock” programs of genetic improvement (on average 500 breeding ewes). The evolution of sheep breeding programs and genetic evaluation procedures since 1970 to date has followed the same pattern of more developed sheep producing countries, mainly Australia and New Zealand.

A performance recording scheme started in 1969 with the purpose of introducing more effective breeding methods, through the objective measurement of economically important traits. This service was implemented and supervised by the Uruguayan Wool Secretariat (SUL), a private growers´ organization. The Flock Testing service is still operating and involves at present 137 studs and 23,000 animals in 2008. The rate of adoption by the most important studs (top studs) has been very high (95% in Corriedale, 80% in Polwarth and Merino studs).

After many years of operation of the Flock Testing service, it gradually became obvious that a formal definition of breeding objectives and selection criteria was essential. It was recognized that such a formal definition would enable to more precisely determine the relative importance of different traits and also to offer breeders the possibility of combining various selection criteria in an index (Cardellino and Ponzoni 1986). In recent years, new updated selection indices were developed for general use.

In 1994, with the objective of comparing the genetic merit of rams from different studs, several Central Progeny Test (CPT) operations started in all the breeds, with the support of their Breeders’

Associations and the technical support of SUL. Until year 2000, dam identification was not recorded, so genetic evaluation of different traits was performed with a sire–model. Gradually the concept of reference sires was introduced, allowing the genetic comparison of rams used in different CPTs and years and also the feasibility of performing across–flock genetic evaluations became more obvious. Multi–trait BLUP methodology was then introduced as well as the concept of EPD's (Expected Progeny Differences), replacing the traditional use of phenotypic values in the selection of the animals. At the same time, new traits were included in the breeding plans: FEC (faecal egg count), as indicator of genetic resistance to internal parasites, weaning weight, eye muscle area and fat depth.

The experience acquired and the results produced by CPTs, created a suitable environment to start with genetic evaluation across–flocks, through the use of reference sires among the participating studs. At present the number of studs involved in across–flock evaluations is: Corriedale (24), Merino (14), Polwarth (6), Merilín (5), Texel (5) and Romney (3) (see sire evaluation results at SUL 2009). Genetic evaluation analyses are performed by SUL and INIA. Every year special meetings with stud breeders and technical staff are carried out, to define the use of "reference sires", checking that the whole system remains well connected.

The initial system of collecting and storing data was not reliable enough which represented a limitation to the growth of a sire reference scheme with a high standard. SUL developed software (called SULAR) which performs quality control of data when it is incorporated. Special emphasis was placed in the registration of information on the performance of dams, and survival of lambs with the objective of producing EPD's for these traits. The centralized data base stores the identification of the animals, plus information on production and pedigree records (Gimeno and Cardellino 2006).

In 1998, it started a Fine Merino Project with the participation of the Merino Breeders' Association, INIA and SUL. A highly selected screened nucleus was formed with the objective of generating and distributing genetically superior sires for the production of fine and superfine wool less than 19.5 microns (Montossi *et al.* 2005). The initial nucleus included 742 ewe hoggets selected from 37 contributing flocks, screened from a population of 5170 ewe hoggets. Contributing producers annually receive genetically superior hogget rams, for their own use. Frozen semen from highly selected Australian merino rams has been used, particularly from the New England area. Results so far have shown very good progress in reducing diameter, while maintaining fleece and body weights.

WOOL vs MEAT IN SHEEP BREEDING PROGRAMS

Historically the production of sheep meat has been a by-product of wool production, with practically no areas specialized in the production of fat lambs. However, in the last 5-10 years, as a result of low and fluctuating wool prices, meat production has increased its importance in sheep production systems, representing a higher proportion of total sheep income.

Uruguay is the first exporter of sheep meat in the region with 22,000 ton, followed by Argentina (6,100) and Chile (5,100). However, the importance of fat lamb production and consequently prices for lamb meat are much lower than Australia and New Zealand, probably due to a lower exporting capacity and also very reduced home market consumption (6.2, 2,5 and 0.3 kg/head in Uruguay, Argentina and Chile, respectively)

In general terms, in Argentina and Uruguay, the increased importance of meat relative to wool has lead to changes in their genetic improvement programs, in particular: the inclusion of new traits more related to meat production (type of birth, weaning weight, muscle and fat depth) as well as changes in the relative importance of meat traits in the breeding objective (H) and the corresponding Selection Indices (I) for the different breeds. In addition, direct and maternal breeding values for weaning weight have been included.

This new scenario has also led to the introduction of new breeds, some of them for terminal crossbreeding (Poll Dorset, Suffolk), and others like the Dohne Merino, in particular to be used on Corriedale flocks to reduce the diameter of the wool, without lowering lamb meat production.

This general trend to improve meat production has also been followed by a generalized emphasis in producing finer wools, both in Merino and Corriedale flocks.

THE PRODUCTION OF OTHER ANIMAL FIBRES

In South America these fibres are produced almost exclusively by smallholders in low input systems where they are critical for the subsistence of its producers. Most fibre production systems are located in marginal areas with goats and camelids grazing natural rangelands. Alpacas, llamas and vicuñas are typically found in high altitudes of the central Andes while goats producing mohair or cashmere and guanacos are largely found in the Patagonian desert.

Alpaca. The Alpaca (*Vicugna pacos*) is a domesticated South American camelid species whose wild ancestor is the vicuña. Alpacas are raised in the highlands of Peru, Bolivia and Chile. More than 80% of the world's alpaca population can be found in southern Peru, northwest of Lake Titicaca at 3700-5000 masl. The alpaca is a symbol of Peruvian national identity. 85% of the alpacas are run by smallholders with less than 50 animals each, or are kept in farmer communities. Alpacas are particularly prized for their fibre, which is noted for its fineness, softness, exceptional warmth, hygroscopic features, resistance, elasticity, and natural colors. The soft touch is related to the fineness of the fibre but also to the arrangement of the scales along the fibre. "Baby" alpaca fibre diameter averages 22 micron and alpaca "fleece" averages 26 micron. An adult alpaca produces 1.5-2.8 kg of fibre per year. Alpaca is the main special fibre produced in South America.

Llama. The llama (*Lama glama*) is the other domesticated South American camelid species, its wild ancestor being the guanaco. Both, llamas and guanacos are larger animals than alpacas and vicuñas. Bolivia has the largest llama population, about 2.4 million, largely on the high-plateau (Altiplano) at 4000 masl in the west of the country. Peru with 1.2 million llamas is the second largest producer, while Argentina ranks third. It is estimated that in Bolivia there are 54,000 producers, 80% having less than 90 llamas each. Llamas are multipurpose animals; they are raised for their meat, power and fibre. As with alpacas, there is a strong cultural tie between llamas and their producers and communities. The fibre produced by llamas is not as fine as that of the alpacas. In Bolivia adult llamas produce fibre with an average diameter of 33 mic, and may yield up to 93% of its original weight when processed. Due to its multiple breeding objectives, llamas were selected for high body weight and fleece weight (1.5-3.5 kg) but less for fibre traits such as fineness and uniformity of color, which are more difficult to measure.

Vicuña. The vicuña (*Vicugna vicugna*) is the smaller of the two wild South American camelids and its undercoat fibres are extremely valuable and "special", not only for its textile characteristics but also for its rareness and association to exotic environments and culture. After a period of near extinction, the vicuña population recovered substantially in population size in all Andean countries. In Peru the vicuña population is now 140,000 and increasing, as well as in Argentina with a population of 133,000. Vicuñas are captured, shorn and released using different methods. At present Peru is producing most of the vicuña fibre, about 5500 kg/year with a fibre diameter between 10-15 mic. Yarn and fabrics made of vicuña fibre have the highest market price of all special fibres but its production is not easy due to its short staple length and the necessity of separating manually guard and dead fibres from the fine down fibres.

Guanaco. The guanaco (*Lama guanicoe*) is the biggest of the two wild South American camelid species and its population is much larger than that of the vicuña. More than 90% of the world guanaco population is in Argentina and the remainder in Chile and Peru. The population of 550,000 guanacos in Argentina is largely concentrated in the southern part of the country (the Patagonian desert). Guanacos roam freely in this sparsely inhabited region where sheep production is the main agricultural activity. Capture of guanacos is difficult as they can easily jump regular fences to escape at very high speed when mustered. Special techniques have been developed in order to capture, calm, shear and release guanacos avoiding unnecessary fear and injury. Fleece weight is approximately 1 kg for a two-year growth. Guanaco fibre is not as fine as that of the vicuña (16-22 microns) but otherwise quite similar, including its color variations of brown.

Mohair. About 650,000 Angora goats are run in the northwest of Argentina's Patagonia where they produce 825,000 kg mohair of competitive quality. Argentina is among the top world producers of mohair. Notable of Angora goats in this part of the world is the uniformity in color. Almost all Angora goats in Argentina are white, as opposed to central Asian Angora goats where other colors are very common. Angoras are shorn twice a year and produce a total of about 1.5-2.5 kg mohair. Mohair from young animals, (first and second shearing) is much finer (24 mic) than mohair from adult animals (29 micron and more).

ACKNOWLEDGEMENTS

The authors wish to thank Drs. Daniel Benítez (Brazil), Ricardo A. Cardellino (Brazil), Raúl Lira (Chile), Diego Gimeno (Uruguay) and William Vivanco (Perú) for their reviews, comments and valuable information used in this paper.

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