5 Domesticated camelids, the main animal genetic resource of pastoral systems in the region of **TURCO**, **BOLIVIA**

6 Management of sheep genetic resources in the **CENTRAL ANDES** of **PERU**

CHAPTER 2
PHYSIOLOGICAL ADAPTATION TO **TROPICAL MOUNTAIN CONDITIONS**

Two livestock systems in tropical mountain ecosystems are presented. One looks at how communities in the Altiplano of Bolivia use and manage llamas and alpacas, while the other examines the sheep farming systems in the Peruvian Andes. Rural households in these regions are confronted with extreme climate and environmental challenges, including altitudes up to 5 000 m, intense solar radiation, low levels of atmospheric oxygen, average annual temperatures of around 6° to 7 °C, limited vegetation coverage and poor forage. Frequent frosts throughout the year are a major obstacle to crop cultivation, so livestock is often the farmer's only resource for food security, clothing and extra income. Livestock raised in these areas are both physically and physiologically adapted to the harsh environmental conditions. They are protected against altitude sickness by the high level of haemoglobin in their red blood cells; can survive on scarcely-available and low-quality feed resources; are capable of digesting plant varieties that no other animal can; and their grazing behaviour does not have a degrading effect on the environment.

Map below:

The Turco region in the Province of Sajama, Department of Oruro, Bolivia

DOMESTICATED CAMELIDS, THE MAIN ANIMAL GENETIC RESOURCE OF PASTORAL SYSTEMS IN THE REGION OF TURCO, BOLIVIA

C.T. Rodríguez and J.L. Quispe

SUMMARY

The Turco region has a harsh, microthermal, semi-arid climate, but people make a living there from llamas and alpacas which have advantages over exotic species and are managed in a transhumant system. These camelids are the main source of food and income for herders. The inhabitants have a holistic world view and see themselves, the land and their animals as an integrated unit. Group selection is being done by herders assisted by the Camelid Research and Improvement Centre. There is little conservation activity by government agencies or NGOs. A programme, compatible with the maintenance of genetic diversity and the producers' interests and economic needs, is needed to focus primarily on *in situ* conservation, inventorying, characterization and utilization.

Bolivia has one of the largest herds of domesticated South American camelids; [illegible]572 llamas and 416 952 alpacas (UNEPCA, 1999), raised by more than 50 000 households.

This paper discusses how ecotypes and breeds of camelids are managed in the Turco region and aims to encourage research to provide a basis to ensure their conservation and appropriate use. The authors have drawn upon secondary information and data from a survey of producers and authorities in the Marcarani and Challuma communities.

Turco is in the Department of Oruro (17° 57' south and 68° 15' west). The Canton is divided into six Ayllus (political division whose borders re-trace those of the region's traditional social organizational patterns, which were in place when the Spaniards arrived and survive to this day) (Izko, 1992, as quoted by Genin, 1995).

THE ECOSYSTEM

Turco is a puna ecosystem (Ellenberg 1981): shrub steppes in which grass steppes, halophytic vegetation, *bofedales* (wetlands conducive to the growth of high-quality forage) and salt marshes are also found (Genin, 1995).

Genin and Alzérreca (1995) define three major topographic zones: the pampas, up to 3 800 metres; the hills and plains which are a transition zone between 3 800 and 4 100; and the intra-Altiplano between 4 000 and 5 000 m. Vegetation is low-quality grasses known as *pajonales* (32 percent), tolar-*pajonal* vegetation (20 percent), montane vegetation and tolar shrubs (35 percent), graminoids (9 percent) and *bofedales* (4 percent) (Genin and Alzérreca, 1995). The main species of the arid plains of the Altiplano are shown in Table 1 and Photos 1–3 (Alzérreca, 1988).

The carrying capacity of natural pastures in the arid

TABLE 1. MAIN TYPES OF PASTURE IN THE ARID BOLIVIAN ALTIPLANO

TYPE	DOMINANT SPECIES	YIELD (kg DM/ha/year)
Tolar	*Parastrephia lepidophylla*	170
Pajonal de Iru ichu	*Festuca orthophylla*	130
Tolar–*pajonal*	*Parastrephia lepidophylla, Stipa ichu, Festuca orthophylla*	210
Graminoid	*Distichlis humilis, Muhlenbergia fastigiata*	600
Bofedal	*Distichia, Plantago*	2 450

Altiplano is low. Cardozo and Alzérreca (1983) calculate those for the Turco region at 0.41 llamas/ha/year in dry areas and at 3.8 llamas/ha/year in humid areas.

The climate is microthermal, lacking a well-defined cold season, with a dry season from April to December and a wet season from January to March. During the dry season, the daily temperature range is over 25 °C. Frosts are frequent (265 days of the year) and may occur at any time. Average annual precipitation is 330 mm (data for 12 years), but varies sharply (90–500 mm). The mean annual temperature is 7 °C (Genin, 1995).

THE ECOLOGY AND CAMELIDS

Camelids are adapted to the Andean region; the "altitude sickness" that strikes many introduced species (such as cattle) does not affect them (Branchero *et al.*, 1971, and Sillao *et al.*, 1972, as quoted in JUNAC, 1990). They cause less damage to the grasslands since they bite off their forage (Wheeler, 1982, as quoted in JUNAC, 1990). Their soft, padded feet do not damage the terrain. Camelids are well able to digest grasses that are high in lignin. San Martín and Bryant (1987) note that the South American camelids are more efficient than other species in digesting fair-to-poor quality forage, due to:

- longer retention of forage in their digestive tract;
- higher frequency of stomach contractions and rumination cycles;
- higher ratio between salivation and stomach size;
- ability to maintain a high concentration of NH3 in the first and second compartments of their stomachs.

INTERACTION BETWEEN HUMANS, THEIR ANIMALS AND THE ENVIRONMENT

According to Soto (1995), Oruro was inhabited in the pre-Inca era. Carangas settled in Sajama Province where the most camelids are; the influence of Aymara settlements of Carangas, Soras and Quillacas is reflected in the present-day community. Throughout the Aymara region, the community is the basic organizational pattern. The Inca presence, the *reducciones* (reservations) set up in the sixteenth century, the Republic of 1825, the 1952 agrarian reform programme and the passage of the Popular Participation Act of 1994 are all factors that – in conjunction with the implementation of other measures by the State, government agencies, foreign development-oriented NGOs or religious groups – have played a role in modifying the organizational structure (Soto, 1995).

In Andean culture, nature is highly sensitive, being capable of both positive and negative responses. Life is an integrated, functional, cyclical entity encompassing all beings and all events that they experience and learn about. The Andean culture's concept of the world relates it to the ongoing changes and domestication of nature. Andean herders' world view is holistic; everything is integrated and revolves around Mother Earth, or the *pachamama* (Llanque, 1995).

In exchange for the benefits that grass bestows on them, herders provide an offering of another *manq'a* so that the land can maintain its life force and continue to provide their livelihood. The *manq'a* is an offering to Mother Earth and the divine community in general. "The land does not belong to man. Man belongs to the land. We are part of the land" (Llanque, 1995). "Animals are loaned to men by the gods, who offer them their wool and meat; in

return, man should take care of them, love them; otherwise, they will be taken away or confiscated and will return to their place of origin, the springs of life" (Llanque, 1989, as quoted by Llanque, 1995).

THE ROLE OF ANIMAL GENETIC RESOURCES IN COMMUNAL SOCIETY AND CULTURAL ACTIVITIES

In the Aymara world, llamas are the people's central offering when they worship and in their magical/religious ceremonies (Photos 4 & 12). Farmers and their families have an affective relationship with them that influences how they handle their herds and the households' way of life (Soto, 1995). In addition to the activities mentioned earlier, inhabitants use their stock during festivals, in roofing their houses (*achuqalla*), in designating officials, as offerings to the gods in seeking good weather, and other activities.

The Andean herder's view of activities takes in sociocultural and religious dimensions (Llanque, 1995). Husbandry practices are rational and have been developed over millennia. "This attests to the effectiveness of this knowledge, whose possessors have historically been the heirs of those who domesticated the camelids and who even today control an absolute majority of livestock businesses of this sort" (Gundermann, 1984, as quoted by Llanque, 1995).

STOCK MANAGEMENT AND THE ORGANIZATION OF PRODUCTION ACTIVITIES

Herders have several dwellings. The main one is the ranch, which is surrounded by corrals and may be next to those of relatives, or near a *bofedal* which provides water. They have temporary, seasonal dwellings in outlying pastures near a source of water, used in the transhumant system (Llanque, 1995).

The main livestock activities are: mating, marking, dipping and shearing (Llanque, 1995). Male and female camelids run together from December to March. Two systems are used: in one, the female is constrained; the other is free mating. Males may be owned, borrowed or leased. Females who have been mounted are daubed. This mating system is waning, as fewer and fewer males are available due to the shortage of grazing lands and the decline in herding males to these locations

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PHOTO 1. ***Bofedal*** **grassland**

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PHOTO 2. Tolar grassland

T. Rodriguez

PHOTO 3. ***Pajonal*** **grassland**

K. Templeman

PHOTO 4. Group of llamas during the annual and traditional *marcación* ceremony (Sajama Province)

(Llanque, 1995). In the ongoing, free system, females are kept with one or two sires. The sires' sexual activity is between December and March.

Females give birth in February and March; those at pasture can be moved to the main ranch to calve there. Weaning is natural; young leave their mothers of their own volition at about 8 months. Some may continue to suckle past their first birthday; in extreme cases, a stick is passed through the calves nostrils (Llanque, 1995). Stock are marked in February–March during festivals to give thanks to Mother Nature when young from the preceding brood are counted (Llanque, 1995). Parasites and diseases are treated with both traditional and veterinary techniques. Shearing takes place between October and December and at other times, depending on the household needs (Llanque, 1995). Alpacas and T'amphulli (thick-fleeced) llamas are routinely sheared. Q'aras (short-haired) llamas are sheared only rarely. Part of the animals' hair is left to protect them from the cold.

PASTURAGE ON THE PAMPAS

Stock are usually herded by wives or children. Herders need extensive, quality grazing lands and sufficient human labour to maintain a numerous herd. Income levels are determined by the number of animals, but expansion of a herd hinges on the availability of

pastures and the constraints associated with social conflicts. The rainy season (December–March) is the busiest time of year; all members of the household work and, if necessary, people are hired. (Llanque, 1995).

Female and male llamas and alpacas graze in separate groups. Males of several households are grouped and herded by one person in remote grasslands. If there are many females, plentiful grazing lands and labour available, the herd may be split. Stock go to graze very early in the morning, with the shepherd guiding them to the pastures that have been selected. The length of time that stock spend in each pasture depends on the type of herbage, its condition, the type of animals and the distance from their base. Drier pastures are used during the rainy season (Llanque, 1995).

Between January and June, stock are kept on the main property (Figure 1); dams and young graze together. Grazing is rotational, with stock being moved from one pasture to the next. When gramineous plants become scarcer (July), stock are moved to far pastures until January. Rotational grazing is combined with circular and vertical movements based on the grazing land's condition. Camelids are always put to graze first, followed by sheep, otherwise, the camelids refuse to graze (Llanque, 1995).

GENETIC RESOURCES AND LOCAL FOOD SECURITY

Herders use their stock primarily for food, but sell some to meet their basic needs. Soto (1995), states that llamas and sheep are virtually the sole source of livelihood for peasant households in the area. Producers use fresh meat, jerky, *chalona* (meat dried on the bone), and offal. Jerky and chalona will keep a long time.

Crops account for 5.2 percent of the land, and are slightly more common where irrigation is possible. The main crops are potatoes, barley and, to a lesser extent, quinoa (*Chenopodium quinoa*) as well as vegetables. Potatoes and vegetables are for on-farm consumption. Some producers say that their vegetables last until June and thereafter they have to buy them.

Livestock products are sold on the ranch, at local and regional markets and in the cities of Oruro and La Paz. Most producers sell llamas on the hoof and as meat; some also sell jerky. Young animals (2 years), males over 4 years and older females are usually sold on the hoof. Stock are sold to middlemen, to a company called Inti Raymi and to jerky-makers. Inti Raymi take stock to its feedlot; for slaughter and sale in La Paz. Six microenterprises producing jerky (using solar dryers) usually buy stock on the hoof but sometimes purchase carcasses.

FACTORS BRINGING ABOUT CHANGES IN THE TRADITIONAL SYSTEM FOR GENETIC RESOURCE MANAGEMENT

Factors that may lead to changes in the traditional stock-raising system are migration, natural disasters, jerky-making, preference for white hair or wool and

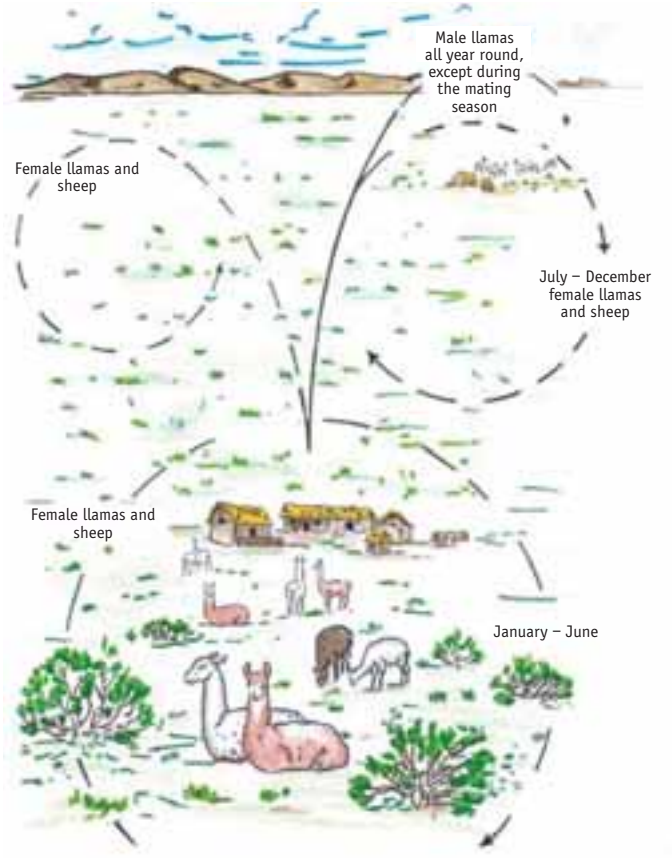

FIGURE 1. Pasturage infrastructure and system in the pampas of the Turco region (adapted from Llanque, 1995)


J.L. Quispe

PHOTO 5. Llama ecotype: Q'ara


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PHOTO 6. Llama ecotype: T'amphulli

some legal statutes. So far these are not prompting major changes. Although there are high rates of permanent (2.6 percent) and temporary (4.2 percent) emigration, the Turco Participatory Municipal Development Plan (1997) indicates that there is always someone in a family who decides to remain in the community and look after the livestock.

The issuance of municipal permits for the sale of fresh meat and the increasing volume of jerky made has not led to indiscriminate culling because herders know that their herds are their livelihood and limit the number of animals that they slaughter. When natural disasters such as droughts and snowstorms occur, producers reduce slaughter rates to offset the losses. Tichit (1994) notes that, during a critical year, a reduction in the number of breeding females, combined with a low birth rate, led to a reduction of up to 18 percent in some herds, but in others the number of breeding females was maintained by reducing slaughtering.

LLAMA ECOTYPES AND ALPACA BREEDS

In Turco, 46.5 percent of llamas are of the Q'ara ecotype, 48.7 percent are intermediate, 4.7 percent are T'amphulli and 0.1 percent are Suri; all alpacas are of the Huacaya breed.

Q'ara llamas are slim, long-bodied, and have short coats with conical, "sausage-curl" locks and visible bristles or guard hairs (Photo 5). T'amphulli llamas are coats with conical, "sausage-curl" locks and visible bristles or guard hairs (Photo 5). T'amphulli llamas are compact, short-bodied (Romero, 1927, as quoted by Cardozo, 1995) and have very thick coats. They have finer hair than the Q'aras and their fleece contains fewer guard hairs (Photo 6).

Huacaya alpacas are handsome, curvilinear animals. They stand taller than the Suris, their fleece is spongy and curly, with the hair perpendicular to the body. They are more resistant to harsh weather and high altitudes (Huanca, 1990) (Photos 7 and 8).

ANIMAL POPULATION AND HERD STRUCTURE

Livestock in Turco includes 93 230 llamas, 28 688 alpacas, 51 041 sheep and 531 cattle (Turco Participatory Municipal Development Plan, 1997). The structure of herds (Table 2) is similar to those elsewhere, such as Saucarí Province (Rodríguez, 1996).

Camelid reproduction behaviour is noteworthy on several counts. Ovulation is induced and occurs 26 hours after mating. Receptive females, when allowing themselves to be mounted, adopt a prone position; fertilized females reject the male's advances. Table 3 summarises the production traits of camelids. Most data are from experimental centres in Bolivia.

OBJECTIVES, CRITERIA AND SELECTION

PROCESSES

Most producers select llamas for meat and alpacas for fleece. Very few are interested in dual-purpose stock. Producers select Q'ara males (meat stock) that are tall and long-bodied and without congenital defects. Some choose animals of any colour; others prefer single-colour ones. They look for long necks and well-formed testicles.

Males are selected in two ways. The first is individual producers selecting sires to keep with the females in the herd. The second is group selection by the Tika Huta Camelid Research and Improvement Centre (IMCATH) which selects males from the herds of its members. These males are the members' contribution to the programme and are raised in Centros de Machaje (where male camelids are kept in isolation from females [Photo 9]). Members are responsible for grazing the animals; the time devoted to this depends on the number of animals contributed by each member.

Selection is based on the criteria described above,

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PHOTOS 7 and 8. Alpaca breeds: Huacaya (left) and Suri (right)

TABLE 2. STRUCTURE OF LLAMA AND ALPACA HERDS IN TURCO

	AGE	LLAMAS		ALPACAS	
		No.	%	No.	%
Crías	Under 1 year	469	18.3	152	25.1
Female yearlings	1 – 2 years	354	13.8	99	16.3
Male yearlings	1 – 2 years	309	12.1	58	9.6
Dams (females)	Over 2 years	1 317	51.5	283	46.7
Sires (males)	Over 2 years	108	4.3	14	2.3
Total		2 557	100.0	606	100.0

TABLE 3. BODY WEIGHT AND CAMELID MEAT AND FIBRE YIELDS

CHARACTERISTIC	LLAMA	ALPACA
Birth rate (%)	61.0	66.0
Birth weight (kg)	9.7	7.5
Pre-weaning weight gain (g/day)	181.0	120.0
Adult weight (kg)	84.1	54.9
Carcass yield (%)	52.1	48.7
Greasy fleece weight (kg)	1.1	1.8
Average fibre diameter (µ)	32.9	20.7
Average diameter of dehaired fibre (µ)	30.9	–

Source: Rodríguez and Cardozo, 1989; Cochi, 1999; and Charcas, 1997.

but care is taken that all males are single-colour. These males are used at stud. In the breeding season, females are tied and each is matched with a specific male. Members take turns using males. The number of males a member receives depends on the number of females in his herd. Each member has the use of the males until they have completed two services (usually 15 days).

After each service, the males are returned to the Centro de Machaje (Photo 10).

Forty-three percent of producers obtain males from other communities. Care is taken to ensure that the location is compatible with the site where they raise their animals. Another 19 percent either: (a) buy breeding males from their neighbours,
(b) choose a sire from their own herd, or (c) borrow or rent sires from the Centros de Machaje. Some producers use sires from the Centro de Machaje as well as their own *jañachos* to boost the herd's birth rate.

Most producers keep their males at stud for over three years; some keep them for two to five years, depending on how aggressive they are. One producer changed his sires every two years.

ANIMAL GENETIC RESOURCE CONSERVATION PROGRAMMES

The Ministry of Agriculture, Livestock and Rural Development is implementing a National Genetic Resource System for Agriculture and the Food Industry which includes a subsystem for camelids to "organize, establish and consolidate the camelid subsystem in

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PHOTO 9. Q'ara male llamas raised in a Centro de Machaje of Chiluma, Turco region

order to ensure the conservation of its genetic potential and optimize its usefulness". The subsystem's main activities are: (a) introduction of genetic material (following quarantine), (b) on- and off-site conservation, (c) exchange of genetic material, (d) access to genetic resources, (e) inventorying, (f) characterization, (g) utilization, (h) documentation, and (i) development of new breeds.

PRODUCERS' KNOWLEDGE AND CONCERN ABOUT ANIMAL GENETIC RESOURCES

Family livestock management is based on traditional knowledge and information obtained at training courses. In all, 47 percent of survey respondents said that the husband knows most about stock-raising because he has attended courses. Wives spend the most time herding, and are helped by their husbands on occasion and by children on vacation. Wives are more knowledgeable about the animals' condition. When asked whether there was a producer who knew more about stock management than the others, 57 percent replied in the negative, but 43 percent said there was such a person and that he had acquired knowledge from training courses. On health, 82 percent of the producers said that the husband tended sick or injured animals; 12 percent said that the wife did and 6 percent said that veterinary care was entrusted to a trained individual.

ACQUISITION, TRANSMISSION, CENTRALIZATION, COMPILATION AND DISSEMINATION OF TRADITIONAL KNOWLEDGE

Information is transmitted verbally to younger family members when tasks are being performed, giving direct experience. Children help with the herd, ask questions and parents teach them. No formal mechanism exists within the community for centralizing traditional knowledge. Information about traditional livestock practices has been compiled by specialists. One such study was reported by Genin *et al.* (1995).

INTERACTION BETWEEN GOVERNMENT AND COMMUNITY STRUCTURES

IMCATH undertakes research in Turco in coordination with the Technical University of Oruro, provides technical assistance and implements a genetic improvement programme which has set up Centros de Machaje in six Ayllus. To improve the centre's participation, each community has designated a coordinator to work with IMCATH. The Camelid Project, which will soon be concluded, uses a revolving fund to provide support for rural micorentrepreneurs providing shearing services (Photo 11) and for two feedlots.

M. Mezzera

PHOTO 10. Q'ara male llama raised in a Centro de Machaje of Chiluma, Turco region

K. Templeman

PHOTO 11. Huacaya alpacas waiting to be sheared, Turco region

KNOWLEDGE ABOUT POLICIES THAT AFFECT DAY-TO-DAY ACTIVITIES

Producers know the laws and policies that affect their business; they receive information from their political representative in the Prefecture, community organizations and in seminars and workshops. Radio is an important source of information.

PROMOTION OF THE USE OF NON-CAMELID SPECIES AND PERCEIVED THREATS

Producers said that there is a tendency to promote camelids and to avoid sheep, whose grazing habits and hooves damage the pastures. Producers see a threat in the proliferation of foxes and pumas that are protected in Sajama National Park. Park officials inform the population about regulations protecting wild animals

the proliferation of foxes and pumas that are protected in Sajama National Park. Park officials inform the population about regulations protecting wild animals and distribute pamphlets accordingly.

SUPPORT FOR RESEARCH, DEVELOPMENT, EDUCATION AND PRODUCER OUTREACH ACTIVITIES

Very little research, training or outreach work is ongoing in the area. IMCATH does some and executes a genetic improvement programme in coordination with the Technical University of Oruro. The Oruro Development Corporation, through the Farmers Self-Help Project and later through that project's consolidation programme, carried out training and outreach over a number of years; along with ORSTOM of France and the IBTA.

VALUATION OF ANIMAL GENETIC RESOURCES AND

K. Tempelman

PHOTO 12. Ear-marking of llama couple during the annual and traditional *marcación* ceremony (Sajama Province)

KNOWLEDGE OF BEHAVIOURAL AND AESTHETIC SELECTION CRITERIA

Ninety-four percent of producers say that camelids are their most valuable possession and only livelihood. A producer left without stock or with few animals, has to seek work, usually in the city. The only respondent not interested in his animals was a young man who wanted to move to town. Producers are unfamiliar with selection criteria based on behavioural and aesthetic traits but 76 percent prefer docile animals. Others prefer normal animals because very docile ones are too lazy.

Producers associate phenotypic traits with meat production. Most prefer tall, long-bodied, long-necked, good-sized Q'ara llamas of any colour. Some said that white animals are easier to see at a distance. It is important for animals to be broad-chested. For alpacas, they prefer good-sized, single-colour animals (especially white, black and grey) with wool-covered faces and feet.

DEGREE OF PRODUCER SATISFACTION WITH THEIR EXISTING GENETIC RESOURCE MANAGEMENT SYSTEMS

In all, 47 percent of producers were not fully satisfied with the way they manage their herds; 35 percent were not satisfied, and 12 percent were only somewhat satisfied. They would like most of all to improve forage production and pasture management. After that, they would like to monitor stock health better and make genetic improvements. Few mentioned irrigation, or weaning.

ATTACHMENT TO TRADITIONAL KNOWLEDGE,

DISSEMINATION OF INFORMATION, AND WILLINGNESS TO USE MODERN TECHNIQUES

Producers did not insist that traditional knowledge was irreplaceable; it complements modern techniques. Traditional disease-control systems are used when veterinary care is unavailable or too expensive. In some areas, there are better techniques than traditional practice, such as cultivation of grasses, selection of breeding stock, reduction of inbreeding, sanitation and health care. Herders will adopt new techniques which increase their earnings.

FUTURE DEVELOPMENT OF THE SYSTEM AND NECESSARY INPUTS

In Turco, 76 percent of producers hope to see specialization in efficient meat production. Some (18 percent) would be interested in a dual-purpose system (meat and fibre), especially if the price of camelid wool rises. Most felt that the main way to increase their herds' meat yields is to boost forage production and upgrade pasture management. Some felt that genetic improvement was important, as was irrigation and health and sanitation cover. Almost all felt that they needed more training to run an efficient meat production system (Photo 13).

In addition, they wanted training in animal health, forage production, pasture upgrading/management, genetic improvement, marketing and irrigation.

OUTLOOK FOR CAMELID PRODUCTION IN THE TURCO REGION

Neither government agencies nor NGOs are very active

K. Tempelman

PHOTO 13. The production of dried llama meat is an important source of income

OUTLOOK FOR CAMELID PRODUCTION IN THE TURCO REGION

Neither government agencies nor NGOs are very active in the conservation and improvement of animal genetic resources. A programme needs to begin as soon as possible to promote the conservation, management, development and sustainable use of South American camelid genetic resources and to focus primarily on *in situ* conservation, inventorying, characterization and utilization. This programme should be compatible with the maintenance of genetic diversity and with the producers' interests and economic needs.

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Map below:

Location of the central Peruvian Andes

MANAGEMENT OF SHEEP GENETIC RESOURCES IN THE CENTRAL ANDES OF PERU

E.R. Flores, J.A. Cruz and M. López

SUMMARY

The peasant communities of the central Andes have developed a system for exchanging genetic material, counteracting the degradation of their natural resources and using earnings from their livestock to improve their social well-being. They have a range of organizational models, genetic material, habitats and strategies for coping with the prevailing level of uncertainty and with the lack of information services and specialized technical assistance. This system has been evolving and has reached the point where it is an essential referent and framework for the analysis and design of sheep improvement policies.

The study is based on a project to improve livestock and natural resources implemented by the peasant community of Pasco region, since 1995, sponsored by the Foundation for Agrarian Development of the La Molina National Agrarian University; on the research findings of the Small Ruminant Collaborative Research Support Programme executed by the University of California in the 1980s; and on interviews, annual and technical reports prepared by the Boards of the peasant communities.

Mixed livestock systems involving sheep, camelids and cattle are common in the central Peruvian Andes, sheep are the most important livestock economically. The central Andes include 5.2 million hectares of pasture and 4.6 million sheep. Communities manage over 80 percent of the small ruminants and pasturelands (INEI, 1996). Low temperatures, frost and drought, make crop growing risky, and livestock is the area's main economic activity.

Peasant communities have devised systems for managing their herds' genetic resources and implement them with very little State support. Traditional organizations are a mixture of organizational and management systems, multicommunal and communal enterprises, communal cooperatives and farms, livestock departments, livestock committees, and family and individual farms. This complex mixture has been analysed to determine how these organizations use the genetic resources at their disposal and to put their role in upgrading livestock production into perspective.

THE ECOSYSTEM

This is a high mountain ecosystem (3 000 – 5 000 metres) of very humid, tropical, sub-alpine plains and rainy tundra-tropical alpine zones. The main plant communities are *pajonales* (stands of low-quality grasses), puna turf and *bofedales* (a type of wetlands) (Flores, 1991). *Pajonales* are made up of relatively tall species of *Festuca*, *Calamagrostis* and *Stipa*; puna turf is formed by low-growing species of *Agrostis*, *Dissanthelium* and *Werneria*. *Bofedales*, are composed of vegetation characteristic of soil that is waterlogged for much of the year; the dominant plants are *Distichia,*

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PHOTO 1. Typical central Andes landscape composed of a combination of various types of *pajonal*, puna turf and *bofedal* vegetation.

Hipochaeris and *Plantago* (Photo 1).

In sub-alpine plains, the mean annual maximum temperature is 6 ºC and the mean annual low is 3.8 ºC. Annual precipitation ranges from 1 255 mm to 584 mm. Potential evapotranspiration ranges from one-fourth to one-half of mean annual precipitation. In the rainy tundra-tropical alpine zones, the mean annual temperature is 3.2 ºC, and total precipitation ranges from 1 020 mm to 688 mm per year. Evapotranspiration is between one-eighth and one-fourth of annual precipitation (Holdridge, 1982).

Acidic, sandy soils that are high in organic matter and low in phosphorus predominate. Most soils are Regosols, Andosols, Cambisols, Calcisols, Vertisols and Kastanozems. Steep slopes, the climate and intensive grazing heighten the risk of erosion and desertification; less than 3 percent of the land is suitable for crops (INRENA, 1996).

HISTORY OF INTERACTION BETWEEN PEOPLE, ANIMALS AND THE ENVIRONMENT

Most sheep belong to peasant communities, organizations created by the Spaniards to facilitate tax collection and speed the flow of manpower to the government. Initially, communities kept camelids which were gradually replaced by cattle and sheep (Recharte *et al.*, 2002); this triggered a reduction in native species, a loss of biodiversity and a decline in the flexibility needed to respond to the constraints of high mountain ecosystems.

Originally, communities were patterned on the ancient Andean Ayllu (Delran, 1981). After 1570 the Ayllu became a *reducción*. Between independence in 1821 and about 1920, these became "indigenous communities" (Pardo-Figueroa, 1995), which were often stripped of their land by large landholders and local chieftains, and the courts handed down rulings that obliged them to fall back on their own resources to defend their rights. Communities pooled their productive land to marshal the funds needed to stand up for themselves. Resources that could have been invested in livestock were diverted, limiting many communal livestock operations' ability to apply improved management.

The Constitution of 1920 laid the groundwork for recognition and registration of the land titles of indigenous communities (Pardo-Figueroa, 1995). The name was changed to "peasant community" as part of the 1969 agrarian reform. The 1979 Constitution established the term "communal and multicommunal enterprise" and promoted the formation of economic

units within them (Pardo-Figueroa, 1995). The 1987 Peasant Communities Act empowers communities to conduct business activities as Communal and Multicommunal Enterprises (Aliaga, 1995).

The communal assemblies of peasant communities have authorized the use of organizational arrangements, including multicommunal and communal enterprises, to increase their livestock production systems' sustainability (Table 1). Communities provide land and commune members provide animals and labour. Individual farmers have maintained their operations or formed groups to set up family farms and livestock committees to manage their resources more efficiently. A community may use two or more models within its territory.

The highest production indices are in community enterprises and the lowest among commune members who work community lands on an individual basis (Bryant *et al.*, 1989). This is attributable to factors summarized in Table 2.

TABLE 1. PRINCIPAL CHARACTERISTICS OF COMMUNAL PRODUCTION SYSTEMS IN THE CENTRAL ANDES

TYPE	ENTERPRISES		INDIVIDUAL FARMERS
	Multicommunal	Communal	
Legally-constituted corporate entities	Pachacutec and Túpac Amaru SAIS (social farming associations)	Communal enterprises, Communal cooperatives, Communal farms, Livestock department	Commune member, Family farm, Livestock committees
Landowner	Several communities	A community	A community
Area (in hectares)	100 000 – 200 000	500 – 14 000	50 – 400
Members	Communities	Commune member	Commune member
Number of households	20 000 – 25 000	200 – 3 000	1 – 30
Number of sheep	40 000 – 60 000	350 – 5 000	60 – 200
Breeds	Corriedale, Junín and Merino	Corriedale, Corriedale x Criollo	Criollo and crosses
Main destination for products	Market and social investment	Social investment	Own consumption and market

TABLE 2. PRODUCTION INDICES AND STATUS OF GRAZING LANDS IN THE CENTRAL PERUVIAN ANDEAN SHEEP PRODUCTION SYSTEMS

UNIT	MULTICOMMUNAL/COMMUNAL COOPERATIVES	COMMUNAL FARMS/FAMILY FARMS	INDIVIDUAL FARMERS
Recommended stocking rate (sheep/ha/year)	1.0	0.5	0.2
Current stocking rate (sheep/ha/year)	1.5	3.0	5.0
Live weight (kg)	38.0	35.0	30.0
Fleece weight (kg)	2.5	1.8	0.9
Carcass weight (kg)	16.0	14.0	10.0
Carcass yield (%)	42.0	40.0	33.0
Lambing rate (%)	88.0	75.0	60.0
Weaning rate (%)	78.0	62.0	40.0
Condition of grazing lands	Fair	Poor	Very poor

E. Flores

PHOTO 2. Contrast between a pasture in good condition (right) maintained by a communal enterprise and a pasture in poor condition (left) being used by individual farmers

THE ROLE OF GENETIC RESOURCES IN THE ECONOMY AND IN ENSURING FOOD SECURITY

Rural communities use livestock for consumption and as a medium of exchange; they also use livestock or wool as loan collateral and in-kind loan repayments, and to a lesser extent, in cultural, recreational and tourism activities. In multicommunal and communal enterprises, sales decisions are based on technical criteria and market demand. With individual farmers, consumption and sales tend to occur on culturally significant dates, when cash is needed, or when an animal is ill or killed in an accident.

Most livestock are sold to traders. Barter is common between farmers. Cash-based, intermediated commercial transactions are more common in organized production systems. More developed systems, such as communal enterprises, command the best prices; their wool may sell for as much as 66 percent more than that of individuals.

Livestock products can be major sources of protein, calories and micronutrients, but their use is restricted by low income levels, mothers' misconceptions regarding nutritional value, and the frequent need to sell livestock to get money (Flores, 2002). Animal products provide 14 percent of the energy requirements of children under five, but meat accounts for only 1 percent because mothers associate it with parasitic diseases (Villasante *et al.*, 1997). Chronic malnutrition and iron deficiencies in children under five and in women during their childbearing years are very frequent (55 percent) in livestock-producing areas of the Andean highlands (CIED, 1996).

Communal and multicommunal enterprises produce more, use more efficient techniques, and assign more of their food output to social programmes than the rest of the production system. Individual farmers use 23 percent of excess stock for home consumption and the rest for sale; communal enterprises consume 6 percent of their excess, 42 percent is for fellow members, and 52 percent for sale (Villasante *et al.*, 1997).

Degradation of grazing lands is more common on individually-held farms (Lozada, 1991); communal enterprises have been more successful than individuals in managing their grasslands, although both use community land (Photo 2). This highlights the need to design mechanisms for promoting communal organizations to help enhance the contribution that they make to the region's social development.

LOCAL BREEDS

Over 20 breeds have been introduced to Peru without any genetic plan; very little is known about their performance or ultimate use. There is much more information about the Criollo and its crossbreeds, Corriedale and Junín (Photo 3), that have been used in Peru on an ongoing basis and exhibit persistence and adaptation to the environment (INIA, 2003).

Criollo sheep are descended from stock introduced in the sixteenth and seventeenth centuries. The original breeds were Merino and the coarser-wool Churra and Lacha from northern Spain (Calle, 1968). The Criollo is known for hardiness, a lower degree of breeding seasonality and as a good grazer. Fleeces weigh 1.5 kg on average, and live-weights vary between 20 kg and 30 kg for adult ewes and 23.0 kg and 40.5 kg for males (Cabrera *et al.*, 1990). This breed, which accounts for 60 percent of the country's sheep, is kept mainly by individual peasant farmers (Photo 4).

Corriedale was created through absorptive crossbreeding of Criollo sheep with Corriedales (Calle,


K. Tempelman

PHOTO 3. Junín sheep raised at the multicommunal Túpac Amaru SAIS in the Junín region


E. Flores

PHOTO 4. This picture of a flock of Criollo sheep grazing on degraded rangelands illustrates the high degree of variability exhibited by the breed.

1999). It is a well-muscled, dual-purpose animal. Calle (1999) reports ram weights of 45 kg to 58 kg, with fleeces averaging 4 kg, and, for ewes, 40 kg to 42 kg, with fleeces between 2.8 kg and 3.5 kg. The fleece is of good quality. This breed makes up 13 percent of the country's sheep and is chiefly kept by multicommunal and communal enterprises and some private breeders. Because of its strength, hardiness and successful adaptation to the high Andean environment, it is of key importance in improvement programmes.

Junín sheep were developed in central Peru out of Criollo crossed with various breeds including the Corriedale, Romney Marsh, Columbia, Panama and Warhill (Villarroel and Gamarra, 1978). They have long, sturdy legs, are bare-faced, have varying degrees of pigmentation in their nostrils and hooves, and produce a high yield of clean wool measuring from 23 to 25 microns in diameter and of 12 cm in length for rams and of 9 cm in the case of lambs. Adult rams weigh, on average, 74 kg and ewes 45 kg. The main nucleus of this breed is held by the multicommunal Túpac Amaru SAIS in the Junín region (Photo 5); it represents 2 percent of the country's sheep herd.

HERD FORMATION AND SELECTION CRITERIA AND PROCESSES

The basis on which herds are formed and the selection


E. Flores

PHOTO 5. Flock of Junín sheep in ryegrass and clover pastures cultivated by the Túpac Amaru SAIS

K. Templeman

PHOTO 6. Criollo sheep being herded in the central Peruvian Andes

criteria and methods used are closely related to the community organizational model, community directors' management capacity and the level of technical assistance from the State, universities, non-governmental organizations and other institutions (Flores, 1996).

Number and structure of herds: multicommunal and communal enterprises are able to maintain genetic pyramids and breeder flocks to supply their needs and to sell or lend to other community members and organizations. Some have participatory breed improvement programmes based on open-nucleus schemes in partnership with universities and other communities (Mueller *et al.*, 2002). The number of replacement lambs varies between 20 and 25 percent, and the number of rams is around 10 percent.

The State sometimes makes large purchases from them to assist less organized communities. They receive genetic material of exotic breeds via State-sponsored imports or may import stock on their own initiative. The biggest import for communal enterprises, of more than 100 000 Corriedales from Australia, was by the State in the 1970s. Once the State began to deal with communities on an equal footing with the private sector in the 1990s, some communal enterprises started to import small lots of Corriedales from the Magellan region of Chile and New Zealand.

Individual farmers obtain breeding stock from cooperatives and communal farms; farmers do not keep replacement rams, but buy or borrow them from communal enterprises within the same community. The percentages of replacement female yearlings (20 percent) and rams (8.5 percent) do not differ substantially from those in communal enterprises.

SELECTION AND BREEDING CRITERIA

Multicommunal and communal enterprises use technical phenotypic selection criteria, relying on visual assessments of live weight, the animals' conformation

and fleece quality, with Corriedale and Junín serving as the standard of comparison (Blackwell, 1985). Mating is seasonal and controlled; artificial insemination with fresh semen may be used. Monitoring and registry systems are not well developed and, where they exist, are applied only to breeder flocks.

These organizations use rating systems to classify sheep for management and selection based on the formation of herds using categories and stock classifications with separate categories for ewes, rams, female yearlings, male yearlings, castrated rams and lambs. Stock are usually grouped into five categories: Super (S), A, B, C and "rejected" (R). Classification is done and adjusted before shearing. Males in categories S and A are used for breeding, while those in categories B are sold to family farms and small-scale producers. Ewes in the R category may be used occasionally in industrial programmes, where they are crossed with Hampshire Down.

With individual farms mating is ongoing and unmonitored. Males of different breeds mate indiscriminately with Criollo and crossbred ewes. Selection criteria are based on visual assessments of size, age, type of wool and lambing performance. These producers may buy, lease or borrow sires from communal and multicommunal enterprises. Improved stock are then mated with unrelated animals to "freshen up" the bloodlines. The result is disorderly crossbreeding which makes it difficult to quantify the effects of differing degrees of crossing or to make further improvements.

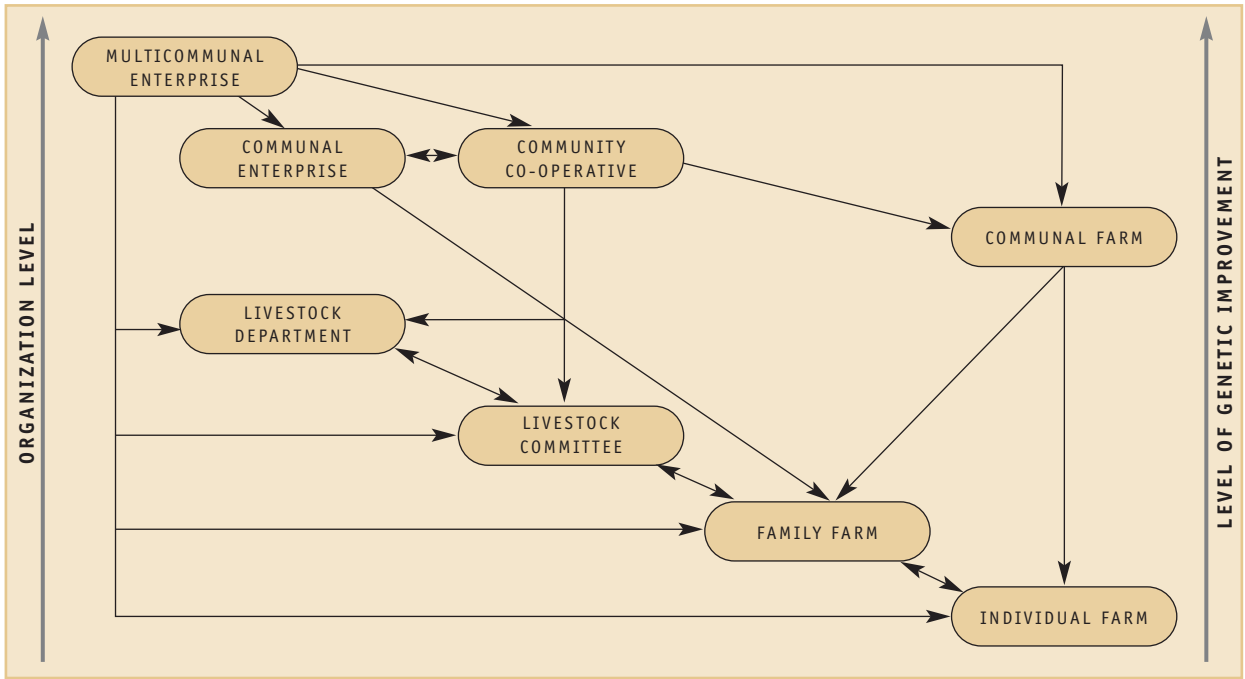
EVALUATION OF TRADITIONAL MANAGEMENT SYSTEMS

Peasant communities use several models to manage their resources more efficiently and increase their production systems' stability. Using such models, they exchange genetic resources, experiences and technology in an effort to raise their production indices (Figure 1).

MULTICOMMUNAL ENTERPRISES, COMMUNAL ENTERPRISES AND COMMUNITY COOPERATIVES

These help to improve the herds' genetic resources by maintaining sound breeder stocks of Corriedale, Junín and Merino. Farmers are very keen to adopt new,

FIGURE 1. GENERAL SCHEME OF GENETIC RESOURCE EXCHANGE IN SHEEP PRODUCTION SYSTEMS IN THE CENTRAL ANDES OF PERU



K. Templeman

PHOTO 7. Individual farms often keep livestock species other than sheep, such as alpacas, to averse risk

affordable technologies and do not care whether these are generated on a participatory basis or come from experimental stations (Mueller *et al.*, 1999). The State usually chooses them as sources for the purchase and supply of breeding stock to less developed peasant organizations. Support is frequently provided to communal farms, livestock departments, family farms and individual farmers in the form of breeding stock, training and technical assistance. When their activities produce sufficient profits these units may set up social programmes to help households buy school supplies and assist the elderly. Since they usually keep their pastures in good condition, their lands can be sources of native-plant germplasm for use in the replanting of degraded areas.

COMMUNAL FARMS, LIVESTOCK DEPARTMENTS AND LIVESTOCK COMMITTEES

Communal organizational models are using absorptive crossing of Criollo with Corriedales; they are socially-oriented and devote profits to educational and health-care infrastructure. They are highly risk-averse and but open to new technologies which are affordable, profitable and have been generated on a participatory basis. Their pastures are in fair-to-poor condition, depending on the level of management.

FAMILY AND INDIVIDUAL FARMS

Family and individual farms hold the Criollo in high esteem and maintain an ample pool, contributing to breed conservation. They are more risk-averse than other components and keep mixed herds of camelids (Photo 7), cattle and smaller animals, such as guinea pig, rabbits and poultry. The coloured Criollo fleeces are prized for making clothes, costumes and craftwork. Their pastures are generally in very poor condition, due to high stocking rates.

PRODUCERS' ROLE AND STATE INVOLVEMENT

Stock-raising communities play a central role in conserving the Criollo breed, preserving local breeds, establishing breeder herds, providing breeder stock and furnishing social assistance to their members. They work with the Sate to resolve poverty-related problems.

They play a key role in developing genetic improvement programmes, and supplying the State with stock for development programmes. Community initiatives are subject to constraints: they do not receive subsidies, tax exemptions, or any sort of tax credit for what they spend on infrastructure and social development programmes. Experimental stations focus on export crops rather than subsistence livestock.

The State should review its livestock policies for the Andean highlands and build up the institutional capacity of producer organizations and peasant communities to conduct genetic resource conservation and improvement. Technology development and transfer should be upgraded through participatory research (Photo 8). Training needs improvement in community-defined priority areas such as health care, pasture management, livestock management aimed at conservation, and genetic upgrading.

Farmers who manage their resources efficiently, even within communal land use, could be trained as promoters and serve as examples for others. They would be ideal candidates to provide animals to form cooperative nucleus herds and improvement programmes, working with technically sophisticated livestock committees and family farms (Photo 9). Breeding and animal husbandry centres to improve Criollo stock could be set up and associations for breeders of Criollo and other local sheep breeds formed to increase the efficiency of genetic resource management. In this new framework, universities, non-governmental organizations and international agencies can play a crucial role in ensuring success.

OUTLOOK

This system for exchanging genetic material, counteracting the degradation of their natural resources and using earnings from their livestock to improve their social well-being is characteristic of the central Andean highlands. It could serve as a model to improve traditional management and organizational systems in other areas; notably because it includes traditional elements and the necessary entrepreneurial components. The State should resume the role it played previously and begin to design policies to build up peasant communities' institutional capacity for improved management of the animal genetic resources and natural pastures that serve as the mainstay for their livestock activities.

K. Tempelman

PHOTO 8. Farmers' participation in the generation of technology is a crucial factor in facilitating its rapid adoption

E. Flores

PHOTO 9. Gathering of farming communities in Pasco region, exchanging experiences to improve traditional management techniques

K. Tempelman

PHOTO 10. Typical landscape in the Central Peruvian Andes

K. Tempelman

PHOTO 11. Criollo sheep owned by an individual farmer in the municipality of Vicco (central Peruvian Andes)

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